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POTENTIAL AND POLICY ISSUES OF INDUSTRIAL COGENERATION IN THE DOMINICAN REPUBLIC

FINAL REPORT

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Prepared by

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LIST OF ACRONYMS AND ABBREVIATIONS

CDE	Corporacion Dominicana de Electricidad
CEA	El Consejo Estatal del Azucar
COENER	Comision Nacional de Politica Energetica
ECSP	Energy Conservation Services Program
FERC	Federal Energy Regulatory Commission
FIDE	Fondo de Inversiones para el Desarrollo Economico
IDB	Inter-American Development Bank
IMF	International Monetary Fund
INRHI	Instituto Nacional de Recursos Hidraulicos
O&M	Operation & Maintenance
PURPA	U.S. Public Utilities Regulatory Policies Act of 1978
TDP	Trade and Development Program

Currency Equivalents

Currency Unit = Peso

U.S. $ 1.00 = R.D.$ 3.0

EXECUTIVE SUMMARY

BACKGROUND

The economic well being of the Dominican Republic is currently threatened by several crises. The most pressing are its $4 billion debt, the low world market price of sugar, its principal export, and the high cost of imported energy which has been between U.S. $400 and $500 million annually over the past several years.. This report deals with the latter by offering a partial solution, i.e., the introduction of cogeneration into the Dominican industrial sector which could save a significant amount of imported fuel.

Dominican industry uses roughly 25 percent of the country's imported petroleum and purchases 37 percent of the electricity supply directly and indirectly. The industrial sector consumes almost 40 percent of the country's petroleum products, all of which are imported from Venezuela and Mexico.

Electrical energy, which is generated primarily from thermal and hydropower plants with a total installed capacity of approximately 1010 MW, is produced and distributed by Corporacion Dominicana de Electricidad (CDE), the country's utility. The other key player in the energy area is the Comision Nacional de Politica Energetica (COENER), which broadly suggests policies from a national standpoint.

Although the government has authorized a number of new generating plants, by it is doubtful that financing can be arranged considering the current debt burden. This debt crisis would only be exacerbated in the short-term by the additional fuel costs (100 percent imported) and the initial capital outlay necessary for construction. Because of a lack of foreign exchange and local capital, other avenues for power generation need to be explored.

One remedy has been the government's own effort to provide better planning and conservation through its program at COENER. A promising aspect of this program is private sector cogeneration, which if implemented, could provide as much as 10 percent of the country's installed electrical generating capacity.

However, before cogeneration can become reality, a number of barriers need to be overcome. These barriers are primarily institutional and regulatory rather than technical, economic, or financial. The underlying question is how electrical energy and low grade heat and steam can be economically provided through cogeneration to the industrial sector. That is the subject of this report.

PURPOSE OF THIS STUDY

This study was funded under the Energy Conservation Services Program (ECSP), of the U.S. Agency for International Development (USAID). COENER, asked for this assessment of the potential for cogeneration by the private sector in the Dominican Republic, and an analysis of the impediments to its development, and recommendations on the first steps required to design and implement a program to exploit the economically viable potential. The sugar industry was to be excluded from the study.

The study was carried out by a team of consultants from Hagler, Bailly & Company consisting of Dr. Jack J. Fritz, Mr. Robert Kowalski, and Mr. Alain Streicher during a two-week trip to the Dominican Republic, October 20 - November 1, 1986. The team spent considerable time visiting industrial plants of major industries in order to obtain up-to-date technical and economic information. The team's scope of work is given in Appendix A.

FINDINGS

As a result of this analysis, the following findings are presented:

1. The Dominican Republic has a modest industrial cogeneration opportunity in the near term, (1986 - 1987) of 51, 16, and 15 MW for the technical, economic, and financial potential respectively. (See Exhibit i). The technical potential is considered that which can be developed. Based on a technical fit (cogeneration systems are only suitable in plants which have a requirement for process heat). The economic potential is that portion of the tech potential which is viable from the standpoint of nation's economy, without

Exhibit i

Cogeneration Potential in the Dominican Republic (MW)

	SHORT TERM 1986-1987	LONG TERM 1986-1997
Technical Potential[1]	51	>150
Economic Potential[2]	16	73
Financial Potential[3]	15	56

Notes:

1. That which can be developed based on thermal and electrical requirements.
2. That portion of the technical potential which can be developed based on the Nation's economy without "transfer payments".
3. That portion of the economic potential which can be developed from an investor's point of view including all "transfer payments".

"transfer payments," such as taxes, duties and profits. The financial potential is that which can profitably be developed from the investor's standpoint, using market values for costs, etc. The difference between the technical potential and economic/financial potential is primarily due to the low price of oil and low electric power rates. The cement and sugar industries are not included in the above figures, but represent a significant additional potential.

2. Over the long term (1986 - 1997), the economic and financial potential increase to 73 and 56 MW respectively, which is roughly 5 - 10 percent of CDE's power capacity. (See Exhibit i). This growth is a consequence of an expected industrial growth rate ranging from 3 to 5 percent annually depending on the specific industry as well as the expected increases into the price of oil in the 1990's.

3. Although the sugar and cement industries are not part of this analysis, a significant cogeneration opportunity. During the processing season, at least 40 kWh/ton of crushed sugar cane crushed should be available to CDE. Based on Dominican sugar production, some 500 GWh/year can be made available at the national level. A conservative long term estimate would be as much as 100 to 150 MW of capacity from sugar wastes.

4. The food processing sector has the largest potential for cogeneration since it requires large amounts of hot water and process steam. The current technical potential in this sector alone is approximately 40 MW. However, most of this potential is for systems of less than one MW, since most of the operations are small. Many of these processors produce for export and are foreign owned. They are able to draw on outside technical and financial resources, making them good candidates for cogeneration.

5. Industry in the Dominican Republic has cogeneration experience, but it has not been formally institutionalized. Two demonstration projects were funded in the past, but they failed because of technical and fuel supply problems and not for institutional, financial, or economic problems. However, most private firms are not aware of this experience. A further examination of these two projects is useful in order to determine the exact

causes of their shutdown. These plants were primarily put in place because of the need for continuous and guaranteed power.

6. Private sector cogeneration could play a major role in reducing current and projected gaps in electric generating capacity. The total potential could represent up to 15 percent of the utility's installed capacity (including sugar and cement). The private sector has shown an interest in cogeneration primarily because of utility service interruptions. However, the private sector will need significant assistance in assessing the technical, economic and financial feasibility of cogeneration for specific industrial plants. Industry tends to concentrate its capital investment on capacity expansion primarily and only secondarily on energy conservation.

7. The private sector will continue to need credit facilities such as Fondo de Inversiones para el Desarrollo Economico in order to finance energy conservation investments. Existing funds would be insufficient to carry out a major cogeneration program. Small system costs vary from $1300 to $2000/kW in the 50 to 500 kW range. To develop 15 MW would require $22.5 million at $1300/kW. FIDE only has a fraction of this amount available. Industry is also reluctance to invest because it feel that the low world market price of oil will continue into the future. On the one hand, this low price ($18 to $20 per barrel) is currently the greatest disincentive for cogeneration, but on the one hand, low oil prices coupled with high electricity prices make cogeneration economically promising.

8. There are no established policies at CDE regarding cogeneration, although the purchase of private sector power (e.g., from Falconbridge Dominicana) has been a practice for some time. Long standing agreements have existed which establish price and quality of service from large scale generators, such as the sugar and mining industries, but it is not clear whether these arrangements could serve as models for cogeneration plants.

9. The principal impediment to cogeneration appears to be institutional, specifically, existing policies and legislation which appear to limit private sector power generation. CDE has been accorded a virtual monopoly over generation and distribution. It views cogeneration as being only practical for

the sugar industry. It also feels that cogeneration will not make a significant contribution to the nation's energy supply. On the other hand, CDE is willing to look into the issues but it may not have sufficient institutional capability to deal with a major cogeneration program. Issues of pricing, technical interface, and contracts would need to be resolved, perhaps guided by the PURPA experience in the U.S.

RECOMMENDATIONS

1. COENER, with CDE concurrence, should begin to formulate a rational, well articulated cogeneration policy. This would have to be a staged process drawing initially on experiences from other countries. Private sector comments should be solicited so that industry's views can be given consideration. This policy should be communicated in a document which identifies cogeneration opportunities in Dominican industry. It should also show how to implement a project outlining the regulatory and legal steps that must be followed. Wide distribution of such a document will prompt a great deal of interest by industrial management.

2. Within COENER, a group of specialists should be created to carry out feasibility studies for industrial clients and to act as consultants to industry. This process might start by retaining a cogeneration specialist for COENER to begin a training process. In addition, U.S. based training is also recommended, perhaps with Pacific Gas & Electric in California which has many cogeneration projects. Initial studies would be brief, similar to pre-audits done by COENER in the past. Eventually, this activity should be financially self-supporting for COENER, requiring that the staff sell the concept to industrial clients.

3. The electricity pricing issue must be broached. Pricing should be based on the factors of production and should be as close to world market levels as possible. Built in subsidies are a disincentive to cogeneration and conservation in general. This effort needs to be implemented through a series of careful adjustments supported by in-depth analysis of the social and

economic impacts. It also needs to be carried out in concert with other donor efforts at price reform, primarily the IMF.

Realistic energy pricing is the most powerful policy tool for conservation and consideration of other energy alternatives. Private industry will initially respond negatively but as oil prices rise, having cogeneration systems in place will make future oil price shocks easier to cope with.

4. In order for cogeneration to take hold, a regulatory structure and institutional framework needs to be established that clearly articulates the roles and responsibilities of CDE and private sector cogenerators. The approach may be similar to PURPA in the United States; but specific provisions must be tailored to the Dominican realty. In conjunction, the regulations which currently govern power generation and distribution need to be carefully examined. A group of regulatory experts and utility economists may be needed to make recommendations on necessary changes that will encourage cogeneration. In addition to an institutional framework, a detailed action plan needs to be drawn up to promote cogeneration in high levels of government. Again comments from the private sector and consultants should be solicited in this process.

5. An information, awareness, and technology transfer or outreach campaign should be initiated by COENER. The campaign should include publications illustrating how the technology fits into existing plants, its economic-financial rationale, and equipment suppliers and costs. This should be in the form of easy-to-read pamphlets in Spanish.

6. One or two demonstration projects should also be developed in both public and private sector industries. These should be funded by FIDE and continually analyzed to monitor technical and economic performance. These projects should be started immediately so that a real-world base of experience can be developed. A separate cogeneration program should be established for public sector companies. This would be in addition to the efforts currently under way in the sugar industry.

7. Increased funding of FIDE must be considered if a major cogeneration program is to be initiated. In the short term, a doubling of financial resources will be needed. In addition, strictly private financing channels should be identified and made available to larger cogenerators.

8. Special emphasis should be placed on the sugar industry since its cogeneration potential is large. Although, the sugar industry has been selling power to CDE for many years, its contribution has been low, never exceeding seven percent of CDE capacity. Current installed potential is only 62 MW, but if all residues are used, the future potential could be in the range of 100 to 150 MW. This could reach 15 percent of CDE's installed capacity.

ACTION PLAN

In order to accelerate cogeneration development in the Dominican Republic, the following activities need to be carried out simultaneously by the designated institutions:

1. COENER

A. Develop Appropriate Human Resources

A small group of specialists should be created to carry out feasibility studies for industrial clients and to act as consultants to industry. This process begins by placing a cogeneration specialist in COENER to train a small cadre of individuals. Some U.S. based training is also recommended. Initial feasibility studies would be brief, similar to pre-audits done by COENER in the past. This activity should be financially self supporting and therefore it will be necessary for COENER staff to sell the concept to clients. In addition, seminars and workshops should be held for industrial managers on the general aspects of cogeneration. These seminars would be given by outside specialists.

B. Prepare Documentation

A technical document needs to be prepared for Dominican industrial management which identifies the benefits of cogeneration and outlines

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preliminary steps to implement a project. This document should be written in Spanish by COENER staff in conjunction with the cogeneration specialists.

C. Begin Feasibility Studies

Feasibility studies on cogeneration projects should begin immediately. Specific industries, starting with food processing, should be contacted and given a formal presentation by COENER on the technical, economic, and financial benefits of this technology.

D. Establish a Working Group

An interagency working group or standing committee needs to be formed to promote cogeneration. This group would be made up of COENER, CDE and private sector representatives. The group would meet periodically to identify cogeneration projects and to advocate the technology within their own organizations. COENER should be responsible for establishing this group and organizing the meetings.

2. CDE

A. Establish an Institutional Framework

The existing legal framework for power generation in the Dominican Republic should be reviewed by an institutional specialist to determine how modifications could be introduced to encourage industrial cogeneration. This process may require specific legislative initiatives and the support of government at the highest level. This process might begin with recommendations from COENER, but CDE must eventually push if reforms are required.

B. Determine Avoided Costs

The electricity tariff must be examined to determine how it can be structured to encourage cogeneration. Specifically, an analysis needs to be done of the "avoided cost" concept, or how much CDE should pay for purchased power. There is a large body of literature that deals with this issue and it should be consulted first before hard and fast rules are established.

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C. Draft a Prototypical Power Contract

A typical power purchasing contract for different types of cogenerators (scale, operating profile, industry, avoided cost procedure) must be developed. Many models for such contracts exist in the U.S. because of the PURPA history.

D. Define an Administrative Structure

An effort to define the administrative and technical aspects of operating a cogeneration program should be undertaken by CDE. This would include queries into interconnection, load management, billing, and buy-back arrangements.

An effort should also be undertaken to incorporate future operational plans of existing private power generators, such as Falconbridge Dominicana into an overall cogeneration plan. The issue is to determine what fraction of CDE capacity they can be counted on to produce in the future.

E. Begin Specialized Training

CDE personnel should receive training in cogeneration technologies, economics to determine subsidy impact, avoided cost and in such areas as dispatching, interconnection and operations. This training could take place at utilities in the U.S.

3. FIDE

Depending on the interest shown by industry after the outreach campaign, further credit may have to be made available to prospective private sector cogenerators. Plans to secure these funds should be considered early. Consultation between COENER and FIDE on a regular basis will be necessary to forecast what the demand for funds will be.

4. CEA

The future role of the national sugar industry in providing electricity through cogeneration to CDE needs to be firmly established. At this time there are

several projects under construction. These should be monitored by COENER to determine when they will go on line.

5. USAID

Financial resources, training and consulting services must be made available in a timely and efficient manner if a cogeneration program is to be implemented. USAID could be very instrumental in encouraging such an effort both financially and through policy initiatives. An appropriate way to begin is to organize a meeting involving COENER, CDE, and industrial groups with several presentations on all aspects of cogeneration.

Exhibit ii shows the roles which various organizations can play in fostering a cogeneration effort.

