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Executive Summary

Puerto Rico Energy Center Study

prepared for

COMMONWEALTH OF PUERTO RICO

in cooperation with the

United States Atomic Energy Commission
and
United States Department of the Interior

JULY 1970

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PUERTO RICO ENERGY CENTER STUDY

EXECUTIVE SUMMARY

PREPARED FOR

COMMONWEALTH OF PUERTO RICO

IN COOPERATION

WITH THE

UNITED STATES ATOMIC ENERGY COMMISSION

AND

UNITED STATES DEPARTMENT OF THE INTERIOR

PREPARED BY:

BURNS AND ROE, INC.
Hempstead, New York

THE DOW CHEMICAL CO.
Midland, Michigan

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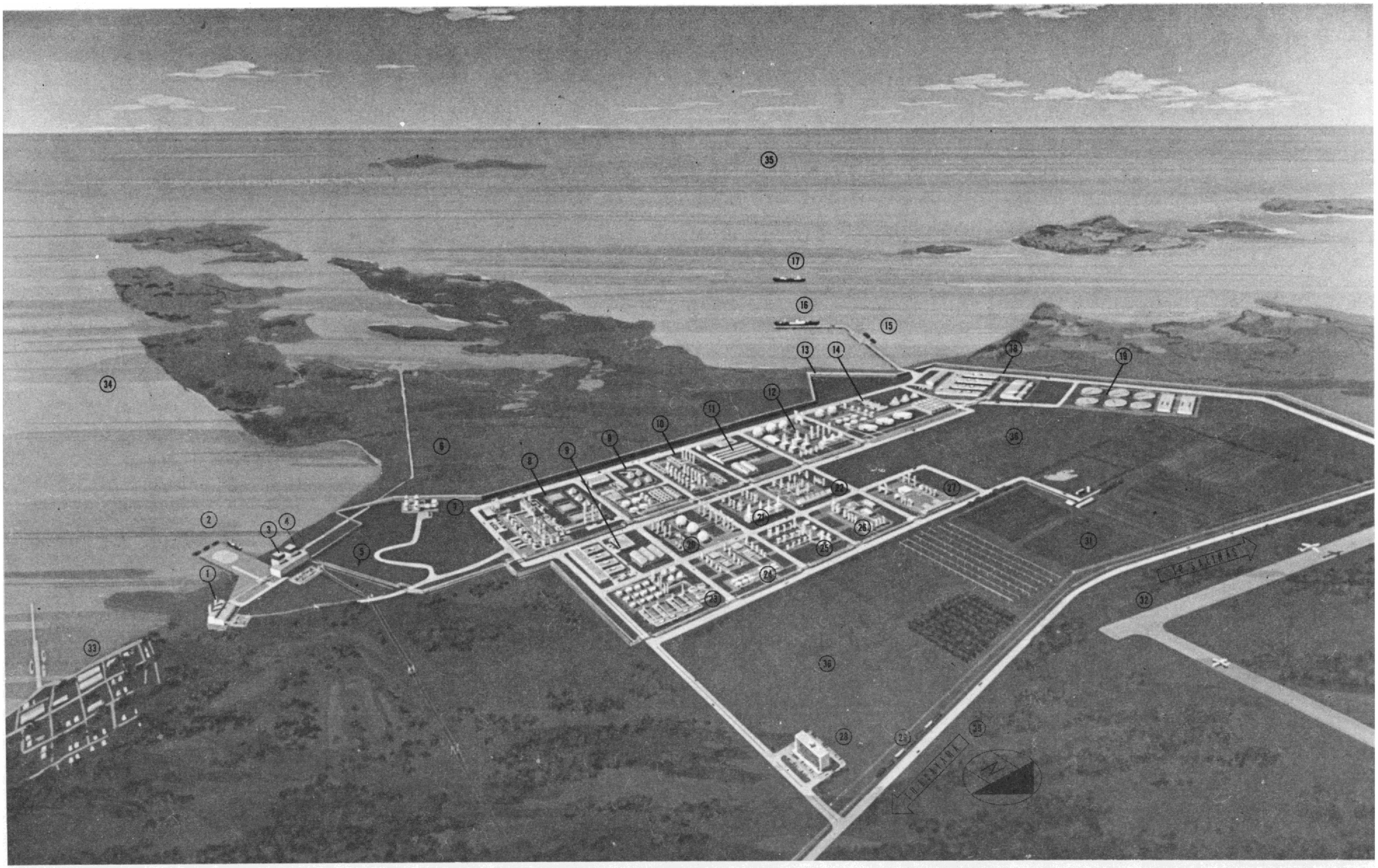

PUERTO RICO ENERGY CENTER

1 1973-74 460-MW FOSSIL POWER PLANT
2 FUEL OIL BARGE UNLOADING
3 1976 570-MW NUCLEAR POWER PLANT
4 1978 DUAL PURPOSE NUCLEAR POWER PLANT
5 STEAM LINES
6 COOLING WATER EFFLUENT CANAL
7 20-MGD DESALTING PLANT
8 SALT RECOVERY PLANT
9 MAINTENANCE & SUPPLY AREA
10 REFINERY
11 UTILITIES
12 POLYETHYLENE
13 LEVEE
14 STORAGE
15 BARGE WHARF
16 CHEMICAL TANKER DOCK
17 CRUDE OIL UNLOADING
18 ALUMINUM PLANT
19 WASTE DISPOSAL
20 CUMENE
21 ETHYLENE
22 ETHYLBENZENE
23 CHLORINE CAUSTIC
24 PROPYLENE GLYCOL
25 ETHYLENE DICHLORIDE
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TECHNICAL ABBREVIATIONS

amp	ampere
Anhy	anhydrite
AT	after taxes
ATBD	after taxes before depreciation
* bbl	barrel
BOD	biochemical oxygen demand
BT	before taxes
Btu	British thermal units
cf	concentration factor
cfm	cubic feet per minute
cfs	cubic feet per second
cif	cost, insurance, and freight
cu	cubic
DCF%	descounted cash flow percentage
Depr	depreciation
DSM	Dutch State Mines wet screen
dwt	dead weight ton
Excl	excluding
f.o.b.	free on board
fps	feet per second
gpd	gallons per day
gpm	gallons per minute
gpy	gallons per year
hp	horse power
hr	hour
ht	height

* Upper Case used in Computer Runs

in.	inch
* k	thousand
kv	kilovolt
kva	kilovolt-ampere
kw	kilowatt
kwe	kilowatt electrical
kwhr	kilowatthour
* lb	pound
* lbs	pounds
LMC	lime-magnesium carbonate
LPG	liquified petroleum gas
* m	million
M & I	municipal and industrial
MCM	thousand circular mills
MEMS	multi-effect multistage
MEVTE	multi-effect vertical tube evaporator
mg	milligrams
mgd	million gallons per day
mva	megavolt-amperes
mw	megawatts
mwe	megawatts electrical
mwt	megawatts thermal
NPSH	net positive suction head
ppb	parts per billion
pph	pounds per hour
ppm	parts per million
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PTBL	potable water
rpm	revolutions per minute
RVT	low quality, desalted water
RVUT	industrial water

* Upper Case used in Computer Runs

sec	second
SEMS	single effect multistage
st	short ton
stpa	short ton per annum
T	transferred product from one plant to another within the Energy Center
t	ton
T-G	turbine-generator
TDS	total dissolved solids
USP	United States Pharmacopoeia
VTE	vertical tube evaporator
wt	weight
* yr	year
%	percent
^{o}C	degrees Centigrade
^{o}F	degrees Fahrenheit

* Upper Case used in Computer Runs

ORGANIZATION ABBREVIATIONS

A-G	Aerojet-General Corporation
AEC	Atomic Energy Commission
EDA	Economic Development Administration
ORNL	Oak Ridge National Laboratory
OSW	Office of Saline Water
PA	Ports Authority
PPG/CORCO	CORCO division of Pittsburg Plate Glass
PRASA	Puerto Rico Aqueduct and Sewer Authority
PRIDCO	Puerto Rico Industrial Development Company
PRWRA	Puerto Rico Water Resources Authority
TVA	Tennessee Valley Authority
USGS	United States Geological Survey
WLB	W. L. Badger Associates, Inc.

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ENERGY CENTER COMMITTEE MEMBERS

Organization	Member
P.R. Water Resources Authority	Mr. Julio Hernandez Fragoso Chairman Mr. Carlos M. Galvan - Alt.
P.R. Aqueduct & Sewer Authority	Mr. Pedro Mora Mr. Enrique Font - Alt.
Planning Board	Mr. Humberto Espinosa Mr. Bienvenido Mejias - Alt.
Economic Development Administration	Mr. Salvador Lugo
Department of Agriculture	Mr. Salvador Alemany Mr. Ramon Velez Olmeda - Alt.
Department of Public Works	Mr. Edwin Cuebas Mr. Juan Olivieri - Alt.
U.S. Atomic Energy Commission	Mr. William A. Williams, Jr.
Bureau of Reclamation, Department of the Interior	Mr. James D. Ellingboe
Office of Saline Water, Department of the Interior	Mr. Joseph J. Strobel

Advisors

Mr. J. W. Michel - Oak Ridge National Laboratory
Dr. Henry J. Gomberg - Puerto Rico Nuclear Center

Puerto Rico Water Resources Authority

Eng. Felix Cordova Diaz — Executive Director
Eng. Julio Negroni — Executive Sub-director

Dr. Modesto Iriarte, Jr.	Assistant Executive Director Electrical Planning, Research and Construction
Eng. Harold Toro	Special Assistant to the Executive Director
Eng. Renan Colon	Chief Engineer Engineering and Construction
Mr. Rafael Betancourt	Attorney at Law
Eng. Rafael Reyes	General Manager - Irrigation
Eng. William Candelario	Chief, Planning

Puerto Rico Aqueduct and Sewer Authority

Eng. Wilfredo Vivoni	Executive Director
Eng. Angelo Fournier	Planning Engineer
Eng. Pedro Rios	

Puerto Rico Planning Board

Hon. E. Soler Cloquel, Jr.	President
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Puerto Rico Department of Agriculture

Hon. L. Rivera Brenes	Secretary
Mr. Ismael Ramirez Murphy	
Mrs. Sonia Velez de Rodriguez	

Fomento - Puerto Rico Economic Development Administration

Mr. Jose M. Caldas
Mr. Julio Cesar Vazquez
Mr. Milton Troches Vargos
Mr. Francisco J. Morales

Fomento - Puerto Rico Industrial Development Company

Mr. Owen Martinez
Mr. Pedro R. Sola
Mr. Jobino de Jesus

Fomento - Puerto Rico Ports Authority

Mr. Cesar Canals	Executive Director
Mr. Jose A. Beniamino	
Mr. A. Segarra	

Fomento - Department of Tourism

Mr. Enrique Garcia Diaz

Puerto Rico Land Administration

Mr. Federico Torres Campos	Executive Director
Mr. Armando Alvarez	

Puerto Rico Land Authority

Hon. Santiago	Executive Director
Mr. J. Acron	

Puerto Rico Department of Public Works

Hon. Antonio Santiago Vazquez - Secretary

U. S. Atomic Energy Commission

Mr. James T. Ramey	Commissioner
Dr. J. P. Morgan	Puerto Rico Area Office Manager

U. S. Corps of Engineers

Mr. Luis C. Mendez

U. S. Department of Commerce - Economic Development Administration

Mr. Arturo Febray

U. S. Department of the Interior - Bureau of Reclamation

Mr. Gilbert Stamm	Assistant Commissioner
Mr. James J. O'Brien	

U. S. Department of the Interior - Office of Saline Water

Mr. Paul Tomalin

U. S. Geological Survey

Mr. Dean Bogart
Mr. Donald G. Jordan

U. S. Weather Bureau

Mr. R. J. Calvesbert

The Aquirre Company

Mr. Bissell	President
Mr. Rafael Castro Amy, Sr.	Vice President
Mr. Miguel A. Burset	Assistant to President
Eng. Exio Mejia	

Buck, Seifert and Jost - Consulting Engineers

Mr. George H. Buck

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1.0 INTRODUCTION

1.1 BACKGROUND

Puerto Rico has had an outstanding rate of economic growth since 1960 due in large measure to an industrialization program promoted by the Government of Puerto Rico. Much of this growth has been in the area of light industry that employs a high percentage of female labor. It is a goal of this program to increase employment of male labor and it is recognized that this may be accomplished by the establishment of heavy industry and the revitalization of agriculture. Notable gains have been made in the promotion of heavy industry, particularly in the petro-chemical industries.

