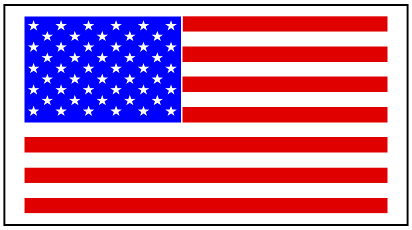

LOUISIANA ALLIANCE/PRESIDENTIAL PROGRAM FOR INVESTORS IN HONDURAS (ALIANZA)

ENERGY MANAGEMENT AND CONSERVATION COMPONENT

Technical Report

(Phase 1)

October 2000-December 2001

METROVISION ECONOMIC DEVELOPMENT PARTNERSHIP
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Louisiana State University Agricultural Center
Loyola University New Orleans
University of New Orleans / New Orleans Environmental Systems Foundation

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Energy Conversion and Conservation Center

University of New Orleans

Energy Management and Conservation for Honduras

Technical Report

submitted to
United States Agency for International Development
(USAID)

through
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and MetroVision Economic Development Partnership

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ABBREVIATION

BIGCC	Biomass Integrated Gasification Combined Cycle
CCT	Clean Coal Technology
CHP	Combined Heat and Power
CMMS	Computerized Maintenance Management Software
COHCIT	Consejo Hondureño de Ciencia y Tecnología
COSIT	Coordinadora de Gestión y Cooperación Internacional
DG	Distributed Generation
ECCC	Energy Conversion and Conservation Center
ENEE	Empresa Nacional de Energía Eléctrica
EU	European Union
FCN	Fondo Cafetero Nacional (a Honduran coffee growers association)
FEDS	Facility Energy Decision System
FIDE	Foundation for Investment and Development of Exports
GT	Gas Turbine
HVAC	Heating, Ventilation, and Air-Conditioning
HRSG	Heat Recovery Steam Generators
IC	International Combustion (engine)
IDB (BID)	Inter-American Development Bank
IT	Information Technology
IGCC	Integrated Gasification Combined Cycle
IPP	Independent Power Producers
IR	Infrared
LLC	Life Cycle Cost
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
O&M	Operations & Maintenance
PdM	Predictive Maintenance
PM	Preventive Maintenance
RE	Rural Electrification
ROI	Return on Investment
SAG	Secretaría de Agricultura y Ganadería
SERNA	Secretaría de Recursos Naturales y Ambiente
SETCO	Secretaría de Técnica y Cooperación Internacional
T&D	Transmission & Distribution
TRACE	Trane Air Conditioning Economics (an HVAC software)
UNITEC	Universidad Técnica
UNO	University of New Orleans
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USDOE	United States Department of Energy

Executive Summary

Hurricane Mitch struck Honduras in the fall of 1998. Shortly afterward, MetroVision, the economic development arm of the New Orleans Regional Chamber of Commerce, convened leaders from five Louisiana universities to help Honduras develop a long-term capacity building program. University teams offered assistance where their academic resources matched the needs of the Honduran people. With support from USAID, the MetroVision alliance focused on providing education, training, and consultation to a broad-based Honduran public-private partnership. The MetroVision program seeks to improve the quality of life for Honduras' people and to enhance the country's role in the global marketplace.

Honduras, the fourth poorest country in Latin America, has a per capita annual income below $800 and a poverty rate higher than 65 percent. Hurricane Mitch heavily damaged Honduras' infrastructure, especially its energy sector. Efforts to stimulate rapid economic growth in Honduras must address the needs of small-scale entrepreneurs and farmers. These people need access to land, technology, financial services, and markets.

The energy management team at the Energy Conversion and Conservation Center (ECCC) of the University of New Orleans was charged with completing a needs assessment of Honduras' electric power capacity, and with offering interim solutions for handling growth across all sectors of business including urban and rural communities.

The ECCC team identified satisfactory baseload needs in Honduras through the addition of new power plants via Power Purchase Agreements (PPAs) and/or private Independent Power Producers (IPPs), such as AES, Enron and Duke Power. Current costs of PPAs are expensive. Furthermore, it was identified that expensive PPAs are caused by a lack of long-term planning; and as a result, power has been added each year in incremental steps rather than through a comprehensive, long-term plan. Long-term planning is recommended to remove Honduras' future reliance on expensive PPAs.

The ECCC team conducted an assessment of energy resources and applications of various power generation technologies in Honduras. This energy resources assessment includes discussions about natural gas, coal, peat, wind, solar, hydropower, biomass, nuclear, and geothermal energy. The technologies employing these energy resources were evaluated under conditions specific to Honduras. Renewable energy technologies using solar photovoltaics, mini-hydro turbines, and wind turbines are considered unreliable and remain too expensive for Honduras. These technologies are suitable for supplemental power, but they are not recommended for baseload power generation in the country at this time. In the next twenty to thirty years natural gas fired combined cycle plants will be the cleanest and most affordable technology. However, large hydropower plants will remain favorable for the longer-term as natural gas reaches its depletion. More coal utilization is encouraged to dilute the risk of price fluctuations or unstable supplies of natural gas and oils. It is recommended that laws and regulations be established, which would enforce utilization of clean coal technologies to prevent excess pollution from burning coal. It is also recommended to explore the potential for co-generation to increase efficient utilization of energy.

ENEE's transmission and distribution systems should also be considered areas where Honduras can improve its service and minimize power losses. T&D losses are high in Honduras. For that reason, ECCC recommends ENEE consider using infrared thermographic technology as a preventive maintenance tool to reduce T&D losses and prevent brownouts or power outages.

Despite planned increases to the country's power generating capacity, more than 40 percent of the population will continue to live without electricity. Most of these people live in rural areas. ECCC concludes that the best method for delivering the basic need of electric power to these people is via distributed generation (DG). The objective is to provide minimum power in remote villages so these villages can develop micro-enterprises, such as drying coffee beans and cooling dairy products. ECCC researchers conclude rural electric power solutions are essential to stimulate economic growth and development in the rural areas of Honduras. Electricity is a primary component in moving these communities towards economic success and self-sustainability. Renewable energy (solar, wind, and mini-hydro) was evaluated as site dependent and unreliable for small-scale industrial use. ECCC recommends the deployment of liquid-fuel fired diesel engines or microturbines for DG solutions in rural areas.

A case study concerning rural electrification was performed on the village of Las Marías in the Department of Olancho. This case study evaluated the pros and cons of employing a diesel engine and a microturbine, both at power generating capacities of 30 kW. Total cost based on a 15-year lifespan indicates diesel engines would cost US $ 0.171 /kWh and microturbines would cost US $ 0.258 /kWh. Many of Honduras' rural villages are located in coffee growing regions. It was further discovered that coffee quality could be improved if coffee beans were dried within four hours of harvest. Many coffee growers currently cannot accomplish this task because of a lack of electricity. A 30kW power system would help farmers overcome this problem.

