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Final Evaluation of USAID Alternative Energy Sources Project in Ecuador

Gerald Maestas
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ORNL-6361

FINAL EVALUATION OF USAID ALTERNATIVE ENERGY SOURCES PROJECT IN ECUADOR (PROJECT NO. 518-0029/ LOAN NO. 518-W-039)

ENERGY DIVISION

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EXECUTIVE SUMMARY

The purpose of this report is to describe the results of a detailed final evaluation of the Alternative Energy Sources (AES) Project (No. 518-0029/Loan No. 518-W-039), carried out under the direction of Ecuador's Instituto Nacional de Energía (INE or National Energy Institute) between 1981 and 1986 with funds provided to the Government of Ecuador by USAID/Quito. This evaluation concentrated on reviewing the project's original purpose and design; modifications to the design over the project's life; the project's accomplishments and shortcomings; and in particular, the record of the project's implementation from the completion of the project's mid-term evaluation in April-May 1984 through June 1986.

The project's goals were to "encourage more rational use of energy resources in order to improve Ecuador's ability to meet the energy needs of its population [and] to better address the energy needs of lower income Ecuadorian families, particularly those in rural areas" (USAID, 1981, p. 15). To achieve these goals, the project was "to strengthen INE's [the National Energy Institute, Instituto Nacional de Energía] institutional capacity to [affect] overall GOE [goverment of Ecuador] energy planning and the promotion of NCE (non-conventional energy) technologies appropriate to Ecuador" (USAID, 1981, p. 15).

The methodology used by the evaluation team was to conduct an in-depth review of the project through interviews, review of project files and documents, field visits to project activities and analysis of selected project reports. Following an orientation briefing and review of basic project documents in AID/Washington the evaluation team spent two weeks in Ecuador conducting its investigations. Prior to departure, the team prepared and presented to INE and the Mission a draft report of its evaluation. A final report was prepared upon return to the United States.

The original project design was overly ambitious and contained a program which created unrealistically high expectations on the part of the Government of Ecuador for an essentially fledgling institution. Nevertheless, INE has developed credible programs in two major areas during its seven-year life as an institution and over the life of this project: energy policy studies and non-conventional energy (NCE) demonstrations/energy conservation. INE has developed technical competence in the following areas of alternative energy: small hydro plants; solar domestic water heaters; family-sized biogas digestors; passive solar architecture; low-temperature, low-enthalpy geothermal energy; and energy-efficient metal cookstoves. INE also has developed a strong technical capability in industrial energy conservation, which has surpassed mid-term expectations and 1985 Plan goals despite limited staff resources. The demand for these services continues to grow among private firms.

INE has developed substantial analytical competence in a number of important technical areas in national energy planning for which they have received public recognition, and in several cases INE has been influential in national decision-making. Despite these successes, INE has been unable to realize fully the initial goals established for it at its inception, namely that it become the dominant agency in the coordination and execution of national energy planning. This appears to have been an unrealistic expectation given the size and financial resources of competing national energy and planning agencies.

INE has reached a stage of institutional maturity in which it is increasing its energy information dissemination and technical outreach activities. This is evidenced by a number of recent conferences, seminars, and workshops on industrial energy conservation audits, passive solar architecture, and biogas digestor construction and maintenance. INE has been designated as the national node of a new regional energy information exchange network being organized by OLADE (Organisacion Latino Americano de Energía, or Latin American Energy Organization). While it does not yet possess the necessary technical equipment or staff expertise to fulfill this role adequately, it has made strides over the course of the project in becoming a major source for energy information.

Over the life of this project INE has developed the capacity to work in effective partnership with private sector firms in the adaptation of NCE technology for selected markets. Their programs have emphasized local manufacture wherever possible.

It is the evaluation team's judgment that during the first two years of the project, when severe implementation problems developed, USAID developed a negative attitude toward the project despite the fact that it was designed as an "institution-building" project. This attitude appears to have persisted throughout the project despite a positive Mid-Term Evaluation and a clear record of improved performance by INE during the last year and a half. Although much was accomplished during this later period, more could have been accomplished if this attitude had not prevailed. In the Mission's defense, it was under considerable pressure to deobligate funds from the Mission portfolio. It was also under severe staffing constraints which affected project management and seemed to amplify bureaucratic impediments. INE also experienced its share of implementation problems for which it must bear responsibility. These resulted from inexperience; personnel turnover, including the Executive Director; and changes in program planning and definition.

The project's development impacts include final consumer benefits delivered by several of the NCE demonstration projects; training and experience gained by INE staff; benefits to other organizations, in both the private and public sectors, that worked with INE as either contractors or counterparts; and general benefits to the nation from INE's strengthened analytical energy planning capabilities.

Several general lessons emerge from the evaluation. First, in an institution-building project, USAID should anticipate an array of delays, institutional fluctuations, and administrative hiatuses. Work plans and schedules should be kept flexible and encouragement should be given consistently. Constant communication is essential to maintenance of fruitful relations between USAID and the recipient institution. Second, new institutions gain credibility only over time and by the high quality of their work; credibility cannot be conferred by edict. Third, the actual progress of a project, particularly an institution-building project, should not be judged by spending patterns; alternative indicators of project achievement need to be devised. Fourth, it is important for a new institution to use accounting procedures which are consistent with those of donor agencies; many delays can be avoided by such prior coordination. In particular, it is important for USAID to give recipient agencies such as INE adequate information on the impact of USAID procurement regulations on project activities.

The evaluation team offers the following recommendations to USAID, in order of priority:

1. Funding should continue for specific, clearly defined project activities. Continued support of INE will insure a higher degree of project success than would be achieved otherwise and will help to protect AID's investment in the project to date. The activities we recommend for extension are, in order of priority:

   i. purchase of a mainframe computer;

   ii. carrying through with the purchase of photovoltaic power systems which would provide electrical power at 30 telecommunications sites;

   iii. development of a solar collector test facility for the purpose of developing manufacturer's standards; and

   iv. carrying through the establishment of a revolving loan fund for family-sized biogas disgestors.

   These are all activities which were initiated well before the extended, and in some cases the original, project assistance completion date (PACD), and all were delayed for reasons beyond INE's control. The PACD should be extended for a period of nine months from June 30, 1986, to permit accomplishment of the activities recommended above.

2. If a longer PACD extension is feasible, two other activities are worthy of funding:

   i. energy audit training and quality control of the audits performed by the trainees, and

ii. two additional small hydro projects.

A PACD extension of fourteen months from June 30, 1986, would be required if these two additional activities are funded.

3. Since the Mission does not contemplate funding a follow-on project and does not have any other activities in the energy sector, we wish to point out opportunities for the Mission to consider selective funding of targeted energy activities with INE through a combination of other Mission sector activities or projects; regional bureau-funded activities; and/or Mission buy-ins to centrally coordinated energy projects in the USAID Office of Energy (S&T/EY). Activities which might be considered include:

   i. Further support to INE's energy planning activities through the Energy Policy Development and Conservation Project.

   ii. Further support to INE's conservation activities could be funded under the Energy Conservation Services Program.

   iii. Selected INE activities in NCE technologies could be further supported through the Renewable Energy Applications and Training Project: feasibility studies for additional small hydro projects; working with private sector solar domestic water heater manufacturers to improve design efficiency, reduce costs, and establish a program of standardization and quality control.

Recommendations 4, 5, and 6 are directed to INE:

4. INE should redouble its efforts to promote dialogue with other government agencies with connected responsibilities.

5. INE should also continue its already strong effort to involve the private sector in creating manufacturing opportunities in renewable energy technology and to perform energy conservation engineering services.

6. INE should focus some of its planning activities on the mid-term consequences of declining oil prices and declining Ecuadorian oil production on investment funds available for national development.

ABSTRACT

This report describes the results of a detailed final evaluation of the Alternative Energy Sources Project (No. 518-0029/Loan No. 518-W-039), carried out under the direction of Ecuador's Instituto Nacional de Energía (INE or National Energy Institute) between 1981 and 1986 with funds provided to the Government of Ecuador by USAID/Quito. The project's goals were to (1) encourage more rational use of energy resources in order to improve Ecuador's ability to meet the energy needs of its population and (2) to better address the energy needs of lower income Ecuadorian families, particularly those in rural areas.

The original project design was overly ambitious and contained a program which created unrealistically high expectations for a fledgling institution. Nevertheless, INE developed credible programs in two major areas during its seven-year life as an institution and over the life of this project: energy policy studies and NCE demonstrations/energy conservation. INE has developed technical competence in the following areas of alternative energy: small hydro plants; solar domestic water heaters; family-sized biogas digestors; passive solar architecture; low-temperature, low-enthalpy geothermal energy; and energy-efficient metal cookstoves. INE also has developed a strong technical capability in industrial energy conservation, which has surpassed mid-term expectations and 1985 Plan goals despite limited staff resources. The demand for these services continues to grow among private firms.

INE has developed substantial analytical competence in a number of important technical areas in national energy planning for which they have received public recognition, and in several cases INE has been influential in national decision-making. Despite these successes, INE has been unable to realize fully the initial goals established for it at its inception, namely that it become the dominant agency in the coordination and execution of national energy planning. This appears to have been an unrealistic expectation given the size and financial resources of competing national energy and planning agencies.

Several general lessons emerge. (1) In an institution-building project, USAID should anticipate an array of delays, institutional fluctuations, and administrative hiatuses. Work plans and schedules should be kept flexible and encouragement should be given consistently. (2) New institutions gain credibility only over time and by the high quality of their work; credibility cannot be conferred by edict. (3) The actual progress of a project, particularly an institution-building project, should not be judged by spending patterns; alternative indicators of project achievement need to be devised. (4) It is important for a new institution to use accounting procedures which are consistent with those of donor agencies; many delays can be avoided by such prior coordination.

1. INTRODUCTION

This report presents the findings of a detailed final evaluation of the Alternative Energy Sources (AES) Project (No. 518-0029/Loan No. 518-W-039) carried out by Ecuador's Instituto Nacional de Energía/National Energy Institute (INE) with funds supplied by the Ecuador Mission of the U.S. Agency for International Develoment (USAID/Quito) between 1981 and 1986. This final evaluation focused its efforts on analyzing the performance of the project during the two-year period from the completion of the project's mid-term evaluation in April and May 1984, through June 1986.

The evaluation also reviewed the project's original design and the modifications made to it over the life of the project. The project's achievements and accomplishments were reviewed, and implementation of the project by INE and USAID was analyzed carefully.

The methodology used by the evaluation team conformed to standard USAID Evaluation Procedures. Following an orientation briefing on May 30, 1986, organized at USAID/Washington by Alberto Sabadell of the Office of Energy of USAID (S&T/EY), the evaluation team reviewed the project documents available in Washington, D.C. The evaluation team then spent two weeks in Ecuador from June 22 through July 7, conducting an intensive review of the project. This review of the project was accomplished through a review of project files at INE and USAID/Quito and through numerous meetings and discussions with the principal staff members of INE; the Mission staff at USAID/Quito; and representatives of other Ecuadorian and American institutions who have been involved with the project and its activities (see Appendix 2 for a listing of persons interviewed). Another important element of the evaluation was a one-day field visit on June 26, 1986 to several sites where project activities had been conducted and to institutions which had participated in the project (see Appendix 3 for a listing of the field site visits). Due to the short time the evaluation team was in the country and the geographic dispersion of project activities, it was only possible to visit a small number of activities in the Quito area. The team prepared a draft report of its preliminary findings and presented it informally to INE and USAID/Quito before the team's departure from Ecuador. The final Evaluation Report incorporated comments from INE and USAID and was prepared after the team's return to the United States. The organization of this evaluation report reflects both the major categories contained in the evaluation statement of work (see Appendix 4) and Latin American and Caribbean Bureau of USAID (LAC/DP) guidance on preparation of evaluations.

The evaluation team was headed by Mr. Gerald Maestas, the program manager for alternative energy programs at Los Alamos National Laboratory in New Mexico. Mr. Maestas, who holds degrees in chemical engineering and business administration, has been involved in directing and managing alternative energy projects for the last eight years. Supporting Mr. Maestas in his role as team leader were

Dr. Donald Jones and Mr. Garland Samuels, Jr., of Oak Ridge National Laboratory's Energy Division in Tennessee and Mr. Dana Younger of Dames & Moore's International Division in Washington, D.C. Dr. Jones is an energy economist with advanced degrees in economic geography, regional economics, and development economics. Over the last four years, he has worked on several energy project evaluations and has developed a program in energy/economy modeling for developing countries. Mr. Samuels, who holds advanced degrees in engineering, has over 36 years of experience with both conventional and non-conventional energy development engineering and has recently participated in the implementation of USAID national energy assessment projects in Haiti and Liberia as well as a global reassessment of USAID renewable energy projects being conducted by S&T/EY. Mr. Younger, who holds advanced degrees in energy economics, planning, and science and technology policy, is a former AAAS Fellow in the Africa-Near East Bureau of USAID (ANE/TR/ENR) and has participated in the design, implementation, or evaluation of USAID renewable energy projects in Egypt, Morocco, Tunisia, Jordan, and North Yemen as well as the global reassessment of USAID renewable energy projects.

The evaluation team expresses its appreciation and gratitude to all those who participated in the preparation of the Evaluation Report and particularly acknowledges the administrative assistance, guidance and logistical support provided by Mr. Alberto Sabadell, S&T/EY; Mr. Thomas Chapman, USAID/Quito; Dr. Fausto Maldonado, USAID/Quito; Ing. Franklin Carrasco, Acting Executive Director of INE; Ing. Marco Acosta and Ing. Raul Nuñez of INE. Lawrence J. Hill and Robert D. Perlack of ORNL and Alberto Sabadell offered useful comments on drafts of the report. And last, but far from least, we thank Srta. María Palacios of the Mission staff for preparing the manuscript of the draft evaluation report and Mrs. Brenda Bush of ORNL for preparing the final manuscript.

2. PURPOSE AND DESCRIPTION OF THE PROJECT

2.1. PURPOSE

The purpose of the Alternative Energy Sources Project (AESP) (518-0029) was to assist the Government of Ecuador (GOE) in "upgrading the institutional and technical capacity of the National Energy Institute (INE). It will support Ecuadorian efforts to improve its energy planning capacity, serve as a positive incentive for conservation initiatives, and expand INE's institutional and technical capacity in non-conventional energy (NCE) development. Through this project, the GOE will gain improved access to NCE technologies in the United States and LAC (Latin America and Caribbean) countries and lay the research and development base for the emergence in Ecuador of a non-conventional energy industry.... Specifically, the project will build up Ecuador's institutional and technical capacity so that it can better deal with its energy problems and attract larger international financial intermediary (IFI) funding to non-conventional energy projects" [USAID, 1981 (PP) PP iii-iv].

The Project Paper envisioned that, "[B]y the end of the project it is expected that INE will provide the GOE with an improved institutional mechanism for better coordinating and integrating decisions in Ecuador's various energy subsectors (electric power, petroleum, natural gas, and non-conventional energy and traditional fuels). INE will also provide a mechanism to transfer to Ecuador international NCE technologies, evaluate and adapt these technologies for Ecuadorian needs and conditions, and facilitate their dissemination throughout the country" (PP, p. v). It also added, "[a] key objective of the project will be to develop INE's capacity to promote alternative energy demonstrations and dissemination by utilizing other Ecuadorian agencies with substantial field level implementing experience." (PP, p. vi).

2.2 DESCRIPTION

The project's description as stated in the Project Paper (pp iv-v) includes a statement of the project goal and a description of the project's four major components.

The project goal is: (1) to encourage more rational use of energy resources in order to improve Ecuador's ability to meet the energy needs of its population; and (2) to address better the energy needs of low income Ecuadorian families, particularly those in rural areas. To contribute to this goal, the project will strengthen INE's institutional and technical capacity to conduct and influence overall GOE energy planning and to promote the development and dissemination of non-conventional energy technologies appropriate to Ecuador. The institution-building and technology transfer purposes of the project

will be achieved through four distinct but interrelated components, as follows:

"(1) Energy Planning and Analysis (also called Energy Studies and Research): Through this component, the project will strengthen INE's technical capacity to carry out macroeconomic energy planning. Alternative energy resource assessments, a rural energy survey and an energy forecasting model will be prepared. INE will also strengthen its relationships with the academic community, especially through implementation of activities under the research and development fund. These activities, in turn, will provide data that will be useful in meeting INE's energy planning needs.

"(2) Technology Transfer and Information Network: This part of the project will make available to INE international information on alternative energy technologies. Information flows will both bolster INE's planning capabilities and provide a data base to guide INE's alternative energy research and demonstrations. This component will also facilitate the dissemination of NCE information to interested Ecuadorian entities as well as support the sharing of in-country experiences and efforts related to NCE research and development in the public and the private sectors.