The role of agriculture has not kept pace with the growth in the economy of Puerto Rico. Since 1960, the net income of Puerto Rico has more than doubled, increasing from $1.4 billion to 3.3 billion in 1969. During the same period, the contribution of agriculture dropped from 15% of the net income to 7%. The production of sugarcane, a major crop, dropped nearly 50%, while the production of many other crops has remained nearly constant, at best. It is a goal of the Government of Puerto Rico to improve the contribution of agriculture by diversification and a revitalization of the sugar industry.

The major contributions that Puerto Rico offers are man-made and are derived from policies of both the U.S. and Puerto Rican governments designed to make Puerto Rico prosper through industrialization. Part of these contributions accrue to industry through certain tax exemptions and for petro-chemical industries through an oil import quota that has the effect of lowering the cost of crude oil.

An additional part of the contribution is developed through the agencies that have been established by the Government of Puerto Rico with policies designed to foster industrialization. The machinery of these agencies has been refined through 15 years of industrial promotion and is capable of carrying out the Government's end of a project. These agencies seek no profit and can raise money by tax-free bonds for the construction of certain of the necessary facilities, thus reducing the cost of these essential services to industry.

As part of the promotional effort directed at heavy industry and the revitalization of agriculture, the United States Government and the agencies of the Commonwealth of Puerto Rico agreed in November 1968 on the framework of a feasibility study of nuclear energy centers for the coastal regions of the Commonwealth. The study is an outgrowth of investigations by the Atomic Energy Commission and the Office of Saline Water into the use of nuclear energy to supply heat for desalting seawater and for generating electricity, and of work on the energy center concept conducted at the AEC's Oak Ridge National Laboratory.

The bases for the study were set forth in a Memorandum of Understanding signed by Commissioner James T. Ramey of the United States Atomic Energy Commission, Under Secretary David S. Black of the United States Department of the Interior, Acting Executive Director Fernando Torrent of the Puerto Rico Water Resources Authority, and Executive Director Orlando Gonzalez of the Puerto Rico Aqueduct and Sewer Authority.

Under the terms of the Memorandum the engineering and economic feasibility data developed was to complement and extend earlier U.S. studies and assist Puerto Rico in its plans for future development.

In addition to the agencies which signed the Memorandum of Understanding, other Puerto Rican organizations which participated are the Commonwealth's Department of Agriculture, Planning Board, Public Works Department, Economic Development Administration, and the Puerto Rico Industrial Development Company.

The Puerto Rico Water Resources Authority, acting as the administrative agency for the study, selected Burns and Roe, Inc. and The Dow Chemical Company to perform the work.

1.2 SCOPE OF STUDY

The scope of work of the study was to compile and analyze information on the resources and requirements of the southwestern, southeastern, and northcentral coastal regions of the Commonwealth, and assess industrial and agricultural activities which in conjunction with the power and desalting plants, might comprise the energy center complex. The study was also to identify the need for any experimental, pilot or demonstration projects which would benefit the practical application of the Energy Center concept in Puerto Rico.

The guidelines suggested that consideration be given to plants which would generate 500,000 to 1 million kilowatts of electricity and desalt 25 to 100 million gallons of seawater per day for municipal, industrial and agricultural use in connection with projects that could become operational between 1975 and 1990. The detailed scope of work is given in Appendix 1.1-1 of this report.

1.3 NATURE OF THE STUDY

The nuclear energy center concept which is still in its conceptual stage, calls for the integration of a low cost source of energy with industries that require large amounts of energy either in the form of electrical power or as thermal energy such as steam. As such, it is not an entirely new idea; many instances are known of energy consuming industries located near low cost sources of energy obtained from gas, coal or hydropower. What is new is the concept of using nuclear power which is not closely tied to a geographical location as is the case with these naturally occurring energy sources. What is also somewhat new is the conscious systematic approach to creating a complex of industries around a nuclear energy source such that their combined loads will permit the economics of large size power plants to be realized and to select those industries that will profit from the low cost energy, from the interchange of products and the sharing of facilities. In short, an integrated complex formed to make the whole more efficient than the sum of the individual parts.

A study of this type is done iteratively or by trial-and-error, i.e. certain assumptions are made, the results are determined and based on the results another iteration or trial is made. Ideally this process is repeated until the assumptions and the results coincide. In a large study of this type with finite time and money available to do the work the process is carried out only until the agreement between assumptions and results are reasonably close and the further iteration, while it would refine the numbers, will not change the conclusions. An illustration is the cost of steam. The final determination of the cost of steam cannot be made until all steam loads are known but the cost of steam will effect the amount of steam that is used both by industry and the desalting plants. After preliminary trials were made it was necessary to fix the cost of steam to industry and to the desalting plants to permit work on these aspects to be completed and in both cases the costs assumed were somewhat higher than the final estimated steam costs. Similar differences occur for other items in the study.

1.4 RESPONSIBILITY

The statements, opinions, conclusions and recommendations made in this report are those of the contractors and are not necessarily those held by any of the agencies of the governments of the United States or Puerto Rico, whose names may be mentioned in the report.

1.5 ORGANIZATION OF REPORT

The report has been bound in four books consisting of an Executive Summary, the Report proper in two volumes and a Site Selection Supplement.

The text of the Executive Summary is divided into nine parts. Following this Introduction, Section 2.0 gives the major Conclusions and Recommendations for the study as a whole.

Section 3.0 deals with the site selection which compared sites in three regions of Puerto Rico. It is a brief presentation of the more extensive report given in the Site Selection Supplement.

Section 4.0 deals with the energy supply and compares nuclear and fossil plants for both single and dual purpose power generators. Various alternates are considered on backup for the steam supply. The interrelationship of the Energy Center power plants to the PRWRA System is considered.

Section 5.0 established the water requirements for industry and agriculture both in the Energy Center and its environs and the prospects and costs of obtaining the needed water from wells, dams and desalting plants. The alternates of basing the desalting plant size on salt recovery versus water needs are presented. The possibilities of surface and underground reservoirs are explored.

Section 6.0 on industry reports on the initial screening of industries for inclusion in the Energy Center, the market studies and the establishment of the recommended complex and its economics.

Section 7.0 on agriculture, reports on the crop screening studies, the market surveys for crops, and the economic analysis of those crops that can be grown in Puerto Rico and their ability to pay for water. A proposed demonstration farm is described.

Section 8.0 on socio-economics gives background information on Puerto Rico and develops the impact of the Energy Center on Puerto Rico's economy and the need for infrastructure.

Section 9.0 on implementation deals with the problems of promoting the Energy Center and bringing it through the initial years of construction and operation. Alternate plans of organization are discussed.

2.0 CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

Based on the results obtained from the several segments of the Energy Center study a variety of conclusions can be drawn. Of these, the most significant ones are that:

A. An Energy Center is economically viable in Puerto Rico. In particular, a commercially feasible complex consisting of a dual purpose (electricity and process steam) nuclear power plant, a petro-chemical refinery and its derivative petro-chemical plants, a desalting plant and a salt recovery plant, a chlorine-caustic plant, and an aluminum plant at capacity levels compatible with forecasted near term (1975 to 1990) domestic USA and worldwide markets yields an acceptable discounted cash flow percentage for the industrial plants.

B. The economic viability of the industrial plants of the Energy Center derives from the benefits of complexing, large capacities of the plants chosen, sharing of facilities and services, tax incentives, oil quota, low cost power and steam, availability of a deep water harbor and low land costs.

C. Salt recovery from the brine effluent of the desalting plant is economically viable if certain development work is successfully completed.

D. Brine products can theoretically be efficiently recovered from the effluent of a salt recovery plant but economic returns are on the lower edge of viability. Extensive research and development work would have to be done.

E. When the profitability of salt recovery is considered, the use of desalted water in the industrial plants compares favorably on a cost basis with the use of natural water.

F. The West Aguirre site in the Guayama Sub-Region in the southeastern region of Puerto Rico is the best site for the Energy Center because of its proximity to the Aguirre Power Station, the availability of sufficient land of desirable topography, the closeness of a deep water harbor, and the least cost to acquire and develop the site.

G. The most economical way of obtaining the steam and the bulk of the power required for the Energy Center is from a 2785 mwt nuclear steam supply system with a 540 mwe turbo-generator. The most economical way of obtaining the necessary backup power is from the PRWRA systems and the backup steam from the other fossil and nuclear plants of the Aguirre Generating Station.

H. The cost of generating power from single purpose nuclear plants is slightly lower than fossil plants. The estimated cost of generation from both type of plants exceeds the present rate schedule for large blocks of power.

I. The proposed industrial development of the Guayama Sub-Region will result in a water shortage requiring development of all available sources including wells, the Toa Vaca project, and desalting plants to satisfy the requirement of availability and economy.

J. The alluvial aquifers of the Guayama Sub-Region should be capable of yielding about 10 mgd of additional well water over and above what they are now providing.

K. Desalted water can be obtained at lowest cost from a multi-effect vertical tube type plant in the 20 mgd plant size range. The VTE type of desalting plant can produce a waste brine at three times seawater concentration that can be used for the economical recovery of salt at no cost penalty to water production cost.

L. Acid pretreatment of the seawater is lower in cost than the caustic, lime-magnesium carbonate, ion exchange or barium recycle processes for a 20 mgd desalting plant using extraction steam from a turbine and with brine concentration limited to a factor of three. Caustic pretreatment is potentially competitive with acid depending on the relative cost of acid and caustic.

M. Food produce is being imported to Puerto Rico which could be profitably grown in Puerto Rico. By 1975, these imports will reach $20 million per year unless production of certain crops is increased. It will require 20,000 acres of land to grow the crops needed to meet the demand and this amount of land can only be obtained by displacing sugarcane.

N. Food produce grown in Puerto Rico may be marketable in east coast cities of the continental United States; and that this marketing venture could be tried as a sideline of the domestic program with little risk.

O. The cost of desalted water is too high to be used for agriculture in Puerto Rico with the exception of certain selected crops. There are lower cost water supplies that can be used for raising the recommended crops, but this use may require the displacement of some sugarcane production.

P. Implementation of the Energy Center is possible through existing agencies of the Government of Puerto Rico acting as promoters or participants. No new authorities or superagencies need be created by legislation.

Q. About one-third of the Energy Center cost can be financed by agencies of the Government of Puerto Rico through bond issues covering the dual purpose power plant, the desalting plant, land acquisition and port facilities. The profit potential is sufficiently high to induce private industry to finance the remaining two-thirds of the cost.

R. The first plants can be placed in operation by 1975 and the last of the plants by 1979, if the Energy Center can be promoted by 1972.

S. There is adequate manpower available to construct and operate the Energy Center but that this manpower must be trained for the construction crafts and for operation and maintenance of the industrial plants.

2.3 RECOMMENDATIONS

From the conclusions stated above a number of recommendations can logically be made. In some cases they may require modification before acceptance because of influencing factors beyond the scope of this study. Nonetheless the major recommendations arrived at are given below to assure thorough coverage. These recommendations are that:

A. The agencies of the Government of Puerto Rico review the results of the Energy Center study and decide whether or not to recommend adoption of the Energy Center project. The further recommendations given below are subject to an affirmative decision on the Energy Center project.

B. Fomento be assigned the key role in the promotion and implementation of the Energy Center plan.

C. Fomento formulate a detailed program to promote and implement the Energy Center plan outlining the areas of responsibility of each of the other governmental agencies and be responsible for coordinating their activities.

D. Fomento promote participation by companies already producing and marketing the proposed products in world markets. The companies be encouraged to form a management structure that can take full advantage of the complexing opportunities and thereby fulfill the economic returns forecast in this study.