In an effort to help Honduran industries improve energy efficiency, two industries: coffee processing and cement manufacturing, were selected for review. Energy can be conserved in the coffee processing industry. ECCC engineers also conducted a feasibility study on cogeneration for the cement industry. This study indicates that cogeneration is not adequate for cement plants. However, ECCC staff determined that improved efficiency of electrical machines used in cement manufacturing could conserve energy.

With regards to energy management and energy conservation, ECCC staff taught a two-day short course in Tegucigalpa. The course exposed Honduran engineers to the latest information related to computer software for energy audits, HVAC design for commercial and residential buildings, and provided an introduction to the merits of using infrared thermographic systems in preventive maintenance programs. Seventeen Honduran engineers and technicians participated in the energy management short course. The course was well received, and many participants asked about future offerings of this and other courses in Honduras.

The project team worked closely with ENEE, SERNA and COHCIT, and ECCC identified areas of mutual interests. ECCC can help ENEE expand its energy conservation program, computerize its energy auditing process, and design an effective preventive maintenance program using infrared thermography as a primary tool. ECCC can help SERNA strengthen its energy conservation education programs, co-host energy workshops, collaborate with its bio-energy program, and train its employees in masters degree programs at UNO. With regards to COHCIT, ECCC can collaborate in its rural electrification program. The ECCC team also approached representatives of the World Bank, IDB, the United Nations, and private companies to discuss the potential for donations aimed at improving Honduras' energy infrastructure.

This project's long-term focus is on rural electrification including the utilization of indigenous renewable energy resources. In addition, ECCC is also committed to the education of business leaders and the general public regarding the importance and practice of proper energy conservation techniques. ECCC can help the Honduran government build a thriving economy and improve the quality of life for its people. Improving access to and the reliability of electric power will stimulate economic growth. This process can aid the country's small-scale entrepreneurs, farmers, and poor communities.

Project Limitations and Disclaimer Statement

Information contained in this report is not intended to represent design or specification level work, nor should this report be considered sufficient for investment level assessment. This report was prepared to initiate project considerations for further detailed studies.

The opinions presented in this report do not represent those of USAID, and are solely those of the authors.

Project Background and Description

A. Background

In October 1998, Honduras, was struck by a natural disaster as Hurricane Mitch lingered along the Central American isthmus, and dumped more than five feet of rain in less than four hours across the countryside. According to reports, more than 12,000 people were killed, hundreds of thousands were injured, and almost 2.5 million people lost their houses in floods and mudslides. Honduras' economy ground to a halt, as many businesses and much of the country's infrastructure were damaged.

The majority of Honduras' capital resources – roads, bridges, ports, factories, hospitals, schools, and utilities – were damaged, and many were destroyed. Estimates for the nations' reconstruction were pegged at more than US $8 billion.

In the months following Mitch, the business, academic, civic, and government leadership in Southeast Louisiana were actively involved in emergency disaster assistance, which included millions of dollars in financial aid, in addition to thousands of tons of food and clothing, dozens of medical relief missions, and the work of thousands of volunteers.

GNP growth the following year (1999) dipped to negative 1.9 percent. MetroVision, the economic development arm of the New Orleans Regional Chamber of Commerce, coordinated a wide range of relief initiatives, including collaboration with U.S. government and military officials to secure relief supplies and the means necessary to transport this aid to Honduras. In response to requests from a broad-based Honduran public-private partnership, MetroVision convened leaders from five Louisiana universities (The University of New Orleans, Tulane University, Louisiana State University, Loyola University, and Southeastern Louisiana University) to develop a plan that would deliver long-term capacity building assistance to Honduras. This plan aimed to match the Universities' research expertise with specific infrastructure needs in Honduras, with a particular focus on education and training. The goal for MetroVision's broad-based coalition was to help rebuild Honduras' economic vitality such that it would lay a proper foundation and improve the quality of life for the Honduran people and enhance the nation's role in the global marketplace.

Mitch and its after effects heavily damaged Honduras' energy sector and some of its energy infrastructure. Honduras, the fourth poorest country in Latin America, has an average per capita annual income below $800 and a poverty rate higher than 65 percent (Source: USAID Year 2000 Congressional Report). Improving infrastructure can stimulate new investments and foster sustainable, stable economic growth. Sufficient and reliable electric power supplies play an important role in the foundation of this infrastructure, which is the primary reason UNO's Energy Conversion and Conservation Center was consulted for this project.

The energy management team at the ECCC was charged with completing an assessment of Honduras' electric power capacity, and with offering interim solutions for handling growth across all sectors of business including urban and rural communities.

B. Project Description and Alignment with USAID Strategic Objectives

The energy management team's objective was to recommend interim solutions to Honduras' emergency and short-term energy problems, and to help establish a national strategy for energy and natural resources for future development. While initial priority was given to providing interim solutions, these considerations were made with long-range planning objectives in mind. The ultimate goal is to help provide Honduras with a means of becoming a self-sufficient supplier of economical, reliable and environmentally acceptable electrical power.

This project made evaluations and recommendations for proper utilization of energy resources, power generation options, reducing electric transmission and distribution loss reductions, fuel options, energy management and conservation, education and training, environmental issues, new technology applications, business and infrastructure planning strategies, and site selection.

USAID objectives in Honduras state that more Hondurans should have direct access to basic needs. Electric power is chief among these needs. The Honorable Frank Almaguer, U.S. Ambassador to Honduras, addressed this issue during a meeting held at the University of New Orleans on April 18th, 2001. Ambassador Almaguer said: "Clearly the country of Honduras cannot move forward without proper infrastructure. Central to this issue is the fact that Honduras needs to make improvements to the basic services of electric power generation and distribution, and the country needs to consider options for areas outside of the industrial corridor."

Furthermore, Paul Klimas, USAID Director of Renewable Energy, said: "Rather than seek energy for energy's sake, the central American nations should look at energy as the life juice of society and the economy."

MetroVision's energy management team concludes that providing safe, clean, reliable, and affordable energy should be established as the cornerstone of a dependable infrastructure. Improving electric power availability will enhance the quality of healthcare, improve options for teaching tools (e.g. wireless internet and personal computes), and bring economic growth, particularly to micro-enterprises and to the country's small-scale entrepreneurs, farmers and the rural communities. This objective is in line with USAID's goals in Honduras, which are to improve education, increase access to healthcare, and stimulate economic opportunities for farmers and agri-business operations in rural areas of the country. (USAID Honduran mission web site, 2001)

This project involves a four-phase approach:

Phase 1 - Assess current status, accompanied by interim solutions.
Phase 2 - Implement interim solutions and assess long-range plans.
Phase 3 - Monitor and analyze results of interim solutions and finalize long-range plans.
Phase 4 - Expand interim solutions and implement long-term solutions with continued monitoring, evaluation, and adjustments.

The first phase began in October 2000 and ended on December 31, 2001. Phase 1 assessed the current energy/power status and recommended an interim solution to provide power to those most in need.