"(3) Alternative Energy Demonstrations and Dissemination (also called Demonstrating Non-Conventional Energy (NCE) Technologies): This component will finance NCE demonstrations such as small mini-hydroelectric (SMH) facilities that can provide power to isolated rural areas, more efficient wood burning stoves, solar water heaters, and other NCE technologies that may be mutually agreed upon by INE and USAID. These demonstrations and field tests will be implemented jointly by INE and public and/or private entities which possess a proven track record of project implementation at the field level. INE will approve, coordinate, supervise and evaluate all NCE demonstrations, and it will ensure that all funds are used in an administratively and technically sound manner. While INE may choose to implement some NCE demonstrations alone, it is expected that the major agencies cooperating with INE in project implementation will be the Ecuadorian Electrification Institute (INECEL), the Ecuadorian Development Foundation (FED), the National Housing Board (JNV), the Sanitary Works Institute (IEOS), and other agencies that have the capacity to implement field level NCE demonstrations. For the entire project, INE will administer an NCE demonstration fund and a smaller energy research and development fund. In administering these funds, INE will operate much like an intermediate credit institution (ICI), receiving, analyzing, approving, and closely supervising sub-grant NCE demonstration and energy research proposals. To the extent feasible, NCE demonstrations will be directed toward immediate application by low income Ecuadorian families, particularly those in rural areas. INE's growing links with field level Ecuadorian agencies and the U.S. Peace Corps will provide INE with an outreach/extension mechanism and will help promote a pragmatic application of NCE technologies to the needs of the low income groups.

"(4) Promotion of Energy Conservation: This component will draw on the data, tests, analysis and plans generated by the above activities to encourage greater conservation of energy throughout Ecuador. Specific actions will include media development for a mass energy conservation campaign, and the development of conservation service in INE to provide technical recommendations to commerce and industry for energy saving actions."

2.3 BUDGET AND IMPLEMENTATION SCHEDULE

The original Project Paper called for a planned obligation of $2.7 million in USAID funding for the project. This funding was to consist of $1.9 million in loan funds and $800,000 in grant funds over a four year project life. The project agreement which authorized project funding was approved on September 29, 1981, with a project assistance completion date (PACD) of December 31, 1985. However, the disbursement of project loan and grant funds was not formally initiated until Project Implementation Letter (PIL) No. 4 was signed by USAID/Quito and conveyed to INE over nine months later, on July 8, 1982.

The Project Paper also anticipated that by the project's third year, an amendment might be made by USAID to increase the loan by $1.0 to $1.5 million (PP, p. ix). A breakdown of the funds to be provided in the project is shown in Table 2.1. This includes the funding levels shown in the original Project Paper and PIL No. 3 (May 5, 1982). The right-hand third of Table 2.1 shows two later "snapshots" of the project's budget. One is drawn from Appendix K of the Project's Mid-term Evaluation (VITA, 1984) and is based on a reprogramming of project funds proposed by USAID/Quito. It also shows the project's total disbursements as of March 31, 1984. The proposed reprogramming was apparently never carried out, although some reprogramming within project elements has taken place. The final view of the project is taken from the May 31, 1986, USAID/Quito Project Financial Status Summary Report (USAID/Quito, June 1, 1986).

Following an internal review of the project by USAID/Quito in early 1985, which took into account the findings of the Mid-Term Evaluation Report and other Mission and USAID/WA guidance, a total of $250,000 was deobligated from the project (Maldonado, September 20, 1985), and the PACD was extended for six months, through June 30, 1986 (PIL No. 12, October 7, 1985). Finally in early June, in order to accommodate delays in the geothermal project activity and to allow the Final Evaluation to be completed, the PACD was extended for two more months, until August 31, 1986, to allow those two activities to be completed (PIL No. 16, June 30, 1986).

Table 2.1 Project budget summary
(US $ x 1000)

Components	Project paper/PIL #3			Proposed re-programming (3/31/84)					Project financial status report (5/31/86)				
	Grant	Loan	Total	Grant		Loan		Total	Grant		Loan		Total
				d[a]	o[b]	d[a]	o[b]		d[a]	o[b]	d[a]	o[b]	
I. Energy planning and analysis	100	250	350	(2.8)	97.3	(94.6)	399.1	496.4	(85.7)	100	(177.3)	250	350
A. Assessments and studies	100	20	120										
B. Measuring instruments	-	80	80										
C. Research and development fund	-	150	150										
II. Technology transfer and information network	400	200	600	(139.3)	259.4	(0.3)	171.8	431.2	(239.7)	400	(83.8)	200	600
A. Technology transfer	200	120	320										
B. Information center	-	80	80										
C. Resident advisor	200	-	200										
III. NCE demonstration and dissemination	-	1,200	1,200	(0)	297.6	(0)	1,202.5	1,500.1	(0)	0	(333.6)	1,200	1,200
A. Mini-hydro	-	500	500										
B. Cookstoves & woodlots	-	90	90										
C. Solar hot water	-	110	110										
D. Others	-	500	500										
IV. Energy conservation	150	100	250	(5.7)	145.7	(0)	126.6	272.3	(58.2)	150	(66.5)	100	250
A. Conservation campaign	100	-	100										
B. Conservation service	50	100	150										
Subtotal	650	1,750	2,400										
Contingencies and inflation	150	150	300						(29.9)	150	(37.3)	150	300
Total	800	1,900	2,700	(147.8)	800	(98.9)	1,900	2,700	(508.4)	800	(698.5)	1,900	2,700

[a]Disbursed
[b]Obligated

3. PROJECT ACHIEVEMENTS

3.1 INE AS A FUNCTIONING INSTITUTION

Originally set up by Decree No. 2888-4 in 1978, INE's creation reflected a level of national commitments to two basic objectives:

- expansion of national energy planning capabilities; and
- assessment and technological development of NCE resources.

INE was formally established as an operating, semiautonomous agency in 1979, reporting to the Minister of Natural Resources and Energy (now the Ministry of Energy and Mines). INE's charter was a very broad, complex, and ambitious one and pulled the organization in several different directions simultaneously.

Among the objectives set for INE in its original charter are the following:

- to develop energy policy alternatives;
- to investigate technological means to diversify sources of energy supply;
- to coordinate the interaction between, and the overall development of, the various energy subsectors;
- to develop integrated energy planning methodologies;
- to study and develop policies for conserving and optimizing the use of hydrocarbons;
- to recommend energy conservation measures;
- to develop a national energy balance, including the quantification of rural energy balances (fuelwood, charcoal, etc.);
- to investigate NCE technologies that offer economic and practical applications such as: biogas digestors, wood energy, small hydro, solar energy, and efficient cookstoves;
- to provide options for satisfying the energy demands needed to advance rural development;
- to develop an inventory of national energy resources with a breakdown of regional and sectoral potential including alternative energy resources; and
- to establish a National Center for Energy Information.

Despite its overly ambitious mandate, INE has made considerable progress in addressing this agenda during the first seven years of its existence. It has also solidified itself as a functioning institution capable of directing and managing a wide-ranging program of energy policy studies and NCE and energy conservation investigations. Through stabilized sources of GOE finance as well as substantial support through this USAID project and smaller activities supported by other donors, INE has established itself as the national center for energy planning studies, NCE investigations, energy conservation audits, and energy information dissemination. All of this has occurred despite a very favorable macroeconomic situation regarding energy pricing policy which acts a strong disincentive to energy conservation and economic development of NCEs; a severe national recession; and an Ecuadorian institutional context for energy planning which has not been entirely receptive to INE's recommendations or activities.

The organizational structure of INE is shown in Appendix 8, which shows the two major branches in INE, the Directorate of Planning and Energy Resources and the Directorate of Energy Development. The former includes Divisions of Energy Planning and Energy Resources and the latter, Divisions of Energy Conservation, Non-Conventional Energy (including solar energy, biomass, small hydro, and geothermal), and Technology Diffusion.

Evidence for INE's growth as an institution can be drawn from several sources including INE personnel records, INE's annual GOE budget figures, and independent records of INE's performance. Table 3.1 provides a detailed breakdown of INE's personnel as of 1979, 1981, and 1986. It clearly shows that the full-time technical personnel in INE's Planning and Energy Development Divisions have steadily increased over the life of this project. Similarly, Table 3.2 shows the pattern of INE's support from annual GOE appropriations. A clear growth trend is apparent despite Ecuador's difficult recession that began around 1982.

The World Bank, in its recent report Ecuador: Issues and Options in the Energy Sector (World Bank/UNDP, 1985), complements INE's activities for building up a significant technological base in a number of areas including small hydro for rural areas, solar thermal applications, family-sized biogas digestors, wood gasifier technology, and low-temperature geothermal energy. That report substantiates the validity and usefulness of much of what INE has carried out over its life as an institution to date, but is somewhat critical of INE's role in national energy planning, a topic that is discussed at greater length in a later part of this chapter and in Chapter 4 of this evaluation. Nevertheless, the World Bank notes that INE's emphasis in energy planning studies has been shifted from areas with low payoff on a national scale "to more important energy issues."

Table 3.1 Personnel breakdown (1979, 1981, and 1986)

	Unit	October 1979	October 1981		Spring 1986	
			Permanent	Contract	Permanent	Contract
1.	Personnel directorate, administrative & support	10	10	6	7	0
2.	Financial unit	0	3	0	7	0
3.	Energy planning, technical personnel	4	6	2	11	2
4.	NCE, technical personnel	2	5	5	11	1
5.	Energy conservation, technical personnel	0	1	1	1	1
6.	Information & technology diffusion				5	0
	Total	16	25	14	42	4
		16	39		46	

Sources: 1979, 1981 - Quevedo, October 1981.
1986 - Centro de Computo, INE, July 1986.

Table 3.2 INE annual budget appropriations from GOE (millions of sucres)

1982	1983	1984	1985	1986	1987
22	25	30	NA	43	NA

NA = not available

Sources: INE records, VITA 1984.

In short, INE has been established as the national energy planning center and appears to be successfully discharging its responsibilities for energy planning and research coordination, as well as development, on non-conventional energy resource applications and energy conservation. The next section of this chapter elaborates in greater detail the specific accomplishments of INE through this USAID project and provides an overall perspective on the project's achievements.

3.2 SPECIFIC ACCOMPLISHMENTS

We consider the activities undertaken within each of the four major project components: NCE demonstration projects, energy conservation, energy studies and research, and information and technology transfer.

3.2.1 NCE Demonstrations

The NCE activities reviewed include small hydro projects, solar energy projects, energy efficient stoves, biomass energy projects, and a geothermal energy exploration program.

3.2.1.1 Small Hydro

The project paper called for an $800,000 expenditure ($500,000 from USAID funds) on a 200-kW generating plant, but, after analysis by INE, smaller plants appeared more practical. The first small hydro project completed by INE was a rehabilitation of a 50-kW plant at Apuela in February 1983, at a total cost of $55,000. This was completed, however, without USAID funds. INE worked with the local utility, EMELNorte, in this activity, and EMELNorte assumed administrative responsibility once the construction was complete. Its operating costs are now (1986) S/.20/kwh (20 sucres per kWh). Two other small hydro projects have been undertaken in 1985: a 60-kW plant at Maldonado, on Rió la Plata, a site previously not served with electricity; and a 15-kW plant at Tacón, which serves roughly 100 families. The Maldonado project initially ran into problems with the turbine because of insufficient head and water pressure from the ditch. Further study showed that the La Plata River could be used as a source, and design of a 60-kW system was completed. The local utility subsequently requested a 100-kW plant to serve another site as well, and some redesign will be required; accordingly, single phase transmission lines, at a cost of S/. 600,000/km, (600,000 Ecuadorian sucres per kilometer) have not been installed. The Tacón project was proposed by the Polytecnic de Chimborazo, which undertook an extensive market assessment and designed the turbine and the engineering layout.

INE has developed its own methodology to study the engineering and socioeconomic feasibility of small hydro sites in rural areas of Ecuador. Presently, some ten other sites are under study. INE

engineers have focused their design efforts so far on low flow-high head sites (in the Sierra) and now plan to extend this effort to high flow-low head situations characteristic of the western coastal lowlands. The projects undertaken have provided valuable design and construction experience for INE engineers. As the World Bank notes, "The resulting successful 50-kW Apuela demonstration plant has provided the design basis for a standard line of turbines to be manufactured locally in eight sizes from 20-kW to 150-kW (World Bank/UNDP, 1985, p. 70). Demand on the Apuela plant subsequently has increased beyond its capacity by the addition of five more localities to its load. Consequently, another plant is now planned for the area.

These activities also have involved private sector participation in the construction of INE-designed turbines, as well as of electronic control systems, and encouragement to local contracting firms to look for similar opportunities in the Oriente. This is in contrast to the Eucadorian Electrification Institute's (INECEL) use of imported equipment in their small hydro activities. INE has participated jointly in these projects with local utilities and with other public sector institutions such as the Polytechnic Institutes. The information on transmission line construction costs indicates that grid extension is relatively expensive compared with small hydro installation: a 3-km extension of transmission line costs as much as a 50 to 60-kW small hydro plant.

A small hydro testing facility was built by INE with USAID funds at the Guangopolo hydroelectric generating station. The facility is designed to test small turbines under actual field conditions. It is also equipped with a central panel and electrical loads (resistors) for testing generators. The hydraulic source is a tap from one of the water delivery lines to the main turbines of the station.

3.2.1.2 Solar Energy Projects

INE's solar energy group within the non-conventional energy division has undertaken a number of activities to evaluate, adapt, and demonstrate solar thermal technologies including solar domestic water heaters and solar crop and wood dryers. The solar energy group also developed a passive solar architecture program and assisted in a number of photovoltaic system installations.

Solar water heaters designed by INE have been manufactured by local private firms and installed in two public housing projects in the Quito area. Fifty units were installed in the Solanda low-income housing project in 1986; delays in water heater installation were caused by delays in construction over which INE had no control. This work was coordinated with the National Housing Board (JNV) which will also assume maintenance responsibility although INE will monitor the performance of the units. Twenty-four units were installed in 1986 in two housing projects constructed by the National Child and Family Welfare Institute, at Ambato and Conocoto. These units are presently working and were recently modified because of excessively hot water.

INE's program of working with manufacturers of commercial and domestic solar water heating systems and other solar thermal systems is at a key juncture. There are at present some nine firms in Quito and five in Guayaquil that offer such systems. INE's program is increasingly aimed at encouraging the private sector firms to adopt improved designs, quality control for manufactured units, and national performance standards (based on ASHRAE standards). This role is an appropriate one for INE and is consistent with the direction taken by other national renewable energy institutions in other countries. While the market for solar thermal collectors in Ecuador is still very limited because of subsidized prices for competing fuels, INE's role as a technical body to help the community of private manufacturing firms may pay important future dividends when energy prices move upward. However, it should be noted that the likely demand for such systems will be limited to the major urban areas in Ecuador, and particularly Quito.

Several experimental efforts have been conducted in solar drying. A solar grain dryer has been constructed with the cooperation of the 4-F Foundation Center at Conocoto, and a solar lumber dryer has been installed and is operating at the Forestry Service (DINAF) Center in Conocoto. The solar grain dryer is over-engineered, and the lumber dryer does not appear to be particularly well-designed (it was found to dry the material tested too rapidly, resulting in large cracks during the process), but both applications have been valuable experiences for INE engineers. They have learned first-hand how to make equipment and, in doing so, have obtained data on effectiveness which could not have been obtained otherwise.

Another area of solar energy applications addressed by INE is passive solar architecture. INE has studied materials and building techniques for hot, humid climates and has applied the findings in the construction of seven passive solar houses at Santo Domingo de los Colorados, on the western side of the Andes. An additional four passive solar houses with solar water heaters and attached greenhouses were constructed at Riobamba in the spring of 1986. INE will be monitoring the performance of these houses. Building technologies for hot, humid climates is an active area of research at U.S. Department of Energy facilities, and INE's findings in this area may be of more than local interest.

Although photovoltaic (PV) applications are not presently economically attractive in Ecuador, except for remote, off-grid areas in applications characterized by low electricity consumption, INE has participated in a number of USAID-funded PV demonstrations.

During the first years of the project, INE participated in a USAID/NASA project to test PV systems for refrigeration and lighting in rural health clinics. Systems were installed at two sites (near Riobamba and Pedro Vicente Maldonado) which functioned well, although at a very high initial cost (VITA, 1984). One of the systems was

later disassembled because of grid extension. INE negotiated for a considerable time with the Institute for Telecommunications (IETEL), the national telecommunications agency, in order to provide a demonstration of the viability of PV power systems as a substitute for diesel generator sets at remote telecommunication facilities. Because of difficulty in getting IETEL to sign an agreement and the approaching end of the project, this activity has not begun.