Exhibit ii

Organizational Roles of Key Institutions

ROLE	COENER	CDE	USAID	FIDE	CEA	PRIV. SECT.	IDB	IBRD
• Set Policy	x	x				x		
• Establish Institutional Structure		x						
• Outreach Program	x							
• Feasibility Studies	x					x		
• Project Funding			x	x		x	x	x
• Training	x		x					
• Demonstrations					x	x		

Source: Hagler, Bailly & Company, Inc.

INTRODUCTION

The economy of the Dominican Republic is currently plagued by a foreign debt of almost $4 billion. This debt has had an adverse effect on investment, particularly in the energy sector. Power generation has grown approximately 25 percent annually since 1973 to approximately 1,000 MW, however, future demand may not be met by the country's principal utility, the Corporacion Dominicana de Electricidad (CDE), because of severe foreign exchange constraints.

The Dominican Republic imports 100 percent of its oil, importing between 12 and 15 million barriers per year at roughly $500 million. The industrial sector consumes approximately one fourth of this oil and purchases roughly a third of the electricity produced by CDE. Indirectly, this means that industry consumes a total of 38 percent of imported petroleum and its derivatives. If industry is to continue growing as it did during the 1970s, more thermal and electrical energy must be provided through increased efficiency and conservation practices.

However, additional solutions to the long standing shortage of power need to be found. A significant contribution to meeting industrial energy needs can come through cogeneration. This technology, primarily applied in the industrial sector, can increase CDE capacity from between 5 and 10 percent. In addition, cogeneration uses fuel far more efficiently, providing more electrical power and thermal energy than would be the case if separate systems produce both heat and electricity. In the United States, installed or planned industrial cogeneration amounts to approximately 20,000 MW or roughly half of all new generating capacity planned since 1980.

The purpose of this report is to evaluate cogeneration as a partial solution by providing both thermal and electrical energy to the industrial sector in the Dominican Republic. To determine the cogeneration potential, a sectoral approach was used based on steam and electricity requirements in various industries as well as pertinent economic and financial data. This report also

includes, approaches to dealing with institutional impediments that must be overcome before cogeneration can make a significant contribution to the industrial energy situation. The report closes with some suggested steps that can be taken immediately to encourage cogeneration in the Dominican Republic.

THE COGENERATION POTENTIAL IN DEVELOPING COUNTRIES

The Dominican Republic is not unique in its energy problems, the industrial sector in most developing countries is the largest consumer of commercial energy and electricity. In 1980, total commercial primary energy consumption for all 104 developing countries was estimated at 1,350 million tons of oil equivalent (mtoe),[1] of which 600 mtoe, or approximately 45 percent, was used by the industrial sector.[2]

A comprehensive cogeneration market study by Hagler, Bailly & Company[3] carried out in 1984, estimates the industrial cogeneration potential in the U.S. industrial sector (between 1984-1995) between 21 and 29 GW. This estimate is based on the survey and analysis of the food, pulp and paper, chemicals, petroleum refining, and steel industries. These industries are the most energy intensive only in the U.S., consuming over 60 percent of the energy used in the industrial sector. A similar study of the cogeneration potential in developing countries followed.

The study team assumed that the ratio of cogeneration potential to the total energy consumption of the industrial sector in developing countries is similar to that of the United States. Extrapolating from these ratios, the team estimated the industrial cogeneration potential in USAID-assisted countries is 6

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[1] World Bank, The Energy Transition in Developing Countries, 1983, p. 3.

[2] World Bank, Industrial Energy Efficiency in Developing Countries, 1984, p. 4. This estimate is based on the survey of energy consumption in the industrial sector of some 30 countries. The results were extrapolated for the remaining countries.

[3] Hagler, Bailly & Company, U.S. Industrial Cogeneration: Market Prospects to 1995 for Process Steam and Electricity Cogeneration Systems, 1984.

to 10 GW. About half of this potential is in seven countries, Egypt, India, Indonesia, Pakistan, Philippines, Thailand, and Turkey, and represents about 5 to 7 percent of the present power supply capacity. However, actual electricity production from cogeneration plants can account for a greater fraction of overall power production in a country, because the capacity factor of industry is usually over 80 percent, while that of a thermal power plant is between 60 and 70 percent.

There is very little information available on the energy consumption patterns in the commercial sector in developing countries. Therefore, the study did not estimate the cogeneration potential in this sector. In theory, hotels, schools, hospitals, and other large commercial buildings could have a continuous demand for cooling, heating, or hot water and electricity, making them candidates for cogeneration, especially if they operate more than 4,000 hours per year. However, the energy consumption patterns in such buildings is so much dependent on each country's climate and energy use habits, that it is difficult to generalize.

Specific information can be found in Cogeneration in Developing Countries, May 1986, by Hagler, Bailly & Company.

STUDY APPROACH

The study team visited the Dominican Republic for 2 weeks, collecting data through a review of the literature and interviews with key representatives of several private and public sector organizations, donor agencies, and USAID. The list of organizations contacted is presented in Appendix B and includes commercial banks, and a number of industrial firms. To estimate the potential for power generation from industrial cogeneration, the team used a proprietary model developed at Hagler, Bailly & Company. This model has been successfully used in the United States and a number of developing countries.

REPORT ORGANIZATION

The study report consists of four chapters:

In Chapter 1, an initial estimate of the technical, economic, and financial potential of private-sector power production from industrial cogeneration is presented.

In Chapter 2, the existing power sector institutions in the Dominican Republic are described and the major issues and impediments associated with cogeneration are identified and discussed.

In Chapter 3, based on U.S. experience with the development of non-utility power options, possible approaches to establishing the purchase price of electricity from non-utility generators are described and preliminary estimates of the range of avoided costs in the Dominican Republic are determined.

Finally in Chapter 4, the study conclusions, recommendations, and action plan are presented.

Appendices A through D provide additional information to support the main text of the report.

CHAPTER 1: NATIONAL POTENTIAL FOR COGENERATION

This chapter evaluates the potential for cogeneration in the industrial sector of the Dominican Republic. First, existing private power generation is described. Second, recommended technology options are given. Third, the technical, economic, and financial cogeneration potential is determined with market projections to the year 1997.

EXISTING PRIVATE POWER COGENERATION

Private sector power generation in the Dominican Republic can be found primarily in the sugar, mining, and cement industries. Sugar production is both a public and private enterprise with 70 percent state owned. El Consejo Estatal del Azucar (CEA), a government organization operates 12 sugar mills (see Exhibit 1.a) with an installed capacity of 62 MW (1985) and an approximate total electrical energy consumption of 140,000 MWh (1985). It sold approximately 7,000 MWh of electrical energy to CDE in 1985 from 8 of its sugar mills.

Over the past few years, since the precipitous fall in sugar prices, CEA has sought to diversify into the production of energy. During the sugar processing season, with energy produced from bagasse, CEA's capacity represents roughly 5 percent of total CDE capacity. CDE's purchases of energy from CEA represents approximately 25 percent of the energy consumption of its sugar mills. Sales of power to CDE ranging from 2 percent of total production in 1979 to 7 percent in 1985. These sales are a rather small percentage of CDE's total energy production, however, it is expected that this fraction will rise as the sugar industry places more emphasis on energy production.

Other major industries in the Dominican Republic produce their own power both for their own process nwwsa and for sale to CDE. (See Exhibit 1.b). The largest energy-producing industry is Falconbridge Dominicana, a Canadian

Exhibit 1.a

Capacity, Generation, and Sale of Electric Power by CEA Sugar Mills (1985)

Mill	Installed Capacity (MW)	Generation (MWh)	Purchased from CDE (MWh)	Sold to CDE (MWh)
Amistad	-	18,614	1,861	-
Barahona	7.0	6,858	5,641	211
Boca Chica	6.5	5,910	4,746	-
Catarey	2.4	2,492	1,773	-
Consuelo	5.0	11,015	7,720	103
Esperanza	1.0	3,537	979	-
Montellano	2.0	5,537	2,460	135
Ozama	5.5	14,167	2,462	1,796
Porvenir	6.0	16,756	2,957	730
Quisqueya	6.5	7,001	5,323	462
Rio Haina	16.0	28,282	3,947	3,625
Santa Fe	4.0	2,784	3,954	5
Total	61.9	122,953	43,922	7,066

Source: COENER

Exhibit 1.b

Installed Capacity and Energy Production of Private Generators in the Dominican Republic (1985)

Producer	Installed Capacity (MW)	Energy Production (MWh)	Maximum Energy Production (MWh)
Central Romana	30.0	N.A.	85,900 (1979)
Falconbridge	198.0	818,440	1,019,592 (1979)
Rosario Dominicana	12.5	N.A.	60,715 (1982)
Cementos Nacional	22.9	N.A.	74,819 (1983)
Cementos CIBAO	8.0	31,600	31,600 (1985)
Total	**271.4**		

Source: COENER

nickel mining venture which began operations in 1973 with the installation of three 66 MW oil-fired units. At that time, this capacity represented roughly half of the country's power generation potential. Over the last three years, sales from Falconbridge accounted for 21, 22 and 15 percent (1983, 1984, 1985) of the net energy generated by CDE thermal plants. Currently only two units, representing some 10 percent of total CDE capacity, generate power for sale to CDE (see Exhibit 1.c).

Installed capacity for all 5 independent power producers totals some 271.4 MW, the largest share-being contributed by Falconbridge. Other producers include private sugar mills (Central Romana) and cement plants. In most cases, the rationale for private sector production of electricity has been power disruptions. In the case of the sugar industry, a further reason is the need to dispose of process wastes (bagasse).

COGENERATION TECHNICAL OPTIONS

Cogeneration refers to the sequential production of electricity and useful thermal energy (usually in the form of hot water and steam) as an integral part of an industrial process. Traditionally, industrial thermal energy is produced by boilers and furnaces that typically have efficiencies of 50 to 80 percent. Electricity is normally produced by a utility using a boiler and steam turbine with a combined efficiency of 30 to 35 percent. Cogeneration produces both electricity and thermal energy with a combined efficiency of 80 to 90 percent, resulting in greater energy efficiency and lower overall energy costs.

Similarly, cogeneration systems can be used in commercial buildings, such as hospitals and hotels, to simultaneously produce electricity and steam. In the Dominican Republic, steam could be used for air conditioning and hot water needs.

In addition to improving fuel efficiency, cogeneration systems can improve power system reliability and reduce the environmental impact of power generation. By decentralizing sources of power generation, cogeneration increases the availability of reliable power in the event of utility problems.

Exhibit 1.c

Electricity Purchased by CDE, 1977-85 (GWh)

Year	Sugar Mills	Falconbridge	Total
1977	1.7	82.2	83.9
1978	2.4	65.7	68.1
1979	1.6	151.8	153.4
1980	1.4	281.9	283.4
1981	1.1	192.9	194.1
1982	2.0	466.1	4478.1
1983	2.6	425.4	428.0
1984	3.2	411.9	415.1
1985	3.2	411.9	415.1

Source: CDE

In addition, a reduction in the fuel used to generate a given amount of energy translates directly into a reduction in thermal and other types of pollution.

Two cogeneration technologies have particular application in the Dominican Republic. These are topping cycle, high pressure boiler-steam turbines and diesel engines with waste heat recovery. Gas turbines were not considered because of limited experience in the Dominican Republic with these systems as well as an uncertain and expensive gas supply.

Fuel Oil-Fired Boiler/Steam-Turbine

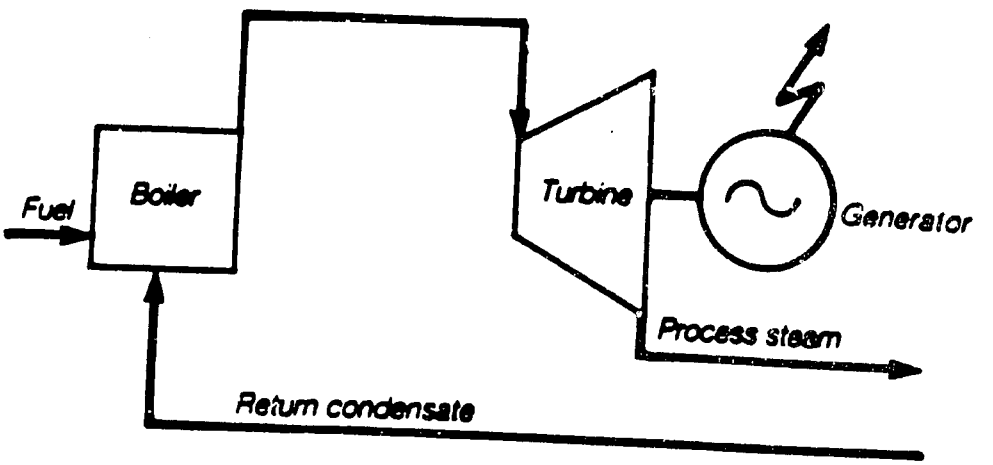
Historically, steam turbines have been the primary cogeneration technology, providing mechanical and electrical power and steam for a variety of industrial processes. A schematic of a steam turbine in a cogeneration application is shown in Exhibit 1.d. The system consists of a boiler and a back pressure turbine. Mechanical energy is produced as the high-pressure steam from the boiler drives the turbine. The mechanical energy is then converted to electricity by turning a generator. The steam which leaves the turbine at a reduced pressure and temperature (300 to 700°F) can be used in many industrial process applications.

Steam turbines are available in a wide range of sizes, from a few hundred kWs to well over 550 MW, although 100 MW is probably a reasonable ceiling for major industrial applications. Currently, steam raising boilers can accommodate a wider variety of fuels than other available cogeneration systems (they can operate on oil, natural or synthesis gas, coal, wood, solid waste, or industrial byproducts), although individual boilers can only be designed to accommodate two fuel sources at one time (i.e., dual-fueled boilers can be built to use oil or gas, coal or oil, gas or coal).

Steam turbine cogenerators also have extremely high unit reliability, availability, and service lifetime with a maximum forced outage rate of only 5 percent. The expected service lifetime of steam turbine cogenerators is from 25 to 35 years. A final technical advantage of steam turbine cogenerators is their high overall fuel efficiency, ranging from 65 to 85 percent, which is not generally affected by turbine inlet temperatures or by

Exhibit 1.d

Fuel Oil Fired Boiler/Steam Turbine Cogeneration Plant



Source: Power, McGraw-Hill.

part-load operation (when less than the maximum possible amount of electricity is being produced).

On the other hand, steam turbine cogenerators have relatively long installation lead times - 12 to 18 months for smaller systems and up to 3 years for larger units - from the time equipment is ordered until operation begins. This is due primarily to the time required to certify and install high pressure boilers.

Steam turbines also have relatively low ratios of electric-to-thermal power production because they have a relatively low upper temperature limit. It is this temperature which, in combination with the desired steam temperature, determines the amount of electricity that can be generated. Of the 85 percent useful energy obtainable in steam turbine cogeneration systems, typically 14 percent would be electric power and 71 percent process heat. However, the electric-to-thermal ratio will vary according to the amount of high-pressure steam that is diverted from the boiler for process heat. Thus, an increase in process steam temperature corresponds to a decline in electric power production and an increase in heat production.