MetroVision's energy component in the Honduras project also aimed to align its plan with USAID's second strategic objective, i.e. the sustainable management of natural resources and maintenance of biodiversity. (USAID mission statement, USAID web site, 2001.) The ultimate goal is to develop clean energy conversion by employing balanced indigenous natural resources and imported resources.

Activities and Accomplishments Summary

A. Activity Summary

Activity 1 – Classify national electric power needs into four categories: (a) baseload for future growth, (b) peakload shaving, (c) minimum load for isolated areas, and (d) installations for increased efficiency, cleaner emissions, and improved reliability.

Approach of Activity 1:

- Collect demographic information of population distribution, highways, local industries, local economy, and electric power consumption
- Collect information of all existing and planned future power plants
- Analyze the collected information
- Categorize the national power need into four categories
- Advise ENEE to establish a digital mapping, automated mapping, facilities management (AM/FM) and GIS program.

Activity 2 – Prioritize needs and evaluate options for electric power generation.

Approach for Activity 2:

- Set up criteria for prioritizing the needs
- Evaluate options for oil fired, or dual fuel, gas turbine and reciprocating engines
- Evaluate hydroelectric power potential
- Compare the pros and cons of using hydroelectric power with thermal power plants
- Compare options between gas turbines and diesel engines
- Assess energy resources for general power generation

Activity 3 – Evaluate Renewable Energy Resources

Approach for Activity 3:

- Evaluate information and existing reports of applying geothermal energy, wind energy, and solar energy in Honduras
- Investigate biomass gasification technology for electric power generation

- Collaborate with LSU's forest component in the Louisiana Alliance project to examine potential of using waste from forest products to produce energy
- Investigate cogeneration potential of using biomass
- Recommend potential sites for biomass gasification / cogeneration projects

Activity 4 – Evaluate distributed generation (DG) options for isolated areas including microturbines, diesels, fuel cells, solar energy, wind, and mini-hydro turbines: The results of Activity 1 will help identify isolated areas that can not be easily assessed by car and are not located near T&D lines. About 40 percent of the Honduran population lives in isolated areas without access to electricity. To provide an interim solution, this activity is to evaluate different distributed generation options to provide residents with minimum electric power needs.

Approach of Activity 4:

- Establish criteria for different levels of minimum electric power needs.
- Evaluate power generation options for sparsely populated areas with limited road access
- Evaluate each power generator's reliability, ease of maintenance, and fuel flexibility
- Evaluate the costs and methods to transport fuels
- Select the best option
- Select a village to perform cost analysis
- Suggest a management plan for a large number of micro-DG systems
- Provide a recommendation for implementing this plan including an economic development plan to help residents become more productive

Activity 5 – Strengthen and expand current energy conservation programs undertaken by SERNA and ENEE: Energy conservation programs can have the highest return on investment (up to 10 -15 percent energy savings). The Honduran government, its private sector, and the general public do not yet have a full appreciation of the importance and value of energy conservation programs. ECCC's work in Activity 5 can help Honduras implement an energy conservation program. The goal is to help Honduras reap savings from energy conservation with minimal investments. This activity is an ongoing effort with ENEE and SERNA.

Approach for Activity 5:

- Collect information of SERNA's and ENEE's energy conservation programs
- Strengthen existing energy conservation training courses
- Specify and procure the infrared thermograph system
- Develop the infrared thermographic technique in UNO laboratory
- Apply the infrared thermographic technique in energy conservation
- Apply the infrared thermographic technique in energy audits
- Train Honduran engineers to use infrared thermograph techniques

Activity 6 – Attract investors and leverage other donors' resources to address long-term needs and potential growth in Honduras: During this project, a constant search for possible collaborators or donors was undertaken.

Approach for Activity 6:

- Continuously track other donors' activities such as UNDP's renewal energy program with SERNA, COHCIT's solar village, Mission China's mini-hydro turbine with ENEE, etc.
- Contact and present this project to U.S. DOE
- Contact energy providers, such as Entergy, Duke Energy, Southern Energy, Reliant Energy (Houston Industries), etc., and energy project developers, such as Calpine, Dynergy, Destec, Mission Energy, ENRON, Global Energy, AES, etc.
- Approach energy equipment and support entities, such as General Electric, Siemens - Westinghouse, Alstom, etc

B. Accomplishments / Results

Activity 1: Demographic information was collected on population distribution, highways, local industries, the Honduran economy, and electric power consumption. Some digital map information was also collected. However, the information is fragmented, and it is recommended the data be organized and compiled for further study and/or the implementation of a comprehensive digital mapping program at ENEE. The detailed recommendation is provided in Section 2.6 of the Technical Report.

ECCC performed all tasks related to this activity as scheduled, and accomplished its primary objective, which was to provide a needs assessment covering national baseload power generation, peakload issues, rural electrification options, and recommendations to help Honduras improve power efficiency and energy conservation. Detailed assessments and recommendations are documented in an independent report entitled "Assessment of Energy Resources and Applications of Power Generation Technologies for Honduras." This report is written in English and Spanish, and is available upon request. The English version is included in Chapter 2 of the Technical Report, with additional information pertaining to digital mapping, automated mapping, facilities management and GIS.

Activity 2: After identifying Honduras' energy infrastructure needs, priorities were assigned for interim, short term, and long-term growth. Baseload power is Honduras' most pressing need, but AES Power Corp., which plans to build an 800 MW liquefied natural gas (LNG) fired, combined-cycle power plant in Honduras, will address short-term baseload needs. However this power plant will offer the greatest benefits to areas along the industrial corridor, and to some areas on the Caribbean coast. Currently almost 40 percent of Honduras' population lives in rural areas, which lack access to safe, reliable electric power. Approximately 30 percent of Honduras' population will continue to live without power for the next 20 years. In view of these statistics, ECCC established baseload needs for rural electrification as a primary focus of its study.

In the industrialized areas and in areas where baseload needs are satisfied, it is recommended that priority be placed on making improvements to the quality of power by managing peak loads to reduce brown outs and blackouts. Means of using DG and co-generation to help manage peak-load shaving, in addition to conventional stand-by units, are discussed in Sections 2.1.5 and 2.3.6 of the Technical Report. It was also discovered that some blackouts in

Honduras were induced by faulty switches and overheated electric components along T&D lines. ECCC recommends ENEE take measures to incorporate infrared thermographic imaging technology into its preventative maintenance routine. This issue is discussed in detail in Sections 2.4.2 and 4.4 of the Technical Report.

Although rural electrification is identified as one priority associated with baseload needs, it would be expensive to provide sufficient baseload capacity to all those in the country in need. Therefore, part of ECCC's efforts focused on identifying minimum power needs, which would be sufficient to initiate local industrial or micro-enterprise activities, which will lead to further economic development. A detailed discussion of rural electrification is documented in Section 2.1.4 of the Technical Report, which leads to an analysis of rural electrification technologies and economics in Chapter 3 of the Technical Report.