3.2.1.3 Energy Efficient Stoves

Studies on fuelwood by INE in 1979 and 1983 pointed to the importance of developing and disseminating efficient woodstoves to help combat deforestation in Ecuador. Consequently, INE initiated a program with technical assistance from West Germany and Canada. INE sponsored laboratory testing of different stove models and studied means of diffusion for improved stoves. INE correctly predicted the unsuitability of the "LORENA" stove design well before that view become widely accepted.

INE subsequently adapted metal stove designs to reduce costs for low-income Ecuadorian consumers. Local artisans have been contracted to build these stoves, with manufacturer's costs ranging from S/. 350 to S/. 650 (at S/.165 per U.S.$), depending upon stove size.

Prototypes were taken to weekly rural village markets and were sent home with consumers to try out for a month and report results back to INE. INE maintained contact with these individuals and incorporated their suggestions into revised designs. Sixty percent of an initial run of four hundred stoves built with USAID funds were installed in homes by January 1986, and monitoring on their durability is continuing (expected stove lifetime is two years). Another four hundred stoves are being sold in stores operated by the Integrated Rural Development Secretariat (SEDRI) and by local community stores. The stoves are being directed at areas where deforestation is a problem and where kerosene use is less extensive. The stoves apparently are experiencing acceptance and appear to be good candidates for purchase by more users in the future as older stoves wear out and stove purchasers find easy access to information regarding more efficient, cheap stoves.

3.2.1.4 Biomass Energy

Biomass activities have been undertaken by INE in a number of areas. These include studies on Ecuador's biomass potential and specific activities such as community wood lots, family-sized biogas digestors, and wood gasifier/small electric power plants. Early in the project USAID funded studies of Ecuador's biomass energy potential. The studies revealed that Ecuador has large supplies of wood and wood wastes, bagasse from sugar cane, and other agricultural residues. However the potential utilization of these resources is inhibited by current energy prices for commercial fuels and the high capital costs of utilizing these resources. With the exception of

bagasse, which traditionally has been a significant contributor to Ecuador's industrial energy sector, little non-wood biomass exploitation presently exists. Fuelwood use in the household energy sector is still quite high, especially in rural areas, and is also used quite heavily in some industrial processes (e.g., brick kilns, bakeries, and crop drying). INE surveyed 43 brick makers in the Quito area as part of its study of fuelwood consumption. Although fuelwood is still abundant in most of Ecuador, the deforestation problem is growing and already has reached serious proportions in the southern half of the Central Sierra region. INE prepared a study of the remaining forest resources of Ecuador, including plantations, in 1985.

INE's activities in biomass have focussed on the possibility of model fuelwood plantations on woodlots, using eucalyptus as the preferred species and on limited trials of other species. INE also has been exploring recently the feasibility of small, wood-fired electric generation systems for remote areas where grid extension and small hydro are not feasible, and abundant wood supplies exist. The World Bank recently concluded that fuelwood-fired plants using wood gasifier/internal combustion engine systems presently are competitive with diesel generators in Ecuador even with subsidized competing energy prices (World Bank/UNDP, 1985, p. 76). INE has been coordinating the installation and operation of a 20-kW system at the Polytechnic in Guayaquil.

Work on woodlots remains at the study and experiment stages. In 1979, INE completed a study of the consumption in the rural sector with a focus on the southern Sierra region. Later it prepared a feasibility study of community woodlots. At the experimental level, INE is conducting species trials and has planted 100,000 trees at eight different sites at altitudes around 3200 meters. Four species were identified as having potential for use as fuelwood crops grown in "energy plantations" or woodlots. But the community woodlot endeavors have gone no further, in part because of the lack of an agreed, joint program with the National Forestry Program (PRONAF).

INE's Planning Group has also undertaken, in March 1986, a study of policy options to help achieve an equilibrium between wood consumption and regrowth. The study analyzed possible changes in tax policies for urban fuel use to provide a cross-subsidy to fund reforestation programs and research on cook stoves.

INE, in cooperation with other Ecuadorian institutions, has developed a significant technology base in family-sized biogas digestor technologies, drawing on the international experience with the Indian and Chinese types of digestor designs. In the initial phases of its program, INE cooperated closely with the Peace Corps, whose volunteers had helped construct some 13 Indian-type digestors. As INE's expertise grew through the construction of two digestors of its own, it began to develop a program to train rural extension workers in digestor construction and to cooperate with other Ecuadorian institutions involved in digestor construction. At

present, INE heads a national network of these institutions that includes the Polytechnic School of the Coast (ESPOL), the National Polytechnic School of Chimborazo, and the Institute of Appropriate Technology. INE also cooperates with other countries in the region through the Latin American Energy Organization's (OLADE) Latin America Biogas Cooperation Network.

Now that it is established, INE's biogas program faces many of the same problems experienced elsewhere in Latin America and around the world. These include a series of technical problems ranging from assuring the quality of digestor design and construction to operation and maintenance of constructed digestors (e.g., traditional cultural resistances, high initial investment costs compared to farmers' buying power, lack of soft-term credit policies, etc.). Demand for digestor construction is growing in areas where successful units have already been installed, and INE is developing a revolving loan fund with the Banco de Fomento to help finance digestor construction.

The next logical step for INE is to expand its program to include consideration of larger-size digestors suited to agroindustrial settings and which have better scale economies. The market for such applications also should be studied carefully by INE. Despite their potential promise in rural areas for helping to ease the consumption of fuelwood or other biomass fuels, the primary market for family-sized digestor units is small farmers with sufficiently large herds of cattle (15-50 head) to maintain and feed a digestor unit. The principal benefits to such farmers are usually not the biogas as an energy source, but rather the improved sanitation and reduced health risks and fertilizer value of the slurry.

3.2.1.5 Geothermal Energy Project

INE has initiated a program to develop low-temperature, low-enthalpy geothermal energy for industrial process heat applications. Lower temperature geothermal fluids which are not normally suited for power production can be substituted for process heat now produced by electricity or the combustion of petroleum fuels. INE has developed a geothermal exploration program for the five industrial areas in Ecuador, but to date only the Quito and Cuenca areas have been evaluated and reported in detail. The entire geothermal program includes the installation of a distribution network for geothermally heated fluids and heat interchanges at points of use.

INE has focused its efforts on the Valle de Los Chillos near Quito, where it has been conducting preliminary geophysical evaluations and an industrial survey in part through USAID funds. A French team commissioned by INE has conducted an economic evaluation of this project. INE hopes to develop a viable demonstration project with an appropriate industrial client (possibly the Cerveceria Andina Brewery) if the results of a program of shallow test well drilling (two to four wells at an estimated $200,000 per well, which includes mobilization and demobilization costs for the drilling rigs, spread

over the four wells to target depths of 1000 to 1200 ft.) are favorable. USAID agreed to fund four elements of INE's geothermal program which is being carried out in cooperation with the Dirección de Geología. These included a resistivity survey, a geophysical study and interpretation, computer training for INE and the Dirección de Geología, and the drilling of a stratigraphic test well (PIL No. 7, September 5, 1983).

INE's efforts to carry out the USAID-funded portion of its geothermal energy resources program has been stymied by a series of "checks lost in the mail" by USAID. Consequently, USAID has authorized an extension for this component of the project so that the contract for gravimetric analysis services can be completed. A resistivity analysis has already been completed.

3.2.2 Conservation

Prior to the interim evaluation, a brochure and media campaign to promote transportation energy conservation was conducted. In 1985, INE sent out with utility bills 900,000 flyers about electricity conservation. An attempt was made to evaluate the effect of the effort in the Quito area, but it was unsuccessful. In general, experimental design for evaluation of such individual-consumer-oriented information dissemination efforts is complicated and expensive, and INE's indeterminate results are understandable.

During 1985, INE conducted eight full and eight preliminary industrial energy audits and eleven feasibility studies for audits, exceeding the number of audit activities specified by the annual operating plan. These audits were started in April 1985 and were finished by mid-December 1985. In 1986, three audits were conducted in the cement industry, and INE is currently reviewing the contractor reports.

Training in industrial energy audits was conducted in 1985. The course consisted of 23 hours of theoretical training over a period of two weeks for thirty participants, and one week of practical training in a textile plant and one week in a bottling plant for ten people. Enrollment in the practical segment of the training was limited because of potential interference with the host plant's activities by larger numbers of people. An information seminar was held in mid-June 1986 on industrial energy cost saving. Presentations by previously audited firms indicated that monitoring had been conducted by the audited firms themselves; outstanding success records were found.

The success of the industrial energy conservation program is indicated by the high demand for audits. The request for audits has outstripped INE's capacity to conduct them or contract for them. INE plans to require that participating firms pay at least one-third of the cost of subsequent audits. As the cost-saving reputation of the audits increases, energy auditing can be turned over to the private sector, with firms paying the full cost of audits.

INE wants to follow up the audits and training by monitoring previously audited industrial firms and initiating some quality control practices on local energy auditors. In 1985, INE began working with the Chamber of Industries to create a fund for industrial energy conservation, to be used for studies and to introduce firms to energy audits. Funding would come from two public agencies, the Development Bank and the National Finance Corporation. Presently there are legal problems in this public financing of lending to the private sector. INE is also trying to find private sector support for this fund.

The evaluation team considers energy conservation to be a very important activity despite Ecuador's heavy energy price subsidy policy and currently low oil prices. The shadow price to Ecuador of saved hydrocarbon energy is far higher than the nominal prices faced by local industrial and private consumers. Low nominal prices reduce firms' incentives to save energy through capital investments, but low-cost "housekeeping" conservation measures are appreciated. Additionally, because Ecuador earns 60% of its foreign exchange from petroleum exports, local oil consumption during a period of low oil prices is important from a macroeconomic perspective as the shadow value of foreign exchange rises. Although the conservation auditing currently involves public sector financing of private sector benefits, we anticipate that private willingness to pay will increase as certainty regarding the benefits of the service increases.

3.2.3 Energy Planning and Analysis

The Project Paper called for two types of activity under Energy Planning and Analysis: energy assessments and modeling, with $100,000 each in grant and loan; and $150,000 in loans for an R&D fund to be used by other Ecuadorian entities for small studies. PIL No. 1 (November 23, 1981) specified that the R&D grants were to be used for "small scale, applied research on NCE or energy planning (e.g., surveys) or grants that complement other project components, especially energy planning and analysis." PIL No. 3 (May 5, 1982) authorized the expenditure of $100,000 to cover costs of studies and surveys to assess the potential for NCE use, $100,000 for vehicles and measuring instruments, and $150,000 to help INE establish the R&D fund for small investigations by other Ecuadorian entities. PIL No. 5 (March 30, 1983) stated that USAID "would appreciate receiving documentation from INE for R&D activities over $10,000."

The R&D fund was to be disbursed to a variety of individuals and institutions in various regions of Ecuador. The majority of these grants were expected to be for less than $5,000 apiece, and they were commonly used to fund thesis research. Between 1982 and 1986, at least twenty theses were supported by this fund (see the list of theses supported by INE in Appendix 9). INE has used the fund to strengthen NCE research in the Ecuadorian university and polytechnic system. The engineer currently in charge of INE's geothermal project

completed his thesis with one of these small R&D grants while working at INE as a student. Upon completion of the thesis, he became a permanent staff member.

The Dirección de Planificación y Recursos Energéticos (DPRE) has been charged with many more responsibilities than those supported by USAID's AES Project, as described in the Project Paper (PP, pp. 17-23). Simple enumeration of INE's milestone achievements of USAID-supported planning and analysis activities would produce a disjointed checklist that would fail to illuminate the overall development of INE as an analytical planning organization during the period of the project. Consequently, we describe quite generally the research and planning work that INE has accomplished. Because of the evaluation team's own resource constraints, we have not attempted to compare actual and originally programmed completion dates of research activities, but rather have concentrated our evaluation on the extent to which the achievements at the end of the project look like reasonable scientific outputs, given the resources INE had available.

The major activities with which the DPRE has been charged are the development of a national energy resource inventory; the construction of energy balances from 1969 through 1984; and preparation of a series of energy supply studies, sectoral demand studies, and medium-term energy use projections. Examination of a current list of INE studies shows that these studies have been completed, and in what appears to be a reasonably timely fashion (this list of studies appears as Appendix 9).

We have examined, in particular, some of the sectoral demand studies and find them to be quite competently executed. One study in particular compares INE's sectoral demand projection methods with comparable estimating equations from the State Petroleum Company's (CEPE) planning unit; INE's methodology is far more sophisticated, while the CEPE methods are very simplistic. We also have examined the energy balance tables constructed for the period 1974 through 1984. We have been unable to evaluate fully the quality of the numbers in these tables, but the exercise of constructing energy balances is a valuable experience for energy planners; it gives them a healthy skepticism for published numbers, including their own.

We call attention to one particular, unprogrammed disbursement from the USAID grant funds which fits roughly into the planning category, because of its large relative size, one fourth of the expended grant funds. In 1985, $100,000 was awarded as a grant to a Washington-based private consulting firm, Petroleum Finance Co., Ltd., to study management and scheduling in the Maritime Division of CEPE. INE's interest in this seemingly unrelated effort centered on developing a relationship with CEPE's Maritime Division that would help INE obtain data on domestic energy transportation and sales, which INE viewed as a particularly important but problematic area from the energy planning perspective.

As called for by the DPRE Master Plan, most of the studies undertaken by the planning staff have been empirical studies aimed at establishing what the current and recent past situations are and what reasonable projections for the future seem to be, for particular scenarios of government policies and external economic environments. At the risk of overlooking some studies, we have identified only one study, apparently internally motivated, that specifically developed and analyzed an energy policy the government could adopt to improve efficiency in the energy sector. This particular study analyzed a policy of differential taxation of wood according to source, as an instrument to encourage plantation wood energy supply and bring prices of owned (plantation) and common property wood (unowned or property rights unforced, e.g., free for the cutting) into line by around year 2000. We have not evaluated the practicality of this particular policy, but we find the economic analysis of specific energy policies a fruitful area of research for INE and one that should be encouraged. Because we consider it unlikely that the Government of Ecuador will move to a low- or no-subsidy energy price policy in the near future, the analysis of second-best policies that the government could implement, probably sectorally, is very useful. Currently, INE is funding two external contracts to conduct studies of the market for small hydro power and of the utilization of small hydro by industry. There appears to be no other energy planning center in Ecuador which is undertaking such analysis, and INE seems well suited, technically and temperamentally, to provide such a service for the nation.

3.2.4 Information Network and Technology Transfer

The original project design envisioned that this component would assist INE to become a clearinghouse for information on NCE technologies to help facilitate NCE technology adoption and use (PP, 6/84, p. 24). This was to be assisted through the project by (a) short-term training and international travel for INE staff as well as for Ecuadorian officials from other agencies; (b) in-country training and workshops; (c) furthering the development of INE's information center, including purchase of reference materials, texts, journals, and information retrieval equipment, as well as to support the costs of INE's publications and information outreach efforts; and (d) funding a U.S. resident advisor to INE to serve as technical advisor to INE's Director and as a liaison between INE and USAID.

From discussions with INE and review of the project files, it is clear that numerous training activities have been carried out successfully under the project. For a variety of INE employees, Polytechnic Institute Staff, and for employees of INECEL, CEPE, and many other Ecuadorian agencies, training activities have included a diverse array of short-term courses, seminars, conferences, and for two individuals from ESPOL, long-term academic training. Activities have included a two-month course on utility and industry energy conservation; a three-month course in power systems engineering; several courses in energy planning and modeling; courses in passive

solar architecture; several courses in wood-based energy production and rural fuelwood use problems; a course in photovoltaic system design; courses in geothermal energy exploration and development; and courses in computer training and information retrieval networks.

INE has also sent participants to present papers at international conferences on biogas digestors, passive solar architecture, Andean coal development, alternative energy sources, alcohol fuels, energy conservation, and rural energy planning. These activities have served to strengthen the technical abilities of individuals at INE as well as other Ecuadorian energy institutions while simultaneously helping INE to realize its role as a national energy planning organization through participation in international forums as Ecuador's representative.

INE has also established the capability to sponsor and execute, often with support from other participating institutions, a series of conferences, seminars, and workshops intended to disseminate information or training to audiences within Ecuador. Recently INE has held well-attended conferences on passive solar architecture (December 1985) and industrial energy conservation (June 1986).

While INE has been nominated to become the Ecuadorian node of the regional Latin American energy information network being established by OLADE, called CIELA (Centro de Información Energetica para Latino America), it does not yet have the computer facilities to fill this role adequately. Through the project INE has expanded its technical library and has acquired certain equipment which will aid it in carrying out its intended role as a national center for energy information retrieval and dissemination. However, because of its lack of an adequate computing facility, it cannot yet develop a viable information retrieval system tied into international computerized data base search services.