The costs of steam turbine cogenerators vary depending on the size of the system, the kind of fuel it uses, and its combustion source. Oil-fired boilers for steam turbines constitute the least expensive option, with installed cost estimates ranging from U.S. $600 to $900/kW. Economies of scale come into play for systems larger than about 10 MW.

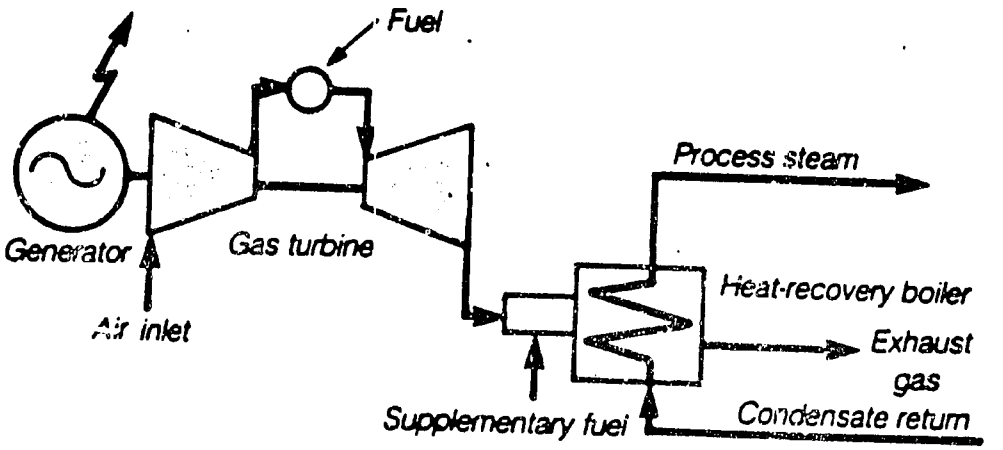
Estimates for variable operation and maintenance (O&M) costs for steam turbine topping cycles (excluding fuel cost) vary from 0.4 to 1.0¢/kWh depending on the source of the estimate. In general, with a residual oil-fired steam turbine, a 0.5¢/kWh O&M cost is a reasonable estimate.

Diesel-Fired Combustion Turbine/Waste Heat Recovery Boiler

Most combustion turbines are open-cycle systems in which air is drawn in from the atmosphere and exhaust gases are released to the atmosphere. Figure 1.e presents the configuration of a simple open-cycle combustion

Exhibit 1.e

Diesel Fired Combustion Turbine with Waste Heat Recovery Boiler Cogeneration Plant



Source: Power, McGraw-Hill.

turbine with a heat recovery unit in a cogeneration application. In such a system, air is compressed, then heated in the combustion chamber to the required turbine inlet temperature, and expanded through the turbine. The waste heat boiler system recovers heat from the hot gas produced by the turbine and generates high- and low-pressure thermal energy to be used in industrial processes or for space conditioning.

Simple open-cycle combustion turbine systems with waste heat recovery boilers currently are available in size ranges from 100 kW to 100 MW. Most combustion turbines burn natural gas or diesel oil and can be converted from one to the other in about one day. Because turbine blades in open-cycle systems are exposed to the products of combustion, these products must be free of impurities that can cause corrosion. As a result, currently available open-cycle combustion turbines cannot use solid fuels (coal, biomass) directly.

Open-cycle combustion turbine cogenerators have a shorter installation lead time than steam turbines, around 9 to 14 months for gas turbines up to 7 MW and as long as 2 years for larger units. The reliability of combustion turbines and their average annual availability should be comparable to that of steam turbines, although units that burn liquid fuels or that are operated only intermittently will require about three times more maintenance and thus will have a lower percent availability than those that use natural gas.

Open-cycle combustion turbine cogenerators tend to have slightly lower overall fuel efficiency than steam turbines, but the most efficient combustion turbines can have a higher overall efficiency than the least efficient steam turbines. On the other hand, open-cycle combustion turbines have much higher electrical to steam ratios than steam turbines (typically 140 to 225 kWh/MMBtu for combustion turbines, as compared to 30 to 75 kWh/MMBtu for steam turbines) and a higher electric generating efficiency at full-load operation. Unlike steam turbines, however, the combustion turbine cogenerator's electric efficiency is reduced significantly by part-load operation. As with steam turbines, the efficiency of open-cycle combustion turbines tends to increase with size up to about 30 MW, and remains relatively constant in larger systems.

The installed costs for open-cycle combustion turbine cogenerators range from U.S. $400/kW installed capacity for very large (100 MW) gas turbine cogenerators, to over U.S. $800/kW for very small units. Economies of scale are apparent in systems larger than about 20 to 30 MW.

Estimated variable O&M costs for combustion turbines are 0.5¢/kWh. Annual fixed O&M costs for combustion turbine topping cycles are low and tend to be about 35¢/kW.

High Speed Diesel/Waste Heat Recovery

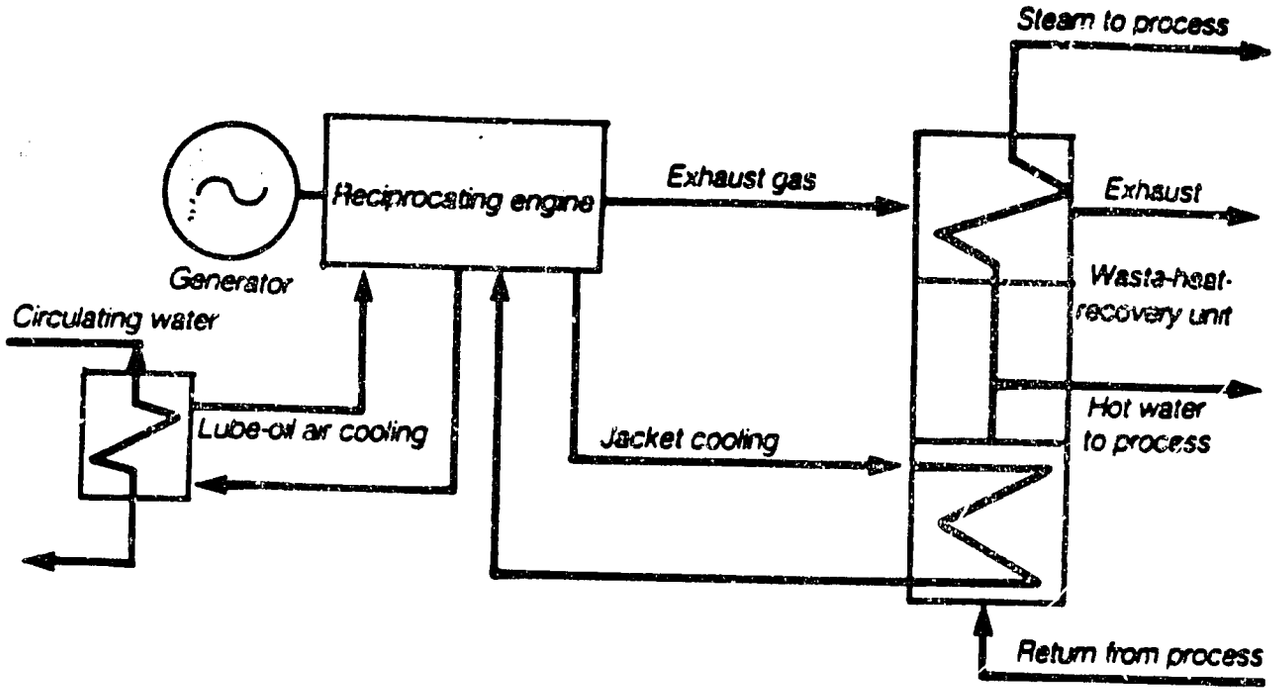
The diesel engine is a reciprocating internal combustion engine which is a fully developed and mature technology. Cogeneration systems using diesel engines are topping systems and are classified according to whether the diesel engine operates at high, medium, or low speed. All three types have been used in electric power generation, medium and low-speed diesels are used by electric utilities for intermediate and peak-load use and high-speed diesels are used in "total energy systems".

A typical diesel engine topping cogenerator is shown in Exhibit 1.f. The major system components include an engine, generator, heat recovery unit, fuel handling equipment, and environmental controls. The engine is cooled with water and the resulting heated water used subsequently for process steam, heat, or hot water applications. Exhaust gases can be used in a similar manner.

Installation lead times for presently available diesel cogenerators range from 9 months for smaller high-speed systems to 2.5 years for larger low-speed units. Maintenance is performed on typical low and medium-speed diesels every 1,500 hours and more frequently on high-speed diesels. Average annual availability ranges from 80 to 90 percent. Expected service lifetimes vary from 15 to 25 years depending on unit size, fuel burned, and quality of maintenance.

Exhibit 1.f

High Speed Diesel With Waste Heat Recovery Cogeneration Plant



Source: Power, McGraw-Hill.

Electricity-to-thermal ratios for diesels are high, from 350 to 700 kWh/MMBtu. Low-speed diesels typically are designed for peak efficiency at 75 percent of full load. Non-peak performance for current and advanced technology high-speed diesels is excellent. Medium-speed diesels, whose rated capacities overlap high-speed diesels at the low end of the range and low-speed diesels at the higher end of the range follow the same trends.

Total installed costs for current and advanced diesel prime movers range from U.S. $400 to $900/kW for current units. Estimates of O&M costs for current and advanced diesels vary significantly depending on the fuel and the unit size. Fixed O&M costs vary from U.S. $8.0 to $10.0/kW annually. Estimates for variable O&M costs range from 0.2¢/kWh for large low-speed units to 2.0¢/kWh for small high-speed units, with 0.6 to 1.2¢/kWh being a common range.

INDUSTRIAL COGENERATION POTENTIAL

Energy Use in the Industrial Sector

During the 1970s industrial growth in the Dominican Republic was significant compared to other sectors of the economy. Annual industrial growth from 1973 to 1979 was 4.6 percent, led primarily by the mining sector. However, the manufacturing sector grew at between 18 and 19 percent annually during the period. The sugar subsector was considered the most important industry during this period and remains so today, accounting for 51 percent of total industrial production. This industry is followed in importance by cement, food processing, chemicals, pulp and paper, and textiles.

The industrial sector used between 15 and 23 percent of the total fuel oil consumed from 1973 to 1980 and 32 percent of the diesel oil. Exhibit 1.g shows total energy consumption in tonnes of oil equivalent for the industrial sector from 1977 to 1982. Steady increases can be noted for Bagasse and electricity. The heavy use of bagasse underlies the prominence of the sugar industry.

Exhibit 1.g

Energy Consumption In the Industrial Sector by Fuel Type (1977 - 1982, TOE)

Energy Source	Year					
	1977	1978	1979	1980	1981	1982
Coal	350	458	366	376	396	760
Electrical Energ	32,390	35,775	58,943	44,084	55,837	51,493
Fuel-Oil	225,640	241,347	273,520	239,837	220,574	193,880
Diesel-Oil	98,068	95,041	47,376	54,674	54,788	65,085
LNG	3,801	5,120	9,525	21,197	29,146	22,985
Kerosene	229	273	253	227	258	65
Fuel Wood	27,414	23,619	26,146	37,307	28,293	32,087
Bagasse	51,100	404,013	370,556	347,161	331,057	418,667
Totals	**438,992**	**805,646**	**786,685**	**744,863**	**720,349**	**785,022**

Source: COENER

Exhibit 1.h presents energy consumption for 9 industrial sectors in 1982 (exclusive of sugar) much of the difference between the two tables is attributable to the extensive use of Bagasse. Also, as noted, the food and cement sectors were the major consumers reflecting continued growth in construction and food processing. The remaining energy consumption is spread over a variety of products such as pulp and paper, textiles and glass.

Notable in the face of escalating fuel prices is the growth in energy consumption from 1977 to 1979, approximately 70 percent; however, that increase is primarily in bagasse utilization. Oil imports cost the Dominican Republic U.S. $42.3 million in 1973 and U.S. $523.2 million in 1984. This last sum represents approximately 66 percent of the value of its exports. During the period 1978 to 1979, the Dominican Republic paid in the range of 20 to 30 RD$/barrel for oil; by 1985 the price had risen to approximately 40 to 44 RD $/barrel.

Since the sugar industry is the subject of a separate investigation, this study will concentrate on the other industrial energy users. From the following table, it is clear that food, beverage, cement, chemicals, and glass production represent some 92 percent of industrial energy consumption. Approximate energy consumption for each of these sectors is:

Food and Beverages	33
Cement	40
Chemicals	11
Glass	8
Total	**92%**

The high consumption of fuel oil in the food production and beverage sectors is of particular interest in this study. Clearly in food production there are many opportunities for cogeneration because of the need for low-grade steam and hot water.

Exhibit 1.h

Energy Consumption in the Industrial Sector
(1982, toe, excludes the Sugar Industry)

Fuel Type	Food Beverages Tobacco	Textiles Clothes Shoes Leather	Wood Furniture	Pulp Paper Printing	Chemicals	Cement	Glass Ceramics	Steel Metal Products	Machinery	Other	Total
Fuel Oil	36,137	2,209	-	11,066	23,652	101,166	9,470	3,335	587	-	187,622
Coal	621	-	-	-	372	-	-	3	-	-	996
Fuel wood	29,295	-	-	-	113	-	75	-	-	-	29,483
Electricity	12,065	2,553	228	3,291	5,507	9,166	1,685	4,617	548	45	39,705
Diesel Oil	20,757	1,979	110	417	4,710	14,710	4,049	2,273	405	51	49,461
Kerosene	-	-	-	-	58	-	-	-	-	-	58
LNG	6,009	435	-	-	3	-	8,644	-	51	-	15,142
TOTAL	104,883	1,176	338	14,774	34,415	125,042	23,923	10,228	1,591	96	316,466

Source: COENER

Technical Potential for Cogeneration

The estimated technical potential for cogeneration in the industrial sector is presented in this section. The technical potential is defined as the amount of generation capacity that can be developed given the current and expected state of the technology and fuel availability. For cogeneration systems, this is defined as the maximum electric capacity that could be installed to meet either the full thermal load or full electric load in existing and future plants.

The technical potential for industrial cogeneration is based on those plants with sufficient process thermal loads to use systems that produce low to medium temperature process heat in addition to generating electricity. Such plants would include those using a significant amount of low pressure steam (exceeding 8 million Btu/hr at 200 psig) for process heat applications on an essentially continuous basis, i.e., exceeding 20 billion Btu/year or operating more than 2,500 hours annually.