Secondary priorities should focus on helping energy intensive industries, make more efficient use of available electric power. Two industries, which fit these criteria, are: coffee processors and cement processors. Other industries, which could be considered for energy efficiency projects, are: lumber, shrimp, and/or food processing. Assessments of energy efficiency and the potential for adapting energy efficient methods, e.g. co-generation, are covered in Sections 4.5 and 4.6 of the Technical Report.

The ECCC's technical report provides an overview of the Honduran energy sector, and offers recommendations for future growth, and an evaluation of available energy resources and technologies in the country. The report can be used to discuss power generation needs by region and/or by resources. This report covers various energy resources, including hydropower, natural gas, coal, biomass, wind, solar, geothermal, and peat. It also discusses various power generation technologies including diesel engines, gas turbines, microturbines, co-generation, and fuel cells. These assessments are available as independent Technical Assessments in Spanish and English, and the information is included in Chapter 2 of the Technical Report (Attachment 4). The technical assessment (Attachments 1 and 2) was submitted to USAID on December 15th, 2001.

Activity 3: Activity 3 was undertaken to track the current state of renewable energy projects in Honduras and to evaluate the application of renewable energy resources available to Honduras. Information was collected on the following ongoing renewable energy programs in Honduras:

a. SERNA is working on a renewable energy program sponsored by the UNDP under its Global Environment Facility (GEF). The UNDP's renewable energy project focuses on (a) compiling and assessing a renewable energy portfolio, (b) assessing sustainable energy investment capital, and (c) establishing indicators and methodologies for monitoring and evaluation.

b. COHCIT completed two solar village projects, which provide limited electric power using solar panels. These projects generate 618 kWh/mo. COHCIT is working on additional solar village projects across the country.

c. Four biomass-fueled power plants (La Grecia, Tres Valles, Lean, and Aguan) have signed PPA agreements with ENEE. On average, Azucarera Yojoa produces 8 MW of power yearly using biomass feedstocks as its fuel source. This plant has operated since 2000. These power plants use sugarcane bagasse as their fuel source

d. There were plans for Enron Wind Development Corporation to construct a 60 MW wind farm in the mountains 24 kilometers South of Tegucigalpa. At the time of this writing, GE Power Systems is negotiating the purchase of Enron Wind Development's assets. GE's purchase would include Enron Wind Development's proposed project in Honduras, but no confirmation has been given with regards to the status of this project.

An assessment of renewable energy, including solar, wind, hydropower, biomass, and geothermal, is included as a segment of the Technical Assessment. This activity is part of ECCC's recommendation for long-term energy management solutions in Honduras. ECCC's assessment indicates solar, wind, mini-hydro, and geothermal can only serve as supplemental power generation sources in Honduras, whereas biomass has great potential to serve as a primary power generation source in rural areas, where currently lack access to the national grid. Discussions about new, clean biomass technology is included in Section 2.3.5 of the Technical Report. The potential for employing gasification technology to generate clean energy by using coffee wastes (husk and skins) is discussed in Section 4.6 of the Technical Report. The idea of using small biomass gasification systems to produce nominal amounts of power (10 - 30 kW) is introduced for future work in rural electrification.

Activity 4: Activity 4 focused on rural electrification. The national power grid is not scheduled to reach many villages in rural or isolated areas for more than ten and in some cases, twenty years. Major actions with regards to this activity are:

a. ECCC concludes DG is the best solution for delivering electricity to remote areas. Various DG technologies were assessed and liquid-fuel fired engines are recommended for rural electrification projects. Comparisons between diesel engines and microturbines were made for small-scale electric power generation.

b. Taiwan Power Company completed a study on the application of mini-hydropower plants for ENEE. We reviewed this report and assessed the potential of using mini-hydropower for rural electrification projects.

c. Three pilot villages were identified during ECCC's initial study. These villages are Las Marías in the Department of Olancho, Ironía, in the Department of Colón, and Lempira and El Paraíso in the Departments of Olancho. Due to safety concerns, planned visits to these villages were postponed indefinitely. However, ECCC did send a survey team to Las Marías. Data regarding population, road access, utility services, village economics, and national growth plans were evaluated for Las Marías in Chapter 3 of the Technical Report.

d. A preliminary national rural electrification plan was drafted, which included a selection procedure for villages and three optional approaches for nationwide rural electrification. General issues related to power demands, fuel supplies, and power generation system reliabilities were assessed. A three-level power demand of 30 kW is proposed to represent typical village needs including power for a city office, a health clinic, a church, a school, and minimum power to initiate industrial and enterprising activities for economic development.

e. A case study was completed using the village of Las Marias as an example. A preliminary design for a local distribution grid was completed. Final cost analyses were performed for a diesel and micro-turbine system.

Chapter 3 of the Technical Report discusses rural electrification in detail. This is part of an interim solution, but the ultimate goal is to increase rural economic activity, spur growth, and improve access to basic services through the availability of electric power. This activity will serve as a model for rural electric power generation solutions in future phases of the project.

Activity 5:

a. Two areas were identified which can contribute to energy conservation activities in Honduras: (i) help ENEE achieve computerized energy auditing capabilities; (ii) train SERNA and ENEE engineers through offering short-courses on energy auditing, energy management, and energy conservation in Honduras. ECCC engineers conducted a short-course (see Attachment 3) with this focus on July 16-17, 2001 in Tegucigalpa.

b. ECCC purchased Trane's Trace 700 software license for one year. This software package was used to assist in the design of efficient HVAC systems for conducting comprehensive energy audits. Trace 700 was introduced to Honduran engineers during the ECCC's energy management short course. Computer aided HVAC design and energy audits are discussed in detail in Sections 4.2 and 4.3 in the Technical Report.

c. ECCC purchased an infrared thermographic imaging system. Infrared thermography can be used as a tool to increase the accuracy and benefits of preventive maintenance programs. This technology can be employed in Honduras to increase energy management effectiveness and to reduce power losses at sub-stations and along T&D lines. Infrared thermography was introduced to ENEE's engineers and was demonstrated in the field at the main sub-station in Tegucigalpa during a trip in October. Infrared thermography is discussed in detail in Section 4.4 of the Technical Report.

e. A preliminary energy audit was performed at the USAID building in Tegucigalpa. Due to some security considerations, the data collection process was incomplete. Nevertheless, a preliminary result was obtained using the FEDS software package.

f. Production and operating information of two cement plants, Cementos del Norte and Industria Cementera Hondureña, were collected. An energy efficiency analysis, which considered co-generation for cement plants, was conducted.

g. Two project team members accompanied by an Engineer from SERNA visited Comarca coffee processing plant in March 2001. The process was recorded on a tape and was analyzed afterwards to determine the potential to make the process more energy efficient.

The energy management short-course was not included in the original proposal, but its value was made apparent during discussions with engineers from ENEE, SERNA and several other government agencies. Well-formulated energy conservation programs are an ongoing effort. ECCC will continue to help ENEE and SERNA in future with similar approaches, and ECCC staff can help these agencies implement effective, energy management and preventive maintenance programs through the use of its infrared thermographic expertise.