The project did fund a resident advisor for two years, as called for in the Project Paper (PP, p. 26). This advisor served from July 1982 through August 1984. There is some confusion as to whether the description of the resident advisor's position had been modified to require staffing for the duration of the project rather than being required for only two years, as described in the Project Paper. Consideration was given first to extending the first resident advisor for an additional two years, and when he decided not to accept the offer, to seek a replacement (CBD July 21, 1984). However, due to a disagreement between USAID and INE over the candidates for the post, the resident advisor position was not extended for the project's final two years.

3.3 OVERALL PROJECT ACHIEVEMENTS

The AES Project should be judged as an institution-building exercise which will have a longer-term payoff, appropriate for public sector support. It is in this light as an institution-building

activity that we interpret the achievements of this project. The AES Project, is small, with a total of $2.7 million in loans and grants spread over four and one-half years, and therefore should not be evaluated on the basis of how much energy it has saved or produced for Ecuador as of the PACD. An amount under $3 million could not reasonably be expected to make a significant impact on aggregate energy consumption of a country of some 8.5 million people, particularly given Ecuador's present subsidization of energy prices. The previous section enumerated the achievements of INE on a broad and diverse array of activities. This section takes those activities and achievements as data and asks the question, "What does it all add up to?"

The diverse array of engineering design and construction experiences gained by INE staff in the activities described above has helped INE develop a local, Ecuadorian capacity to design and execute (or contract for) NCE projects, which would save foreign exchange required to pay for foreign technical assistance. We have noted that some of the activities undertaken make more economic sense than others, that some NCE projects were over-engineered, and that some experimental efforts were, in practice, failures. Nonetheless, the educational experience of trying out technologies is important to INE as an institution, and to its young staff's professional development. The engineers learned from failed efforts as well as successful ones.

The demonstration projects were necessary because technical achievements are required to achieve a measure of institutional credibility. By 1986, INE's planning efforts appeared to have gained a grudging recognition by its competitors [interview with Dra Magdalena Aguilar of the National Development Planning Office (CONADE)]. The timing may be completely coincidental, but INECEL has recently put more efforts into small hydro development, after INE has visibly entered the market. In fact, both INE's small hydro and geothermal activities provide some interagency competition in the provision of these services, which the evaluation team believes is healthy. Generally, INE has grown in experience and externally perceived status during the course of the project, as a direct result of the activities undertaken with USAID funding.

Private sector initiatives and opportunities are very important developments associated with the project. INE contracted with two local private firms for the manufacture of solar water heating systems and with one local private firm for the manufacture of small hydro turbines and electronic control systems. Working with INE's small hydro equipment, a turbine manufacturer recognized a promising market in turnkey contracts in small hydro development and is seeking business in that area (interview with Pedro Romo Leroux, Electro Ecuatoriana). The industrial energy conservation work also has high potential for private sector involvement, as noted previously. Private firms currently are expressing a high demand for energy audits, and INE is, quite properly, raising the price. We anticipate that another year of public sector support will dispel early

uncertainty about the benefits of audits, and private energy auditors will then be selling their services to private firms at full price. The support should therefore continue from GOE and/or USAID.

Most of INE's technology demonstration efforts are aimed at low income people in both urban and rural areas, who comprise roughly 60% of the population. Although the U.S. Peace Corps is an active and effective agency which directs its energy efforts at low-income segments of the population, no Ecuadorian government agency other than INE directs extensive attention to the energy needs of the poor. INE should be encouraged to improve its effectiveness in targeting the rural poor by more closely integrating its social science analytical arm with its engineering technology arm, but INE clearly has an opportunity to become a major governmental advocate for the energy needs of Ecuador's poor.

In view of the fact that the cost of demand assessments are very high, an economically sensible way of assessing the demand for many such projects is, in fact, to put a few in place as INE did and let follow-up monitoring generate the demand-side information which can be used in subsequent applications. A few economically failed projects (or even one) can be cheaper than a single, well-executed demand study which may be of limited use outside the case for which it is undertaken. Development efforts must get off the drawing board, and INE's field efforts should be given adequate recognition and credit. INE is monitoring the NCE projects which have installed operating facilities, but to our knowledge the monitoring is largely restricted to obtaining equipment performance and cost data. INE should be encouraged to devote some of its social science staff resources to assist the engineering staff in generating genuine demand assessments from post-installation monitoring.

In summary, during the course of the AES Project, INE has grown in knowledge and externally perceived status. It has done so by having its staff get practical experience in projects, some of which are successful by all criteria, some only on the criterion of giving the involved staff a lesson. INE is beginning to be perceived as an institution with a level of staff experience and competence that commands the respect of competing and complementary institutions. An important next step for INE is to develop more cordial relations with other institutions, but in a competitive political environment it may have done well in the years of the AES Project to assert and maintain its independent voice.

4. INSTITUTIONAL ISSUES

A series of important institutional issues has accompanied the evolution of this project and bears further discussion. These issues range from INE's internal organization and operation to its relationships with other Ecuadorian and non-Ecuadorian institutions. This chapter also includes sections on USAID's project management activities, communication between USAID and INE, and a commentary on overall project management and implementation issues.

4.1 INE AS AN INSTITUTION

A series of difficult institutional development issues has affected INE during the course of this project. This is not surprising, given the fact that INE is a young institution with still limited resources of staff and funding which is competing for influence and respectability within an Ecuadorian institutional setting that is not always supportive.

In common with other government agencies, INE has a pattern of low salaries which results in high staff turnover. It has even been difficult for INE to get salary increases from the Ministry of Finance to keep up with inflation in the last four years. By contrast, Ecuador's two leading energy implementing agencies, CEPE and INECEL, have special laws which authorize higher salaries than the standard government scale. This problem has affected staff morale at INE and may have led to moonlighting to augment income. However, in the judgement of the former Director of INE, Dr. Carlos Quevedo, staff turnover at INE had not caused any major problems. Key personnel had been retained, and turnover had not seriously impaired institutional continuity although occasionally some project implementation may have been slowed down somewhat. See Section 5.2 for information on the destination of INE job-leavers.

In the early years of the project the Ministry of Finance also rejected INE's requested staff increases, a factor which slowed the progress of INE's program development. This staff shortage was compounded by INE's limited abilities to contract for outside technical and administrative support. As the project has transpired, INE has gradually established a financial and administrative arm capable of contracting for external support. A management study of INE by CEFE was completed last year. It is being used to reorganize INE's managerial structure and to improve the staff's attentiveness to management issues. A series of weekly seminars is held to improve INE's management.

INE is characterized by several important institutional issues that affected its performance during the project's early years and which continue to affect its planned activities today. INE's program is subject to the approval of a ten-member Consejo Tecnico or Board of

Directors. Chaired by the Subsecretary of the Ministry of Energy and Mines, the Board includes representatives of several other agencies including CEPE, INECEL, CONADE, and the Institute for Water Resources (INERHI). According to several sources, INE experienced difficulty in convening a quorum of Board members to ratify its decisions, including those of this project. INE's former Director Quevedo questioned this view and maintained that in recent years the Board's chairman, Francisco Navarro, had executed strong leadership and helped INE approve its program promptly. It is interesting to note that the original conception of the Board was to include private sector representatives from the Chambers of Industry and Productivity.

Another important institutional issue relates to INE's dual mission and bi-partite structure. Its simultaneous implementation of major programs in energy planning and analysis as well as non-conventional energy and energy conservation was bound to create organizational conflicts and uncertainties. This schism between the energy planning section (DPRE), run by economists, and the energy development section (DDE), run by engineers, has been difficult to overcome, in large part because their programs are so different. DPRE's efforts are centered on national energy planning concerned with conventional energy sources while DDE is mainly focused on technology adaptations in the non-conventional area. There is little evidence that the two sections have been able to work effectively together although a current project on the geography of energy resources in Ecuador, funded by the Organization of American States (OAS), has been designed to encourage the two to work together.

This situation has been compounded by the low political and economic priority of non-conventional energy and the difficult national energy planning environment within which INE is attempting to assert its influence. Consequently it is not surprising that it has taken a new institution staffed primarily with young and relatively inexperienced personnel several years to develop a set of programs that accurately reflects clear priorities based on substantive analysis and consultation. Nevertheless, despite these problems, INE is now receiving firm budgetary support from the GOE and has demonstrated the institutional flexibility to tap private sector capabilities where appropriate.

In the areas of nonconventional energy demonstrations and energy conservation which were the focal points of this project, INE's program has developed progressively, but with some unavoidable starts and stops. Because of its small and centralized nature as an institution, it is nearly completely dependent on the cooperation of other agencies and institutions to carry out its national programs. On many occasions, INE experienced considerable difficulties in executing agreements with other agencies for reasons beyond its control, as described in the next section of this chapter. It appeared to have a greater degree of success in programs or areas in which it did not have to compete with another agency or depend on it for critical elements needed to achieve successful demonstrations.

Thus to a considerable degree in its NCE programs in rural areas INE has experienced recurring difficulties because of its dependence on other agencies. INE's young engineers were also generally inexperienced in renewable energy applications and had to learn by doing, often providing less than overwhelming results at first.

Although they have begun to administer competent technical programs in a number of areas, it is important that INE develop a full-fledged monitoring capability. Due to its staff limitations it will need to evolve as an institution and improve its ability to catalyze and then monitor activities by others. Institutional models drawn from the experience of other developing country renewable energy institutions tend to suggest that once an institution like INE has established its basic technical competence it needs to turn its attentions to mobilizing, directing, and monitoring the efforts of others. INE is at a critical stage in its institutional growth and needs to be encouraged to make this transition. In this role INE must also be able to learn not only from an experience base within Ecuador, but also from its neighboring Andean countries, Latin America generally, and other parts of the world.

On the energy planning side of INE, an equally formidable set of institutional problems appears. While NCE demonstrations and commercialization and energy conservation are constrained by Ecuador's low energy prices, INE's efforts in energy planning studies and national energy policy coordination have been limited by bureaucratic and political constraints and realities. INE faces a formidable task in establishing itself as a major actor in national energy policy planning and development planning. At INE's inception it was hoped that INE would play a key role in developing national energy policies and plans through establishing a close relationship with the Minister of Energy and Natural Resources (now Energy and Mines). This close relationship has not materialized, and, despite INE's strong and growing analytical capabilities, national energy planning and policymaking appear to be based largely on political rather technical grounds.

In sum, despite a set of high expectations, INE's energy planning activities have tended to be complementary or secondary to those of the major agencies such as CONADE, CEPE, and INECEL. The recent World Bank report commented that INE's performance in this area "can be attributed directly to the political sensitivities surrounding the major energy issues such as energy policy and increased exploration activities, and the political vulnerability of [INE]" (World Bank/UNDP, 1985, pp. 76-77). In short, although concerned with highly technical material, much energy planning remains ultimately political.

Given importance of energy policy issues within Ecuador, it is vital that a good energy data base be constructed, computerized, analyzed, and regularly updated. INE has shown in its energy planning activities to date that, if provided with suitable equipment, funds,

and staff, it can produce valuable energy planning studies. While in the past it focussed its attentions on issues which were interesting but not vital, it is now attempting to target more important issues such as energy pricing and the need for refinery expansion.

There is evidence that this sharpened focus on important national energy issues is beginning to produce an impact. An INE study on the economics of a proposed petrochemical industry in Ecuador was decisive in cancelling plans for this ill-advised investment program. INE has been chairing a national interagency commission on the analysis of future energy demand and is participating in the work of another national commission studying the optimal use of Ecuador's oil and gas resources. INE's planning studies have been featured in major lead articles recently in El Comercio in Quito, including one on utilization of natural gas reserves (April 7, 1986) and one on projections of future energy demand (May 10, 1986).

In short, INE appears to have achieved grudging acceptance as the national energy planning entity although it is still not routinely consulted on important issues. It will take a new INE Executive Director who is politically astute and far-sighted to help guide INE's growing energy planning capabilities into politically supported and important areas of investigation.

In conclusion, INE seems to have grown, matured, and to some extent achieved acceptance and credibility as an institution over its first seven years of existence. Much of this has been due to the financial support of this USAID project. Various estimates place the percentage of INE's budget supported by the USAID project at 40%, 10% of its salaries and 30% of its capital expenditures (estimates by F. Carrasco and C. Quevedo). INE is presently constructing a new facility which will include adequate lab space for its existence. Given this project's original "institutional-building" emphasis, it appears that INE has done relatively well despite a difficult playing field.

4.2 INE'S RELATIONSHIPS WITH OTHER INSTITUTIONS

An important element in the project has been INE's ability to interact with a diverse array of other Ecuadorian institutions in carrying out subproject activities. This was particularly vital in enabling INE to meet the project goal of addressing rural energy needs since as a small institution it had limited outreach capabilities. It should be noted at the outset that the Ecuadorian institutional environment is a difficult one, riven by competing interests, turf squabbles, and limited availability of adequate staff and financial resources in public sector institutions. This pattern of weak institutions is fully recognized by USAID and becomes a factor in nearly all development projects.

Despite this backdrop, INE appears to have been relatively successful in establishing a variety of subproject activities with a range of geographically dispersed and heterogeneous institutions, despite a pattern of institutional conflicts between INE and other institutions over particular subproject activities. These disputes seem to have arisen in part because INE as a new institution was lacking in experience and credibility but also because INE generally was dealing with larger and more powerful institutions which had little to lose from poor implementation of a particular subproject of the AES Project.

Some representative examples of these institutional interactions are briefly elaborated to illustrate the types of problems faced by INE. On the problem side, INE consistently experienced difficulties in interacting with its two larger and more established energy planning competitors, CEPE and INECEL. CEPE provided little reciprocity to INE in return for receiving nearly one-quarter of the project's grant funds. No convenio, or cooperation agreement, was ever signed to enable INE to participate in, and benefit from, the Petroleum Finance Company, Ltd. study. In fact CEPE seems to have successfully blocked INE from participating in any vital way in its petroleum sector planning activities, despite CEPE's own weak planning capabilities in some areas.

INECEL was supposed to enable INE to use its main computer through remote terminals but later reneged on the agreement, forcing INE to develop plans for its own computing needs. Despite its larger staff and budget, INECEL was an unwilling participant in the geothermal project and has acted as a competitor in the small hydro field, despite its divergent approach of relying on donor funding for hydro projects while INE was encouraging local Ecuadorian manufacture of hydro components.

INE, despite several years of negotiation, was unable to get a signed convenio with IETEL for a remote PV telecommunications subproject. INE also had a falling-out with the U.S. Peace Corps over the current approach to rural biogas digestor and solar water heater programs. These seem to have been honest philosophical differences with the Peace Corps pursuing the minimalist, low-cost approach while INE strived for commercialization in large-scale applications able to pay for higher-quality, moderately-priced systems.

INE also successfully established relationships with other bilateral and multilateral donor agencies and a range of regional institutions. In conclusion, it has functioned reasonably well as a young and inexperienced institution in an often treacherous institutional environment.

4.3 OVERALL PROJECT MANAGEMENT AND IMPLEMENTATION ISSUES

INE was slow to use project funds, particularly the loan portion. Fig. 4.1 shows the projected and actual cumulative spending. After the project agreement was signed in late September 1981, it took until May of 1982 to approve disbursal of funds (PIL 3, May 5, 1982). Because of a shortage of staff, INE took six months to satisfy the "Condition Precedent to the AESP" sufficiently that USAID funds could be disbursed. A "condition precedent" is a condition that a project paper requires the local counterpart agency to satisfy before some project activity or activities -- or sometimes any activity -- may be initiated. An example would be that the counterpart agency must state in writing the resources it is willing to commit to a particular project component before AID can disburse the funds it is authorized to spend on that component. The other three months of the delay were caused by the Ministry of Finance and USAID (see PIL file, Project 518-0029, USAID/Quito). Additionally, philosophical differences between the Minister of Natural Resources and Energy and the Executive Director of INE retarded project spending because the President of the Consejo Tecnico, the subsecretary of the Ministry of Natural Resources and Energy, could not convene that body, whose approval is necessary for major activities.

The Apuela small hydro project was originally scheduled to be paid for with project funds, but work began before the USAID funds were available and was completed with Ecuadorian money. Additionally, $500,000 in project money was originally allocated to the small hydro component to develop a 200-kW plant, but after problems with INECEL regarding construction, INE dropped back to the idea of constructing smaller plants which were less expensive. The Apuela project cost, altogether, around $55,000.