Based on industry experience, both in the United States and in developing countries, the team computed the technical cogeneration potential for the various industry sectors and subsectors. This was done by calculating the technical cogeneration potential for typical industrial plants in the most important subsectors. (The team then determined what proportion of the total energy this plant represented as a fraction of the total energy used in the subsector.) By dividing the cogeneration potential of this single plant by this fraction, the technical potential of the entire subsector was determined. Exhibit 1.i is a breakdown of energy use (1982) by sector and subsector in industry. Exhibit 1.j is a list of representative plants in the most important industries. Several of these plants were visited by the team to obtain site-specific data. (See Appendix B for a list of site visits.) The remaining information was gleaned from COENER energy audit reports. The results of the analysis are summarized in Exhibit 1.k.

For the purpose of this study, the team assumed that cogeneration systems would be steam load-following, that is, they would be installed to satisfy all the steam demands of the industrial plant. On the basis of the analysis, the team estimates that almost 51 MW of cogeneration systems could technically

Exhibit 1.i

Detailed Industrial Energy Use by Sector and Subsector (1982)

	Fuel Oil (1,000 Gallons)	Diesel Oil (1,000 Gallons)	Electricity 1,000 kWh	LNG 1,000 kg
Food Production				
Meats	100	315	5,915	688
Dairy	864	558	16,810	104
Fruits & Veg.	1,707	178	7,374	-
Oils	3,139	346	13,576	-
Milling	-	1,305	27,750	-
Baking/Sweets	94	2,326	38,502	1,817
Salt	198	-	447	34
Animal Feed	17	32	3,162	-
Beverages				
Spirits	2,205	149	5,408	-
Beer	1,561	205	16,580	-
Water	128	691	2,817	-
Tobacco	5	402	4,850	-
Textiles	344	489	25,435	198
Leather & Shoes	273	108	5,275	-
Wood & Furniture	-	32	2,722	-
Pulp & Paper				
Raw Materials	2,796	22	25,474	-
Cartons & Products	229	46	6,769	-
Printing	-	55	7,355	-
Chemicals				
Basic Chemicals	6,296	146	19,737	-
Fert. & Insect.	-	84	1,275	-
Synth & Paints	-	108	3,152	-
Pharma.	-	33	1,707	-
Clean Prod.	267	416	7,374	-
Refinery				
Pet. Products	-	136	16,328	-
Rubber Prod.	11	362	7,045	-
Plastic Prod.	43	23	24,084	-
Ceramics	-	271	3,511	-

Exhibit 1.i (continued)

	Fuel Oil (1,000 Gallons)	Diesel Oil (1,000 Gallons)	Electricity 1,000 kWh	LNG 1,000 kg
Glass	2,436	137	7,188	-
Sand	212	54	1,691	-
Cement & Limestone	28,310	4,443	110,292	-
Cement Products	-	758	7,863	-
Metal				
Iron & Steel	933	248	44,776	-
Metal Prod.	-	438	10,760	-
Machinery	28	92	6,073	-
Transport.	136	10	123	-
Other Mfg.	-	175	3,700	-
Total	52,332	15,193	493,867	2,841

Source: COENER

Exhibit 1.j

Energy Data For Selected Industrial Plants

INDUSTRY			THERMAL - BOILER							ELECTRICAL					
Sector	Sub Sector	Company Name	Total H.P.	Steam lbs/hr	Year	Temp. F	Press. psi	Fuel Oil gal/yr	Fuel Cost RD$/yr	Emerg. Diesel (kW)	Diesel Oil gal/yr	Diesel Cost RD$/yr	Instal. Cap. kW	Elec. Energy kWh/yr	Elec. Cost RD$/yr
Food	Meats	Iduveco	355	12,248	75/81	327	85	116,430	105,065	-	37,152	44,532	479	720,940	124,000
Food	Dairy	Pasturizado	250	6,285	-	327	100	80,893	293,616	1,240	139,985	515,354	532	3,912,480	810,300
Food	Fruits/Veg	Agro-Industrial	500	13,234	-	352	105	-	-	-	504,000	2,721,600	375	400,044	220,000
Food	Cooking oil	Indogasco	250	1,200	-	358	150	64,641	231,368	250	12,279	60,777	250	318,480	70,900
Food	Milling	Molinos Dominicanos	-	-	-	-	-	-	-	160	17,900	20,602	800	11,020,000	1,600,000
Beverages	Beer	Cerveceria Nacional Dominicana	2,700	21,000	-	-	-	1,118,700	-	-	164,000	-	200	13,820,071	-
Beverages	Soda	Embotelladora Dominicana	300	1,730	75	334	45	34,320	36,012	-	45,900	75,330	1,500	523,200	3,000,000
Beverages	Spirits	Destileria del Yaque	-	12,000	67	-	120	-	-	300	1,000,000	2,510,000	149	700,000	140,000
Textiles	-	Gonzales & Co.	200	2,300	75	340	115	67,032	255,392	400	4,403	17,392	129	575,840	115,000
Pulp & Paper	Raw Materials	Cartones Haina	-	20,000	74	344	125	720,000	2,736,000	300	-	-	3,000	10,080,000	2,620,000
Chemicals	Plastic Products	Industrias Asociadas	-	-	-	-	-	24,400	28,792	500	27,000	31,000	113	3,097,620	467,000
Chemicals	Pharmaceu-ticals	Quimicas Industrial	-	-	-	-	-	-	-	-	-	-	250	595,128	1,800,000
Cement	Cement	Cibao	-	-	-	-	-	8,366,900	3,044,145	300	-	-	149	700,000	964,100

Source: COENER and Hagler, Bailly & Company surveys.

Exhibit 1.k

Technical Cogeneration Potential by Industry (in MW)

Food Production	31.4
Beverages	6.5
Textiles	2.1
Pulp & Paper	7.0
Refinery	3.3
Total	**50.6 MW**

Notes:

1. Sectors not listed, e.g., chemicals, glass, metals, have no requirement for low grade steam or heat.
2. Cement and sugar are the subject of separate studies.

Source: COENER

be installed in existing Dominican industries today. Food, beverages, and pulp and paper plants account for over 70 percent of the total potential, with food processing clearly representing the largest potential.

There is a large amount of steam (thermal energy) available for cogeneration in the sugar industry as well. In-plant use of energy from sugar cane is approximately 20 to 30 kWh/ton of cane crushed and electricity production can be as high as 70 kWh/ton. Therefore some 40 to 50 kWh/ton of energy is available from cogeneration during the processing season. CEA, the government-owned sugar company, processes approximately 8 million tons of cane annually and private mills process some 3 million tons. Together they produce 500 GWh/year from their wastes. Based on a 2,000 hour processing season, 250 MW of capacity could be available for cogeneration from the sugar industry. In fact by year end 1987, some 90 additional MW will be in place (Rio Haina 42 MW, Boca Chica 12 MW, Barahone 37 MW) for cogeneration and sale to CDE. On a conservative basis, at least 100 MW of cogeneration capacity will be available from the sugar industry over the next two years.

ECONOMIC AND FINANCIAL POTENTIALS

The team subjected their data to further analysis to determine the economic potential. The economic potential (16 MW) is that portion of the technical potential that can be developed with resulting electricity costs lower than the production costs of electric utilities. To determine the economic potential, the analysis uses only the true economic costs and benefits and factors out "transfer payments," such as taxes and duties, that do not represent actual costs, but rather shifts of resources from one sector to another. The details of this analysis are given in Appendix D.

Finally, in recognition of the fact that investment decisions are made by private investors using financial data and market conditions, the team also developed an estimate of the financial potential (15 MW). The financial analysis weighs the project from the viewpoint of the investor. The actual cash flow is determined using market values for capital costs, labor, and

materials. It incorporates taxes, duties, profits, and other transfer payments explicitly, and determines the actual return to the investor. As with the technical potential, the most significant market is in the food processing sector, although most of the systems would tend to be less than one MW in size. The results of this analysis are also given in Appendix D.

Since this study concentrates on the role of the private sector in power generation, the emphasis of the decision making process should be on the financial potential.

CHAPTER 2: INSTITUTIONAL ASPECTS OF PRIVATE SECTOR COGENERATION

BARRIERS TO COGENERATION

Although there is a strong technical potential for cogeneration in the Dominican Republic, this energy conservation opportunity may not be exploited in the near future because of a number of institutional and policy barriers. This conclusion is based upon information gathered from CDE, COENER, and five companies, including one cogenerator and two that had attempted on-site cogeneration without success.

The details are presented below. First, the barriers are identified and discussed, together with possible actions to overcome them. Then, the perceptions of the utility and the companies relative to cogeneration are described.

Some indication of the low level of development of cogeneration in the Dominican Republic is given by the fact that neither COENER nor CDE was able to name any cogenerators outside of the sugar and cement industries. The principal hindrance to cogeneration development appears to be that its economic potential has been seriously eroded by energy pricing practices that distort the internal market price relationship between petroleum fuels and electricity. Over the period 1973 to 1985, the price of Bunker C rose 1,600 percent while industrial electricity rates rose 700 percent. Thus, given the present energy price structure that is characterized by expensive petroleum fuels, the economic potential for cogeneration appears to reside mainly in industries that generate waste that can serve as fuel. Interviews with COENER staff, CDE, and several companies revealed regulatory, institutional, communications, and structural impediments to cogeneration development. These impediments are set forth in Exhibit 2.a, together with resulting problems and possible solutions.

Exhibit 2.a

IMPEDIMENTS TO COGENERATION DEVELOPMENT IN THE DOMINICAN REPUBLIC

Impediment	Problem	Action Required
Policy, Legal and Regulatory		
• Lack of a clear national policy on cogeneration.	• Failure to manage cogeneration development on a national level to maximum advantage.	• Formulate optimum cogeneration policy.
• CDE monopoly on sale of power within the Dominican Republic.	• CDE hesitates to promote new cogeneration projects except for process waste plants.	• Implement optimum national cogeneration policy with clear role for CDE.
• Indirect subsidies provide CDE with a cost advantage over non-utility generators.	• Preferential fuel prices and duty-free equipment imports for CDE result in low electricity prices and a disincentive to potential cogenerators.	• Determine if CDE subsidies support national energy policy objectives. • Adjust electricity prices to reflect economic costs.
• Sharp fuel price increases in recent years relative to the industrial electricity tariff.	• Cogeneration costs were inflated relative to purchased power. Potential cogenerators declare that it is cheaper to buy CDE electricity than to cogenerate.	• Adjust energy prices to reflect economic costs.
• Lack of provisions for purchase of electricity from cogenerators: each case is negotiated individually.	• Causes uncertainty to potential cogenerators and increases their risk.	• Regulatory action in line with national policy decisions (perhaps following the PURPA example).
Institutional		
• Lack of an institutional framework to manage application of cogeneration technology.	• Lack of a coordinated approach to the exploitation of cogeneration technology as an element of the national energy program. • Loss of an opportunity to close the nation's energy gap to conserve energy and to stimulate industrial development.	• Provide an institutional framework that will promote exploitation of cogeneration technology in the nation's best interest as an integral element of national energy management.

Exhibit 2.a (continued)

IMPEDIMENTS TO COGENERATION DEVELOPMENT IN THE DOMINICAN REPUBLIC

Impediment	Problem	Action Required
Communications		
• Lack of awareness and knowledge of cogeneration technology and its benefits.	• Lack of initiative in cogeneration development on the part of industry.	• Conduct an information, awareness, and technology transfer program for cogeneration.
	• Investment in electricity generating systems with a lower initial cost/kWh than cogeneration, but with a higher life cycle cost.	• Provide a directory of cogeneration equipment and suppliers.
• Lack of successful cogeneration examples to follow, and news of unsuccessful projects.	• Reduced confidence in cogeneration and inhibition of its exploitation.	• Promote demonstration projects using FIDE energy conservation funds.
Structural		
• Sugar mill cogeneration installations were designed primarily as process waste incinerators; consequently, they are inefficient. Also, sugar mills do not treat the sale of power to CDE as revenue.	• Lack of management incentive to increase cogeneration efficiency.	• Correct accounting of cogeneration costs and benefits.
• State-owned companies form a large part of Dominican industry. Most are unprofitable and do not generate sufficient funds for capital investment.	• Public companies are less flexible in reacting to cogeneration opportunities than private firms. They lack funds for exploiting capital investment opportunities.	• Restructure or sell unprofitable public companies. • Conduct a centralized cogeneration information program for public companies.

Policy, Legal, and Regulatory Impediments

In the absence of a specific government policy on cogeneration, a number of measures taken over a period of several years have had the effect of subsidizing electricity generation by CDE (via preferential equipment and fuel import prices) and have not promoted cogeneration. Thus, the degree to which the development of cogeneration is encouraged (or discouraged) is reported to depend upon the views of CDE senior management at any given time. This may have resulted in failure to exploit the technology to maximum advantage and the consequent loss of an opportunity to alleviate a chronic national power shortage.

A national cogeneration policy is therefore required, based on economic costs and benefits, and backed by coordinated regulatory and pricing actions that will provide the necessary environment for optimum development of cogeneration. In this connection it is worth examining the case of the United States which enacted the Public Utility Regulatory Policies Act (PURPA) in 1978. PURPA will have facilitated the generation of more than 20,000 MW of private sector power by 1987. An in-depth discussion of PURPA is given in Chapter 3.

Institutional Impediments

The country needs an institutional framework for analyzing the cogeneration potential, formulating policy, drafting legislation, and managing a cogeneration program. The two government organizations which are involved in energy issues are CDE and COENER. COENER has overall policy responsibility but in practice many policy decisions are made by CDE management, certainly in the power sector. The roles of these two institutions need to be better defined within the government to determine how they can be organized to support the development of cogeneration.

Lack of Information and Technology

Interviews with institutions and companies revealed a lack of understanding of cogeneration principles, technology, and potential. The two cogeneration projects examined were motivated by a need to dispose of biomass waste or by a low fuel oil price advantage that subsequently evaporated. In the former case cogeneration efficiency was not a prime consideration and in the latter the engineering design was deficient, resulting in a technical and economic failure. In neither case was the sale of excess power a major consideration. There is a need to provide potential cogenerators with information, technology, and assistance in conducting financial analyses. A successful cogeneration project in the Dominican Republic would convey confidence and credibility to potential cogenerators.

Structural Impediments

Much of the installed cogeneration capacity is in the sugar industry, where the state-owned CEA accounts for about 2/3 of Dominican sugar production. As mentioned previously, the existing cogeneration units were designed primarily as process waste incinerators. Since the ailing sugar industry is scaling back production, there appears to be little hope of improving cogeneration efficiency, or even reaching past energy generation levels. However, in view of the fact that sugar mills use indigenous fuels (bagasse and cane residue), a financial analysis based on economic costs might indicate the desirability of providing conditions for increasing their generation of electricity for sale to CDE.

Recognizing the need to reduce petroleum imports, CDE favors development of cogeneration capacity based on industrial process waste. In practice, CDE support for cogeneration appears to center on the state-owned sugar mills. The technical and managerial capabilities of potential cogenerators was not regarded as a problem by CDE.