Activity 6: We secured the support of Lockheed-Martin through its NASA/Michoud facility in New Orleans. Lockheed-Martin's Vice President for Manufacturing, Joseph Marcus, allowed one of his engineers, Victor Garcia, to meet with the ECCC-UNO team on a weekly basis. Garcia is a recent UNO graduate and a native of Honduras. Garcia spent 10 percent of his time on this project. It is estimated that his effort was worth US $8,000.00.

ECCC contacted the following potential donors: representatives of the UN in Honduras, AES Corporation, U.S. DOE, the Bill Gates Foundation, Dell, and Compaq. In addition, we met with the Chamber of Commerce in Tegucigalpa, Fondo Cafetero Nacional, and representatives from the Inter-American Development Bank. ECCC's approach was to publicize the present work and utilize USAID funding to increase awareness, and to eventually leverage additional funding and/or solicit future donations. ECCC staff contacted potential donors and conducted negotiations, which would secure contributions of hardware and equipment needed for the continuation of this project. Primary items needed are: Diesel engines, microturbines, computers, refrigerators, power lines, meters, streetlights, etc.

Quarterly reports were submitted in English to USAID through MetroVision on January 15, March 30, June 30, September 30, and December 15, 2001. A report of assessing Honduran energy resources and application of power generation technologies was submitted on December 15, 2001. The final Technical Report was submitted in March 2002.

C. Obstacles Overcome/Lessons Learned

ECCC accomplished its goals as outlined in the original proposal. Furthermore, ECCC staff made suggestions and implemented additional tasks during Phase I. For the most part, the project proceeded smoothly. As with any new venture there were minor wrinkles, but no insurmountable obstacles were presented. Matters on which ECCC could make improvement are below:

1. Visiting Villages – In addition to Las Marías, ECCC would like to make trips to two other villages: Ironía in the Department of Colón and Las Dificultades in El Paraíso, or San Ramon in Lempira. ECCC's contracted Honduran engineers were reluctant to visit Ironía due to reports of drug trafficking in that area. In November, ECCC staff rented a 4x4 jeep to visit a village in El Paraíso, but they were advised not to proceed without the security of a local guide from that region. Information obtained form Las Marías allowed ECCC to perform a case study of a Honduran village.

2. Short Course and Seminars – The energy management short-course was not part of the original proposal, and thus expenses had not been budgeted for these services. However, course

attendees placed a high value on the seminar, and the ECCC agrees its value far outweighed the costs of offering it in Honduras.

3. Limited time frame –The project was "officially" begun in October 2000, but actual activities did not start until Mid-January 2001 after funds were allocated. This left less than 12 months to conduct the project and write reports. It took the ECCC team about six months to study the Honduran energy sector, meet the appropriate people, and build momentum. This momentum was curbed at its apex just six months later.

4. Donors – Almost all potential donors approached by ECCC staff have shown interest in providing assistance to future work related to this project. However, most businesses indicated an interested in donating hardware or manpower for future phases (i.e. implementation phase) of the project, but not in providing funding. If ECCC doesn't reach the implementation phase of this project, offerings from these firms will not be realized. This indicates the power of "leverage." ECCC sees great potential to leverage USAID's funds to obtain donations for future phases of this project.

Specific Outputs

Attachment 1 – Assessment of Energy Resources and Applications of Power Generation Technologies for Honduras (Submitted: December 15, 2001 – in English)

Attachment 2 – Assessment of Energy Resources and Applications of Power Generation Technologies for Honduras (Submitted: December 15, 2001 – in Spanish)

Attachment 3 – A two-day short-course was offered on July 16-17, 2001 in Tegucigalpa. The short course notes were distributed and are attached with this report. The short-course was the first of its kind offered in Honduras.

Attachment 4 – Final Technical Report (five chapters):

- Summary of Workplan and overall achievements
- Energy Resources and Technology Assessment
- Distributed Generation and Rural Electrification
- Energy Management, Efficiency, and Conservation
- Conclusions and Recommendations

Conclusions and Recommendations

Prompted by urgency to help Honduras recover from the destruction of Hurricane Mitch, staff from the Energy Conversion and Conservation Center (ECCC) of the University of New Orleans began work on a USAID-funded project to complete an assessment of Honduras' energy resources and electric power infrastructure. ECCC sought to provide Honduran officials with interim solutions for energy sector growth in urban and rural communities. This report summarized those solutions, and made additional recommendations. A brief summary of this project's workplan is listed below.

- **Activity 1:** Classify national electric power needs into four categories: (a) baseload for future growth, (b) peakload shaving, (c) minimum load for isolated areas, and (d) installations for increased efficiency, cleaner emissions, and improved reliability.
- **Activity 2:** Prioritize needs and evaluate options for electric power generation.
- **Activity 3:** Evaluate Renewable Energy Resources.
- **Activity 4:** Evaluate distributed generation (DG) options for isolated areas including microturbines, Diesel engines, fuel cells, solar energy, wind, and mini-hydro turbines.
- **Activity 5:** Strengthen and expand current energy conservation programs undertaken by SERNA and ENEE.
- **Activity 6:** Attract investors and leverage other donors' resources to address long-term needs and potential growth in Honduras.

Summary of Assessments of Energy Resources and Technologies

Honduras lacks fossil fuel resources; its major indigenous energy resources are hydropower and fuelwood. Honduras imports oil and hard coal, there isn't an oil refinery in country, nor does Honduras have natural gas production or import facilities.

In 2000, ENEE had a combined power generating capacity of 911.7 MW. Average available power during that 12-month period was 639.4 MW, total power consumption was 3.9 TWh, and peak load demand was 738 MW. Honduras' installed power generating capacity is not adequate for peak load demand. Frequent brownouts and blackouts are expected until additional power plants are built.

ENEE's projected growth rate for power consumption is approximately six percent annually. This translates to less than 60 MW of increased capacity each year. Meeting annual capacity increases with low cost electricity is one of the greatest challenges facing ENEE.

Honduras previously met emerging demands for incremental power capacity through expensive private diesel plants under Power Purchase Agreements (PPAs). This practice should be replaced by a comprehensive, long-range plan.

Diesel plants do not operate efficiently, and their power costs and emission levels are high. These high costs will hamper energy sector growth in Honduras for decades, as many existing PPAs are contracted for durations of 10 to 15 years. To alleviate the high costs associated with existing PPAs, it is recommended that Honduras develop a long-range plan that would allow these units to provide lasting value beyond the original intent of addressing short-term needs. For example, these small power plants could be used as standby units to meet peak load demands as larger, and more efficient power plants are commissioned. The small units could also be removed from the grid and used for specific DG needs throughout the country. It is necessary to commission larger-scale, combined cycle power plants (>200 MW with efficiencies higher than 50 percent) to improve long-term energy infrastructure and base load needs, and to reduce future electricity costs in Honduras.