E. Fomento draw up a detailed physical, managerial plan for the site that will insure that it is developed on a coordinated basis to take full advantage of the savings that can be effected through the sharing of facilities. Professional consulting assistance be retained to assist in planning and negotiations.

F. The Land Administration or the Puerto Rico Industrial Development Company acquire or otherwise gain control of the land at the West Aguirre site to insure its availability for industry under the Energy Center plan.

G. The Puerto Rico Water Resources Authority cooperate in the Energy Center plan through a willingness to build the dual purpose power plant and to supply backup process steam from the other power plants at the Aguirre Generating Station.

H. The Puerto Rico Water Resources Authority reexamine the present power rate schedules in the light of rising costs of power generation.

I. The Puerto Rico Water Resources Authority perform additional system studies to accurately determine the cost of supplying process steam to industrial users and to establish rate bases for steam.

J. The Puerto Rico Water Resources Authority undertake a study of the effects on the environment of thermal and chemical discharge from the power and industrial installations at the site.

K. The Puerto Rico Aqueduct and Sewer Authority formulate an overall program for meeting the water needs of the Guayama Sub-Region taking into account the potential availability, costs and financing aspects of well water, the Toa Vaca project and desalting plants so that industry will be satisfied that this essential utility will be available when needed.

L. The Puerto Rico Aqueduct and Sewer Authority establish a rate schedule for supplying industrial water in the district served by the Toa Vaca project. The rates should be the same for all industries within the district, regardless of the source from which the water is supplied, and differing only on the basis of quantity used and quality of water required.

M. The Puerto Rico Aqueduct and Sewer Authority consider expansion of the studies being carried out by USGS to include the characteristics of the entire alluvial aquifer from Salinas to Patillas in order to determine the adequacy of this aquifer to furnish additional water.

N. The Government of Puerto Rico proceed with proposed legislation to control the pumping of underground water and the establishment of an agency having overall control of all available sources of water in order that these can be managed in the best interest of Puerto Rico.

O. After acquisition of the West Aguirre site, the Puerto Rico Aqueduct and Sewer Authority consider the possibility of using existing wells on the West Aguirre site in combination with booster pumps to supply water to the area from West Aguirre to Guayama.

P. The Ports Authority cooperate with the Energy Center plan through a willingness to provide the necessary harbor facilities.

Q. The Ports Authority undertake engineering studies of the proposed harbor facilities to obtain geological and hydrographic data necessary to more firmly establish the harbor design basis.

R. The Highway Authority provide public road access to the east and west perimeters of the West Aguirre site.

S. The Department of Agriculture develop a plan for the diversification of agriculture designed to meet Puerto Rico market requirements, and to test east coast United States market.

T. The Department of Agriculture, as part of the agricultural diversification plan, establish a demonstration farm on the south coast of Puerto Rico, possibly at the West Aguirre site.

U. The Planning Board review, and if necessary revise and expand their development plan, for the Guayama Sub-Region taking into account the Energy Center plan in order to coordinate and foster the development of infrastructure that is essential to the ultimate success of the program.

V. The Planning Board, after completing the up-dating of their computer program, perform input-output analysis for the Energy Center to more fully evaluate the impact of the Energy Center on the economy of Puerto Rico.

W. The Department of Labor, the Department of Education and the University of Puerto Rico acting in cooperation formulate plans for training the manpower required for the Energy Center.

X. The Office of Saline Water consider supporting development programs in the areas listed below to the extent that these are not part of their present programs:

(1) Equipment design data for the caustic pre-treatment process for seawater.

(2) Use of condenser and preheater tubes of 200 feet in length in desalting plants.

(3) Further detail design and development work to determine which of the VTE designs holds the greatest promise and the construction and operation of the selected plant to demonstrate its capability.

(4) Further verification of enhanced (fluted) vertical tube heat transfer data.

(5) Economics of polymerized concrete vessel shell.

(6) Pilot plant studies of $CaSO_4$ precipitation step in the recovery of salt from brine.

(7) Brine products recovery by the process outlined in the report.

3.0 SITE SELECTION AND LAYOUT

3.1 Site Selection

To establish conformance of the Energy Center studies with the plans of the Government of Puerto Rico for the development of Puerto Rico, meetings were held with the Planning Board. It was decided that consideration could be given to sites at Guayanilla in the southwest region, the Bay of Jobos (Aguirre) in the southeast region and the area east of Arecibo in the north central region as shown in Exhibit 3-1.

Site visits were made and site descriptions were prepared covering layout, geology, seismology, hydrology, agronomy, demography, meteorology, transport, finance and socio-economics. Estimates of the relative site development capital cost were prepared for each site including a capitalized operating cost to take into account that the south coast sites would incur higher costs for water. The cost data obtained was:

	Cost - (in Millions of $)		
	Capital	Capitalized Operating	Total
Guayanilla	39.7	38.2	77.9
Aguirre			
West	35.4	38.2	73.6
East A	32.8	38.2	71.0
East B	38.1	38.2	76.3
Arecibo	78.1	2.3	80.6

All sites were considered equal from a shipping standpoint and none afforded raw materials that were used by the Energy Center industries. The choice was then reduced to other qualitative considerations and costs.

The Aguirre area was recommended on the basis of the following:

A. Availability of the amount of land needed.

B. Lowest cost to acquire and develop the land.

C. Indicated acceptability of the site from a nuclear safety standpoint by virtue of a good rock foundation for the reactors, adequate exclusion radius and low density population zones around the power plant. Public hearings have been held and Planning Board approval of this site for nuclear power plants has been given.

D. The availability on the power plant site of two 460 mwe fossil plants scheduled for operation in 1973-74 and a 560 mwe nuclear plant scheduled for 1976 that can provide backup power and steam.

E. Good possibilities for a deep water port development.

F. Site layout lends itself to staged development thus reducing initial costs.

G. Capable of being protected from flooding from the sea and with minimal danger of flooding from the land side.

H. Good highways to serve the area which will help to diffuse the socio-economic impact of the Energy Center over a large area of Puerto Rico and supply labor needed for construction and operation.

I. Relative stability of ecological factors.

J. The greater potential need for water from a desalting plant that affords an opportunity to help solve water problems of the south coast of Puerto Rico and to recover salt economically from brine waste.

The Guayanilla site was considered acceptable but had the disadvantages of potential flooding from the landward side, the site did not lend itself readily to staged development, the amount of land available was marginal, a potential

SCALE

0 10

MILES

BURNS AND ROE, INC. HEMPSTEAD, NEW YORK	THE DOW CHEMICAL CO. MIDLAND, MICHIGAN
MAP OF PUERTO RICO SHOWING ENERGY CENTER SITES	
PUERTO RICO ENERGY CENTER STUDY PUERTO RICO WATER RESOURCES AUTHORITY	

EXHIBIT 3-1

disturbance of the ecology of the area existed and site development costs were higher.

The Arecibo site was considered unacceptable on the basis of nuclear safety, need for constant pumpage to prevent flooding, difficulties of developing the harbor, navigational problems in winter and high site development costs.

The three sites at Aguirre were compared in greater detail based on actual site layouts with relative costs as follows (but not including capitalized operating costs that were common to all Aguirre sites):

West Aguirre	-	$45,127,000
East Aguirre A	-	60,911,000
East Aguirre B	-	62,324,000

The West Aguirre site was recommended on the basis of lower costs. The higher costs of the East Aguirre site stemmed from the extended length of the layout with the power located west of Aguirre and the harbor located at Las Mareas, a distance of over six miles away. This leads to high cost for utility and process piping. It also raised questions as to the reliability of the extended length of large size steam lines and whether industrial firms would deem such a solution to be practical. Use of the East Aguirre sites was preferable from the standpoint of conserving insular land for agricultural and other uses.

It was recommended that the Energy Center be located at West Aguirre and this was accepted by the Energy Center Committee as the basis for completing the reference design.

3.2 Energy Center Layout

3.2.1 General

The Energy Center layout at the West Aguirre site is shown in Exhibit 3-2. The site is in the Municipality of Salinas. The site lies to the west of Central Aguirre, north of Lugo Vina mangrove area, and south of Route 3. The land is privately owned including the Lugo Vina mangrove area, a portion of which is used. The land is currently used for