The Mid-term Evaluation reported that INE was even more reluctant to use the loan portion of the funds because of potential national debt problems. Whether and to what degree INE was pressured by other agencies to restrict loan spending is indeterminate. Additionally, INE apparently hoarded committed project funds rather than spend them, for fear of losing GOE budgeted funds: Ecuadorian law requires that unspent funds be remitted to the national treasury (see Duisberg, n.d., c., December 1982). This situation was explained to Carl Duisberg by Gonzalo García at INE, and Duisberg subsequently explained it to Randy Roeser. During this period, staffing shortages were acute at INE, and it is likely that INE simply had insufficient staff to execute the work which would have required project funds. Duisberg's memo explains that USAID was also aware of this situation and attributed it to the effects of national austerity on INE. Duisberg mentions the need for continued discussions with the "National Director of Personnel... regarding staffing of INE."

Furthermore, the Project Paper's expectation of a straight-line expenditure pattern as shown in Fig. 4.1 was unrealistic for an "institution building" project such as this one (PP, p. v). The long,

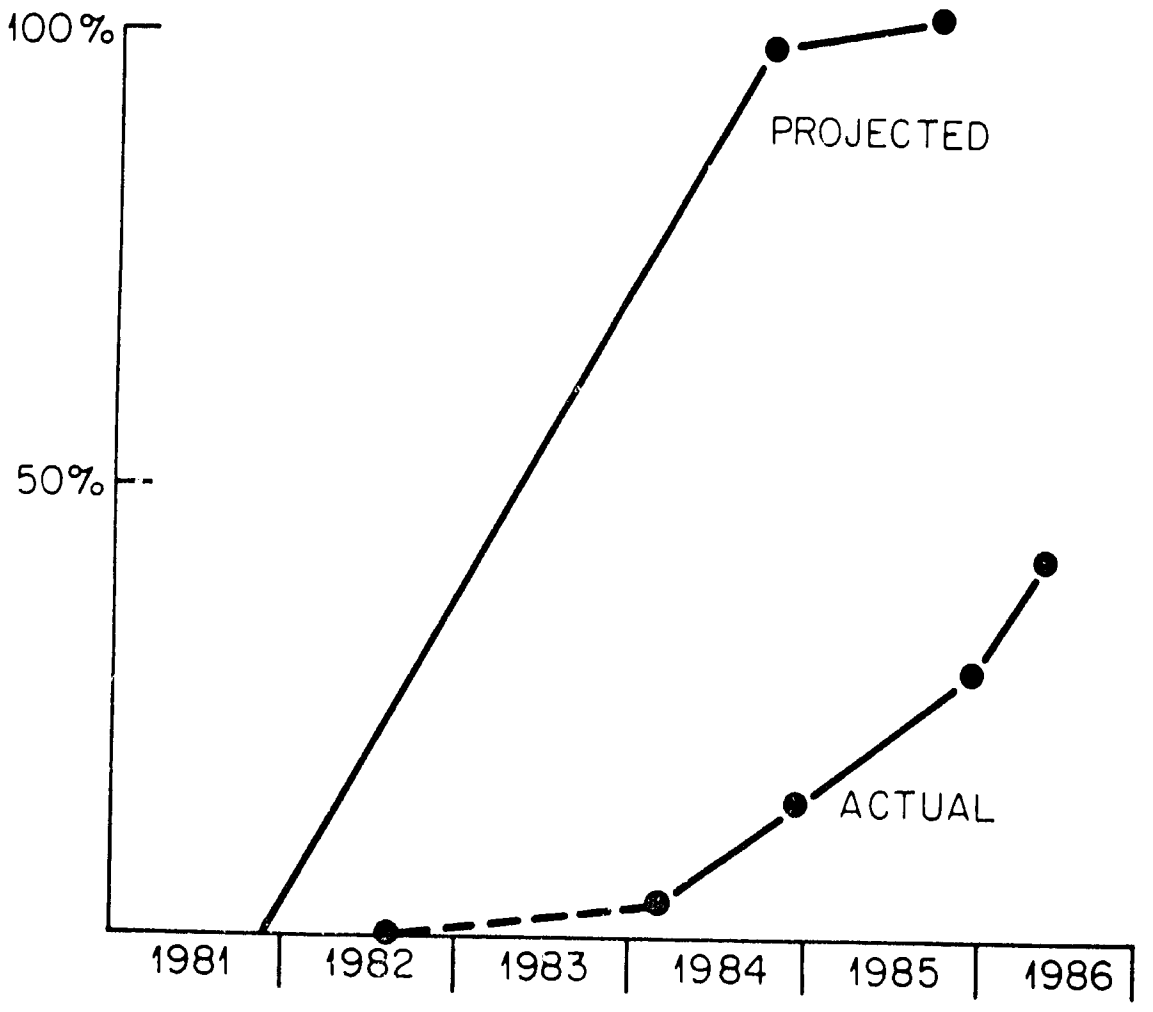

Fig. 4.1. Projected and actual disbursed funds, as % of original project funding.

flat period of actual disbursements can be interpreted as a learning and building period for INE rather than as the result of simple incompetence.

Some of the slowness in project fund disbursement must be credited to USAID, in both its routine, bureaucratic approval process and occasional errors. The clearest example of USAID errors retarding disbursement involves INE's attempted equipment purchase for the geothermal project. With a PACD extension through June 1986, INE initiated the paperwork on the purchase in October 1985. A check was issued by USAID/WA in November 1985, to the vendor in Tucson, Arizona, but the check was lost in the mail. A second attempt, in February 1986, was also unsuccessful (Wieduwilt, May 4, 1986). A third check was issued but was sent to USAID/Quito instead of the vendor (interview with F. Maldonado, USAID/Quito). USAID has authorized an extension for this particular contract.

INE's attempt to purchase a mainframe computer to meet its planning responsibilities appears to have gotten entangled in USAID red tape. INE initiated the request in October 1984, and procured a feasibility study. In May 1985, USAID/Quito required further technical specifications and notified INE that approval of USAID/WA was necessary. INE submitted the information required. USAID/WA approved the request, and INE notified USAID/Quito in June 1985, that the computer could be installed by December 1985. In the meantime, an accounting discrepancy appeared between INE's and USAID's records. By the time the discrepancy was resolved the price of the computer had risen to $135,000 from the $100,000 allocated, requiring further paperwork. Part of the problem lay in INE's not obtaining sufficiently firm price information at the budget planning stage of preparing the Operating Plan. USAID/Quito decided that the purchase, installation, and required inspections could not be made before December 1985, and disapproved the request. The PACD was subsequently extended to June 30, 1986, but the decision to not approve the purchase of the computer was not rescinded.

Internal USAID correspondence indicates that USAID/Quito was never enthusiastic about this purchase. Notes from a February 1985 meeting of C. Duisburg, F. Maldonado, J. Wein, P. Maldonado, R. Roeser, and B. Kernan to discuss INE's proposed Operating Plan for 1985, question whether the proposed $100,000 for a computer is an "appropriate investment under the project?" (USAID/Quito, February 5, 1985). Immediately following the question regarding the computer purchase, the notes state that a $100,000 contract to a Washington-based private consulting firm for one-time technical assistance to CEPE (see Section 3.2.3), of marginal relevance to the purpose of the AES Project, "...could be justified under the project authorization, but competition and contracting issues remain." The competition and contracting concerns noted for the latter proposal expenditures were solved by disbursing the funds in a grant to an unsolicited proposal (interview with R. Roeser). The disbursement was eventually made

without INE authorization, at the exclusive responsibility of USAID (Carrasco, July 1986).

Interagency agreements within the Ecuadorian government were also a source of delays and have resulted in slow fund disbursement. The agreement between INE and the National Child and Family Welfare Institute was held up several months for the latter agency's publicity requirements (interview with R. Nuñez, INE). Contracting for the photovoltaic power systems project was even more tedious. INE, IETEL, and USAID began negotiations in January 1985, and reached verbal agreement in April; a request for proposals (RFP) was issued then. USAID gave formal approval in November, but more RFPs were required because of the delay. In February 1986, INE's Consejo Tecnico approved an $80,000 expenditure. Because of ministerial changes at IETEL, INE could not obtain IETEL signatures on a contract until May 1986, at which time USAID disapproved the expenditure because insufficient time remained under the extended PACD to receive, install, and inspect the equipment. The funds for the photovoltaic project remain unspent.

The evaluation team also discovered in discussions with the current project officer, Dr. Fausto Maldonado, that of the roughly $1,650,000 in project loan funds available to INE under the project, some $700,000 to $900,000 in loan funds remain undisbursed to INE as of the June 30, 1986 PACD. This is despite the fact that nearly all of these funds ($1,643,600) have been approved previously by USAID and earmarked for expenditure by INE. We understand that USAID/Quito is under pressure from USAID/WA to deobligate as much of the uncommitted project balance as possible soon after the PACD. Given the project's history of delays and problems, it seems unfair to penalize INE by restricting its use of these loan funds at the close of a project that has been, in the opinion of this evaluation team and the Mid-Term Evaluation, decidedly successful despite a series of adverse circumstances.

Support for the position that the project has been successful despite many problems can be found not only in the Mid-Term Evaluation, (VITA, 1984, pp 73, 84), which recommended that the PACD be extended for at least one year to "a new completion date of December 31, 1986" and that a "further extension of the project be requested if necessary;" but also in USAID files. In response to a memo from L. Garza of USAID/Quito commenting on "lack of progress on the part of INE in fulfilling its contract," resident advisor Hugh Pierson claimed that "INE is fulfilling its obligations" (Garza, October 1982; Pierson, October 18, 1982).

Hugh Pierson, in the memo accompanying his final report pointed out that, "[I] recommend that a review be held in the fall of 1985 and that in fairness to INE, the agreement be extended for another year." In response to a letter from the Minister of Energy and Mines, Javier Espinosa Terán (Espinosa Teran, August 15, 1985), in which Espinosa Terán encouraged USAID to pay more attention to proper implementation

of the project, USAID/Quito Mission Director Orlando Llenza commented that, "INE has made considerable progress and has shown demonstrable dynamism in the last year." (O. Llenza, August 28, 1985).

Finally, in a covering memo to obtain the Mission Director's signature on PIL No. 12, the project officer commented "that INE's performance has improved significantly during this year" (Maldonado, November 21, 1985). The memo also requested a PACD extension of nine months.

4.4 COMMUNICATIONS BETWEEN USAID AND INE

This section documents the progress of the relationship between USAID and INE between the beginning of the project, when USAID was consistently optimistic about the project, and the time of the final evaluation, by which time the AES Project had gained a very poor reputation at USAID. The story is one of deteriorating communications, with the end result of mutual bad feelings and misimpressions. The topic is one of subjective impressions, and some of what follows in this section is itself subjective, but we offer documentation of the major events in the story.

The relationship got off to a rough start with the selection of the resident advisor called for by the Project Paper. USAID presented a list of seven candidates to INE (see resident advisor contract file; also see C. Quevedo, March 9, 1982), one of whom USAID strongly advocated. Another candidate was preferred by the executive director of INE; he was unavailable, and in the end, INE accepted a candidate who was neither their first choice nor USAID's (interview with Dr. Carlos Quevedo).

The resident advisor's contract was not signed until June 1982, and he did not arrive until early July, some eight months behind the project schedule (see resident advisor contract file Project No. 518-0029, USAID/Quito). Examination of the resident advisor's quarterly reports reveals good impressions of INE's efforts and intentions if not always of their results, but the memorandum accompanying his August 1984 final report indicates frustration directed at INE. In an interview in July 1986, however, the former resident advisor expressed the satisfaction with INE which was expressed in the earlier quarterly reports and reported persistent difficulties in working with AID during his period as resident advisor, in large part because of difficulties in mastering USAID's bureaucratic procedures. The mid-term evaluation team appears to have found some evidence of problematic communications between USAID/Quito and INE in the spring of 1984. They recommended that, "The mission should also keep the advisor appraised of reactions/remarks bearing on the project that are generated at the mission and Washington levels so that responses are based on fact and events as they occur rather than conjecture and misinformation" (VITA, 1984, p. 77).

The team which conducted the mid-term evaluation of the AES Project in April and May 1984, was headed by the person whom USAID had advocated for the resident advisor position in 1981. The evaluation contract was not awarded competitively or via an energy indefinite quantity contrast (IQC), but rather was arranged through a cooperative agreement with VITA that was intended for other purposes. This was subsequently disapproved by USAID/WA Contracts Office, which was then required to ratify the informal commitment previously made to VITA by the AES project officer, who lacked contracting authority. The ratifying memorandum states that "...the transaction should have been awarded competitively..." and "...It is problematic as to whether VITA would have been the successful proposer in a competitive transaction. However it is clear...that VITA is quite qualified to conduct project evaluations such as the one requested by USAID Ecuador" (Hawley, September 21, 1984). USAID/WA involvement was required because the evaluation team had proposed to leave the United States before the PIO/T was executed. In fact, a signed agreement between USAID and VITA was not formally completed until after the evaluation was completed and the memo of authorization was written by USAID/WA (CM/ROD/LAC). The draft of the evaluation report contained passages which were offensive to the executive director of INE, who had selected an alternative resident advisor, but they were removed from the final report.

Beginning in July 1984, with publication of a notice in the Commerce Business Daily, USAID acted to contract for a replacement resident energy advisor for the second half of the project. However, rather than review a number of candidates, the project officer sent a letter to INE for the executive director's signature, recommending the hiring of the leader of the Interim Evaluation team as resident advisor (Duisberg, September 25, 1984a, and September 25, 1984b; letter and note absent from project files, supplied by C. Quevedo). The executive director found the person more objectionable after the mid-term evaluation than in 1981, and rejected the offer. In consequence, INE took advantage of the clause in the Project Paper that stated that a resident advisor should be present for at least two years to opt for not extending the position of resident advisor for the remainder of the project. The project officer suggested orally that the absence of a resident advisor might precipitate deobligation of the entire project.

Since an important duty of the resident advisor was to provide a communication link between USAID and INE, the absence of a resident advisor in the second half of the project contributed to the deterioration of communication and the overall relationship between the two institutions. Despite some reservations about the effectiveness of the resident advisor, his quarterly reports and correspondence files indicate that he did keep USAID informed of INE activities and helped move along the USAID paperwork for the project (interviews with C. Quevedo, INE; and P. M. Wright, University of Utah; also see resident advisor files, Project 518-0029, USAID/Quito). In the absence of a resident advisor, it appears that paperwork in the

USAID system was often left to take care of itself, with attendant delays.

The attitude of the AES project officer toward this project had been cautious, but generally favorable and optimistic, in summary memoranda as late as December 1983 (Duisberg, December 14, 1981; Duisberg, December 23, 1983). The next general correspondence regarding USAID attitudes toward the project appears early in 1985, and is distinctly pessimistic in tone, anticipating substantial deobligation of funds from the project: "...approximately $461,500 are presently available for deobligation. It is highly probable that a further increase in funds available for deobligation will occur as a result of the June 'evaluation'" (Duisberg, February 15, 1985).

It appears that during CY 1984, USAID began to lose contact with INE's activities and developed a decidedly more negative opinion about INE and the AES Project despite generally favorable conclusions in the draft and final reports of the Mid-Term Evaluation. In early 1985, USAID/WA strongly urged USAID/Quito to deobligate the entire project, but considerations within the Mission resulted in a compromise in which only $250,000 was deobligated (interview with G. R. Wein, Acting Mission Director, USAID/Quito). The final evaluation team heard several oral reports from USAID staff during the evaluation that INE was chronically late with annual operating plans, but examination of project files shows that plans were submitted early in each calendar year, usually January or early February, once as late as March, which is difficult to interpret as excessive tardiness. It is difficult to account for these particular impressions. Other oral reports cite what can be described as administrative control problems which were irritating to USAID/Quito, but which occurred early in the project. For an example of such an oral report which is also documented, there is the case of INE staff requesting training, apparently in the United States, but without adequate English language skills (R. Roeser, January 1, 1983). However, the optimistic memoranda and mid-term evaluation conclusions noted above survived these early complaints.

During 1984, INE began to use project funds at a much higher rate than previously in the project (see Fig. 3.1), although total spending by that time was far behind schedule; USAID appears to have recognized the prior condition but not the improvement. This new rate of spending continued through CY 1985, and the pace actually picked up in the first three months of 1986. Beginning in 1985, the NCE project supervisor hired at INE began to prepare quarterly reports on activities in that component of the project, but INE did not send them to USAID, and it is not clear that USAID requested regular progress reports during that period.