Approximately 40 percent of the country's population lives without electric power, and about 75 percent of this group will continue to lack coverage for up to twenty years because of the high costs associated with grid expansion. DG is worth considering in these areas. There are loans from donors including IDB and EU, which are available for rural electrification projects. Adequate professional assistance is required to help these villages write proposals and apply for loans. The ECCC's energy management project could be directed to play such a role via the use of USAID funds.

Distributed generation (DG) implies the application of placing power generation systems at or near power consumption sites. Its advantages include low capital costs, lower (or limited) transmission and distribution costs, increased power quality and reliability, and the ability to provide self-generated power during high-cost, peak-power periods. An adequate legal framework for allowing private factories to build on-site DG systems could alleviate concerns about poor power quality in Honduras.

Hydropower is a clean and renewable energy resource, but power output is subject to seasonal disturbances caused by hurricanes and drought. It is recommended that Honduras' reliance on hydropower be reduced from its current level of 47 percent of total installed capacity to less than 30 percent. This goal can be accomplished by increasing electric power generation from other energy sources. Other sources worth consideration are mainly fossil fuels (natural gas, oil, or coal). Using diverse fuel sources enhances national energy security by limiting the economic impact of fluctuating energy prices and help reduce susceptibility to damages associated with natural disasters. Diversity also promotes competition between energy suppliers, which keeps prices lower. However, hydropower remains an attractive option in Honduras because natural gas prices will rise, and natural gas reserves will eventually be depleted (40 - 50 year duration). This does not preclude the urgency and importance of building natural gas-fired combined cycle power plants now and throughout the next twenty years.

Installation costs for mini-hydro (less than 1MW) are expensive. Capital costs range from US $1,500 to $4,000/kW, and mini-hydro is location specific (i.e. mini-hydro must be built along rivers). These locations are not always near villages, and it is not always cost effective to build long-distance transmission and distribution systems for mini-hydro plants. Therefore, it only makes sense to explore those sites that are adjacent to villages. Mini-hydro can serve as a supplemental power generation system, but not as a primary power generator.

Gas turbines are superior to diesel engines at power capacities greater than 4 MW. At larger capacities, gas turbines are more compact, require less maintenance, and are less expensive to install. Gas turbines provide lower capital costs per kW and operate with cleaner emissions. Short installation times for an aero-derivative gas turbine is comparable to installation times for diesel engines. Gas turbines rate favorably for future power generation use in Honduras.

Natural gas is a clean fuel, and it has projected availabilities for at least another forty years. However, strong demands and price increases can lead to price spikes and volatility. A sound energy strategy should be plotted, which hedges potential price volatilities against secure diversified sources for national energy supplies. To this end, coal and other energy sources should be considered. Development of a long-range plan is recommended for importing coal and for taking advantage of technologies developed by US DOE's Clean Coal Technology program. It is further recommended that policies be written concerning the use of coal in small-scale factories and plants.

Biomass is an attractive fuel source because it is renewable, sustainable, and indigenous. Carbon dioxide generated by combustion of bio-fuels does not contribute any net increase of carbon dioxide to the atmosphere. Fuelwood is used in cooking by more than 70 percent of rural families, and it is recommended that Honduras consider constructing charcoal plants to reduce air pollution caused by burning fuelwood over the short to mid-term. Charcoal has higher carbon content and can be burned with less smoke than fuelwood. To avoid deforestation, the government should provide education and guidance on forest conservation for many regions.

The agricultural, forest and paper industries often employ direct firing of biomass in boilers to create processed steam or to generate electricity via steam turbines. This conventional method is subject to low efficiencies and high emissions. A new technology, biomass integrated gasification combined cycle (BIGCC), employs gasification technology to produce higher energy outputs with fewer emissions. Although BIGCC is not now commercially available, the development of BIGCC technology should be tracked and should be considered for future bio-energy generation.

The benefits of implementing a sound bio-energy plan can be maximized in rural areas where electricity is not available. In areas currently covered by the national grid, biomass power plants can be economical only with the aid of government subsidies. However, biomass power generation from waste products is worth consideration if the power would be used internally and optimized for co-generation. Harvesting fast-growing crops as fuel sources is not encouraged and should be evaluated because (in many cases) land can be better utilized to grow higher-value conventional crops. Furthermore, using marginal land to grow energy crops is usually not desirable.

Small biomass-fueled power generators can also be considered for intermediate term electrification needs in isolated areas. These commercially available systems are modularized and portable with an output range of 10 – 15 kW. These systems can use indigenous biomass to produce electricity.

Assessment of potential uses of cogeneration is strongly encouraged for all industries in Honduras. A proper co-gen plan requires adequate legal framework, and co-gen laws should be clearly written and streamlined.

Wind energy is clean and the fuel is (essentially) free. However, wind is an unpredictable resource. Because of this nature, wind energy is most appropriate to be implemented as a supplemental generation source. For a wind farm to be profitable, special incentive packages need to be provided by the government. The government must be cautious in providing incentives, and it must also consider the probability of the owner's ability to operate the wind farm after incentives expire.

Due to inherent features of photovoltaic systems, solar electric systems are most appropriate to serve as supplemental power systems. High initial capital costs (per unit of power) prohibit large on-grid installations. For off-grid applications in residential households, low DC voltage outputs limit photovoltaics to low levels of power production. These levels can provide lighting and improve minimum social values, but they are not sufficient to exert economic impact. Ambitious projects with large-scale expansion plans using solar power do not seem cost effective for stimulating sustainable economic development.

Nuclear power generation is a mature technology, which is proven to be reliable, safe, and economically feasible. However, fuel rod disposal presents the greatest problem in managing nuclear power plants. Until public opinion shifts on matters of safety, operating procedures, and spent-fuel disposal processes, anti-nuclear sentiment will remain high in most countries including Honduras. Nuclear power is not recommended as a power option in Honduras.

Fuel cells are a promising technology, but fuel cells are expensive and heavy. Fuel cells are not recommended for grid power generation in Honduras. Biomass-fueled fuel cell systems using gasification technology have the potential for DG in remote areas, but the technology is not yet mature. Except for some niche markets, fuel cells cannot yet offer affordable commercial power.

Exploration of geothermal energy is expensive and should be a low priority for Honduras.

Peat is a soft organic material consisting of partly decayed plant matter together with deposited minerals. Honduras has an estimated area of 453,000 hectares of peat. It is worthwhile to investigate the potential of using it to replace part of the country's fuelwood consumption.

Construction of a national fuel pipeline is recommended even if no extensive local distribution systems are immediately planned. This would allow strategic power plant and industrial park locations to be assigned along this fuel supply "backbone" that will be of considerable value as the country expands in coming decades.