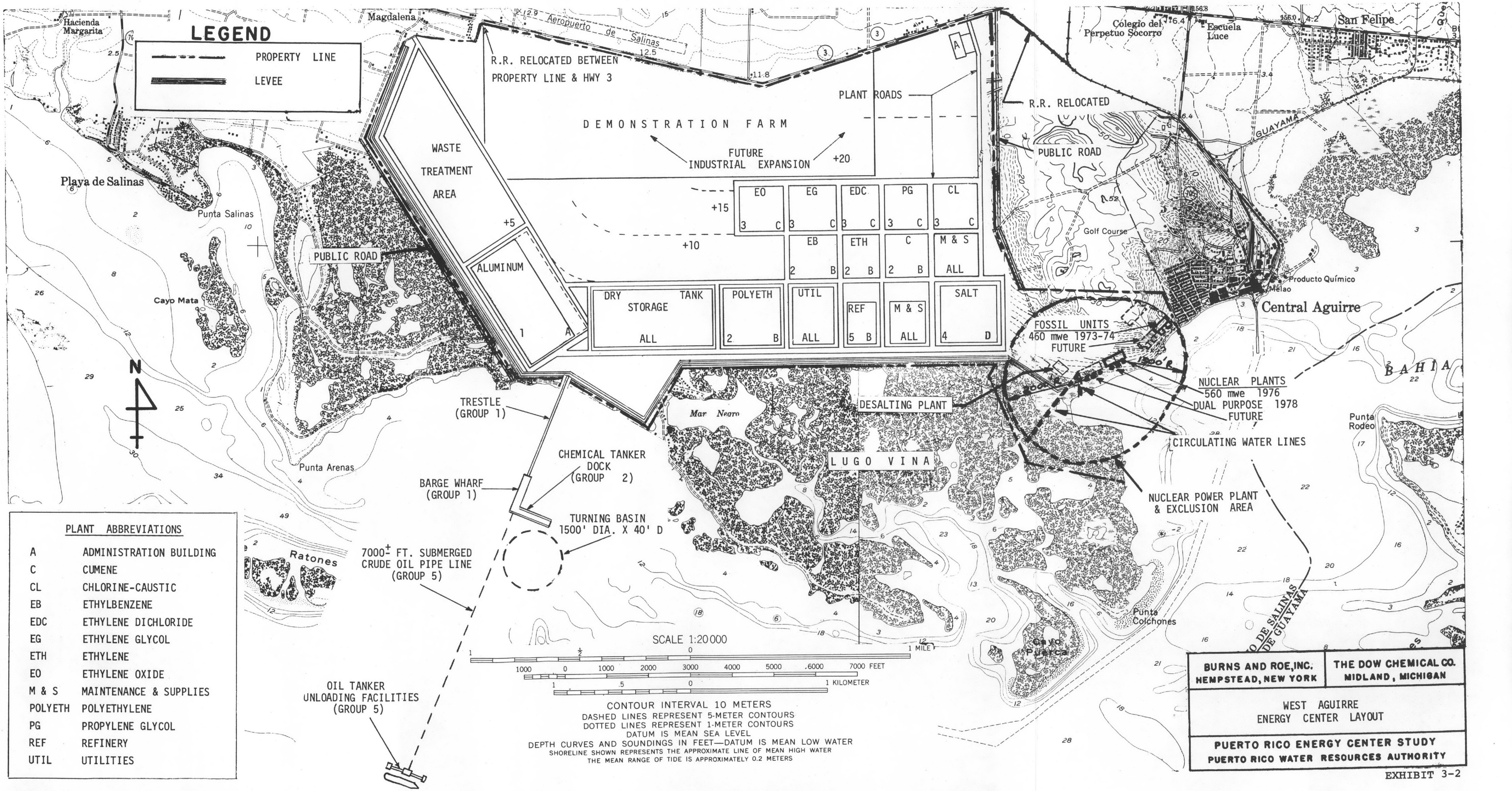

LEGEND
PROPERTY LINE
LEVEE
Hacienda Margarita
Magdalena
Aeropuerto de Salinas
R.R. RELOCATED BETWEEN PROPERTY LINE & HWY 3
PLANT ROADS
R.R. RELOCATED
Colegio del Perpetuo Socorro
Escuela Luce
San Felipe
DEMONSTRATION FARM
FUTURE INDUSTRIAL EXPANSION
+20
WASTE TREATMENT AREA
+5
ALUMINUM
1
A
PUBLIC ROAD
Playa de Salinas
Punta Salinas
Cayo Mata
+15
+10
EO
EG
EDC
PG
CL
EB
ETH
C
M & S
ALL
DRY STORAGE TANK
POLYETH
UTIL
REF
SALT
GUAYAMA
Golf Course
Producto Químico
Melao
Central Aguirre
FOSSIL UNITS
460 mwe 1973-74
FUTURE
NUCLEAR PLANTS
560 mwe 1976
DUAL PURPOSE 1978
FUTURE
DESALTING PLANT
CIRCULATING WATER LINES
BAHIA
Punta Rodeo
TRESTLE (GROUP 1)
Mar Negro
LUGO VINA
CHEMICAL TANKER DOCK (GROUP 2)
BARGE WHARF (GROUP 1)
TURNING BASIN 1500' DIA. X 40' D
NUCLEAR POWER PLANT & EXCLUSION AREA
Punta Arenas
Ratones
7000± FT. SUBMERGED CRUDE OIL PIPE LINE (GROUP 5)
OIL TANKER UNLOADING FACILITIES (GROUP 5)
Punta Colchones
Cayo Puerca
DE SALINAS
DE GUAYAMA
PLANT ABBREVIATIONS
A ADMINISTRATION BUILDING
C CUMENE
CL CHLORINE-CAUSTIC
EB ETHYLBENZENE
EDC ETHYLENE DICHLORIDE
EG ETHYLENE GLYCOL
ETH ETHYLENE
EO ETHYLENE OXIDE
M & S MAINTENANCE & SUPPLIES
POLYETH POLYETHYLENE
PG PROPYLENE GLYCOL
REF REFINERY
UTIL UTILITIES
SCALE 1:20000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 10 METERS
DASHED LINES REPRESENT 5-METER CONTOURS
DOTTED LINES REPRESENT 1-METER CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 0.2 METERS
BURNS AND ROE, INC. HEMPSTEAD, NEW YORK
THE DOW CHEMICAL CO. MIDLAND, MICHIGAN
WEST AGUIRRE ENERGY CENTER LAYOUT
PUERTO RICO ENERGY CENTER STUDY
PUERTO RICO WATER RESOURCES AUTHORITY

EXHIBIT 3-2

raising sugarcane.

The main geological features of the site consist of rock underlying the high ground on the east end on which the nuclear reactors will be founded and the alluvial deposits that underlie the industrial area. These alluvial deposits are part of the Salinas alluvial fan that provides a good aquifer below the site that will act as a reservoir to backup the desalting plants in the event of shutdown.

Puerto Rico is a moderately active seismic zone and the Aguirre site could produce a base acceleration in the bedrock as high as 0.2g.

The site is served by highway Route 3 running along the northern edge which connects with Salinas and Ponce to the west, Guayama to the east and San Juan on the north shore of Puerto Rico.

The Salinas Airport lies just north of the site and is presently capable of handling light aircraft.

The average rainfall in the area is about 42 inches per year. The prevailing wind is from the east. The area has brief temperature inversion in the morning and evening, but they never persist throughout the day. The average annual air temperature is 80°F. Tides normally run about one to two feet, but could reach fifteen feet above mean sea level in a maximum intensity hurricane striking directly on the area.

3.2.2 Power Plant Area

The land in the southeast corner to be used for the nuclear power station is owned by PRWRA. Public hearings have been held regarding the use of this area for a nuclear power plant and Planning Board approval has been given.

The site has been arranged by PRWRA for four fossil fired power plants on the east end and four nuclear units near the center of the exclusion area. Construction is under way on the easterly two 460 mwe fossil fired power plants. PRWRA has announced that a nominal 560 mwe nuclear power plant will be built at this site to go into operation in 1976 and will occupy the most easterly of the nuclear plant sites. The second nuclear plant position could be the Energy Center dual purpose power plant to go into operation in 1978.

3.2.3 Industrial Area

The industrial area consists roughly of a rectangular plot of 2400 acres of land nicely sloped toward the sea. The plot would be graded into a series of terraces conforming to the general contours of the land and set at elevations of 5, 10, 15, 20 and 35 feet above mean sea level. To protect the lower levels from the 15 foot tide that is possible during a major hurricane, an 18 foot high levee would be placed on the seaward side.

The industrial plants presently planned for inclusion in the Energy Center would occupy the approximately 1,300 acres in the south portion of the plot. A demonstration farm could be located in the northern half of the plot which could later serve as an industrial expansion area.

The industrial plant layout shown in Exhibit 3-2 has taken into account five interrelationships for each plant, namely (1) with other plants, (2) with the power plant, (3) with the harbor, (4) with the project schedule and (5) with the possible plant ownership.

3.2.4 Harbor

The harbor facilities for the Energy Center have been located in the southwest corner of the site to take advantage of the naturally occurring water depths to minimize dredging and have good deep water access to the sea and yet keeping it within the barrier reef islands to afford protection against swells and heavy seas.

Berthing facilities would be provided to accommodate three classes of vessels as follows:

A. Barges of 10,750 short ton capacity with an overall length of 350 feet and a required water depth of 22 feet.

B. Multiproduct chemical tankers of 40,000 short ton capacity with a length of 680 feet and a required water depth of 40 feet.

c. Oil tankers of 150,000 dead weight ton capacity with an overall length of 990 feet and a required water depth of 65 feet.

4.0 ENERGY SEGMENT

The Energy Center uses energy in the form of electrical power and steam which would buildup over an eight year period to reach peak estimated loads as follows:

Electrical Power		700 megawatts
Process Steam		
400 psig	-	400,000 pounds per hour
150 psig	-	3,000,000 pounds per hour
40 psig	-	1,600,000 pounds per hour

It is proposed that the power and steam be furnished to industry from plants owned and operated by the Puerto Rico Water Resources Authority to obtain the benefit of their low financing charges as well as backup for electrical power from the grid and backup for steam from other power plants located at the site.

Preliminary studies compared the cost for producing electrical power in single purpose plants and indicated that nuclear power generation costs (4.34 mills per kilowatt-hour) are slightly lower than fossil power costs (4.44 mills per kilowatt-hour) based on 1969 costs. The data does not take into account escalation for either plant or the possible need for sulphur removal from the stack gas of the fossil plant.

The estimated generating costs from both types of plants would support rates at least 15% above the present rate schedule of 4.17 mills per kilowatt-hour for firm power loads greater than 40 megawatts at 100% load and power factors.

Six (6) alternate cases were studied to determine the most economical method of obtaining the required electrical power and steam from dual purpose plants. The results of these six cases are summarized in Exhibit 4-1. The six cases vary the number and size of reactors and compare nuclear with a dual purpose fossil power plant (Case VI). Where the amount of power generated by the dual purpose plant exceeds or falls short of that required by the Energy Center, it is assumed that the difference is furnished to or obtained from the power grid system. In addition, the power grid system firms the power by furnishing the backup power during emergencies or planned outages.

The steam supply to the industrial plants of the Energy Center must have a high degree of reliability just the same as the electrical power supply system. Since nuclear reactors must be shut down approximately once a year for refueling, the reactors must either be furnished in duplicate to achieve a continuous steam supply (Case II) or else steam must be obtained from other sources. Three other possible sources of steam can be obtained at Aguirre, namely package boilers (Case I), the two 460 mw fossil plants scheduled for operation in 1973 and 1974 (Case V) and the single purpose nuclear power plant scheduled for operation in 1976 (Cases III, IV and VI).

The capital cost of each of the six cases is shown in Exhibit 4-1. The capital cost covers the cost of the dual purpose power plant and the steam lines up to the PRWRA property limit. The capital costs associated with the additional generating capacity for the power furnished by PRWRA over and above that generated by the dual purpose plant or the backup steam capacity, except for the package boilers in Case I, are not included. The equivalent of these capital costs is included by the rates charged for electrical power from the grid and for the backup steam service.

The unit cost of steam based on full load is also shown in Exhibit 4-1. The procedure used to obtain the steam costs was to calculate the total annual operating costs including fixed charges for producing power and steam. Credit was then taken for power on two different bases, the first being the cost of generation of power from an equivalent sized single purpose plant or 4.34 mills per kilowatt-hour. The second basis was income from power sales based on the present rate schedule which was taken at 4.4 mills per kilowatt-hour and of this 4.0 mills per kilowatt-hour was credited to the dual purpose power plant with the remainder of 0.4 mills per kilowatt-hour going to the PRWRA system for backing up the power supply. The difference between the total cost and the power credit was charged to steam. Apportionment between the various steam pressures was made according to the available energies obtained by multiplying the theoretical steam rates by the appropriate steam flows. Standby steam costs were estimated by calculating the production cost of this steam in Cases I and II which require no backup from the Authority's plants. Where backup from the Authority's plants is required (Cases III, IV, V and VI), standby steam costs were estimated

COMPARISON OF DUAL PURPOSE POWER PLANT ALTERNATES

	I	II	III	IV	V	VI
Number of New Reactors	One	Two	One	One	One	None
New Reactor Rating - mwt	2785	1750	2785	1750	2785	2415[a]
Number of New T-G's	One	One	One	One	One	One
Gross Rating of New T-G - mwe	539	771	539	225	539	539
Source of Standby Steam	Package Boilers (New)	New Reactor	1976 Reactor	1976 Reactor	1973-74 Fossil Plants	1976 Reactor
Capital Investment - Millions of Dollars[b]						
	182	210	162	125	162	125
Total Steam Cost[c] - Cents Per 1000 lbs						
For Power Credit Based on Cost of Generation for Single Purpose Plant						
400 psig	32.8	26.8	27.3	36.2	33.2	35.3
150 psig	27.7	22.6	23.0	30.6	28.0	29.7
40 psig	19.7	15.5	15.7	21.1	19.2	20.5
For Power Credit Based on Income from Power Sales Using Present Rates						
400 psig	36.7	31.6	30.6	37.3	35.7	38.0
150 psig	31.0	26.6	25.8	31.5	30.2	32.0
40 psig	22.0	18.3	17.7	21.7	20.8	22.2

a. For this case the steam generator is oil fired. The value shown is input energy, the output energy is 2125 mwt.
b. Fixed charges for investment included in steam costs.
c. Does not include makeup water cost or 3% PRWRA overhead.

EXHIBIT 4-1

by calculating the loss in kilowatt-hours to the Authority's plants and using a rate of 4.34 mills per kilowatt-hour for the lost electrical energy.

The data in Exhibit 4-1 shows that when the power credit is based on income from power sales under the present rate schedule then Case III gives the lowest steam cost, but when it is based on cost of generation then Case II is slightly more economical. However more important than the small difference in the unit cost of steam is the much larger capital investment required for Case II and on this basis Case III is recommended.

A schematic diagram of Case III is shown in Exhibit 4-2. The exhibit also shows the contribution to the steam cost from the dual purpose plant, backup steam, and the cost of steam lines.