Industry Impediments

Industrial managers consider that with present fuel and electricity pricing it is cheaper to buy power than to generate it on-site. Cogeneration would be desirable to relieve the problem of CDE power interruptions; however, this is commonly accomplished by providing diesel standby generating capacity. On the whole, cogeneration is not considered an attractive investment under present circumstances, again because of the subsidized electricity prices, low oil prices, and industry's investment priorities which center on increasing production capacity.

In the on-site generation projects examined by the study team, sale of power to CDE was not a critical revenue element. A clear policy on power purchase price might increase the importance of this element, so that together with a revision of fuel and power prices and measures to reduce cogeneration's risks, the sale of power to CDE could become a factor in investment decisions.

POLICY ENVIRONMENT

Corporacion Dominicana de Electricidad (CDE)

Generating Capacity:

CDE began operating as a public enterprise in 1955 and has an exclusive right to sell electricity to the public. The utility has 1,010 MW of gross installed generating capacity and approximately 563 MW net firm reliable capacity. Exhibit 2.b shows the utility's installed capacity by plant. Rehabilitation of

Exhibit 2.b

CDE Installed Generating Capacity by Plant, 1986

INSTALLED GENERATING CAPACITY, MW											
STEAM			GAS			DIESEL			HYDRO		
PLANT		STEAM CAPACITY	PLANT		TURBINE CAPACITY	PLANT		CAPACITY	PLANT		CAPACITY
Itabo	1	125.00	Los Minas	1	35.00	Santiago	1	6.00	Tavera	1	40.00
				2	35.00		2	6.00		2	40.00
Haina	1	54.00									
	2	54.00	Tiobeque	1	21.10				Valdesia	1	27.00
	3	84.00		2	21.10	Constanza	1	0.25		2	27.00
	4	84.90					2	0.30			
	5	84.90	S.P.Macoris	1	28.30		3	1.00	Sabana Yegua		13.00
							4	1.00			
Sto Dgo	5	12.65	S.P.M.-Weber		20.00				Rincon		10.10
	6	12.65				S.de la Mar	1	0.50			
	7	12.65	Barahona		28.30		2	0.50	Las Damas		7.50
	8	26.50									
						Pedernales	1	0.25	Sabaneta		6.00
Pto Plata	1	27.63					2	0.34			
	2	36.75					3	1.10	Jimenoa		7.50
									Hatillo		8.00
									Constanza		0.25
									S. Jose Ocoa		0.19
									Los Ranchitos		0.85
TOTAL		616.53			188.8			17.24			187.39

Source: CDE

several generating units is in progress with a view toward adding 141 MW of reliable capacity.

Some feel that over the past 20 years CDE has failed to provide satisfactory service to its customers and is not likely to improve its service level in the near future. In an attempt to satisfy demand, CDE has built hydroelectric complexes and has attempted to develop non-conventional energy sources; nevertheless, frequent power interruptions continue to be the rule.

In the period 1973-85, CDE increased its installed capacity some 300 percent (1,010 MW vs. 250 MW), primarily by adding hydroelectric generating capacity. Exhibit 2.c shows the growth of generating capacity over this period by plant type. The net generation of power over the same period is shown in Exhibit 2.d, also by type of generating plant.

An analysis of generating capacity utilization shows that it has been well below the optimum range of 80-85 percent during the period 1973-85 and has followed a downward trend. Capacity utilization is defined as the ratio of energy produced to installed generating capacity. Capacity utilization data are presented in Exhibit 2.e.

Since 1977, CDE has supplemented its own generated power with purchases from two principal sources, CEA, the state-owned sugar group, and Falconbridge Dominicana, to fill the gap between supply and demand.

CDE Policies:

In general, CDE's energy policies reflect the fact that the company is required by law to satisfy the nation's power demand. There is room for interpretation of the utility's obligations, however, and policies reflect the views of senior management at any given time.

Present policies are reported to be as follows:

- CDE will satisfy demand primarily by generating power in its own plants.

Exhibit 2.c

CDE Installed Generating Capacity

by Power Plant Type, 1973-85 (in MW)

Year	Steam Turbine	Gas Turbine	Diesel	Hydro	Total
1973	213.6	0.0	20.9	15.3	249.8
1974	213.6	98.8	18.7	95.3	4,426.4
1975	213.6	98.8	18.3	149.3	480.0
1976	377.4	98.8	18.3	149.3	643.8
1977	377.4	98.8	19.3	149.3	644.8
1978	377.4	118.8	18.5	159.4	674.1
1979	377.4	118.8	12.4	159.4	668.0
1980	370.0	118.8	14.9	159.6	663.3
1981	370.0	188.8	5.7	178.4	742.9
1982	491.6	188.8	10.0	186.4	876.8
1983	491.6	188.8	9.9	187.4	877.7
1984	616.6	188.8	16.9	187.4	1,009.7
1985	616.6	188.8	17.2	187.4	1,010.0

Source: CDE

Exhibit 2.d

CDE Net Power Generated

by Power Plant Type, 1973-85 GWh

Year	Steam	Gas Turbine	Diesel	Hydro	Total
1973	1,115.4	0.0	22.2	59.6	1,196.8
1974	969.9	167.7	20.4	188.0	1,445.9
1975	890.3	461.6	30.0	161.0	1,542.8
1976	1,0103.1	295.4	17.0	292.3	1,607.9
1977	1,514.1	280.0	8.7	172.0	1,974.8
1978	1,634.9	301.6	6.9	279.6	2,232.1
1979	1,563.4	219.6	6.5	310.0	2,099.5
1980	1,882.6	245.3	10.9	107.7	2,346.5
1981	1,801.4	273.5	6.6	512.1	2,593.7
1982	1,777.5	280.1	6.4	317.1	2,381.0
1983	2,068.6	275.9	10.8	352.0	2,707.4
1984	1,882.6	460.9	10.0	433.9	2,787.3
1985	2,312.8	241.4	11.9	426.6	2,992.8

Source: CDE

Exhibit 2.e

CDE Generating Capacity Utilization*

by Power Plant Type, 1983-85 (%)

Year	Steam	Gas Turbine	Diesel	Hydro	Total
1973	63	-	10	44	58
1974	55	31	9	23	40
1975	51	54	13	12	38
1976	32	34	9	22	30
1977	48	33	5	13	37
1978	53	30	3	20	39
1979	50	21	4	22	38
1980	61	24	6	15	42
1981	59	17	3	33	42
1982	44	17	4	20	33
1983	65	17	7	22	37
1984	37	28	6	27	33
1985	46	15	8	26	36

* Ratio of energy produced to installed capacity.

Source: CDE

- In expanding capacity priority is given to a high return on investment and to replacing imported petroleum with indigenous energy sources.
- The utility will support industrial on-site generation projects only in cases where the energy source is process waste that requires disposal.
- The price paid for purchased electricity will not exceed CDE's production cost less distribution and collection costs.

The above policies are currently manifested as follows:

- CDE plans to phase out power purchases from Falconbridge Dominicana because the supply is perceived to be high-priced and not reliable in the medium term.
- All on-site generation projects must be submitted to CDE for approval.
- Expansion plans include projects of CEA and INRHI using indigenous energy sources.
- Of the 17 generation projects under construction, authorized, or planned, 8 use hydropower, 5 use biomass (supplemented by coal in 3 cases), and 4 are fueled by coal.

Growth Forecast:

Electric power demand is expected to increase at a rate of 9.2 percent annually over the coming nine years, rising from 610 MW and 3,597 GWh net in 1986 to 1,280 MW and 7,543 GWh net in 1995. The growth forecast takes into account the fact that there is a significant suppression of urban and rural demand at present. This demand will develop rapidly when service is improved as a result of capacity expansion plans, rehabilitation of the distribution system, and rural electrification.

Projects currently under construction and authorized will provide 321.7 MW of additional capacity by 1991. They are listed in Exhibit 2.f. In addition, CDE's current expansion plan envisions further additions to generation capacity as shown in Exhibit 2.g. The list comprises 7 CDE projects, 1 CEA project, and 2 INRHI projects. These projects would add 584.5 MW of capacity by 1995. However, although authorized, international financing for these additions must still be secured and is by no means certain. For this reason, cogeneration should be given more serious consideration by CDE.

Pricing Polices:

Although subsidized by a number of factors, the price of electricity in the Dominican Republic has been linked to the cost of imported fuels. The average price for a kWh of electricity was approximately RD$ 0.033 in 1973 rising to RD$ 0.137 by 1984, and to approximately RD$ 0.25 (U.S. $0.08) for industrial users by 1986. In 1973, the cost of imported fuel represented roughly 58 percent of the cost of generating electricity; it represents 90 percent of generation cost today. By mid-1986, the average residential tariff had risen to RD$ 0.141, the commercial tariff to RD$ 0.314, and the industrial tariff (per kWh) to RD$ 0.295. Rates had been automatically increased some two percent per month until June, 1986.

The tariff structure for both residential and commercial users is slightly progressive after the first 15 kWh and flat for industrial users above the demand charge. (See Exhibit 2.h). Fuel purchases by CDE are almost evenly split between the refinery and direct imports. CDE pays the following for its fuels:

	Fuel Oil (1986)	Diesel Oil (1986)
Refinery Produced	$2x10^6$ bbl @ RD$ 29/bbl	$0.8x10^6$ bbl @ RD$ 44/bbl
Directly Imported	$2x10^6$ bbl @ RD$ 42/bbl	$0.6x10^6$ bbl @ RD$ 58/bbl

Exhibit 2.f

CDE Generation Projects Under Construction or Authorized

Plant Name	Capacity (MW)	Type Plant	Year On-Line
Itabo	110.0	Coal	1987
Lopez A	16.2	Hydroelectric	N.A.
S. Pedro de Macoris	27.9	Bagasse	1988
Rio Blanco	18.0	Hydroelectric	1989
Barahana	40.0	Bagasse/Coal	1989
El Torito-Los	13.6	Hydroelectric	1991
Veganos Maraboa-Bejucal Tavera	96.0	Hydroelectric	1991
Total	321.7		

Source: CDE

Exhibit 2.g

CDE Expansion Plan Projects

Plant Name	Capacity (MW)	Type Plant	Date On-Line	Investment* RD$ Millions
Arroyo Barril #1	110.0	Coal	1990	364.0
San Pedro #2	27.9	Bagasse	1992	78.3
Cumayasa	40.0	Wood/Coal	1992	138.0
Barahona #2	40.0	Bagasse/Coal	1992	134.0
Ingenio Rio Haina -CEA-	41.5	Bagasse/Coal	1992	140.6
Proy. Riego Yaque Norte -INDRHI-	9.5	Hydroelectric	1992	54.0
Las Placetas	82.7	Hydroelectric	1993	438.8
Arroyo Barril #2	110.0	Coal	1994	364.0
Jiguey -INDRHI-	89.2	Hydroelectric	1995	322.5
Piedra Gorda	33.7	Hydroelectric	1995	205.9
Total	584.5			

* In 1985 RD$. For thermoelectric plants the cost data refer to net capacity in MW. The cost data for hydroelectric plants refer to firm capacity, and not to installed capacity. Interest expense during construction is excluded.

Source: CDE

Exhibit 2.h

CDE Electricity Tariffs (1986)

Commercial	per kWh
0 - 15 kWh	RD$ 5.19
next 85 kWh	RD$ 0.167
next 100 kWh	RD$ 0.168
next 140 kWh	RD$ 0.170
next 160 kWh	RD$ 0.170
next 250 kWh	RD$ 0.171
next 2000 kWh	RD$ 0.172
next 7000 kWh	RD$ 0.174
next 1000 kWh	RD$ 0.175

General Power (Industrial)	
Demand Charge	
0 - 25 KVA	RD$ 80.80
over 25 KVA	RD$ 3.09
Energy Charge	RD$ 0.183

Approximate Levelized Cost Paid by Industry

RD$ 0.23 - 0.25/kWh

Source: CDE and COENER

La Refineria Dominicana de Petroleo, S.A.

Liquid fuel distribution in the Dominican Republic is handled through seven distributors, one of which is Shell International, the builder and operator of the country's single refinery. Shell has been managing operations of the 30,000 barrel per day refinery since its construction in early 1973. The hydroskimming plant purchases its crude oil from Mexico and Venezuela - about 14,000 barrels per day from each. CDE obtains all its fuel supplies from the refinery and through direct importation. Currently, the refinery pays approximately RD$ 42.6 per barrel to its suppliers. Recent and current fuel prices are given in Exhibits 2.i and 2.j.

The refinery does not have its own electric power source (except an emergency set) and is forced to buy electricity from a CDE plant located adjacent to the refinery. The refinery has sought its own generation source since 1978 but its board has consistently denied permission. The refinery is 50 percent government owned and 50 percent privately owned with a board of eight members evenly split.

In 1981, a feasibility study recommended a low speed diesel or gas turbine for the refinery. The refinery is often plagued by power failures (5 for this year as of October 1986) and voltage drops (20 for the same period). Plant personnel have exhibited concern because safety systems fail when power is not adequate.

The refinery is also a good candidate for cogeneration since it has low pressure steam requirements of between 15 and 30 tons per hour, currently being met with fuel oil (roughly 2.7 percent of incoming petroleum used within the plant). The plant's installed demand is 2.2 MW with a peak of 2.6 MW. The refinery pays a levelized charge of 0.23 RD$/kWh to CDE. If allowed to generate its own power, a 3.2 MW slow speed diesel would probably be installed at a cost of approximately $1.2-1.5 million (1981 capital cost).

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Exhibit 2.i

Recent Fuel Prices

(RD$ per gallon)

Year	Diesel Oil	Fuel Oil	LPG (per 100 lbs)	Kerosene
1970	0.20	-	9.75	0.32
1971	0.21	-	9.75	0.33
1972	0.21	-	9.75	0.33
1973	0.32	0.23	10.76	0.64
1974	0.50	0.40	15.50	0.87
1975	0.48	0.41	15.50	0.80
1976	0.48	0.41	15.50	0.71
1977	0.53	0.47	15.50	0.76
1978	0.53	0.46	15.13	0.76
1979	0.75	0.52	15.79	0.81
1980	0.90	0.54	18.33	0.83
1981	1.15	0.72	22.85	0.96
1982	1.15	0.72	22.85	0.96
1983	1.15	0.72	20.50	0.96
1984	1.52	1.12	23.00	1.31
1985	3.95	3.80	31.50	3.75

Source: COENER

Exhibit 2.j

Current Fuel Prices and Characteristics

Product	Density	Lower Calorific Value			Unit Cost	
	lb/ft^3	lb/g	Btu/lb	Btu/g	RD$/g	RD$/MMBtu
Petroleum	52.93	7.08	18,420	130,345	-	-
LPG	31.86	4.26	17,300	73,698	3.80	51.56
Gasoline	46.26	6.18	19,046	117,790	3.00	25.47
Kerosene	49.81	6.66	18,600	123,868	2.75	22.20
Diesel Fuel	52.93	7.08	18,569	131,400	2.50	19.03
Fuel Oil	55.54	7.42	19,091	141,740	3.85	27.16

Source: COENER

Fondo de Inversiones para el Desarrolla Economica (FIDE)

In mid-1984, the government of the Dominican Republic introduced an energy project financing mechanism which was implemented in April of 1986. Appropriately named Fondo de Inversiones para el Desarrolla Economica (FIDE), its goal was to create a financial pool for investments in industrial energy conservation measures. The program was jointly funded by USAID for RD$ 4.0 million and the Banco Central for RD$ 4.0 million. Funds were to be used for such measures as new energy saving process equipment, ventilating, air conditioning, illumination, fuelwood plantations, and, of course, cogeneration equipment. All interested industries were encouraged to participate, but generally an in-depth energy audit by COENER was required as a first step.