Honduras' T&D losses are between 18 and 26 percent. To reduce T&D losses and prevent circuit damage during peak load periods, implementation of infrared thermographic technology is recommended to help identify imbalanced fuses, faulty circuits, hot components, and energy leakage. A preventative maintenance plan should also be implemented.

ENEE has a rudimentary digital mapping program; however, progress is almost at a standstill. ECCC recommends ENEE spend between US $30,000 - 40,000 to update its hardware and software as a "new" starting point for a long-term digital mapping project. It is further recommended that ENEE consider implementing Automated Mapping/Facilities

Management and GIS (AM/FM/GIS) technology following a five-step, three-year agenda as proposed in this report. It is further recommended that ENEE seek assistance from a professional consulting company, which specializes in digital mapping and GIS.

Summary of DG and Rural Electrification (RE)

Motivation: While Honduras has managed to extend its public utility grid into many rural areas; the vast majority of remote villages are currently not served by any viable, substantial supply of electric power (aside from some minimal solar powered and battery augmented power supplies for basic functions). It is estimated that at least 35 percent of Honduras' population, and perhaps as much as 40 percent do not have access to reliable electric power, and about 75 percent of this group will continue to lack coverage for up to twenty years because of the high costs associated with grid expansion and O&M. In these areas, DG is an affordable solution. It is estimated that at least 30 percent of the population will continue to live without electricity during next twenty years. This situation creates a series of associated problems impacting everything from quality of life, to severe economic development constraints, including health and public education issues.

Benefits: From a global perspective, providing a reliable and cost effective source of electric power in remote communities can improve the overall quality of life and provide the primary basis for economic development. Initially, electrification can increase the efficiency of basic agricultural operations while allowing associated industries to develop to refine these products and provide value added benefits for exports. From a longer-term perspective, electrification makes it feasible to start the process of technology transfer by facilitating increased productivity and economic development. Productive uses are essential to establishing the long-term economic viability and sustainability of rural electrification. Therefore, it is concluded that electricity is a primary component in moving these communities towards economic self-sustainability.

Objective: Rural electrification (RE) should support the development of rural areas by improving general welfare and stimulating economic growth and business activities. Rural electrification must be planned in conjunction with economic development to achieve a measure of sustainability.

Rural Electrification Methods

Three methods are proposed:

Method 1 – National utility grid extension (limited to US $500 per household)
Method 2 – Regionalized power generation with localized mini-grid (mid-term solution)
Method 3 – Self-contained individual village electrification (interim solution)

Currently Honduras' national utility grid extension is limited to sites accessible for less than US $500 per household installation cost. Within a decade the national utility can probably reach another 10 – 15 percent of the population. ECCC recommends Method 3 (self-contained individual village electrification) as an interim solution for rural electrification in Honduras. Extension of Method 3 to Method 2 would form a regionalized mini-grid for a logical mid-term solution. Ultimately, the entire country will be wired with some pockets of regionalized mini-grid systems and some villages operating on self-contained power generation units.

DG Power options: Renewable energy (solar, wind, and mini-hydro) was evaluated as site dependent and not reliable for small-scale industrial use. Therefore, this project focused on evaluating liquid-fuel fired diesel engines and microturbines as viable DG options in rural areas. ECCC provides a comparison between diesel engines and micro-turbines.

The diesel engine represents a well-established technology, which has a long track record of proven performance in power generation applications. The engines are available from a wide variety of suppliers and are supported for O&M services throughout the world. Capital costs for the engines are competitive and they typically represent the lowest dollar investment cost for a given power output. Normal O&M costs for the engines are generally reasonable although considerable routine maintenance is required and the engines must be brought down periodically for this service. Diesel engines produce high levels of noise and emissions.

The microturbine engine represents a relatively new technology for power production applications. The engines are available from a limited group of manufacturers and support for O&M services in remote operations is uncertain. Microturbines require larger capital investments than Diesel engines (about 60 percent higher), but it is claimed that O&M costs for microturbines are low, with most units requiring only limited routine maintenance at or around 8,000-hour operational intervals. Microturbines are fuel flexible. They can burn natural gas, propane, LPG, oils, and producer gas from biomass. Microturbines are about 40 percent lighter and smaller than diesel engines of similar capacities. Microturbines are not as efficient as diesel engines in simple cycle operation, but microturbines are quieter and produce fewer emissions. One inherent problem associated with microturbines is the negative effect on efficiency accompanied with high ambient air temperatures and high elevations. This will pose problems considering Honduras' summer temperatures and mountainous terrain. Microturbines can loose up to 15% percent of their output at temperatures above 86º F.

Case Study: A case study concerning rural electrification was performed on the village of Las Marías in the Department of Olancho. This case study evaluated the pros and cons of employing a diesel engine and a microturbine, both at power generating capacities of 30 kW. The total cost based on a 15 year lifespan indicates that diesel engines would costs US $ 0.171 /kWh and microturbines would cost US $ 0.258 /kWh. This cost analysis shows that diesel engines are about 34 percent less expensive than microturbines. However, other considerations such as environmental issues, transportation difficulty, and ease of O&M could impact these results and make microturbines a better option. Selection between engine types depends on many factors.

Many of Honduras' rural villages are located in coffee growing regions. It was further discovered that coffee quality could be improved if the coffee beans are dried within four hours of harvesting. Many coffee growers currently cannot accomplish this task because of lack of electricity. A 30kW engine would help villagers overcome this problem.

Summary of Energy Management, Efficiency, and Conservation

Full-scale energy management and energy conservation programs have yet to be implemented in Honduras. Besides a project, which replaced incandescent light bulbs with more energy efficient compact fluorescent bulbs, Honduras has not effectively taken any measures to implement a commercial or residential energy management/conservation program. The above-mentioned project was sponsored by SERNA, Philips Co., and the European Union. Moreover, Honduran energy professionals lack tools such as customized computer software and infrared thermographic imaging systems, and Honduran energy professionals also lack opportunities for advanced training and experience with computerized energy audits and building retrofits.

In the mid 1990's the Gauree Project aimed to expose and educate Honduran energy professionals about techniques and equipment used in energy audits and building retrofits. The project resulted in energy seminars held in San Pedro Sula and Tegucigalpa, and was culminated with an informative campaign directed at elementary school teachers. ENEE asserts its energy conservation education program reached approximately 300,000 students. However, upon completion of Gauree project, the corresponding activities quickly diminished due to a lack of funding. It is essential to recognize that an investment in saving the first 10 percent of energy through conservation practices is minimal in comparison with building a new power plant to cover the otherwise 10 percent additional electricity consumption.

To continue its energy conservation effort, it is recommended the Honduran government provide adequate funding to SERNA to maintain and sustain an effective energy conservation program. SERNA would serve as the coordinating agency for energy conservation education. The knowledge transfer could be facilitated through either a master-teacher program (as was pioneered in the Gauree project), or through professional short courses and seminars (as was done this USAID project). It is also recommended that ENEE assist SERNA in executing some of the activities and provide technical consultancy to the energy conservation program.