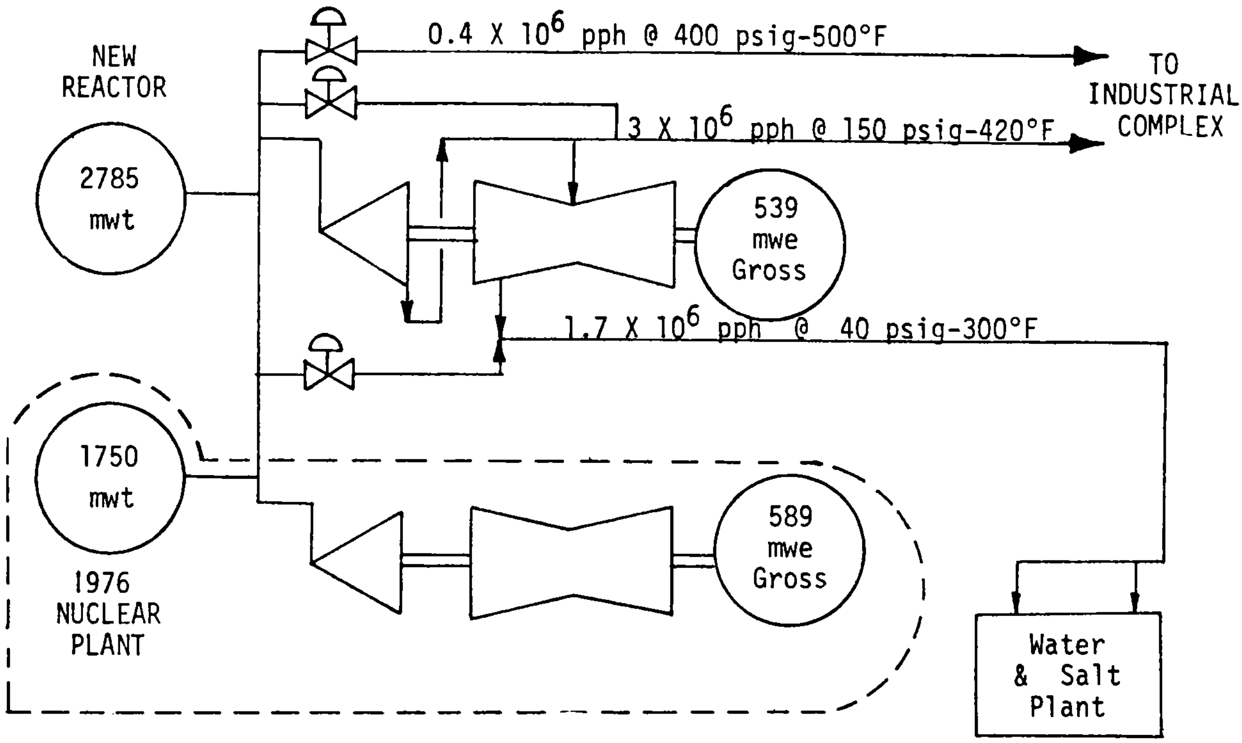
The savings for the dual purpose nuclear plant (Case III of Exhibit 4-1) compared to a dual purpose fossil plant (Case VI) is about $3,000,000 per year. This may be contrasted with the savings of single purpose nuclear compared to single purpose fossil of 0.1 mill per kilowatt-hour which corresponds to $490,000 per year. The increased advantage of the dual purpose nuclear plant comes in part from a larger unit, but primarily from the lower energy cost of nuclear fuel.

Based on the recommended Case III of Exhibit 4-1, a complete heat balance was developed to serve as a basis for preparing a detailed capital cost for the plant which gave an estimated capital cost as of June, 1969 of $161,203,000. With escalation, this cost would be about $196,800,000 by the time the plant was completed in 1978 if current escalation trends continue.

The industrial process steam load starts in 1975 and reaches full load in 1982. In 1975, the steam would be supplied from the 1973-74 oil fired fossil plants. For 1976 and 1977, the primary source of steam will be the 1976 single purpose nuclear plant with the fossil plants as backup. For 1978 and beyond, the primary source of steam will be the dual purpose power plant with steam backup from the 1976 nuclear plant. Based on this method of providing the steam during the buildup period, levelized steam costs over the 35-year life of the plant were developed with results as follows:

CASE III

DUAL PURPOSE POWER PLANT WITH BACKUP STEAM FROM 1976 NUCLEAR PLANT



Steam Costs
Cents Per 1000 lbs[a]

Steam Pressure psig	(1) Steam From New Plant 85% of Year	(2) Standby Steam 15% of Year	(3) Weighted Average	(4) Pipe-Lines	Total[b]
For Power Credit Based on Cost of Generation for Single Purpose Power					
400	23.5	42.7	26.4	0.9	27.3
150	19.9	36.1	22.3	0.7	23.0
40	14.0	25.5	15.7	---	15.7
For Power Credit Based on Income from Power Sales Using Present Rates					
400	28.0	39.4	29.7	0.9	30.6
150	23.7	33.3	25.1	0.7	25.8
40	16.7	23.5	17.7	---	17.7

a. Based on 100% condensate return; load buildup penalty not included.
b. Sum of Columns (3) and (4).

Steam Pressure psig	Steam Demand lbs/hr	Steam Cost (6/1000 lb.) with power credit based on:	
		Cost Of Generation	Income From Sale
400	400,000	29.1	32.3
150	3,000,000	25.8	29.1
40	1,700,000	16.3	18.6

In order to insure full cost recovery to PRWRA, these steam costs may require adjustment to take into account less than full steam use and the relative changes in costs due to escalation as compared to income from power rate increases. In addition these steam costs may require upward adjustment when system studies are performed by PRWRA that will assess the full impact and cost of the proposed method of supplying the power and steam requirements of the Energy Center on the entire PRWRA system.

The estimated steam costs, ranging from 16.3 to 32.3¢ per 1,000 pounds, are expected to be attractive to industry since it is not uncommon for industry to pay 50 to 75 cents per 1,000 pounds for steam. The lower unit costs for the Energy Center could represent a savings in the range of $10,000,000 per year. This savings is in part due to the use of the dual purpose nuclear power plant and in part to the ownership of the power plant by a governmental agency, which results in lower fixed charges.

The location of a large complex of power plants at Aguirre could have significant environmental effect on the Bay of Jobos due to use of this water for cooling purposes. It is recommended that a study be made of the effects of the discharge from such plants into the Bay and the immediate aquatic region.

5.0 WATER SEGMENT

5.1 Water Requirements and Supplies

The provision of an adequate supply of fresh water is essential to the development of the Energy Center and the Guayama Sub-Region in which it is located. The municipal and industrial water requirements of the Guayama Sub-Region are shown in Exhibit 5-1. Most of the water requirements are for industrial water and include the estimated requirement of 19 mgd for the Phillips development reached in 1977 and 26.8 mgd for the Energy Center reached in 1982. In the case of the Energy Center, all this fresh water is used for process purposes and only sea water is used for cooling.

The irrigation water requirements for the Guayama Sub-Region are largely satisfied by the existing South Coast Irrigation District and water pumped from wells. It is expected that the demand for irrigation water will remain steady or may decline in future years as food crops, other than sugar cane, are introduced which require less water.

The water supplies available to meet the projected municipal and industrial water requirements are shown in Exhibit 5-1 and consists primarily of water from wells and from the Toa Vaca Project.

Existing industrial and municipal wells produce 7.8 mgd and this could be supplemented with 4.0 mgd from wells on the West Aguirre Energy Center site presently used for irrigation. Well water generally costs less than 5 cents per thousand gallons at the well.

The Toa Vaca Project is scheduled to deliver 28 mgd in late 1977 and a total of 75 mgd in 1989 which will meet a major part of the requirement. The cost of water at Toa Vaca Reservoir is about 15.7 cents per 1,000 gallons and delivery costs are about 3.2 cents per thousand gallons to give a total raw water cost of 18.9 cents per thousand gallons. The quality of this water is probably adequate for direct use in most industrial processes. For municipal purposes, further treatment would be needed at a cost of 6.6 cents per thousand gallons bringing the total cost for this service to 25.5 cents per thousand gallons.

In addition, the chlorine-caustic plant of the Energy Center produces about 1.4 mgd of water from the caustic evaporators.

It can be seen from Exhibit 5-1 that two shortages of water occur, the first reaching a peak of 28 mgd in 1977 before it is relieved by Toa Vaca and the second reaching 33 mgd in 1989 before it is relieved by Toa Vaca.

These shortages must be supplied either from other wells or from desalting plants.

The alluvial aquifers of the Guayama Sub-Region should be capable of yielding about 10 mgd of additional well water over and above what they are now providing and these should be developed to the greatest extent possible. This leaves a shortage that must be met by desalting plants.

5.2 Basis of Sizing Desalt Plant

There are two bases on which the desalting plant can be sized, the first being to recover enough salt from the waste brine of the desalting plant to feed the chlorine-caustic plant i.e., 3,000 tons of salt per day. The second basis is satisfying the water needs of the Guayama Sub-Region including the Energy Center and buying all the salt needed for the chlorine-caustic plant. The water supplied on the two bases can be summarized as follows:

Water Source	Salt Basis	Water Basis
Desalt Plant	20.0 mgd	15.0 mgd
Salt Recovery Plant	8.3 mgd	--------
Chlorine-Caustic Plant	1.4 mgd	1.4 mgd
West Aguirre Wells	4.0 mgd	4.0 mgd
Toa Vaca	-------	6.4 mgd
Total	33.7 mgd	26.8 mgd

Sizing the desalting plant on the basis of meeting the salt needs results in a surplus of 6.9 mgd of water which would be available to the Guayama Sub-Region outside of the Energy Center. Sizing to satisfy salt needs makes the Energy Center independent of Toa Vaca Project and the surplus of water might make it desirable to delay the delivery of water from Toa Vaca until 1981. Based on satisfying the water

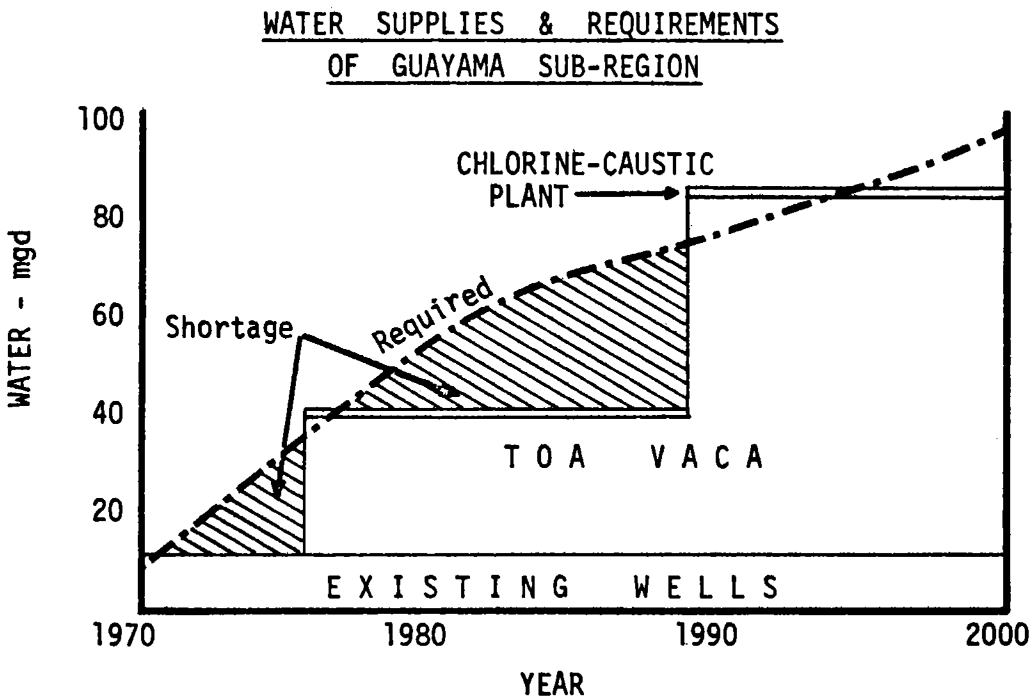

WATER SUPPLIES & REQUIREMENTS
OF GUAYAMA SUB-REGION
100
80
60
40
20
WATER - mgd
CHLORINE-CAUSTIC
PLANT
Shortage
Required
TOA VACA
EXISTING WELLS
1970
1980
1990
2000
YEAR

EXHIBIT 5-1

needs, a plant of 15 mgd going into operation in 1974 will take care of matters until 1985. This solution makes the Energy Center dependent on receiving water from Toa Vaca.

It was decided to study the desalting plant on the basis of satisfying the salt needs, i.e., a 20 mgd plant. This was arranged in two 10 mgd trains to give redundancy to reduce the chances of the total water supply being interrupted. The desalting plant is backed up by an underground reservoir with well capacity of 22 mgd to serve as an emergency supply. It is estimated that mining this underground reservoir could meet the water needs of the Energy Center for a period of one month.