Financing was made available at up to 90 percent of total project costs with a minimum of RD$ 10,000 and a maximum of RD$ 1.0 million. The conditions included loan terms from 2 to 12 years with grace periods from six months to five years for long term loans. Interest rates varied from 7 to 12 percent depending on geographic location in the Dominican Republic. This financial mechanism has been used by several private firms to support process and building changes recommended in the COENER audits.

This mechanism is ideal for financing cogeneration equipment. However, it should be noted that RD$ 8 million will be insufficient to support a major program. In addition, with the importation of energy conservation equipment, the investor must also pay import duties totaling approximately 26 percent of the F.O.B. equipment price. Therefore, plans to carry out cogeneration projects must include increased financial resources through FIDE.

POLICY INITIATIVES TO ENCOURAGE COGENERATION

In the Dominican Republic, independent cogenerators will need to rely on CDE to sell their power, either directly or indirectly to other customers through the distribution network. In addition, these cogenerators will need to rely on CDE for back-up power during system failure or maintenance. Therefore, the nature of interaction between CDE and independent cogenerators plays a

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key role in the feasibility and viability of such power generation schemes. The main component of such interactions is the purchase price that CDE is willing to pay for cogenerated power and the fee they charge for transmitting the power to other customers. The purchase price, to a large extent determines the financial viability of any cogeneration project.

This section focuses on identifying major issues of utility-cogenerator interactions and defining an electricity purchase price in the Dominican Republic. First, the U.S. experience with regulatory reforms intended to enhance cogeneration options is reviewed. This experience is not intended to be replicated in the Dominican Republic but can serve as a guide to a possible course of action. Possible approaches for defining electricity purchase price are explained in Appendix C and finally, some preliminary estimates of the CDE purchase price are made.

The U.S. Experience: PURPA

The Public Utility Regulatory Policies Act (PURPA) passed by the U.S. Congress in 1978 dramatically altered the legal standing of certain broad categories of private power production in the United States. Prior to 1978, U.S. electric utilities were under no obligation to interconnect with private power producers for the purpose of accepting power from them nor were there clear guidelines on how rates for supplementary and backup power to such facilities should be developed.

Today U.S. electric utilities are obligated to purchase power from qualifying cogenerating and small power producing facilities at rates that reflect the value of the power to the utility and to provide supplementary, standby, and maintenance power to such facilities at reasonable rates.

Key Provisions

PURPA contains several key provisions that significantly alter the legal standing of cogenerators and small power producers meeting certain size, fuel use, and efficiency criteria ("qualifying facilities" or "QFs").

First, it authorizes the Federal Energy Regulatory Commission (FERC) to order electric utilities to interconnect with such qualifying facilities for the purpose of purchasing power from them and selling power to them.

Second, it requires that the rate for purchase of power from such facilities be based on the energy costs (i.e., fuel and operation and maintenance costs) and capacity costs that the electric utility avoids incurring as a consequence of the power provided by the qualifying facility.

Third, it requires electric utilities to sell power to the facilities for the following purposes: 1) to supplement a facility's own generation; 2) to serve as backup for use during forced outages at the facility; and 3) for use during periods of scheduled maintenance. Finally, it exempts most qualifying facilities from federal and state regulation as electric utilities.

Eligibility Criteria:

To be eligible for the benefits of PURPA, a facility must qualify as either a "small power producer" or a "cogenerator." Cogeneration facilities are defined as those using energy sequentially to generate both electricity and thermal energy that is usefully employed.

Cogeneration must meet certain operating and efficiency standards. For topping cycle cogeneration systems, the usefully employed thermal energy must constitute at least 5 percent of the total energy output. For oil or natural gas-burning cogeneration systems, the sum of the electrical output and one-half the total useful thermal output must be at least 42.5 percent of the total oil and gas input to the facility, or 45 percent if the useful thermal energy output is less than 15 percent of the total energy output of the facility. For bottoming cycle cogeneration facilities, the only requirement is that the useful power output be at last 45 percent of any oil or natural gas used for supplementary firing. There is no upper limit on the size of a qualifying cogeneration system.

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Implementation Process:

PURPA established a two-step implementation procedure that involves both FERC and the state commissions. FERC's role was to establish broad rules defining the fuel use and efficiency criteria that must be met to qualify for the benefits of PURPA and to specify how rates for purchases and sales are determined. Based on these FERC rules, the state commissions were to establish detailed rules covering the determination of avoided costs and to be responsible for the establishment of tariffs, rates, and interconnection equipment standards. In 1980, FERC implemented PURPA and since that time several thousand MWs of cogeneration have been brought on line.

Applicability In The Dominican Republic

Fundamentally, there are no differences between the definition of "avoided cost" for a utility in the United States and CDE in the Dominican Republic. The selection of a methodology for calculating the avoided costs, however, depends on each utility's generation mix, load shape, future expansion plans, and technical and personnel capabilities in using certain methodology. There are a number of specific guidelines that may prove to be helpful in the Dominican Republic:

1. Since CDE has a large capacity deficit, independent generation units should be given both capacity and energy credit.

2. The level of sophistication of the purchase price structure should not differ much from the utility's rate structure. For example, CDE does not have time-of-day charges (no peak, off-peak pricing) at present; therefore, the purchase price should follow the same structure. Otherwise, CDE may need additional personnel to administer such rates. This does not mean however, that CDE should underestimate the value of cogenerated power. If there is an understanding that electricity will be sold to the grid during peak hours, when the expensive generation units are in operation, the credit for such supply should include the high variable generation costs.

3. CDE has transmission and distribution losses in its system (as high as 25 percent). As a result, when the power supplied to the grid by a cogenerator can be used locally, extra credit should be allowed for the purchase of power.

4. In the United States, PURPA allows utilities to negotiate the purchase price with a cogenerator within the indicated general guidelines and provisions. Although this arrangement provides enough flexibility to ensure an effective rate for each facility, it may create difficulties in the Dominican Republic, putting too great a strain on the utility's limited manpower. Therefore, CDE should use one fixed rate -- or a limited number of fixed rates -- across the board.

5. The establishment of purchase price requires detailed analysis of CDE operation schedules, fuel and O&M costs, mix of generation units, and system losses both at present and during the term of an announced purchase price. Furthermore, the establishment of these prices should consider the role of CDE in the Dominican Republic. Utilities are agencies of the government and follow its overall national policies with regard to the need for power and its importance to the country. Therefore, the purchase price should take into consideration the attributes of non-utility power generation that are not easily quantifiable, such as improved national power system reliability and resiliency and increased industrial productivity. Consideration of these attributes would require a separate detailed analysis, however.

Avoided Cost Estimates in the Dominican Republic:

The detailed calculation of utility avoided costs in the Dominican Republic requires comprehensive system simulations that are beyond the scope of this study. This section, therefore, concentrates on making some preliminary estimates of the range of avoided costs for CDE. The unique structure of CDE in the Dominican Republic provides some simplified approaches to estimating the value of electricity.

The tariff charged by CDE includes both generation and distribution costs, therefore representing avoided costs. If a cogenerator is capable of providing firm capacity and energy to CDE with the same technical specification, then it should be paid the same price. Exhibit 2.k presents both generation and distribution marginal costs for CDE.

If the cogenerator is not able to provide firm capacity, its power should be valued only at the level of generation. In the Dominican Republic, this will be the case with most cogenerators. Because the distribution network is small, line losses should not influence avoided costs to a large extent.

There is also a precedent for the sale of power by private generators to CDE in the form of Falconbridge Dominicana, whose sales represent some 10 to 22 percent of the energy available from the system. CDE also purchases power from CEA, the state owned sugar industry; however, at this point CDE has stated it would purchase power only at its production cost and not its avoided cost.

From a policy standpoint, it may be advisable for the government to reflect the high cost of additional utility supply during the 1990s in higher purchase prices in the late 1980s. The government could offer a higher purchase price for the rest of this decade to non-utility cogenerators as an incentive for early entry into such an investment and thus postpone the need for utility expansion in later years. From a long-term government policy perspective, this pricing method could be an effective mechanism for introducing private capital into power generation activities.

To reflect the true value of independent power to CDE there should be a mechanism for periodic calculation of marginal costs. Since the input components of such studies -- energy cost, demand growth, load shape, and generation mix -- change constantly, CDE should initiate a program to continually evaluate the marginal cost of supply.

Exhibit 2.k

CDE Marginal Costs of Electricity

Generation	RD$/kWh
Coal Fired, Hydropower	0.085
Oil Fired	0.195
Gas Fired	0.353
Generation and Distribution	
High Tension	0.206 - 0.211
Medium Tension	0.215 - 0.218

Source: CDE

CHAPTER 3: CONCLUSIONS, RECOMMENDATIONS AND ACTION PLAN

In this chapter the major findings of the study are summarized as conclusions and recommendations intended to stimulate the development of cogeneration in the Dominican Republic.

CONCLUSIONS

1. The Dominican Republic has a modest industrial cogeneration opportunity in the near term, (1986 - 1987) of 51, 16, and 15 MW for the technical, economic and financial potential respectively (see Exhibit 3.a). The technical potential is considered that which can be developed. Based on a technical fit (cogeneration systems are only suitable in plants which have a requirement for process heat). The economic potential is that portion of the tech potential which is viable from the standpoint of nation's economy, without "transfer payments" such as taxes, duties, and profits. The financial potential is that which can profitably be developed from the investor's standpoint, using market values for costs, etc. The difference between the technical potential and economic/financial potential is primarily due to the low price of oil and low electric power rates. The cement and sugar industries are not included in the above figures, but represent a significant additional potential.

2. Over the long term (1986 - 1997), the economic and financial potential increase to 73 and 56 MW respectively, which is roughly 5 - 10 percent of CDE's power capacity (see Exhibit 3.a). This growth is a consequence of an expected industrial growth rate ranging from 3 to 5 percent annually depending on the specific industry as well as the expected increases in the price of oil in the 1990's.

3. Although the sugar and cement industrial are not part of this analysis, they represent a significant cogeneration opportunity. During the processing season, at lease 40 kWh/tone of crushed sugar cane should be available to

Exhibit 3.a

Cogeneration Potential in the Dominican Republic (MW)

	SHORT TERM 1986-1987	LONG TERM 1988-1997
Technical Potential[1]	[illegible]	>150
Economic Potential[2]	16	73
Financial Potential[3]	15	56

Notes:

1. That which can be developed based on thermal and electrical requirements.
2. That portion of the technical potential which can be developed based on the Nation's economy without "transfer payments".
3. That portion of the economic potential which can be developed from an investor's point of view including all "transfer payments".

CDE. Based on Dominican sugar production, some 500 GWh/year can be made available at the national level. A conservation long term estimate would be as much as 100 to 150 MW of capacity from sugar wastes.

4. The food processing sector has the largest potential for cogeneration since it requires large amounts of hot water and process steam. The current technical potential in this sector alone is approximately 40 MW. However, most of this potential is for systems of less than one MW, since most of the operations are small. Many of these processors produce for export and are foreign owned. They are able to draw on outside technical and financial resources, making them good candidates for cogeneration.

5. Industry in the Dominican Republic has cogeneration experience, but it has not been formally institutionalized. Two demonstration projects were funded in the past, but they failed because of technical and fuel supply problems and not institutional, financial, or economic problems. However, most private firms are not aware of this experience. A further examination of these two projects is useful in order to determine the exact causes of their shutdown. These plants were primarily put in place because of the need for continuous and guaranteed power.

6. Private sector cogeneration could play a major role in reducing current and projected gaps in electric generating capacity. The total potential could represent up to 15 percent of the utility's installed capacity (including sugar and cement). The private sector has shown an interest in cogeneration primarily because of utility service interruptions. However, the private sector will need significant assistance in assessing the technical, economic and financial feasibility to cogeneration for specific industrial plants. Industry tends to concentrate its capital investment on capacity expansion primarily and only secondarily on energy conservation.

7. The private sector will continue to need credit facilities (such as Fondo de Inversiones para el Desarrollo Economico) in order to finance energy conservation investments. Existing funds would be insufficient to carry out a major cogeneration program. Small system costs vary from $1300 to 2000/kW in the 50 to 500 kW range. To develop 15 MW would

require $22.5 million at $1300/kW. FIDE only has a fraction of this amount available. Industry is also reluctance to invest because it feel that the the low world market price of oil will continue into the future. On the one hand, this low price ($18 to $20 per barrel) is currently the greatest disincentive for cogeneration, but on the other hand, low oil prices coupled with high electricity prices make cogeneration economically promising.

8. There are no established policies at CDE regarding cogeneration, although the purchase of private sector power (e.g., from Falconbridge Dominicana) has been a practice for some time. Long-standing agreements have existed which establish price and quality of service from large scale generators, such as the sugar and mining industries, but it is not clear whether these arrangements could serve as models for cogeneration plants.

9. The principal impediment to cogeneration appears to be institutional, specifically, existing policies and legislation which appear to limit private sector power generation. CDE has been accorded a virtual monopoly over generation and distribution. It views cogeneration will not make a significant contribution to the nation's energy supply. On the other hand, CDE is willing to look into the issues but it may not have sufficient institutional capability to deal with a major cogeneration program. Issues of pricing, technical interface, and contracts would need to be resolved, perhaps guided by the PURPA experience in the U.S.

RECOMMENDATIONS

1. CCENER, with CDE concurrence, should begin to formulate a rational, well articulated cogeneration policy. This would have to be a staged process drawing initially on experiences from other countries. Private sector comments should be solicited so that industry's views can be given consideration. This policy should be communicated in a document which identifies cogeneration opportunities in Dominican industry. It should also show how to implement a project outlining the regulatory and legal steps that must be followed. Wide distribution of such a document will prompt a great deal of interest by industrial management.

2. Within COENER, a group of specialists should be created to carry out feasibility studies for industrial clients and to act as consultants to industry. This process might start by retaining a cogeneration specialist in COENER to begin a training process. In addition U.S. based training is also recommended, perhaps with Pacific Gas & Electric in California which has many cogeneration projects. Initial studies would be brief, similar to pre-audits done by COENER in the past. Eventually, this activity should be financially self supporting for COENER, requiring that the staff sell the concept to industrial clients.