Another indication of the communication gap which had grown between USAID/Quito and INE is the lack of agreement between the financial accounts of the project maintained by the respective agencies. According to discussions with INE officials, USAID complained, in November 1985, about the lack of agreement between the

two sets of financial accounts. INE subsequently hired a contract accountant, using project funds, in January 1986, to reconcile the differences. USAID acknowledged the need for this service in the PIL approving this use of project funds, as follows: "the differences between INE and USAID accounting records have become an increasingly difficult problem. Unliquidated advances, unrecorded entries, direct payments, etc., are financially hindering project implementation" (PIL No. 14, February 13, 1986). Nevertheless, the independent accountant hired by INE was unable to complete her report until April 1986, because of the inability of USAID/Quito to cooperate fully and provide the manpower needed to support her efforts and supervise her use of project files and accounts. This situation seems to be yet another indication of the steady deterioration in communications between INE and USAID.

At the time of the final evaluation, USAID was unaware of a number of activities that had been successfully undertaken by INE. It is clear that while both INE and USAID share the responsibility for the deterioration in communication, the project definitely suffered from the poor state of communications: USAID did not particularly facilitate required paperwork which would have sped up the pace of project implementation, and INE attempted to do little to alter USAID's opinions of the project.

With the appointment of the last project officer, an Ecuadorian citizen himself, relations between INE and USAID regarding the AES Project appear to have improved.

5. DEVELOPMENT IMPACTS OF THE PROJECT

In the first subsection below, we identify four categories of beneficiaries from the project and make a back-of-the-envelope calculation of the benefits required from some of the NCE demonstration projects if they are to completely repay project costs. We find, using rough numbers but stringent assumptions about what is included in benefits (specifically, excluding demonstration and institution-building benefits), that the small hydro program might repay project costs, but the stove and solar water heater projects are less likely to repay project costs. We consequently suggest some further cost benefit analysis of the program activity composition. The subsequent sections recapitulate accomplishments noted in various places above in the report, but collecting these in one place highlights what we see as major development impacts of the project.

5.1 RECIPIENTS OF BENEFITS AND COST-BENEFIT CALCULATIONS

We can identify four categories of recipients of the AES Project's development benefits: (1) the consumers of project activities such as small hydro-generated electricity and owners of firms receiving energy audits; (2) INE staff who received formal training and on-the-job experience; (3) coordinating institutions who benefited from INE planning and/or NCE demonstration activities; and (4) the nation at large, which has gained a sophisticated energy planning organization in INE. There may be some duplication of benefits assigned to categories (2) and (3), but there are separate benefits as well.

The first category of direct recipients is relatively small because the project aimed at institution building, and technology and services were distributed only on a demonstration basis. Counting the numbers of solar water heaters, stoves, small hydro projects, etc., and estimating the number of family members likely to be associated with each installation yields no more than some 1500 people at the most optimistic count. If we allow product price reductions or increased outputs at constant costs by firms receiving energy audits, we can add in these firms' customers as secondary beneficiaries (but most of these secondary benefits could be captured by an estimation of profit increases by the firms' owners). Precise calculation or estimation of the present discounted value of all these dispersed benefits would require more time and information than the evaluation team has, but we can offer a very rough, back-of-the-envelope calculation of benefits.

Since the evaluation team has virtually no benefit data from these projects, we adopt a requirements approach in an investigation of whether the NCE components of the AESP are likely to pay for themselves. In this approach we make a conjecture regarding the income of the recipients and estimate the percent increase in these

incomes which the NCE projects would have to generate in order to just pay for themselves. Below, we calculate the amount by which an individual annual income must increase to pay for these projects, as an annualized, per capita project cost. Following that, we make a rough calculation of what annual per capita income is likely to be in the areas served by the NCE projects. We are then able to determine the proportionate increase in those incomes which would be required to cover the annualized project costs and consider whether increases of such magnitudes are plausible.

We use the June 1986 project expenditure figures of roughly $1.55 million, and divide by four to account for the share of expenditures going to NCE projects. We assume that USAID funds paid for one-half of the total expenditure on the NCE projects, and take the optimistic number of recipients as 1500; note that this accounting excludes the conservation activities. However, final consumer benefits derive only from the solar water heaters, the stoves, and the small hydro projects, which account for roughly one-half of NCE expenditures from USAID funds (reported in USAID/Quito, June 1, 1986), so we consider the benefits required to cover the costs of only those projects and assume that GOE expenditure patterns are similar. Use the approximation for the capitalized value of a perpetual income stream, $K = R/i$, where K is the per capita expenditure (USAID and GOE) on NCE demonstration projects, and $K = \$516.50$; R is the annual return (the increase in income generated by the project), and i is the interest rate. At an interest rate of 10%, the annual increase in per capita income among the 1500 benefit recipients required to exactly recover the project costs is $51.65 in a country for which the World Bank reports an estimated $1180 per capita gross domestic product (GDP) for 1981 (World Bank, 1983, p 50). Estimating the labor share of Ecuador's GDP to be 80%, and assuming that these 1500 NCE project beneficiaries receive no capital income but do receive the national average per capita income, a 5.5% increase in annual per capita income would be required to recover the full project costs with final consumer benefits alone (excluding all other benefits of the undertaking, such as engineer training, demonstration effects, etc.). But acknowledging that these beneficiaries are low-income Ecuadorians, the required income increase is larger. Ecuador's income distribution is particularly skewed, and a person earning the average income would be well above the median. The low-income beneficiaries of the NCE projects may well earn only one-third of the average income, and a 16.5% increase in individual income would be required to fully pay for these three NCE projects.

It is implausible that the stoves or the solar water heaters could confer such savings, and the direct income and consumer surplus (roughly speaking, "nonmonetary benefits") increases from the small hydro-supplied electricity probably would not reach this level either. However, the financial saving from the solar water heaters must be considered against the subsidized energy costs of alternative water heating sources. In addition to direct, full resource cost savings of fuel expenditures must be added benefits from improved health for

people previously without access to hot water and benefits from easier access for people who previously had less convenient access to hot water.

This rough calculation that these three NCE demonstration project must generate, in the aggregate, approximately a 16.5% increase in per capita income among the beneficiaries requires discussion. First the 16.5% figure is an average, and each project individually will have a number greater or less than this average, depending upon the expenditure on that component, but we have not disaggregated the disbursement data in that detail. If the benefit generation is more expensive in the stove and solar units heater programs than in the small hydro program (and we have no information that leads us to believe that this is the case), the economics of the expenditures in the former two programs should be reviewed carefully. One ultimate purpose of the institution building is to deliver benefits directly to consumers, and the costs of building an institution to initiate these activities should not exceed the value of the direct and indirect benefits derived from the NCE activities. Another purpose of the institution building is, of course, to develop a sophisticated, analytical energy planning capability in Ecuador, but again, the ultimate purpose of that activity is to increase the welfare (income) of Ecuadorian citizens. Assessing the indirect benefits of the institution building and planning components would be intricate, but it would be a valuable activity for INE's planning staff to undertake. That cost-benefit exercise should include an effort to evaluate the optimal levels of activity in the various project components and sub-components. Such an analysis should not be allowed to become a major drain on resources, but should provide some first-approximation information to guide the allocation of efforts and/or cost-cutting among various NCE options. But the rough calculations made here indicate that the cost-benefit viability of this project will hinge on the benefits of the institutional development of INE. This is not particularly surprising, but it is a useful reminder to realize that this project is unlikely to pay for itself with only the direct benefits of the demonstration component that delivered final consumer benefits.

5.2 INCREASED TECHNICAL COMPETENCE IN ENERGY-RELATED PROFESSIONS

The training and experience that both the engineers and economists at INE gained in the course of the project has increased their individual technical competence and productivity. Whether they remain at INE or elsewhere is mostly a distributional issue rather an overall productivity retention matter. For example, one engineer left INE for CEPE; his salary increase benefited himself, but his improved productivity simply traveled from INE to CEPE, and Ecuador still benefits (and, of course, if CEPE pays him more than INE did, there is at least the possibility that the value of his contribution to national income is higher at CEPE). Another INE staff member left for employment in a manufacturing firm, where he used what he had learned

at INE to improve the energy efficiency of the firm's production (interview with Dr. Carlos Quevedo).

5.3 PRIVATE SECTOR DEVELOPMENT

Local private manufacturers of solar water heaters, stoves, and small hydro components stimulate new lines of products in the private sector as well as save foreign exchange in the case of small hydro component manufacture. Although the industrial energy audits are not yet fully privately financed, they are an excellent candidate for private financing, and energy audit trainees from INE's programs will form the basis of the supply side of a new industry whose service is to help firms save energy.

5.4 STRENGTHENED ANALYTICAL ENERGY PLANNING

INE's internal technical competence and external perceptions of INE's credibility both have increased as a result of the AES Project. INE's weight in policy circles cannot reasonably be expected to match the influences of such agencies as CONADE, INECEL and CEPE, but INE's relatively high level of technical competence and political neutrality will raise the tone of the debate on energy issues in Ecuador in the future.

5.5 BENEFITS TO COORDINATING INSTITUTIONS

The small R&D grants provided are an example of INE's USAID-funded activities benefiting coordinating institutions. Bachelor's degree candidates in engineering are required to complete a thesis, and the funding support offered by INE enables students' institutions to buy equipment that could also be used by other students (the equipment stays with the institutions). Additionally, the projects that could be pursued with this larger-than-ordinary funding often turned out to be more stimulating than could have been undertaken otherwise, adding to the stock of knowledge of the institution itself. (From interview with Ing. Marco Acosta, INE, who received such as grant as undergraduate).

6. LESSONS LEARNED

- This project was designed at a time when the GOE placed a high priority on energy development and conservation. The project was to assist Ecuador strengthen its National Energy Institute (INE) and promote alternative energy development. The change in Ecuador's administration in 1984 resulted in a major change in philosophy and consequently a shift in the role of INE. Even without major shifts in an institution's operating philosophy, a four- to five-year program will evolve, and external conditions will change to a point where much of the original project design may not be applicable. Administration of a project therefore should recognize that these changes will occur and that rigid implementation of a project paper can actually be counterproductive. Project amendments or revisions during the course of the AES program would have reduced the misunderstanding and frustrations which were observed during this evaluation. More frequent communication and short, monthly activity reports from INE to USAID also would have provided a vehicle for closer collaboration, not to mention for the audit trail for evaluations such as this one.

- The progress of this project during its early years was measured almost exclusively in terms of its spending pattern. Given the immaturity of INE at the time, it is not surprising that initial spending would be slow. Nonetheless, the pattern was interpreted as lack of progress, and it labeled INE negatively for the remainder of the project. It should be recognized that slow, careful growth will produce a more stable institution in the long run, which should have been the main objective in this case. Futhermore, introduction of new technologies to a country requires time for social acceptance, thus mitigating against an early, rapid spending pace.

- Another consideration in assuring the success of a future project of this type is that a new agency will operate among established institutions, which perceive it as an intrusion into their responsibilities. INE was occasionally described as "weak," which, unfortunately, burdened it with an undeserved label. The description undoubtedly was used without sufficient thought for the consequences and to some extent began a self-fulfilling prophecy.

- The project design included too many activities for most institutions, let alone a group just getting organized. A 1980 USAID Asia Bureau report on renewable energy projects pointed out the difficulties associated with a project such as the AES Project in Ecuador (cited in CDER and RTI, 1982). This project would have accomplished NCE demonstrations more quickly if the effort had focused on fewer, well-defined technologies. Doing so certainly would have looked better on paper but may have resulted

in a slower acquisition of experience and expertise by INE personnel. There are costs and benefits to both options, and ex post judgement is easier than prediction. In any case, technical missteps can be viewed profitably as part of the learning process and institutional development.

- There is a tending among originators of energy projects, particularly nonconventional energy projects, to be unaware of lessons learned in previous energy projects and to relearn all or most of other projects' hard-learned lessons by making the same mistakes. This problem is partly attributable to the dispersed character of evaluating those projects: evaluations of previous projects do not get into the hands of project designers in other missions or bureaus. The design and execution of energy projects would benefit from the use of some central office, such as the Office of Energy of USAID, as a library for energy project evaluations, and possibly as an integrator of findings from those evaluations.

7. CONCLUSIONS

- The original project design was overly ambitious and contained a program which created unrealistically high expectations for an essentially fledgling institution.

- INE has developed a credible program in two major areas during its seven-year life as an institution and over the life as an institution and over the life of this project: energy policy studies and NCE demonstrations/energy conservation.

- INE has now developed improved capabilities to execute agreements with counterpart agencies and service contracts to help carry out elements of its program.

- INE has now developed internal technical competence in the following areas of alternative energy: small hydro plants; solar domestic water heaters; family-sized biogas digestors; passive solar architecture; low-temperature, low-enthalpy geothermal energy; and energy-efficient metal cookstoves.

- INE has developed a strong technical capability in industrial energy conservation which has surpassed initial expectations despite limited staff resources. The demand for these services continues to grow among private firms.

- INE has developed a substantial analytical competence in a number of important technical areas in national energy planning for which they have received public recognition and which in a number of cases have been influential in national decision-making. Despite these successes, INE has been unable to fully realize the initial goals established for it at its inception, namely that it become the dominant agency in the coordination and execution of national energy planning. This appears to have been an unrealistic expectation given the size and financial resources of competing national energy and planning agencies.

- INE has reached a state of institutional maturity in which it is increasing its energy information dissemination and technical outreach activities. This is evidenced by a number of recent conferences, seminars, and workshops on industrial energy conservation audits, passive solar architecture, and biogas digestor construction and maintenance.

- INE has been designated as the national node of a new regional energy information exchange network being organized by OLADE. While it does not yet possess the necessary technical equipment or staff expertise to adequately fulfill this role, it has made strides over the course of the project in becoming a major source for energy information.

- Over the life of this project INE has developed the capacity to work in effective partnership with private sector firms in the adaptation of NCE technology for selected markets. Their programs have emphasized local manufacture wherever possible.

- It is the evaluation team's judgement that during the first two years of the project when severe implementation problems developed, USAID developed a negative attitude toward the project despite the fact that it was designed as an "institution-building" project. This attitude appears to have persisted throughout the project despite a positive Mid-Term Evaluation and a clear record of improved performance by INE during the last year and a half. Although much was accomplished during this later period, more could have been done had this attitude not prevailed. In the Mission's defense, it was under considerable pressure to deobligate funds from the project because of its troubled early record as well as to deobligate funds from the Mission portfolio generally. It was also under a severe staffing constraint, which affected project management and seemed to amplify bureaucratic impediments.

- INE also experienced its share of implementation problems for which it must bear responsibility. These resulted from inexperience; personnel turnover, including the Executive Director; and changes in program planning and definition.

- Many, if not most, of the delays encountered during this project were not the fault of either INE or USAID but rather the result of the normal complications, problems and bureaucratic procedures which are inherent in project undertakings of this kind. They include failure of cooperating agencies to execute agreements and contracts on time, the need to satisfy normal USAID procurement regulations and a recurring condition precedent (see Section 4.3 for a definition of a condition precedent), delivery or malfunctioning equipment, and site preparation delays.

- The project's most recent accounting records indicate that a significant amount of loan funds ($700,000) have not been disbursed to INE as of the PACD despite the fact that these funds have already been earmarked for expenditures on items on a USAID-approved INE Operating Plan. We understand that a large percentage of these funds would be routinely deobligated since they are not covered under the latest two month PACD extension.

8. RECOMMENDATIONS

- Funding should continue for specific, clearly defined projects. Continued support of INE will insure success of the project and protect USAID's investment. The activities we recommend for extension are, in order of priority:

  1. INE should be permitted to purchase the mainframe computer which it attempted to purchase in 1985. This facility is indispensible to INE's continuing ability to discharge its energy planning responsibilities, and it will be a major support system for the information network responsibilities. ($140,000)

  2. The photovoltaic system which would provide electrical power at 30 remote telecommunication sites. All necessary agreements have been made, and equipment purchase and installation are all that remain to complete this component of the project. ($112,000)

  3. Development of a solar collector test facility for the purpose of developing manufacturers' standards. This will help standardize the private sector market. ($65,000)

  4. Revolving loan fund for family-sized biogas digestors. All agreements are in place and client demand has been identified. ($75,000)

- The PACD should be extended for a period of nine months to permit accomplishment of the activities recommended above.

- If a longer PACD extension is feasible, there are two other activities worthy of funding:

  1. Energy audit training and quality control of the audits performed by the trainees. This will raise energy conservation in the popular conscience and help move energy conservation activities into the private sector. ($140,000)

  2. Two additional microhydro projects. This would be acquiring equipment for economically viable projects, rather than demonstration projects, for which prefeasibility studies have already been done. ($150,000)

A PACD extention of fourteen months would be required if these two additional activities are funded.

- Since the Mission does not contemplate funding a follow-on project and does not have any other activities in the energy sector, we wish to point out opportunities for the Mission to

consider selective funding of targeted energy activities with INE through a combination of other Mission sector activities or projects; regional bureau funded activities; and/or Mission buy-ins to centrally coordinated energy projects in S&T/EY. Activities which might be considered include:

1. Further support to INE's energy planning activities through the EPDAC Project. Ideally, any new USAID support in the energy planning area should be linked to a policy dialogue process with the GOE aimed at energy pricing policy reform.