5.3 Desalting Plants

Five different desalting plant designs were considered as summarized in Exhibit 5-2. Two multistage flash distillation plants were considered, one with a single-effect and the other with two effects. The single-effect multistage plant (SEMS or MSF) is the type of desalting plant most commonly built to date and on which the greatest experience has been developed. It is, however, not capable of producing a brine at a concentration factor of 3 using only acid pretreatment. It was primarily included to serve as a point of reference on desalted water costs. The multi-effect multistage flash distillation plant (MEMS) is similar to the SEMS except 2 effects are used and it can produce a brine of 3 times sea water concentration because the higher brine concentration occurs in the lower temperature effect. Fouling of heat transfer surfaces by invertly soluble calcium sulfate, is thus minimized.

Three multi-effect evaporators using vertical tubes with falling film evaporation were considered based on concepts developed by the Oak Ridge National Laboratory (ORNL) Aeroject-General (A-G) and W. L. Badger, Inc. (WLB). The ORNL and Aerojet-General designs use multistage flash preheaters (MSF). The W. L. Badger arranges the effects in two vertical towers. All the designs use enhanced heat transfer surface (fluted tubes) in the vertical tube evaporators.

The annual cost data is based on the fixed charge rate of capital of 7.835%, the use of exhaust steam from the

COMPARISON OF 20 mgd DESALT PLANTS

	MULTISTAGE FLASH		M E V T E		
	SEMS	MEMS	ORNL	WLB	A-G
EFFECTS	1	2	11	16	12
PERFORMANCE RATIO	10.0	9.0	9.6	12.0	9.6
CAPITAL-$ MILLIONS	20.0	20.6	16.9	19.0	15.4
ANNUAL COST-$ MILLIONS	3.2	3.3	2.9	2.8	2.8
COST OF WATER-¢/k GAL.	52	53	47	44	45

EXHIBIT 5-2

dual purpose nuclear power plant at 20¢ per million Btu, electrical power at 5 mills per kilowatt-hour and an on-stream efficiency of 85%.

The cost data given in Exhibit 5-2 indicates that the multi-effect vertical tube plants all produce water at lower costs than the multistage flash distillation plants. A waste brine stream at three times sea water concentration can be obtained from the VTE plants at no cost penalty to the production of water. Increasing the on-stream efficiency from 85 to 90% would lower the cost of water about 1 cent per thousand gallons. Reducing the plant capacity to 10 mgd increases the unit cost of water to 57 cents per thousand gallons for a SEMS plant and 49.9 cents per thousand gallons for the ORNL MEVTE plant.

The seawater feed to the desalting plant is pretreated to prevent scale formation at the elevated temperatures in the evaporators. Four processes were considered in detail, namely, acid, caustic, lime-magnesium carbonate (LMC) and ion exchange. The barium desulfating process was given preliminary consideration but was eliminated on the basis of unfavorable economics in the size range of interest in this case. The data for the four processes that were studies are shown in Exhibit 5-3 and indicate that for a desalting plant in the 20 mgd range using exhaust turbine steam and limiting brine concentration factor to three, the acid process is lowest in cost. The caustic process is close in cost to the acid process and might be competitive depending on the ratio of acid to caustic costs in specific instances.

SEAWATER PRETREATMENT DATA

FOR 20 mgd DESALTING PLANT

ITEM	PROCESS			
	ACID	CAUSTIC	LMC	ION EXCH
CAPITAL-$ MILLION	440	680	2,750	2,630
ANNUAL COST-$ MILLION	264	328	555	577
COST-¢/k GALLON	4.3	5.3	9.0	9.3

EXHIBIT 5-3

6.0 INDUSTRIAL SEGMENT

6.1 Establishment of the Industrial Complex

The industrial segment of the study evaluated a group of potential product modules with the objective of assembling them into an interrelated, viable production complex. A prospective list of plants and products of the most likely candidates were:

Chemical Refinery	Vinylchloride	Salt By Solar Evaporation
Ethylene	Aluminum	Salt By Steam Evaporation
Ethylbenzene	Magnesium	Magnesium Hydroxide
Cumene	Silicon Metal	Hypochlorite
Propylene Glycol	Copper Refining	Elemental Phosphorous
Chlorine-Caustic	Electric Furnace Iron	Phosphoric Acid Wet
Ethylene Dichloride	Hydrogen & Ammonia	Heavy Water
Ethylene Glycol		Fuel Processing
Petroleum Coke		

Each module selected for inclusion in the industrial segment was tested against the following criteria:

A. Is there a market position for this product during the 1975-1990 study period?

B. Can it be profitably manufactured for this market during this period?

C. Is the indicated profitability such that it can probably stand the test of competition with other manufacturing locations?

D. Do pollution or other factors make it unsatisfactory for Puerto Rico?

E. Are there plans for the same or a similar product for Puerto Rico which might predate construction of this plant?

F. Can derivative products be manufactured so that additional jobs may be created?

In addition, potential product modules were considered in light of the advantages that Puerto Rico offers, such as:

A. Possible oil quota position

B. U.S. Tariff protection

C. Tax incentive plan

D. Low cost electrical power and steam

E. Deep harbor

F. World geographical distribution location

G. Proximity to certain raw materials

There are also disadvantages:

A. Shipment to the Gulf and East Coast must be in United States ships involving higher shipping costs

B. Lack of a large local industrial market

C. Distribution costs

D. Absence of local mineral deposits except for copper ore.

The economics of the potential products were screened and after the products were identified as being candidates for the industrial segment, it was necessary to size them so that:

A. Raw materials balance

B. The plant size is compatible with projected technology

C. The plant capacity makes business sense for the 1975-1990 period

It was necessary to forecast the size of operation for these years which could economically fit into the market picture without disrupting the price structure and which would be feasible to build in the light of competitive efficiency and construction technology.

Although it is important to look at the economic viability of each module, the ultimate judgment of feasibility is made on the industrial segment as a whole, taking into consideration the economic advantage of complexing. This means consolidating the facilities and services which, if well coordinated by good management, can be shared by all, thus eliminating costly duplication.

Using the criteria, advantages and disadvantages outlined above, a trial complex was assembled (Case I) based on a 60,000 barrel per day chemical refinery with liquified petroleum gas (LPG) used as cracking stock for making ethylene and propylene. A chlorine-caustic plant supplied raw materials for reacting with hydrocarbons. A 130,000 ton per year aluminum plant was included. The capital cost of this complex was estimated to be $289.8 million. The discounted cash flow was found to be 10.2% which is generally not favorable. The discounted cash flow is equivalent to the maximum interest rate that could be paid for a 100% loan without loss if the cash flows are realized. It was concluded that the plants selected were too small to give favorable economics.

A second complex (Case II) was then assembled again based on a 60,000 barrel per day refinery, but in this case, the naphtha as well as the liquified petroleum gases were cracked giving substantially larger plants. The aluminum plant was kept the same size. The capital cost was estimated to be $459.1 million. The discounted cash flow was 14% which is more favorable. However, further study disclosed that of the 1610 million pounds per year of caustic produced that 808 million pounds would have to be sold on the open market which was deemed to be too much.

Case III was then developed again based on a 60,000 barrel a day refinery, but the chlorine-caustic plant was cut back to a capacity of 1470 tons of chlorine per day to reduce the caustic production to a level that could be sold in the years 1975 and 1990. The reduction in chlorine production necessitated a reduction in ethylene dichloride production and the excess of ethylene was used in the manufacture of ethylene glycol and high density polyethylene. The estimated capital cost was $468.2 million. The discounted cash flow was 14%.

Cases III A and B were then developed which refined the economic data used in Case III including the quantity of utilities required and their cost, the selling price for high density polyethylene and ethylene dichloride, and a reduced estimated cost of the harbor facilities. The material balance flow sheet for Case III A is shown in Exhibit 6-1. The difference between these two cases was that Case III A included a plant for the recovery of salt from the brine effluent of the desalting plant and used an industrial water cost of 40 cents per thousand gallons on the basis that most of this water would come from desalting plants. In Case III B, the salt was purchased and the cost of industrial water was assumed to be 30 cents per thousand gallons on the basis that it would be supplied from lower cost water sources outside the Energy Center.

The capital costs of Cases III A are summarized in Exhibit 6-2 and gives a total estimated capital cost of $476.2 million. The economic data for Case III A are summarized in Exhibit 6-3 and gives an overall discounted cash flow of 15.4% which is considered favorable for implementation. The economic ground rules used are summarized in Appendix 6.1.

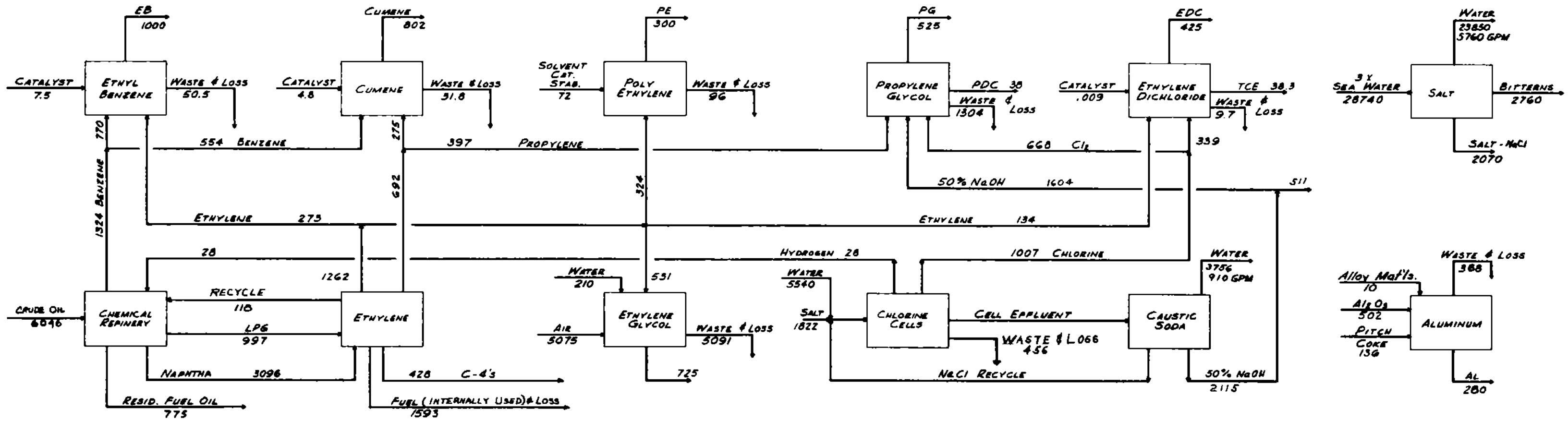
The total estimated capital cost of Case III B is $467.8 million. The discounted cash flow was found to be 15.4% or the same as Case III A indicating that the discounted cash flow is not too sensitive to the cost of industrial water and the profitability of the salt recovery plant provided in Case III A has offset the higher cost of the industrial water.

6.2 Effect of Changes in Assumptions

Changes in key economic factors will effect the projected discounted cash flows. Examples of these factors are given below:

Oil Quota: If the oil quota position were not obtained, the costs of oil would increase in the range of $.80 to $1.20 per barrel. Annual costs would increase from 15 to 25 million dollars. This would be reflected in a lower discounted cash flow percentage of 2-3%.

Tax Incentive: If the tax incentive program were removed, the economic returns would be very severely affected. If taxes having an equivalent effect of 40-50% on profits were imposed, the adverse effect would be in the range of 4.5-5.5%.



Note:
All quantities measured in million (m) Lbs/Yr.
Operating factor - 345 Day / Yr.