3. The electricity pricing issue must be broached. Pricing should be based on the factors of production and should be as close to world market levels as possible. Built in subsidies are a disincentive to cogeneration and conservation in general. This effort needs to be implemented through a series of careful adjustments supported by in-depth analysis of the social and economic impacts. It also needs to be carried out in concert with other donor efforts at price reform, primarily the IMF.

Realistic energy pricing is the most powerful policy tool for conservation and consideration of other energy alternatives. Private industry will initially respond negatively but as oil prices rise having cogeneration systems in place will make future oil price shocks easier to cope with.

4. In order for cogeneration to take hold, a regulatory structure and institutional framework needs to be established that clearly articulates the roles and responsibilities of CDE and private sector cogenerators. The approach may be similar to PURPA in the United States but specific provisions must be tailored to the Dominican reality. In conjunction, the regulations which currently govern power generation and distribution need to be carefully examined. A group of regulatory experts and utility economists may be needed to make recommendations on necessary changes that will encourage cogeneration. In addition to an institutional framework, a detailed action plan needed to be drawn up to promote cogeneration in high levels of government. Again comments from the private sector and consultants should be solicited in this process.

5. An information, awareness, and technology transfer or outreach campaign should be initiated by COENER. The campaign should include publications illustrating how the technology fits into existing plants, its economic-financial rationale, and equipment suppliers and costs. This should be in the form of easy-to-read pamphlets in Spanish.

6. One or two demonstrations projects should also be developed in both public and private sector industries. These should be funded by FIDE and continually analyzed to monitor technical and economic performance. These projects should be started immediately so that a real-world base of experience can be developed. A separate cogeneration program should be established for public sector companies. This would be in addition to the efforts currently under way in the sugar industry.

7. Increased funding of FIDE must be considered if a major cogeneration program is to be initiated. In the short term a doubling of financial resources will be needed. In addition, strictly private financing channels should be identified and made available to larger cogenerators.

8. Special emphasis should be place on the sugar industry since its cogeneration potential is large. Although, the sugar industry has been selling power to CDE for many years, its contribution has been low, never exceeding seven percent of CDE capacity. Current installed potential is only 62 MW, but if all residues are used, the future potential could be in the range of 100 to 150 MW. This could reach 15 percent of CDE's installed capacity.

ACTION PLAN

In order to accelerate cogeneration development in the Dominican Republic, the following activities need to be carried out simultaneously by the designated institutions:

1. COENER

A. Develop Appropriate Human Resources

A small group of specialists should be created to carry out feasibility studies for industrial clients and to act as consultants to industry. This process begins by placing a cogeneration specialists in COENER to train a small cadre of individuals. Some U.S. based training is also recommended. Initial feasibility studies would be brief, similar to pre-audits done by COENER in the past. This activity should be financially self supporting and therefore it will be necessary for COENER staff to sell the concept to clients. In addition, seminars and workshops should be held for industrial managers on the general aspects of cogeneration. These seminars would be given by outside specialists.

B. Prepare Documentation

A technical document needs to be prepared for Dominican industrial management which identifies the benefits of cogeneration and outline preliminary steps to implement a project. This document should be written in Spanish by COENER staff in conjunction with the cogeneration specialists.

C. Begin Feasibility Studies

Feasibility studies on cogeneration projects should begin immediately. Specific industries, starting with food processing, should be contacted and given a formal presentation by COENER on the technical, economic, and financial benefits of this technology.

D. Establish a Working Group

An interagency working group or standing committee needs to be formed to promote cogeneration. This group would be made up of COENER, CDE and private sector representatives. The group would meed periodically to identify cogeneration projects and to advocate the technology within their own organizations. COENER should be responsible for establishing this group and organizing the meetings.

2. CDE

A. Establish an Institutional Framework

The existing legal framework for power generation in the Dominican Republic should be reviewed by an institutional specialist to determine how modifications could be introduced to encourage industrial cogeneration. This process may require specific legislative initiatives and the support of government at the highest level. This process might begin with recommendations from COENER, but CDE must eventually push if reforms are required.

B. Determine Avoided Costs

The electricity tariff must be examined to determine how it can be structured to encourage cogeneration. Specifically, an analysis needs to be done of the "avoided cost" concept, or how much CDE should pay for purchased power. There is a large body of literature that deals with this issue and it should be consulted first before hard and fast rules are established.

C. Draft a Prototypical Power Contract

A typical power purchasing contract for different types of cogenerators (scale, operating profile, industry, avoided cost procedure) must be developed. Many models for such contracts exist in the U.S. because of the PURPA history.

D. Define an Administrative Structure

An effort to define the administrative and technical aspects of operating a cogeneration program should be undertaken by CDE. This would include queries into interconnection, load management, billing and buy-back arrangements.

An effort should also be undertaken to incorporate future operational plans for existing private power generators, such as Falconbridge Dominicana into an overall cogeneration plan. The issue is to determine what fraction of CDE capacity they can be counted on to produce in the future.

E. Begin Specialized Training

CDE personnel should receive training in cogeneration technologies, economics to determine subsidy impact, avoided cost and in such areas as dispatching, interconnection and operations. This training could take place at utility in the U.S.

3. FIDE

Depending on the interest shown by industry after the outreach campaign, further credit may have to be made available to prospective private sector cogenerators. Plans to secure these funds should be considered early. Consultation between COENER and FIDe on a regular basis will be necessary to forecast what the demand for funds will be.

4. CEA

The future role of the national sugar industry in providing electricity through cogeneration to CDE needs to be firmly established. At this time there are several projects under construction. These should be monitored by COENER to determine when they will go on line.

5. USAID

Financial resources, training and consulting services must be made available in a timely and efficient manner if a cogeneration program is to be implemented. USAID could be very instrumental in encouraging such an effort both financially and through policy initiatives. An appropriate way to begin is to organize a meeting involving COENER, CDE, and industrial groups with several presentations on all aspects of cogeneration.

Exhibit 3.b shows the roles which various organizations can play in fostering a cogeneration effort.

Exhibit 3.b

Organizational Roles of Key Institutions

ROLE	COENER	CDE	USAID	FIDE	CRA	PRIV. SECT.	IDB	IBRD
• Set Policy	x	x				x		
• Establish Institutional Structure		x						
• Outreach Program	x							
• Feasibility Studies	x					x		
• Project Funding			x	x		x	x	x
• Training	x		x					
• Demonstrations					x	x		

ORGANIZATION

Source: Hagler, Bailly & Company, Inc.

APPENDIX A: SCOPE OF WORK

POTENTIAL AND POLICY ISSUES OF INDUSTRIAL COGENERATION (Excluding the Sugar Industry):

The objective of the study is to provide energy policy decision-makers with a basis for deciding whether or not specific policy initiatives should be taken to promote industrial cogeneration in the Dominican Republic. The preliminary information gathered during an early fact-finding mission indicated that the potential for cogeneration in industry will be limited to 25-35 plants representing only a fraction of current CDE generation capacity. However, the potential in new plants may be quite significant.

Industry is expected to grow at a healthy rate during the remainder of this century and it is much easier to install cogeneration systems in new plants than in existing ones. Based on this preliminary information and our experience in other countries, we estimate that the total technical potential i.e., the maximum electric capacity that could be installed to match process heat needs, is likely to be 20-30 MW in existing facilities and slightly more in new plants, for a total of 40-80 MW, or roughly 10 percent of existing CDE generating capacity. When combined with the potential in the sugar industry and cement industry (currently analyzed under a parallel U.S. Trade Development Program initiative), the overall potential and benefits may well be dramatic.

In order to develop the necessary information needed to decide whether or not a specific policy will be needed to encourage the development of cogeneration in the Dominican Republic, three tasks were proposed.

Task 1: Estimate Potential

Using the existing COENER database which contains recent fuel and electricity consumptions for large energy using plants, a representative sample was selected for analysis. Using a market penetration model, the analysis focused

on this sample (included about 20 plants) in order to identify those where electric/low-grade heat and energy demand characteristics (loads) matched cogeneration system characteristics. Plants for which a match may existed constituted the "technical potential". Next, five representative case studies (plants) were selected and visited to validate their selection. Upon validation, simple economic and financial feasibility analyses were conducted to test the option viability and indicate possible policy needs. For example, if the economic attractiveness appeared to be high but the financial performance poor, financial incentives could be proposed. The result of this task was an estimate of the economic and financial market for industrial cogeneration at present and to the year 1997. The results of the analyses conducted on the sugar and cement industries were incorporated to develop these market estimates.

Task 2: Identify Barriers

The objective of this task was to identify nonfinancial impediments to the natural development of the economic market (identified in Task 1). Such impediments were institutional (awareness, attitudes) or regulatory (CDE regulations on independent power producers). Interviews with existing cogenerators such as papermills and sugarmills, potential cogenerators, CDE, FIDE (a specialized financing institution), and CGENER staff were conducted to identify and analyze these impediments. The results of this task were summarized in tabular form to show the various impediments in relevant categories together with possible initiatives to remove them. Throughout the analysis particular attention was given to CDE operational and managerial requirements in order to help eliminate rather than create problems. For example, the development of cogeneration may well alleviate the financial problems facing CDE in meeting higher demand but could also create managerial difficulties if it is necessary to purchase or "wheel" power from a large number of small cogenerators.

Task 3: Prepare Action Plan

Based on the results of the previous tasks, the team recommended further studies and policy initiatives, together with a clear definition of the possible roles of the various parties involved, i.e., private sector and public industries, banks, CDE, COENER, and equipment vendors.

Finally, because of COENER's interest in investigating whether the private sector could play a major role in the Dominican Republic power picture, the study also described broader terms of reference for examining this sector's potential in both generation and distribution. The study team based this on their recent experience in conducting similar studies in Pakistan, Thailand, and India.

APPENDIX B: LIST OF CONTACTS

USAID/SANTO DOMINGO

William H. Smith, Energy Advisor

Leo Perez, Energy Project Advisor

COENER

Oscar LaMarche, Secretario Ejecutivo

Felix Tolentino, Head, Energy Audits

Il Canario, Energy Efficiency Project Coordinator

Ramon Duval, Director Depto. Sistemas Electricos

Francisco Gomez, CDE Coordinator

Ramon Arturo Pichardo, Tecnico

CDE

Candido Martin, Ing. de Proyecto

Eduardo Martin, Ing. Gerente de Planificacion

FLUOR

Alicia Kandarpa, Senior Process Engineer

Aduana

Hernandez Pacheco, Undersecretary for Imports

Industry

Cartones Haina

Melvin Tilson, Asesor Financiero

Refineria Dominicana de Petroleo

Eduardo Rodriquez, Jefe de Tecnologia

Productos del Tropico

Frank Morales, General Manager

Ingenio Porvenir

Ing. Garcia, Factory Manager

Distileria del Yaque

Rogelio Ramirez, Engineer

Alberto Dominguez, Head, Mechanical Department

Victor Suarge, Plant Superintendant

Helmut Schorgmeyer, Auditor

APPENDIX C: POSSIBLE APPROACHES TO DEFINING ELECTRICITY PURCHASE PRICES

AVOIDED COSTS

The FERC Order required that rates for purchase be set equal to the electric utility's full avoided costs. Avoided costs were defined as those energy and capacity costs that the utility would avoid incurring as a consequence of the power provided by the qualifying facility, i.e., the utility's marginal rate. Avoided costs have little relation to the utility's normal rates for sales which are based on the utility's average costs; avoided costs may be either higher or lower than rates for sales.

The energy component of avoided costs, consisting of fuel and O&M expenses, can be interpreted as the variable cost component of the utility's marginal savings. Since there will always be some variable cost savings when power is provided by cogeneration (except during rare low-load periods), there will always be some energy component to avoided costs.

The capacity component consists of those generation, transmission, and distribution capacity expenses that can be avoided because of the contributions of the cogenerator. In determining the utility's ability to avoid capacity costs, it is necessary to consider future needs for capacity, not just immediate needs. In addition, the value of power from a group of QFs should be evaluated in aggregate (rather than considering the effect of each facility individually). Moreover, a utility's ability to avoid purchases from other utilities and to increase sales to other utilities should be taken into account.

METHODS FOR CALCULATING AVOIDED COSTS

Several methods of computing avoided costs have been developed for use in designing purchase rates. Avoided costs are, for all practical purposes, marginal costs, and these methods are essentially marginal cost computational procedures. The approaches differ not only in their computational details but

also in their implicit conception of marginal costs. Among the major differences in the methods are the treatment of capacity costs and the use of either short- or long-run costs as the basis for the analysis.

Independent electricity generators will, in most cases, need to rely on the electric utilities to sell their power, either directly to utilities or indirectly to other customers through the utilities distribution network. Cogeneration systems, in addition will need to rely on utilities for back-up power during system failure or maintenance. Therefore, the terms of interactions between utilities and independent generators play a key role in the feasibility and viability of such power generation options. The main component of such interactions is the purchase price that utilities are willing to pay for independently generated power or the fee they charge for transmitting the power to other customers. The purchase price, in fact, determines the financial viability of any non-utility power generation project.

The three most frequently used approaches for computing avoided costs are 1) the peaker approach, in which both marginal energy and marginal capacity costs are computed in the short run, 2) the proxy unit approach, and 3) the long-run differential revenue requirements approach (LRDRR), in which both marginal energy and marginal capacity costs are computed in the long run.

The Peaker or Short-Run Approach:

One of the more common methods for separately calculating marginal energy and capacity costs involves using the so-called peaker approach. In this approach, short-run production costs are combined with short-run capacity costs. This approach has the virtue of simplicity; short-run production costs can be obtained from an auxiliary system simulation model or from recent data on actual utility operations, yielding the short-run production costs with a minimum of effort. The marginal capacity cost is estimated as the cost of a small peaking unit.

The peaker approach will yield acceptable marginal costs results if a utility's generating mix is already optimal. Even in a non-optimal utility, such an approach may yield reasonable estimates of the short-run marginal costs of

energy and capacity if oil-fired peaking units are used during peak loading periods. As long as oil is the marginal fuel during most hours of the year, the peaker approach will yield approximately correct marginal costs. The peaker approach is especially suitable for determining short-run avoided costs used in tariffs for the purchase of energy provided on an "as available" basis; i.e., with no firm commitment by the facility owner.

However, this approach is generally inappropriate for estimating long-run marginal costs if 1) oil is not the marginal fuel most of the time, and 2) the utility is also investing in new capital-intensive baseload facilities. Only if the "energy" component is redefined to include that portion of a capital-intensive plant that is properly associated with the plant's fuel displacement function will the peaker approach yield an acceptable result. Such a broad interpretation of "energy" costs is rarely seen in practice. Hence, the sum of the components of the marginal costs, computed using the peaker approach as it is usually applied, is not necessarily representative of actual present or future marginal costs.

The Proxy Unit Approach:

An approach that is used in several states in the United States for long-run rates in long-term contacts is the "surrogate" or "proxy" plant approach. In essence, this is a long-run marginal costing procedure. In this approach, the cost of a generic generating facility or a generating facility actually being planned by the utility is selected as a measure of the value of power to the utility and, hence, as an appropriate measure of marginal costs. Marginal energy and marginal generation capacity costs are calculated jointly.