2. Further support to INE's conservation activities could be funded under the Energy Conservation Services Program. This vehicle has already been used to conduct a number of energy audits in Ecuador in conjunction with the existing project and could be used to help INE train private sector engineering companies to conduct energy conservation audits on a fee-for-service basis.

3. Selected INE activities in NCE technologies could be further supported through the Renewable Energy Applications and Training project. Appropriate activities include feasibility studies for additional small hydro projects, working with private sector solar domestic water heater manufacturers to improve design efficiency, reduce costs, and establish a program of standardization and quality control.

4. LAC Bureau is planning a regional energy project which is still in early design stages. There may be opportunities to support selected INE activities through this project. One possible activity would be further support to INE's role as the central node in OLADE's regional energy information network (CIELA).

5. There may also be opportunities to support selected INE activities through other Mission projects. For example, further support of INE's efforts to develop local manufacturing of renewable energy equipment could occur through projects of the Mission's Private Sector Office.

- INE should redouble its efforts to promote dialogue with other government agencies with connected responsibilities.

- INE should also continue its already strong effort to involve the private sector in creating manufacturing opportunities in renewable energy technology.

- INE should focus some of its planning activities on the mid-term consequences of declining oil prices and declining Ecuadorian oil

production on investment funds available for national development.

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APPENDIX 1

LIST OF ACRONYMS

APPENDIX 1

LIST OF ACRONYMS

AESP/ (AES)	- Alternative Energy Sources Project
CEFE	- Center for Executive Business Training
CEPE	- State Petroleum Corporation
CIELA	- Latin American Energy Information Center
CLIRSEN	- National Center for Remote Sensing
CONACYT	- National Science and Technology Council
CONADE	- National Development Planning Office
DDE	- Dirección de Development de Energía, Directorate of Energy Development of INE
DINAF	- Ecuadorian Forestry Service
DPRE	- Dirección de Planificación y Recursos Energéticos, Directorate of Planning and Energy Resources of INE
EPN	- National Polytechnic University (Quito)
ESPOL	- Polytechnic of the Coast (Guayaquil)
FED	- Ecuadorian Development Foundation
FEDETA	- Ecuadorian Foundation for Alternative Technology
GDP	- Gross Domestic Product
GOE	- Government of Ecuador
ICI	- Intermediate Credit Institution
IEOS	- Sanitary Works Institute
IETEL	- Institute fo. Telecommunications
IFI	- International Financial Intermediary
INECEL	- Ecuadorian Electrification Institute
INERHI	- Institute for Water Resources
IQC	- Indefinite Quantity Contract
JNV	- National House Board
LAC	- Latin America and Caribbean Bureau of USAID
OAS	- Organization of American States
OLADE	- Latin American Energy Organization
OVI	- Objectively Verifiable Indicator
PIL	- Project Implementation Letter
PIO/T	- Project Implementation Order/Technical

LIST OF ACRONYMS (CONTINUED)

PP	- Ecuador Project Paper: Alternative Energy Sources
PRONAF	- National Forestry Program
PV	- Photovoltaics
SEDRI	- Secretariat for Rural Development
SMH	- Small Mini-Hydro
TDY	- Temporary Duty
USAID	- U.S. Agency for International Development
VITA	- Volunteers in Technical Assistance

APPENDIX 2

PERSONS INTERVIEWED

APPENDIX 2

PERSONS INTERVIEWED

INE

Franklin Carrasco, Acting Director
Raúl Nuñez, Coordinator
Marco Acosta, Geothermal Engineer
Juan Zak, Energy Conservation Engineer
Miguel Acuña, Biomass Engineer
Amilcar Salazar, Biomass Engineer
Fernando Barriga, Small Hydro Engineer
Santiago Ordoñez, Director of Planning Department

CONADE

Magdalena Aguilar, Chief, Division of Hydrocarbons and Energy Resources Planning

Victor Paredes, Engineer, member of INE Technical Board

INECEL

Wilson Carrillo, Small Hydro Program, Division of Distribution and Commercialization

OLADE

Roberto Cáceres, Chief of Renewable Energy Program

ELECTRO-ECUATORIANA

Pedro Romo Leroux, President

CONSIDE

Rene Ortiz, President

USAID

Gerald Wein, Acting Mission Director, USAID/Quito
Thomas Chapman, Chief, General Development Office, USAID/Quito
Fausto Maldonado, Project Officer, USAID/Quito
Hugh Pierson, ex-PSC Energy Advisor to INE

Randy Roeser, Project Backstop Officer, USAID/Quito
Robert Jordan, LAC/DP
USAID (CONT'D)

Carl Duisberg, ROCAP
Alberto Sabadell, S&T/EY
James Hester, LAC/CAR
Jack Francis, LAC/DP

Peace Corps

Napoleon Cevallos, Energy Project Coordinator, Quito

VITA

Gary Garriott

E/DI

James Westfield

Hagler - Bailly

Alain Streicher

University of Utah Research Institute

Phillip M. Wright

National Academy of Sciences/BOSTID

Jack Fritz

APPENDIX 3

FIELD VISITS TO PROJECT SITES

APPENDIX 3

FIELD VISITS TO PROJECT SITES

June 26, 1986

1. Solaris-Demersol, Solar Heater Manufacturing Valle de Los Chillos.
2. 4-F Foundation Center, Solar Forage Dryer, Valle de Los Chillos.
3. Conocoto Forestry Center, Solar Wood Dryer, Valle de Los Chillos.
4. INE, Small Hydro Turbine Testing Center, Guangopolo.
5. JNV, Solanda Housing Project, Solar Water Heater Installation, Quito.
6. Electro-Ecuatoriana, Small Hydro Turbine Manufacturer and Photovoltaic System Distributor, Quito.

APPENDIX 4

STATEMENT OF WORK

APPENDIX 4

STATEMENT OF WORK

A. Purpose

To conduct a final evaluation of Project 518-0029, Alternative Energy Sources.

B. Focus

The proposed evaluation will concentrate on a detailed review and analysis of the administrative, organizational, technical, planning, and operational aspects of the project to determine whether original project objectives have been achieved as scheduled. The Project logical framework matrix will serve as the basis for measuring achievement. This evaluation will examine the effectiveness of the exchange of data and cooperation between INE and other national and regional institutions, and the effects on Ecuador's energy situation. This evaluation will assess INE's capacity as an energy planning/energy development and coordinating institution.

C. Scope of Work

The project, as originally designed, has four major components: Energy Studies and Research, Energy Technology Transfer and Information Network, Alternative Energy Demonstrations, and Energy Conservation. Where applicable, the evaluation team will review each of these components with regard to the following principal concerns for the evaluation:

1. Assess the organization and operation of INE's technical teams within INE's overall management structure, in terms of their effectiveness in carrying out planned development and demonstration of various renewable energy technologies, conservation and energy planning activities.

2. Review the appropriateness of past and current operating plans in terms of relationship to overall energy planning and priorities set by INE, staffing, comparative advantage of INE, and implementation record.

3. Examine whether planning, selection, and assignment of responsibilities have been adequately coordinated with cooperating institutions. Has INE's promotion of subproject activities with various executing entities been sufficient?

4. Look at linkages both within INE and between INE and other institutions to determine the extent to which INE's energy

planning work has been usefully applied to energy-related policies and progress in the country.

5. Assess the success of INE's efforts to involve other national institutions, and the private sector in their work, including local PVOs and Peace Corps. Have the experiences of other appropriate technology groups in Ecuador been successfully incorporated into INE's planning and activities?

6. Review INE's experience in building institutional capability through training (both technical and administrative) for its own staff and those of other institutions. This implies both the use of INE conducted training and seminars plus international opportunities.

7. Discuss the validity of project activities in relationship to achieving original project purposes. Specifically, with regard to the major project components the evaluation team will:

7.a. (Energy Studies and Research). Review the quality of studies and assessments made during the project, and the extent to which INE has established linkages with, and created demand from GOE, policy bodies (CONADE, etc.).

7.b. (Technology Transfer and Information Network). Evaluate progress in the INE's data generation and reporting system. Review the utility and progress of the information system used in the course of project implementation. Assess the extent to which INE has succeeded in establishing information sharing linkages, both internationally and locally, and in creating local demand for this information.

7.c. (Alternative Energy Demonstrations). Conduct technical reviews of specific demonstrations noting the adequacy of criteria for selecting demonstrations, adequacy of methodology for site identification, impact on users, data collection for future analysis, economic viability, and potential for replication.

7.d. (Energy Conservation). Review INE's plan and outputs of its conservation program, including efforts in the public awareness campaign and its results. Evaluate the extent to which demand for INE-sponsored conservation services (e.g., energy audits) has developed.

8. Identify the major factors that have inhibited project implementation and purpose achievement, both globally and in the four above components.

D. Team Composition

The team should be composed of two or three members. A team leader, with Spanish S-3/R-3, will be responsible for completion of a final report and an initial debriefing in country. The estimated level of effort is 50/person days in country. Six-day work weeks will be authorized. Team skills must include:

- Technical experience with renewable energy technologies (project includes: hydro, biomass, solar, and geothermal).
- Administrative/operational understanding of national/regional energy institutions.
- Economic and social evaluation of renewable energy technologies and the interaction of the natural resource base and human settlements.
- General evaluation of development projects.

Team members with broad background and generalized experience in non-conventional energy, fuel efficiency, information systems, energy planning, organization and management, and evaluation will be most useful.

USAID/Quito and INE will concur on team composition before services are initiated. If available, ST/EY or LAC/DR participation would be advantageous, although no Mission OE funds are available for such TDYs.

E. Timing

The estimated schedule for the evaluation would be starting mid-May for about four weeks in country. At the end of stay in country, including visits to field sites, and other agencies concerned with energy, the team will debrief INE and USAID and leave a draft report of the evaluation. This draft report should be ready at least three days before team departure, so both USAID and INE can clarify potential problems, etc.

Ten copies of a final report, prepared in English, will be submitted to USAID within four weeks after completion of the evaluation. Up to three person-days of professional time in the U.S. for report preparation are authorized.

APPENDIX 5

REVIEW OF THE INTERIM EVALUATION

APPENDIX 5

REVIEW OF THE INTERIM EVALUATION

The final evaluation team studied the Mid-Term Evaluation to assess mid-term opinions and evidence regarding early progress in the AES Project and mid-term opinions regarding the outlook for the project's success. The Mid-Term Evaluation expressed generally very favorable conclusions regarding the conscientiousness and technical competence of the INE staff. It noted the low disbursement of funds and attributed that to four causes: delays with the USAID bureaucracy (VITA, 1984, p. 70); INE's administrative inexperience and short staffing (VITA, 1984, p. 24); INE's reluctance to use loan funds before they were prepared to use them well (VITA, 1984, pp. 23, 24); and problems with Ecuadorian interagency coordination (VITA, 1984, pp. 29, 46, 47, 58, 70). The Mid-Term Evaluation was critical of the original project design for setting "specific information dissemination goals in advance of prefeasibility and feasibility studies" (VITA, 1984, p. 28), which accounted for delays in implementing the technology transfer component of the project. But the evaluations concluded that "INE's slow progress with the AESP during 1981-83 is not a barometer for the future" (VITA, 1984, p. 30); and that "post implementation problems are not an indication of its present accomplishments" (VITA, 1984, p. 84).

The Mid-Term Evaluation reported that, "Opinion was nearly unanimous among other Ecuadorians, Europeans, and Americans affiliated with or knowledgeable about the project that, generally speaking, technical competence of INE in development and adaptation of NCEs is high and a match for similar institutions anywhere in the world" (VITA, 1984, p. 64). They were additionally impressed with the extent to which INE was, at that time, trying to work with other institutions, especially the universities and technical schools and private voluntary organizations. The interim evaluation team also recognized that "Relationships with governmental institutions, such as INECEL or MNRE, are of a complex nature and INE must necessarily be deliberate in the way it deals with these organizations" (VITA, 1984, p. 70).

The Mid-Term Evaluation recommended that "the interpretation of which activities should be undertaken continue to be made loosely, without a great deal of concern whether the specific tasks as called for by the Project Agreement are being followed to the letter" (VITA, 1984, p. 74). The evaluators noted that the "mission project officer has already requested a new project completion date of December 31, 1986, (one additional year) with which the evaluation team concurs" (VITA, 1984, p. 73). They also suggested that the possibility of further extensions might prove useful (VITA, 1984, p. 70). Additionally, "The INE-AID relationship should be strengthened" (VITA, 1984, p. 77). The evaluation team concluded with the recommendations that "...the project should be continued and extended" and that the

project should be given the full support of both AID and the GOE for its remaining life" (VITA, 1984, p. 85).

APPENDIX 6

CRITIQUE OF THE LOGICAL FRAMEWORK OF THE PROJECT PAPER

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CRITIQUE OF THE LOGICAL FRAMEWORK OF THE PROJECT PAPER

The program or sector goals (1. to encourage more rational use of Ecuador's energy resources, and 2. to better address energy needs of the poor) make sense and are reasonable. The AES Project fits comfortably within them. The objectively verifiable indicators (OVI) of the program or sector goals make little sense. Two of them (5%-8% reduction in hydrocarbon use by 1985, and more rational pricing of commercial energy) are totally conditioned by the two "Important Assumptions" (political climate permits further increases in energy prices, and general public is receptive to conservation pressures), over which neither USAID nor INE has any control. The third OVI (more rational commercial energy pricing) is vague, has questionable relationships to either goal (it is a sufficient condition but not a necessary one), and is largely conditioned by the first "Important Assumption." The means of verification are reasonable, given the program or sector goals, but are pertinent to only one of the OVIs (the 5%-8% reduction in hydrocarbon use). The "Important Assumptions" are simply wishful thinking. No country that has seriously subsidized energy prices over a long time has significantly approached marginal cost pricing over a four-year period.

The project purpose (to increase INE's capability to affect energy policy and to promote NCE appropriate to Ecuador) satisfactorily recapitulates the activities described in the Project Paper. The OVIs are uneven, however. OVIs 1 and 2 (1. INE consulted by CONADE/CONACYT and Superior Energy Council for studies and recommendations; 2. information network becomes operational with international transfer of energy technology, as well as local sharing of information) are laudable but are too optimistic for a four-year program. The first OVI ought to be a measure of INE's capability to do good policy work, not evidence of its having been admitted to high policy councils. A more appropriate OVI would have been enumeration of its published studies. An appropriate "Important Assumption" required to make sense of OVI No. 1 is INE's admission to high policy councils, which seems naive. The second OVI requires extensive cooperation from agencies which are sometimes competitors, and it is not obvious that there are simple and informative measures of this indicator. The third and fourth OVIs are adequate (3. continued public and private demand for INE assistance in designing and evaluating NCE demonstrations; 4. increased public awareness of energy conservation needs and practices). The only "Important Assumption" (acceptance of NCE by urban and rural poor) is a reasonable necessary condition for the attainment of the second component of the project purpose, but its status as a sufficient condition is contingent upon the program/sector "Important Assumptions," which were characterized as naive. The project outputs are quite ambitious. They are also very dispersed technically, and it is not clear that a young institution should have been sent (or allowed to go) in so many

directions at once. The reasoning behind the magnitude of the outputs is unclear: were they derived by arbitrary partition of financial resources or by some logical procedure? The text of the Project Paper does not answer that question. The means of verification (USAID implementation files, contractor reports and implementing agency reports) are satisfactory. The "Important Assumption" (GOE and private organizations are forthcoming as implementing agencies) glosses over a plethora of coordination problems.

The project input description is satisfactory, but the implementation targets are unrealistic for an institution-building project. They start too rapidly and call for a straight-line spending path. The means of verification (USAID voucher records) are reasonable. The "Important Assumptions" are, once again, highly optimistic (minimal turnover of key staff, INE hires four additional staff, NCE equipment/parts available in U.S. or free world market, and GOE provides timely counterpart funding). The first two assumptions may have been reasonable expectations in 1980 or 1981, but with the recession of 1982, they needed revision. The third and fourth assumptions imply a degree of coordination that was not always forthcoming during the life of this project, and it is not clear that such coordination should have been expected prior to the project implementation.