Utility Requirements

Utilities & Waste	Units	Chem. Ref.	Ethylene	EB	Cumene	PG	EDC	EG	PE	Chlorine Caustic	Al	Salt	Utilities Site	Sub Total	Extra Allow.	To Be Provided	
Steam 150 psi	k Lbs/Hr.	421	23	61	63	670	43	255	455	588	0	870*	6.0	870* 2585	170* 415	1040* 3000	
Steam 400 psi	k Lbs./Hr.	0	0	0	0	120	0	191	27	0	0	0	0	338	62	400	
Power	mw	23.0	53.1	1.9	1.6	4.2	.5	15.1	13.6	180	223	1.6	66.2	583.8	116.2	700*	
Sea Water	k GPM	81	19	6	7	76	15	45	46	59	8	36	1.0	399	51	450	
Industrial Water	gpm	0	500	50	38	7500	47	0	3030	1340	133	0	0	12638	2362	15000	
Potable Water	gpm	20	30	6	5	25	10	25	50	35	60	20	60	346	54	400	
LQ. Desalted Water	gpm	160	600	0	0	1060	0	80	0	0	0	0	0	1900	400	2300	
Comp. Air	k SCFM	1.0	1.1	0.2	0.2	5.0	0.6	2.9	1.1	1.6	4.0	3.0	1.4	22.1	2.9	25	
Nitrogen	k SCFH	0	0	0	0	5.4	0	3.1	22.7	0	0	0	0	31.2	3.8	35	
Fuel	m/btu/hr.	0	0	80	68	0	0	0	36	12	24	0	17	237	63	300	
Condensate Out	gpm	800	40	100	100	1500	80	800	800	1100	0	1650	5	6975	+ 1065	8040	
Liquid Waste	gpm	841	454	50	15	7600	47	120	3000	0	100	0	0	12,227	2773	15,000	
Solid Waste	k Lbs./Hr.	0	0	0	0	0	0	0	0	35	0	0	0	35	5	40	
Tar	k Lbs./Hr.	0	0	1.6	2.6	0	0	0	0	0	0	0	0	4.2	0.8	5	

* 40 PSIG

ORIGINAL B/M NO.

Burns and Roe, Inc. Hempstead, New York	The Dow Chemical Co. Midland, Michigan
Case III A Material and Utility Balance	
Puerto Rico Energy Center Study Puerto Rico Water Resources Authority	

EXHIBIT 6-1

CAPITAL SUMMARY FOR INDUSTRIAL PLANTS

CASE III-A

(In Millions of Dollars)

Product	Battery Limits	Storage, Pollution Control	Interest During Construction	Total Investment
Chemical Refinery	$ 53.7	$ 2.1	$ 5.0	$ 60.8
Ethylene	57.0	.9	5.2	63.1
Chlorine-caustic	24.8	.5	2.3	27.6
Ethylbenzene	5.0	.8	.5	6.3
Cumene	4.9	.7	.5	6.1
Ethylene Dichloride	2.9	.4	.3	3.6
Ethylene Glycol	36.0	1.0	3.3	40.3
Propylene Glycol	18.8	4.4	2.0	25.2
High Density Polyethylene	46.9	.9	4.3	52.1
Aluminum	92.1	1.5	8.4	102.0
Salt Recovery	7.6	.1	.7	8.4
Other		2.6	.2	2.8
	$349.7	$15.9	32.7	398.3

Site and General Facilities	$31.1	2.8	33.9
Utilities Distribution	$25.9	2.3	28.2
SUBTOTAL		37.8	460.4
Harbor and Docks	$14.5	1.3	15.8
TOTAL		$39.1	$476.2

EXHIBIT 6-2

EXHIBIT 6-3

ECONOMIC EVALUATION OF INDUSTRIAL MODULES CASE III-A

Product	Capacity Millions of lb per year	Cost for Sale $ per lb	Net Selling Price $ per lb	Market Price Delivered $ per lb	Discounted Cash Flow %
Ethylbenzene	1000	.0257	.0378	.0400	16
Cumene	802	.0238	.0378	.0400	18
Ethylene Dichloride	425	.0180	.0245	.0267	13
Ethylene Glycol	725	.0250	.0500	.0525	18
Propylene Glycol	525	.0511	.0866	.0900	18
High Density Polyethylene	300	.0778	.1193	.1296	14
Salt Recovery	2070	.0010 (T)			
Chlorine	1007	.0082 (T)			
Caustic	802	.0078 (T)			
	256	.0087	.0125	.0140	14
Ethylene	1262	.0192 (T)			
Propylene	692	.0129 (T)			
Benzene	1324	.0207 (T)			
Aluminum	280	.2039	.2646	.2714	14

ECONOMIC SUMMARY Case III-A

	Industrial Chemicals	Aluminum	TOTAL
Total Fixed Investment (Millions of $)	345.8	114.6	460.4
Working Capital (Millions of $)	40.5	17.2	57.2
Total Annual Sales (Millions of $)	199.2	74.1	273.3
Total Annual Costs (Millions of $)	123.2	57.1	181.9
Discounted Cash Flow %	16.3	13.9	15.4

(T) Transfer

Steam Energy: If the steam from the dual purpose, electric-steam energy system became unavailable, the conventional fossil-fueled boilers would be required. Purchased cost of 150 pound steam would range in price from 50-60¢ per thousand pounds (5.5-8.5 million dollars per year). The adverse effect on the discounted cash flow percentage would be 0.7-1.0%.

Deep Harbor: Should it become impossible to use large 150,000 deadweight ton ships for importing crude oil for the chemical refinery, the distribution cost would be substantially increased. Fifty-thousand ton ships using the harbor designed for the chemical tankers would incur an additional cost of $4 million annually. This would have an adverse effect of 0.5%.

Power Rate: An increase in the power rate of 1 mill per kilowatt-hour would reduce the discounted cash flow by 0.8-1.1%.

Land Cost: Increasing the assumed land cost of $4,000 per acre to $12,000 per acre would decrease the discounted cash flow 0.4-0.5%.

It should be recognized that, with the exception of the tax impact, these factors are additive and the overall impact is only slightly below the cumulative figure.

6.3 Thermal and Chemical Effluent Control

It is essential that the discharge of thermal and chemical wastes from the industrial plants be acceptable to all regulatory agencies having jurisdiction. The criteria used by these agencies and the interpretation of the criteria are in a period of change so that the only way to determine acceptability is to study the effects of proposed discharges and to submit a proposed solution for their review and acceptance. As such it is not possible for this study to definitely resolve the problem of waste disposal, however, the assumptions made and the provisions included in the physical plant can be outlined.

In regard to thermal discharge it has been assumed that the seawater used for industrial cooling would be returned to the discharge canal of the power plant so that all cooling water is disposed of together. In the Energy Segment of this study it was recommended that a study be made of the effect of this thermal discharge on the environment.

It is also recommended that a study of the chemical waste discharge be conducted to insure the adequacy of the systems that have been incorporated into the industrial plants as described in the remainder of this section.

Waste control facilities are provided for liquid, solid and gaseous wastes from the industrial plants.

The chemical refinery, ethylene, polyethylene, and propylene glycol plants discharge organic wastes either dissolved or suspended in water. A bioxidation process treatment plant is provided to reduce the total oxygen demand of this waste water by 85%.

The ethylbenzene, cumene and chlorine plants will produce wastes that will be disposed of in a tar burner and scrubber. In addition, incinerators are provided for the disposal of combustible wastes without pollution.

The chlorine and aluminum plants will produce solid wastes that will be disposed of by land filling.

The aluminum plant will provide fume scrubbing for the anode gas to remove gaseous fluorine compounds and dust particles consisting mainly of fluorides, alumina and carbon. Pot room air is exhausted through a spray chamber.

6.4 Other Products Studied

In addition to the plants recommended for inclusion in the Energy Center, several other products were studied.

Calcined coke, a product made from the residual fuel oil of the chemical refinery, is used in the manufacture of electrodes for the aluminum plant. This plant has a discounted cash flow of 16% and is recommended for inclusion in the Energy Center, the only reason for not including it in Case III was its late development in the study which prevented it being incorporated into the material and economic balances of Case III.

Brine products consisting of sodium sulfate, potassium chloride, bromine, and magnesium can be recovered from brine effluent of the salt recovery plant. The discounted cash flow of this group of products was 13.9% which is on the lower edge of viability. Extensive development of the evaporative-crystallization processes would be needed. For these combined reasons, the brine products are not recommended for inclusion at this time but might be incorporated in the future if development work proves successful.

Elemental phosphorus and ferrosilcon were studied and it was concluded that the shipping costs for importing raw material and exporting the product were too big a handicap for the tax and power advantages of Puerto Rico to overcome.

Vinyl chloride was not economical for the Energy Center because manufacture of the raw material (hydrogen chloride) and the distribution problems in shipping a low boiling point product, incur special costs which adversely affect its competitive position in world markets.

Recovery of salt by solar evaporation of the brine from the desalting plant was investigated and it was determined that 4,700 acres of land would be required. For the process to be competitive, the land cost could not exceed $800 per acre and suitable land is not available in Puerto Rico at this price.

Production of magnesium oxide from seawater was investigated, but the potential market in Puerto Rico of 1,000 tons per year in the sugar mills was too small to make its recovery economic.

Production of bleach which is made from chlorine, caustic and purified water was studied. It was found that a modest market existed in Puerto Rico, but that several local producers were already active in this area.

6.5 Other Products Considered

A series of additional products were considered and then dropped and these are listed below with the reason for their elimination:

Product	Reason for Elimination
Electric Furnace Iron	Project being developed
Copper Refinery	Project being developed
Hydrogen and Ammonia	Power too expensive and local markets too small
Phosphoric Acid Wet	Phosphate rock and low cost acid not locally available
Nuclear Fuel Reprocessing	No fluorine plant available - Uncertain Market
Heavy Water	Uncertainity of market

7.0 AGRICULTURAL SEGMENT

Although agriculture production in Puerto Rico has been relatively static in recent years, the demand in Puerto Rico for fruits and vegetables has greatly increased. This rising demand includes many fruits and vegetables that can be grown in Puerto Rico but instead has largely been met by increased imports as shown below:

Produce	Imports - Thousand of Pounds 1968	Potential 1975
Avocados	0	1,000
Citrus Fruits		
Processed	17,000	30,000
Fresh	7,000	10,000
Peppers	3,000	4,000
Plantain	0	20,000
Tomatoes		
Processed	32,000	29,000
Fresh	18,000	32,000
Yautia	1,700	13,000

Imports of these fruits and vegetables as well as others are projected to reach a value of $20 million by 1975. This offers a ready-made market for local production of these crops. Additional markets exist for the produce listed above in the larger cities on the eastern coast of the United States, where some Puerto Rican produce can be competitive because of rising farm labor costs in the U. S. or because of high prices which prevail during certain seasons.

The cost, income and net earnings from growing selected crops on the South Coast of Puerto Rico were calculated and the results are summarized in Exhibit 7-1. These results are based on a 500 acre fully mechanized farm, with equipment operators paid $1.75 per hour and field labor $1.25 per hour with a 50% allowance for fringe and social benefits. The net earnings shown are based on land rental at $120 per acre per year but no costs are included for water. The net earnings are also shown after allowing for the cost of water assuming it costs 1.3¢, 10¢, 30¢, and 45¢ per thousand gallons. The cost of 1.3¢ per thousand gallons represents the approximate cost of irrigation water supplied by the South Coast Irrigation District. The value of 45¢ per thousand gallons represents the cost of desalted water.

The net earnings for sugar cane of $159 per acre per year is higher than that presently reported and stems from the assumption of full mechanization. In spite of this, all but one of the crops show a higher net earning than sugarcane. Exhibit 7-1 also shows the effect on the net earnings of the cost of water; some crops are sensitive to water costs, others are not.