There are various ways of implementing this approach. One possibility is provided as an illustration: if a utility coal plant is selected as the basis for the rates, the energy costs associated with that facility, namely its fuel and O&M costs, are paid to the cogenerator on a kWh basis, based on the costs for the fuel and estimated O&M costs in each year.

The total estimated installed costs of the utility plant is deflated to the year in which the cogenerator begins providing power and is converted into a

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levelized annual payment. This annual payment can be paid on a peak kW basis, provided the cogenerator meets certain reliability and supply characteristics criteria, or on a kWh basis where the kWh rate is determined using the estimated annual capability factor for the utility plant.

The Long-Run Differential Revenue Requirements Approach:

In this approach, avoided costs are based on long-run costs. The utility's future revenue requirements (total annual costs) are estimated both with and without the contribution of the cogenerators for a 15 to 25-year period into the future. The utility's capacity plan is separately optimized for the two cases; the present value of utility operating and capacity expenditure over some defined period (usually about 20 years) is minimized for utility loads that in the first case ignore the cogenerators and in the second include their contributions. The difference in future revenue requirements between the two cases is directly attributable to the assumed contributions from the cogenerators and, hence, is the estimated total avoided cost.

With the LRDRR approach, the avoided costs are computed in a single, integrated analytical procedure, eliminating the need for separate avoided energy cost and avoided capacity cost computations. This integrated computation ensures that energy and capacity components of the resulting total avoided cost are consistent.

The LRDRR approach permits the avoided costs of the small power producing and cogenerating facility to be tailored to the particular supply characteristics of the generating facility. In calculating the utility's revenue requirements with the facility present, the net loads to be met by the utility are reduced in a manner consistent with the supply characteristics of the qualifying facility. Furthermore, by breaking up the utility's future capacity options into small increments, and by treating the contributions from the facility as part of an aggregated group of similar facilities, a realistic assessment of the capacity value of the facility to the utility is obtained.

APPENDIX D: ECONOMIC AND FINANCIAL ANALYSES

To determine the relative attractiveness of the various private sector power cogeneration options, two types of analyses were performed: an economic analysis and a financial analysis. The economic analysis examined the project from the viewpoint of a national economic planner. It attempted to determine the true costs and benefits to the nation's economy and to decide which of the available options represented the best investment of the nation's scarce resources. To do this, it considered only the resource costs actually incurred. For example, it factored out the "transfer payments" such as taxes, duties, and profits which did not represent true actual costs but rather represent shifts of resources from one sector to another. Rather than using the "market prices" of labor and material, it used their "shadow prices" which represent the opportunity costs to the country by not having these resources available for other projects. Finally, instead of using the market cost of capital, it used a social cost which represented the opportunity cost of capital to the Dominican economy.

The financial analysis examined the project from the viewpoint of the investor. It determined the actual cash flow of a project using market values for capital costs, labor, and materials. It incorporated taxes, duties, profits, and other transfer payments explicitly and determined the actual returns to the investor.

If there is a wide divergence between the relative attractiveness of projects as indicated by these two types of analyses, then serious thought must be given to restructuring the government policies which cause these distortions. For example, policies on energy pricing and taxation which cause the relative financial costs to depart significantly from the relative economic costs will cause investors to make non-optimal energy system choices. If these distortions are large enough they can result in a slowdown in the overall economic growth with the potential for contributing to social unrest.

To determine the economic costs and benefits of cogeneration options, the true "shadow costs" of capital, labor, and material for both the specific projects and for the conventional CDE power generation options must be known. These are difficult to determine accurately and their values can vary significantly from year to year as the nation's and world economies change or as government policies change. The values used in this study were derived from documents and reports of the World Bank, CDE, and COENER.

The study team developed detailed estimates of the Dominican Republic cogeneration market using a dynamic model developed by Hagler, Bailly & Company. The model developed estimates of the cogeneration market over a 12-year period, using the steam demand in the various industries and their growth rate.

The cogeneration technologies considered were:

1) oil-fired boiler with straight back pressure steam turbine (F.O. Boiler/ST)

2) high speed diesel-fired combustion turbine with waste heat recovery boiler (H.S.D. GT/WHRB)

3) high speed diesel-fired diesel (H.S.D. Diesel)

The model determined the market for existing facilities and for new facilities, as well as the allocations for each technology in each market. These allocations were calculated through weighing coefficients derived from the life cycle costs of the various alternatives competing in a given market. The data on industry operation parameters are summarized in Exhibits C.1 through C.6.

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The estimates for economic and financial cogeneration potential have been developed under a set of assumptions summarized in Exhibit C.6. The markets examined are as follows:

	National Market (MW)	New Facilities (MW)	Existing Facilities (MW)
Economic	73	40	33
Financial	56	30	20

More detailed results of the model are presented in Exhibits C.7 to C.20.

Exhibit D.1

Steam Distribution, by Fuel Types, in Percent

	Fuel Oil	Diesel Fuel	Natural Gas	Waste
1. Food Products	39	23	7	31
2. Beverages	79	21	-	-
3. Textiles	48	43	9	-
4. Pulp & Paper	100	-	-	-
5. Chemicals	83	17	-	-
6. Refinery	100	-	-	-
7. Glass	43	18	39	-
8. Cement	87	13	-	-
9. Metal	59	41	-	-

Source: Hagler, Bailly & Company, Inc.

Exhibit D.2

Steam Distribution, by Capacity Factor, in Percent

	0 - 40%	40 - 70%	70%+
1. Food Products	15	70	15
2. Beverages	15	70	15
3. Textiles	40	30	20
4. Pulp & Paper	0	20	80
5. Chemicals	10	60	30
6. Refinery	0	60	40
7. Glass	-	-	-
8. Cement	-	-	-
9. Metal	25	50	25

Source: Hagler, Bailly & Company, Inc.

Exhibit D.3

Steam Distribution, by Size, in Percent

Size Range: 10^6 Btu/hr

	Total 10^6 Btu/yr	0 - 5	5 - 10	10 - 20
1. Food Products	210	25	50	25
2. Beverages	110	20	60	20
3. Textiles	21	30	40	30
4. Pulp & Paper	45	5	15	80
5. Chemicals	152	10	60	30
6. Refinery	30	0	0	100
7. Glass	-	-	-	-
8. Cement	-	-	-	-
9. Metal	27	50	50	0

Source: Hagler, Bailly & Company, Inc.

Exhibit D.4

Steam Distribution, by Electric/Steam Ratio, in Percent

Electric/Steam Ratio, Btu/Btu

	Total 10^6 Btu/yr	0 - 0.2	0.2 - 0.5	0.5+
1. Food Products	210	60	30	10
2. Beverages	110	80	15	5
3. Textiles	21	30	50	20
4. Pulp & Paper	45	10	85	5
5. Chemicals	152	30	60	10
6. Refinery	30	0	100	0
7. Glass	-	-	-	-
8. Cement	-	-	-	-
9. Metal	27	0	0	100

Source: Hagler, Bailly & Company, Inc.

Exhibit D.5

Ratio of Steam to Total Fuel Used

	Ratio
1. Food Products	0.92
2. Beverages	0.92
3. Textiles	0.90
4. Pulp & Paper	0.93
5. Chemicals	0.93
6. Refinery	0.93
7. Glass	-
8. Cement	-
9. Metal	0.15

Source: Hagler, Bailly & Company, Inc.

Exhibit D.6

Input Data for Cogeneration Market Analysis Model

Fuel Prices

Annual Escalation
2%

	1986 Prices (U.S.$/$10^6$Btu)	Shadow Price (U.S.$/$10^6$Btu)
Fuel Oil	9.05	7.06
Natural Gas	17.20	13.42
Electricity	28.72	21.00
Diesel Oil	6.34	4.95

Industry	Current Steam Demand (10^{12} Btu/yr)	Annual Growth Rate (%)
1. Food Products	1.393	4.0
2. Beverages	0.618	5.0
3. Textiles	0.088	3.0
4. Pulp & Paper	0.429	4.0
5. Chemicals	1.006	3.0
6. Refinery	0.262	0.0
7. Glass	-	3.0
8. Cement	-	5.0
9. Metal	0.222	4.0

Other, Financial & Economic Data

	Financial	Economic
Tax Rate	50%	0%
Depreciation	Linear, 10 Yrs.	None
Discount	13%	10%

Source: Hagler, Bailly & Company, Inc.

Exhibit D.7

Market Projections for Cogeneration, National Totals

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	1	0	0	0	0	2
H.S.D. GT/WHRB	14	7	4	3	3	3	34
H.S.D. DIESEL	1	2	4	7	10	13	37
Totals	16	10	8	10	13	16	73

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	1	0	0	0	0	2
H.S.D. GT/WHRB	13	6	3	3	3	3	31
H.S.D. DIESEL	1	1	3	4	6	8	23
Totals	15	8	6	7	9	11	56

Source: Hagler, Bailly & Company, Inc.

Exhibit D.8

Market Projections for Cogeneration, New Installations

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	2	2	2	2	2	2	12
H.S.D. DIESEL	0	1	3	5	8	10	27
Totals	3	3	5	7	10	12	40

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	1	0	0	0	1
H.S.D. GT/WHRB	2	2	2	2	2	2	12
H.S.D. DIESEL	0	1	1	3	5	7	17
Totals	2	3	4	5	7	9	30

Source: Hagler, Bailly & Company, Inc.

Exhibit D.9

Market Projections for Cogeneration, Replacement

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	1	1	1	1	1	6
H.S.D. DIESEL	0	0	1	1	2	2	6
Totals	1	1	2	2	3	3	12

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	0	1	1	1	1	1	5
H.S.D. DIESEL	1	0	0	1	1	1	4
Totals	1	1	1	2	2	2	9

Source: Hagler, Bailly & Company, Inc.

Exhibit D.10

Market Projections for Cogeneration, Retrofit

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	10	4	1	1	0	0	16
H.S.D. DIESEL	1	1	1	1	0	0	4
Totals	12	5	2	2	0	0	21

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	10	3	1	0	0	0	14
H.S.D. DIESEL	0	1	1	0	0	0	2
Totals	11	4	2	0	0	0	17

Source: Hagler, Bailly & Company, Inc.

Exhibit D.11

Market Projections for Cogeneration, Size Range, 2 - 8 MMBTU/hr

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	2	1	1	1	1	0	6
H.S.D. DIESEL	0	0	1	1	1	2	5
Totals	3	1	2	2	2	2	12

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	1	1	1	1	1	0	5
H.S.D. DIESEL	0	0	0	1	1	2	4
Totals	2	1	1	2	2	2	10

Source: Hagler, Bailly & Company, Inc.

Exhibit D.12

Market Projections for Cogeneration, Size Range, 8 - 25 MMBTU/hr

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	6	4	2	2	1	1	16
H.S.D. DIESEL	0	1	2	3	5	6	17
Totals	7	5	4	5	6	7	34

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	6	3	2	2	1	1	15
H.S.D. DIESEL	0	1	1	2	3	4	11
Totals	7	4	3	4	4	5	27

Source: Hagler, Bailly & Company, Inc.

Exhibit D.13

Market Projections for Cogeneration, Size Range, >25 MMBTU/hr

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	1	0	0	0	0	2
H.S.D. GT/WHRB	5	2	1	1	1	1	11
H.S.D. DIESEL	0	1	1	3	4	5	14
Totals	6	4	2	4	5	6	27

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	1	0	0	0	0	1
H.S.D. GT/WHRB	5	2	1	1	1	0	10
H.S.D. DIESEL	0	0	1	2	2	3	8
Totals	5	3	2	3	3	3	19

Source: Hagler, Bailly & Company, Inc.

Exhibit D.14

Market Projections for Cogeneration, Food Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	4	2	1	1	1	0	9
H.S.D. DIESEL	0	1	1	2	3	4	11
Totals	4	3	2	3	4	4	20

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	3	2	1	1	1	1	8
H.S.D. DIESEL	0	0	1	1	2	2	7
Totals	3	2	2	2	3	3	15

Source: Hagler, Bailly & Company, Inc.

Exhibit D.15

Market Projections for Cogeneration, Beverage Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	2	1	1	1	1	1	7
H.S.D. DIESEL	0	0	1	2	2	3	8
Totals	2	1	2	3	3	4	15

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	2	1	1	1	1	0	6
H.S.D. DIESEL	0	0	1	1	1	2	5
Totals	2	1	2	2	2	2	11

Source: Hagler, Bailly & Company, Inc.

Exhibit D.16

Market Projections for Cogeneration, Textile Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	0	0	0	0	0	1
H.S.D. DIESEL	0	0	0	0	0	1	1
Totals	1	0	0	0	0	1	2

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	0	0	0	0	0	1
H.S.D. DIESEL	0	0	0	0	0	1	1
Totals	1	0	0	0	0	1	2

Source: Hagler, Bailly & Company, Inc.

Exhibit D.17

Market Projections for Cogeneration, Chemical Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	4	2	1	1	1	0	9
H.S.D. DIESEL	0	1	1	2	2	3	9
Totals	4	3	2	3	3	3	18

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	1	0	0	0	0	0	1
H.S.D. GT/WHRB	4	2	1	1	0	0	8
H.S.D. DIESEL	0	0	1	1	1	2	5
Totals	5	2	2	2	1	2	14

Source: Hagler, Bailly & Company, Inc.

Exhibit D.18

Market Projections for Cogeneration, Pulp & Paper Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	2	1	1	1	1	0	6
H.S.D. DIESEL	0	0	0	1	1	1	3
Totals	2	1	1	2	2	1	9

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	2	1	1	0	0	1	5
H.S.D. DIESEL	0	0	0	0	1	1	2
Totals	2	1	1	0	1	2	7

Source: Hagler, Bailly & Company, Inc.

Exhibit D.19

Market Projections for Cogeneration, Refinery

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	1	0	0	0	0	2
H.S.D. DIESEL	0	0	0	0	0	1	1
Totals	1	1	0	0	0	1	3

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	0	0	0	0	0	1
H.S.D. DIESEL	0	0	0	0	0	1	1
Totals	1	0	0	0	0	1	2

Source: Hagler, Bailly & Company, Inc.

Exhibit D.20

Market Projections for Cogeneration, Metals Sector

Economic Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	1	0	0	0	0	2
H.S.D. DIESEL	0	0	1	1	1	1	4
Totals	1	1	1	1	1	1	6

Financial Market (MW)

Technology	86-87	88-89	90-91	92-93	94-95	96-97	Total
F.O. Boiler/St	0	0	0	0	0	0	0
H.S.D. GT/WHRB	1	1	0	0	0	0	2
H.S.D. DIESEL	0	0	0	1	1	1	3
Totals	1	1	0	1	1	1	5

Source: Hagler, Bailly & Company, Inc.