It is further recommended that more stringent requirements on manufacturing codes and energy performance codes for indigenous and imported products be instituted in Honduras. A poor-quality electrical device requires more energy to operate, while a low-reliability device will have more frequent breakdowns and will operate longer in an inefficient, overheated mode. All of these problems will cause much larger negative economic impact than that is just shown by the higher energy bill.

ENEE's engineers were trained to conduct energy audits during the EU-sponsored Gauree project. However, the calculations and analyses of these audits were conducted manually. Hand-calculated processing is time consuming and inefficient, and there are technological advances in this field which effectively render manual audits a thing of the past. **Computerized energy audits** using FEDS (Facility Energy Decision System) and TRACE (Trane Air Conditioning Economics) software are introduced in this report. An example of a preliminary energy auditing is provided using the USAID building in Tegucigalpa as a reference. Results show that an investment of US $78,000 in retrofits would save $184,547 in energy demand and O&M expenses with a payback of approximately seven years at 6.6 percent interest per year.

Many office buildings and private residences will install air-conditioning systems as living standards continue to improve. It is expected the peak load over base load ratio will continue to increase and will continue impose more stress on the existing power supply system, especially in summer when peak demands for A/C occur. In addition to formulating well-planned power supply systems to meet future peak-load demands, it is worthwhile to improve energy management and conservation of buildings (large or small) by designing efficient HVAC systems. TRACE software is introduced in this report to provide ENEE's engineers with computerized HVAC design information, which can create new jobs in Honduras.

Infrared (IR) thermography has been widely used for preventive maintenance in industries such as electric power, mining, steel, petrochemical, transportation, etc. It also serves as a useful tool for improving energy efficiency and product quality in the manufacturing industry. Many energy conservation programs employ infrared thermography to detect heat losses in houses and buildings. Building envelope and roof inspections are two areas where IR technology is used to improve energy efficiency. IR predictive maintenance inspections and statistical analysis can be used to examine the current condition and predict future behavior of the equipment. The results of analysis can direct specific maintenance needs to individual pieces of equipment. IR technology can also be used to view transmission and distribution line overload, defects, and power leaks, which increase power losses. IR thermography is the basis for successful preventive maintenance programs. IR thermography can provide broad-based benefits; therefore it is recommended that ENEE acquire IR thermography technology for its preventive maintenance, energy efficiency, and energy conservation programs.

Two Honduran industries: coffee processing and cement manufacturing, were selected for studies in an effort to improve energy efficiency in these fields.

Two cement plants, Cementos del Norte and Industria Cementera Hondureña, are considered. Cement plants are intensive power users. One of the plants was requesting assistance from SERNA to help reduce its energy costs. A preliminary feasibility study of cogeneration application performed by this study indicates that using the exhaust gas of a gas turbine (GT) to heat kiln is not feasible because the GT exhaust gas temperature is not high enough. Using the exhaust gases from a GT or an IC engine to provide preheating is plausible, but more technical data are required for further analysis. It is feasible to consider using the long dry kiln for bottoming cycle energy recovery. This cycle would utilize the Rankine cycle steam turbine for primary power generation. The applicability and economics of this practice will depend on specific operational conditions at each plant. The Kalina cycle is more flexible and more efficient than the Rankine cycle, but the Kalina cycle is not yet a proven technology for cogeneration applications in cement plants. It is ECCC's opinion that retrofits of electrical machines used in cement manufacturing could reduce energy consumption. It is recommended that each plant commission a comprehensive energy audit. These audits would help identify specific areas where energy losses could be reduced via energy conservation, and they could help improve machinery efficiencies throughout the manufacturing process.

The coffee industry has consistently earned a large portion of Honduras' export revenue. However, competition in the international market is intense, and Honduras recently announced that it would export one million fewer quintales coffee in 2002 than it exported last year. The

Honduran coffee industry is subject to pressure to reduce production costs and to improve coffee quality in order to remain in business. Energy management can help coffee processors reach these goals. Adequate electric and thermal power supplies can improve coffee quality, especially high-quality, specialty coffee for niche markets.

Two project team members accompanied by an Engineer from SERNA visited Comarca coffee processing plant in March 2001, near the end of coffee production season. The process was recorded on videotape and analyzed by ECCC's engineers. Fermentation and drying were identified as potential areas, which might realize cost savings from reduced energy consumption.

Many coffee growers live in villages without access to electricity. Lack of electricity negatively affects the quality of coffee in some of these areas because coffee cherries should be processed and dried within four hours of picking. Therefore, it is concluded that rural electrification would improve processing operations for many coffee farmers in these rural areas. Higher quality coffee could be sold to niche markets with increased profit margins.

ECCC recommends that Fondo Cafetero Nacional (FCN) hire consultants to help coffee growers conduct feasibility studies and write proposals for loans to install energy efficient coffee-drying machines including power generation sets at certain coffee production sites. It is also recommended that governmental agencies such as SAG and SERNA request funding for these projects from international donor agencies like USAID, USDA, and the European Union. The proposals should be submitted to IDB or the World Bank to facilitate hardware purchases and to cover installation costs. Finally, private investors such as the coffee importers in foreign countries may be interested in investing in production of Honduran specialty coffee. Feasibility studies would have to be conducted by consultants to attract private investment.

In terms of an integrated small biomass power generator, it is recommended that FCN contact UNDP to request funding to convert existing commercial systems, which use coconut shells to systems, which would utilize coffee bean parchment and skins. These modularized, commercial units are portable with an output range of 10 – 15 kW. After successful conversion, this product can be produced in quantity and be provided to coffee growers at reasonable prices.

With regards to energy management and energy conservation, this project offered a two-day short course on energy management in Tegucigalpa. The course exposed Honduran engineers to software used in energy audits and HVAC design for commercial and residential buildings, and the course provided an introduction to the merits of using infrared thermographic systems in preventive maintenance programs. Seventeen Honduran engineers and technicians participated in the short course. The course was well received, and many participants asked about future offerings of this and other courses in Honduras.

ECCC worked closely with ENEE, SERNA and COHCIT, and identified areas of mutual interest. ECCC can help ENEE expand its energy conservation programs, computerize its energy auditing process, and design an effective preventive maintenance program using infrared thermography. ECCC can help SERNA strengthen its energy conservation programs, co-host energy workshops, collaborate with its bio-energy program, and train its employees in masters degree programs at UNO's College of Engineering. With regards to COHCIT, ECCC can collaborate with its rural electrification programs. The ECCC team also approached representatives of the World Bank, IDB, the UN, and several private companies to discuss the potential for donations aimed at improving Honduras' energy infrastructure.

ECCC focused its efforts on rural electrification and the utilization of indigenous renewable energy resources in Honduras. In addition, the energy management team sought to educate business leaders and the public about the importance of energy conservation techniques. Reliable electric power can stimulate economic growth, and aid Honduras' entrepreneurs, farmers and poor communities. ECCC's efforts can help improve the quality of life in Honduras.