APPENDIX 7

DOCUMENTS EXAMINED

APPENDIX 7

DOCUMENTS EXAMINED

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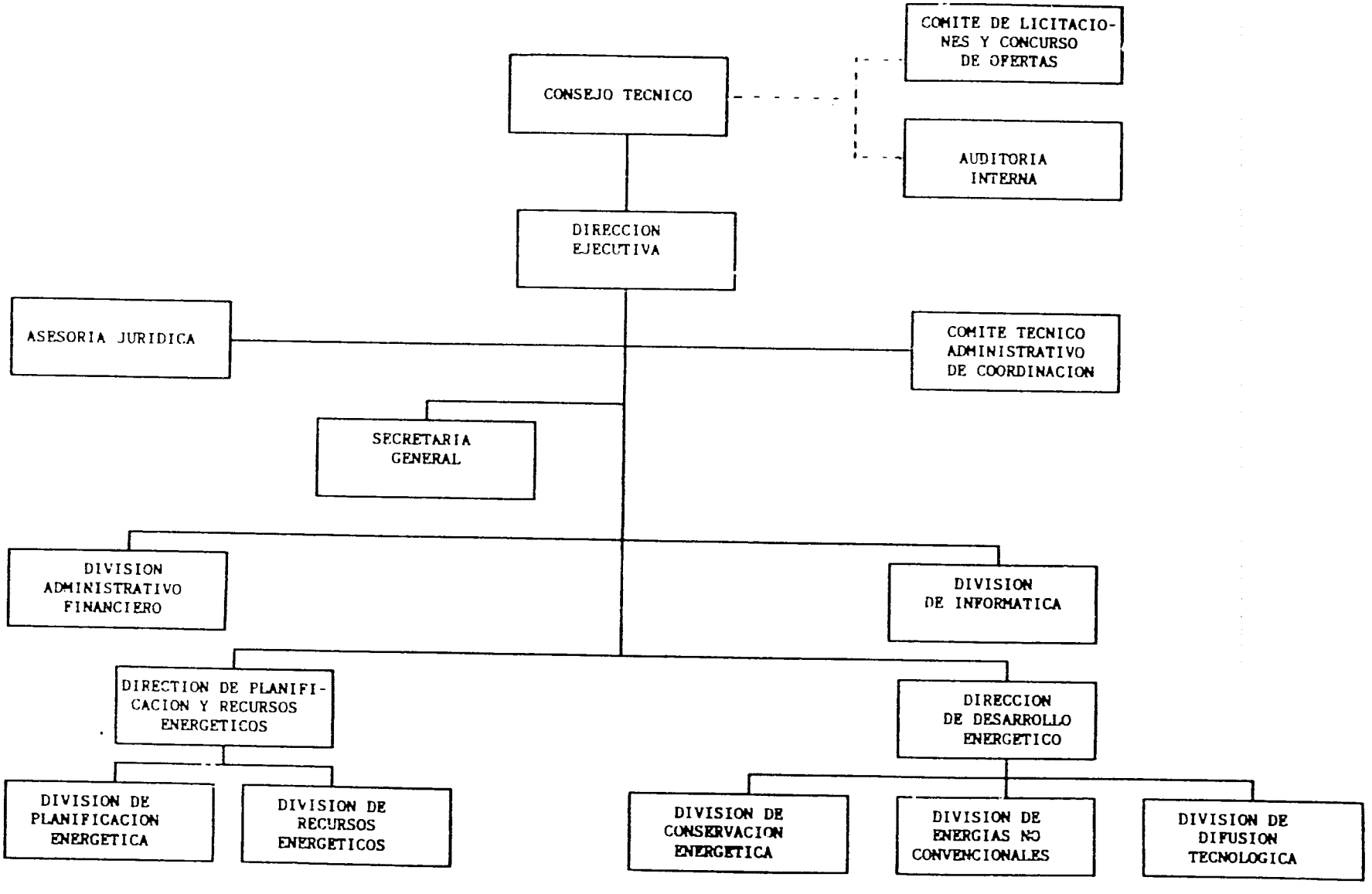
ORGANIGRAMA ESTRUCTURAL DEL "INE"

ORGANIGRAMA ESTRUCTURAL DEL "INE"



APPENDIX 9

PUBLICACIONES EDITADAS POR EL INSTITUTO NACIONAL DE ENERGIA (I.N.E.)

APPENDIX 9

PUBLICACIONES EDITADAS POR EL INSTITUTO NACIONAL DE ENERGIA (I.N.E.)

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1 Ejemplar sin Anexo

DISEÑO Y CONSTRUCCION DE UN SISTEMA DE CALENTAMIENTO DE AGUA PARA USO DOMESTICO CON COLECTORES SOLARES PLANOS Y CIRCULACION FORMADA
Por: Víctor Castellanos e
Ivan Arellano
Escuela Politécnica Nacional - 1984
2 Ejemplares sin Anexos

ECODISEÑO
Por: Eva Celleri
Magali Cordero y
Jaime Pesantes
Universidad de Cuenca - 1982
2 Ejemplares sin Anexos

PROGRAMA DE SECADO CON ENERGIA SOLAR
Por: Jorge Cando
(Colegio Simón Rodriguez - Latacunga)
1981 - 1982
1 Ejemplar sin Anexos

DISEÑO Y CONSTRUCCION DE UN PURIFICADOR SOLAR DE CERA
Por: Marcelo Zurita
(Colegía Simón Rodríquez - Latacunga)
1980 - 1981
1 Ejemplar sin Anexes

LIST OF WORKING DOCUMENTS NOT INCLUDED IN PUBLICATION LIST

MICROCENTRALES

1. Microcentral Hidroeléctrica Apuela.
   - Evaluación técnica - económica INE
   - Diseño de obras hidráulicas. Planos INE
   - Evaluación técnica de funcionamiento de las obras hidraúlicas
   - Seguimiento y evaluación técnicas en la construcción y funcionamiento de la microcentral
   - Evalucació de la Turbina Michel Banki

2. Manual de Operación y funcionamiento
   - Cálculos y construcción de una Turbina Michel Banki de 50 Kw. Tesis de Grado.
   - Planos de diseño electromecánico
   - Informe Final Proyecto Apuela/EMELNORTE

3. Programa de implementación de Mini y Microcentrales Hidroeléctricas/ INE.

4. Aspectos de la planificación y de un Sistema de Generación Hidroeléctrica con Mini y Microcentrales INE-INECEL

5. Laboratorio de Pruebas de Microcentrales/INE

6. Microgeneración y Desarrollo

7. Mini y Macrocentrales Hidroeléctricas, Alternativas Técnológicas y Perspectivas Futuras/Seminario de Planificación Energética/INE.

8. Propuesta para la implementación de programmas de electrificación mediante microhidrogeneración INE/INECEL

9. Evaluación tecnica del regulador electrónico por Triacs

10. Estudio sobre la pérdida de carga en la tuberia de presión.

11. Criterios técnicos generales para las obras hidráulicas en proyectos de MHG (Sin publicación)

12. PORPUESTA Y Términos de Referencia para estudios y elaboración de la Guía de Diseño de Obras Hidráulicas para Mini y Microcentrales Hidroeléctricas INE-EPN

13. Diseño de obras civiles-hidráulicas para la microcentral hidroeléctrica La Merced de Buenos Aires. Tesis de Grado ESPE/ EMERNORTE.

MICROCENTRALES: (continuación)

14. Estudio Hidrológico Proyecto La Merced de Buenos Aires.

15. Estudio de Estandarización de Turbinas Michel Banki. Planos Estandarizados, tablas de cálculo

16. Hojas tecnológicas de construcción de la turbina modelo SKAT.

17. Manual de Pruebas de Turbinas Michel Banki y Peltón.

18. Términos de Referencia para estudios de factibilidad y diseños de Obras Hidraúlica INE

19. Circuito de Disparo para el Regulador Electrónico RT-III (50 KW)

20. Optimización de Regulador de Carga RT III/INE

21. Especificaciones para la Construcción de un Regulador Electrónico de Carga (programable) INE.

22. Especificaciones técnicas para el diseño y construcción del tablero de control y regulador electrónico de carga, Sistema Triacs.

23. Especificaciones principales de freno Hidraúlico

24. Análisis del regulador oleomecánico RO-II

25. Informe sobre el regulador oleomecánico

26. Estudio de Factibilidad para los siguientes proyectos de MCH, Documento Técnico:
    - La Plata
    - Cuellaje
    - Juan de Velasco
    - Golondrinas
    - Lita

27. Diseño de Obras Hidraúlicas para los siguientes proyectos de MCH, Documentos técnicos y planos:
    - La Plata
    - Cuellaje
    - Juan de Velasco
    - Lita

28. Informes técnicos de reconocimiento de varios sitios para MCH, Informas y Formularios.

MICROCENTRALES: (continuación)

29. Estudios de Prefactibilidad de los siguientes proyectos
    - Proyecto Oyacachi, Documentos Técnicos
    - Proyecto Miguir
    - Proyecto Cochaló
    - Proyecto Pululahua, (planos de Diseño de obras hidraúlicas)

30. Estudios investigativos para elaboración de la Guía de Diseño de Obras Hidraúlicas para mini-microcentrales hidroeléctricas. Documento técnico.

31. Diseño y construcción de un regulador electrohidráulico. Documento Técnico.

32. Estudio de Diagnóstico sobre el desarrollo de turbinas PELTON en el Ecuador.

33. Estudio de Mercado para Microcentrales Hidroeléctricas.

34. Estudio sobre Formulación Methodológica para el uso intensivo de MCH con tecnología nacional.

35. Diseño y construcción de un regulador electrónico de carga de fase completa programable.

36. Estudio de calbiración de los codos del centro de pruebas de Guangopolo. Instalación de un manómetro diferencial de presiones.

SOLAR ACTIVA

1. Diseño y Construcción de un prototipo de secador solar de café de producción continua.

2. Diseño y construcción de un equipo para determinación de humedad de granos.

3. Diseño y construcción de un equipo de laboratorio de curvas de equilibrio higroscópico de granos.

4. Diseño y dimensionamiento de Secadores Solares Director para café y cacao.

5. Evaluación de pruebas de secadores solares tipo directo.

6. Evaluación del proyecto de secadores solares de café y cacao.

7. Evaluación de pruebas del secador solar Indirecto de Granos.

8. Metodología de Pruebas para el Secador de madera del PRONAF.

9. Evaluación de pruebas del secador de madera del PRONAF.

10. Memoria Técnica de Diseño del Secador de Madera del PRONAF.
11. Compendio de Teoría y Aplicación del Secador Solar.

12. Evaluacion de Pruebas del Secador del CREA.

13. Evaluación del Funcionamiento del Regulador de Operación de Sistemas Fotovoltaicos.

14. Evaluación del Funcionamiento de Colector Solar de Tubería Aleteada de Aluminio.

SOLAR PASIVA

1. Estudio sobre metodología de ecodiseño.
2. Estudio sobre teoria y cálculo de viviendas para Sierra y Costa.
3. Estudio de materiales sierra.
4. Estudio de inventario de materiales de construcción en la costa. ESPOL
5. Tesis de Ecourbanismo - Cuenca.
6. Estudio de balances energéticos para viviendas en la sierra.
7. Estudio de materiales, técnicas y elementos arquitectónicos. FEDETA
8. Estudio de materiales, técnicas y elementos arquitectónicos Costa, FUNDACION JOSE JOAQUIN OLMEDO.
9. Estudio para proyecto de casas demostrativas INE-JNV.
10. Seminario de Arquitectura Solar para el Trópico.
11. Estudio de datos técnicos para viviendas demostrativas INE-JNV.

BIOMASA

1. Manual Técnico de Construcción, Operación y Mantenimiento de Biodigestores.

2. Evaluación Técnica y Socio-Económica de los Biodigestores Instala- dos en las Provincias de Manabí, Esmeraldas, Pichincha, Imbabura, y Carchi (Documento Interno).

3. Estudio del Potencial Bioenergético de Desechos Agroindustriales y Agricolas con fines de producción de biogas (por concluir) AID.

4. Análisis de Bio-abono con fertilizantes en los cultivos de fréjol Remolacha y Lechuga, AID.

5. Pruebas de Laboratorio para Fogones Mejoradas.

6. Manual para la producción de fogones metálicos.

7. Los nuevos fogones campesinos.

8. Documental sobre construcción de biodigestores.

9. Material de divulgación técnica varios (biogas y fogones).

EN EJECUCION:

1. Diagnóstico de consumo energético en áreas rurales.

2. Investigación de especies nativas en viveros.

3. Introducción y difusión de fogones para leña.

GEOTERMIA

1. ESTUDIO GEOTERMICO EN EL VALLE DE LOS CHILLOS INE-EPN II FASE: GEOLOGIA ESTRUCTURAL DEL CERRO ILALO Y SUS ALREDEDORES (22 de Abril 1983).
Marco Estrella, Jansen y Hépez - EPN

2. ESTUDIO GEOTERMICO EN EL VALLE DE LOS CHILLOS INE-EPN II FASE: LOS VOLCANICOS ILALO (25 de Abril 1983).
Renán Cornejo

3. POSIBLE MODELO GEOTERMICO PARA EL ILALO INE-EPN (Septiembre de 1983).
Ramón Vera

4. RECONOCIMIENTO GEOLOGICO GENERAL DEL VALLE DE LOS CHILLOS INE-EPN (Noviembre 1982).
R. Vera, Yépez y Estrella - EPN

5. PROYECTO GEOTERMICO VALLE DE LOS CHILLOS (PREETUDE DE FAISABILITE TECHNICO-ECONOMIQUE) (Febrero 1985).
Bureau de Recherches Geologiques et Minieres (BRGM)

6. ETUDE HYDROGEOLOGIQUE DE L'AQUIFERE DE QUITO ET DE LA VALLEE DE LOS CHILLOS PAR LES ISOTOPES DE L'ENVIRONNEMENT; Premier Rapport d'Interp./ (Mayo 1985)
J. F. Aranyossy

7. LEVANTAMIENTO AEROFOTOGRAMETRICO, PLANIMETRICO PARA EL PROYECTO GEOTERMICO VALLE DE LOS CHILLOS, MEMORIA TECNICA, QUITO, ECUADOR. Cartotecnia. (1984).

8. ESTUDIO DE FRACTURAS Y FALLAS EN PUENGA SI Y ALREDEDORES DEL VOLCAN ILALO, (EPN) INFORME DE PRACTICAS VACACIONALES. Changkuon, L. y otros. (1983)

9. ESTUDIO HIDROGROQUIMICO, QUITO, ECUADOR, PROYECTO, GEOTERMICO DE BAJA ENTALPIA, VALLE DE LOS CHILLOS. Lopoukhine, M. (1985)

CENTRO DE COMPUTO

1. ESTUDIO DE FACTIBILIDAD; AMPLIACION DEL CENTRO DE COMPUTO./ MICROSOFT. (Abril 1985)

2. BASES TECNICAS PARA EL SUMINISTRO DE EQUIPOS DE COMPUTACION./ MICROSOFT

BIOMASA

1. ESTUDIO PROVINCIA CHIMBORAZO; DIAGNOSTICO ENERGETICO AMBIENTAL (Adj. 1 anexo)./ (1985)
   María del Carmen Silva

TESIS

1. DISEÑO, CONSTRUCCION Y PRUEBAS DE UN TERMOGASIFICADOR EXPERIMENTAL DEL FLUJO DESCENDENTE PARA RESIDUOS FORESTALES Y AGRICOLAS (Proyecto de Gas Pobre)./ (Octubre 1985)
   Mario Patiño Aroca - ESPOL

2. ESTUDIO ENERGETICO DE LA INDUSTRIA NACIONAL SUBSECTOR MINERALES NO METALICOS (MARZO 1986).
   Edmundo Vera R. - ESCUELA POLITECNICA NACIONAL

3. ESTUDIO ENERGETICO DE LA INDUSTRIA NACIONAL; SUBSECTOR ALIMENTICIO./
   (Marzo 1986).
   César Carrillo, ESCUELA POLITECNICA NACIONAL

4. ECOURBANISMO "DISEÑO BIOCLIMATICO DE ASENTAMIENTOS HUMANOS."/ (Septiembre 1985).
   Barrera, Barzallo, Bustos, León, Universidad Estatal de Cuenca

PLANIFICACION

DOCUMENTOS TERMINADOS EN IMPRENTA

1. Estudio energético del sector industrial manufacturero en el Ecuador
2. El problema Ecológico Forestal del Ecuador.
3. El sector petrolero en la economía del País.
4. Balances Energéticos
5. Actualización de los Balances Energéticos Serie 1974-1981
6. Balance Energético Provincial 1985
7. Balance Energético Exploratorios 1986-1987
8. Modelo Markal
9. Descripción del Modelo y Aplicación al Sistema Energético Ecuatoriano.

CONSERVACION ENERGETICA

1. Conservación Energética en el Sector Industrial
   (Memorias de Seminario)
   Por: D.C.E.

2. Experiencias y Perspectivas de la Conservación Energética en el Ecuador.
   Por: D.C.E.

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