A study was made of a 500 acre commercial farm operation for those crops that showed high unit profitability as follows:

Crop	Acres
Orchard	
Mangos	50
Avocados	40
Grapefruit	30
Semi-Orchard	
Plantain	100
Root Crops	
Yautia	50
Sweet Potatoes	50
Vegetables	
Tomatoes	100
Peppers	35
Squash	15
Buildings and Roads	30
Total	500

A COMPARISON OF COSTS, INCOME, AND NET EARNINGS FROM CROPS TO BE GROWN ON THE SOUTHERN COAST OF PUERTO RICO, CALCULATED ON A 12-MONTH BASIS

	SUGAR CANE[a]	AVOCADOS	GRAPEFRUIT	MANGOS	ORANGES	PLANTAIN	PUMPKIN-SQUASH	SWEET PEPPERS	TOMATOES	SWEET POTATOES	YAUTIA	LANDSCAPE PLANTS	FOLIAGE PLANTS (SHADE)
NORMAL CROP CYCLE (Months)	36	12	12	12	12	15	4	4.5	4.5	4	12	12	12
IRRIGATION WATER[c] (Acre-feet per year)	2.2	1.0	.75	1.0	.75	1.5	2.8	3.7	2.8	2.8	1.6	2.5	3.3
YIELD	4.95 tons/acre	14,000 fruit	15,000 fruit	80 cwt/ac	30,000 fruit	24,000 fruit	240 cwt/ac	320 cwt/ac	300 cwt/ac	140 cwt/ac	93 cwt/ac	10,000 plants	(f)
PRICE ($ per cwt)	137 per ton	100 per k	70 per k	12.00	30 per k	37.50 per k	5.00	13.50	10.00	8.00	10.40	1.25 each	(f)
DIRECT COST ($ per acre)	331	290	362	285	362	466	565	1,934	1,527	1,332	429	9,173	4,624
INDIRECT COST ($ per acre)	233	410	483	401	483	285	274	766	654	542	272	1,866	5,033
TOTAL COST ($ per acre)	564	700	845	686	845	751	839	2,700	2,181	1,874	761	11,039	9,657
GROSS INCOME ($ per acre)	722[b]	1,400	1,050	960	900	955	1,200	4,325	3,000	3,360	958	12,500	13,500
NET EARNINGS ($ per acre)[d]	159[e]	700	265	274	55	204	361	1,625	820	1,486	257	1,461	3,843
AFTER WATER @ 1.3 per k gal	150	696	254	270	52	198	349	1,608	808	1,474	251	1,450	3,829
AFTER WATER @ 10¢ per k gal	87	667	181	241	31	155	268	1,505	728	1,394	205	1,380	3,735
AFTER WATER @ 20¢ per k gal	15	634	156	208	6	106	176	1,385	637	1,302	153	1,299	3,677
AFTER WATER @ 30¢ per k gal	(56)	602	132	176	(18)	57	85	1,265	546	1,211	102	1,218	3,620
AFTER WATER @ 45¢ per k gal	(163)	546	94	127	(55)	(17)	(52)	1,085	409	1,074	25	1,096	3,534

a Average of three 12-month crops of Primavera and two ratoons
b Without Government crop bonus of $1.00 per ton of cane
c Irrigation water is that water required over and above natural rainfall
d After rental of $120 per acre per year and before deducting cost of water
e This value is larger than that achieved in present practice because it is based on full mechanization
f Based on 50,000 stock plants yielding cuttings worth 30¢ per year per plant less 10% brokerage fee

Abbreviations

cwt: hundredweight
ac: acre
k: thousand

EXHIBIT 7-1

The capital investment in the farm would be:

Fixed Capital:

Buildings	$150,000
Farm Machinery	152,000
Irrigation Equipment	300,000
Total Without Land	$602,000

Working Capital:

Accounts Receivable	$ 75,000
Crops in Process	75,000
Total	$150,000

The annual operating profit for the farm is estimated to be:

	Years 1-4	Years 5-15
Sales	$ 780,000	$ 916,000
Costs	-585,000	-588,000
Annual Operating Profit	$ 195,000	$ 328,000

The orchard crops will not yield fruit for sale until the fifth year, accounting for the increase in sales shown beginning in the fifth year. If it is assumed that orchard land can be intercropped with plantain then the operating profit can be increased by $60,000 in the second year and $40,000 in the third year which would bring the operating profit for year 1 to 4 to $295,000.

The operating profit is based on the same labor rates, crop yields and prices as used for individual crops shown in Exhibit 7-1 except that no rental is included for land which is now handled as a fixed capital investment. Property tax was taken at $15 per acre per year, income tax rate at 35% and project life at 15 years. Irrigation water was assumed to cost 10¢ per thousand gallons.

The discounted cash flow return as a function of land cost is given in Exhibit 7-2 with water costs shown

ECONOMICS OF COMMERCIAL FARM

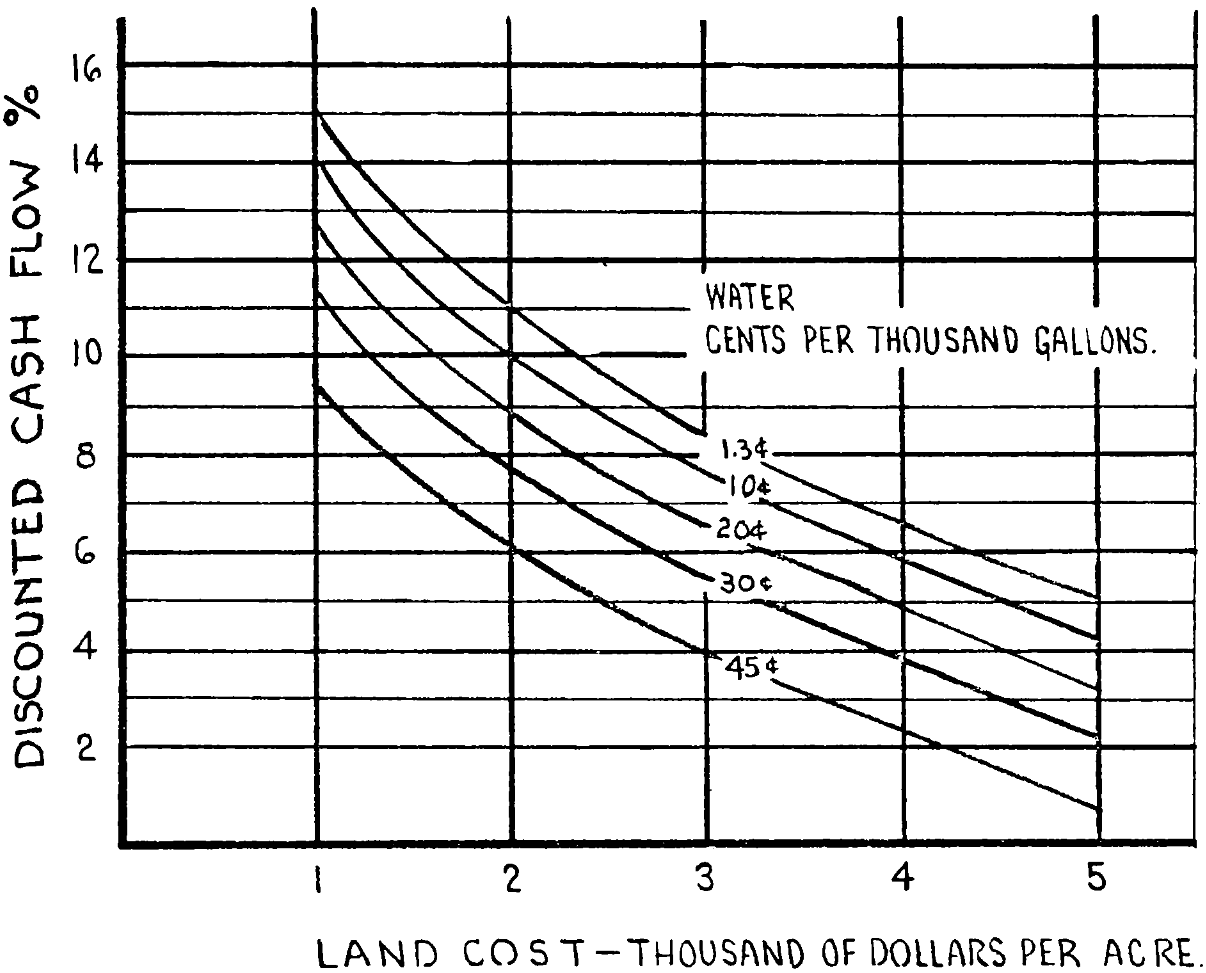


EXHIBIT 7-2

parametrically. The operating profit data cited above (without the intercropping of plantain) corresponds to the 10 cents per thousand gallon water cost line in Exhibit 7-2. As an illustration, if the water cost 10¢ per thousand gallons and land cost $1,000 per acre, then the discounted cash flow is about 14%. Established farms with low cost irrigation water available such as those with ample wells or those in the South Coast Irrigation District could achieve a discounted cash flow approaching 15%.

Generally speaking, desalted water at 45 cents per thousand gallons is too expensive for agriculture in Puerto Rico.

As part of a program to implement these changes in agriculture, it is proposed that a 500 acre demonstration farm be established to prove the economics set forth in this study. A possible site is at the West Aguirre Energy Center. However, since this farm will not necessarily use desalted water, it need not be located in close proximity to the Energy Center. The operation of the demonstration farm, its capital cost, annual cost and income is described at length in the main report.

8.0 SOCIO-ECONOMIC CONSIDERATIONS

The Energy Center will provide direct employment for about 5,000 people for construction and about 4,000 for operation. Total complex derived employment, in the area in 1979 is estimated to be 11,600. Area population supported at that time by the Energy Center will be about 50,000. Personal expenditures for goods and services in the area should total $54 million and complex purchases will be $35 million. Substantial tax revenues will be built up, but extensive training programs, community development and infrastructure will be required before these revenues can be achieved. The estimated cost of the needed investments in the community is $300 to $400 million by 1980 of which roughly half would be by the Government of Puerto Rico and half by private investment. No major problems in financing are anticipated. Extensive cooperative planning and imaginative implementation will be needed for the developments outside the complex itself.

Consideration of the major socio-economic effects leads to the following conclusions:

A. Construction will require a substantial addition to the skilled labor force (4,500 - 5,000).

B. Skilled operating personnel will need to be trained in a wide variety of skills (4,000 or more).

C. The area will have an additional $80 - 100 million of business in goods and services which will support an additional 7,500 - 8,500 jobs.

D. While the Energy Center and the Phillips development should reduce unemployment and underemployment within the Sub-Region to a minimum large numbers of people will have to move into the area.

E. Community development will need to be extensive, early and attractive to in-migrants while preserving the rights of current inhabitants.

F. Infrastructure growth in the area must be great in both breadth and depth as a new major industrial center will result.

G. The area most affected by the complex will be Guayama, Salinas, Santa Isabel, and Cayey. Planning and implementation for developments outside the complex will require cooperation of many groups in a coordinated program to see that people with proper skills are attracted, made welcome and identified with the community.

Training programs for construction skills should be started before the end of 1970 in the Energy Center area. This will need to be supplemented by programs elsewhere on the island. Federal assistance should be sought.

Technical and professional programs for education should be expanded. The regional branch of the University of Puerto Rico at Cayey should be expedited. Medical and other health care programs should be included in the speedup.

Formal planning for the entire Energy Center area should encompass land use zoning, residential and public housing development, commercial and services center development, traffic pattern for road and street programs, infrastructure locations and timing and other community development needs.

Plans for community facilities to be provided should provide background for all necessary financing, including arrangements for the private housing, etc.. A group should be formed under the sponsorship of the Planning Board which includes the four municipalities primarily affected plus appropriate commonwealth departments and agencies to coordinate the planning, financing and implementation of the program to develop the area as needed, and to minimize the dislocations and adjustments.

Specific programs and new community service groups should be developed to assist potential new inhabitants to locate suitable housing, to provide information and advice about available services and stores, to aid in establishing constructive social relationships and identification with the community. Existing social, religious and government organizations should be reoriented to give specific services to this development of the new communities.

9.0 IMPLEMENTATION PLANNING

The total estimated cost of the Energy Center is as follows:

Item	Cost Millions $
Industrial Plants	398.3
Site and General Facilities	33.9
Utilities Distribution	28.2
Harbor and Docks	15.9
Dual Purpose Power Plant	161.2
Desalting Plant	17.0
	$654.4

The proposed project schedule is shown in Exhibit 9-1. This schedule limits the capital expenditures to about $100,000,000 per year and construction manpower to about 4000 to 5000 men per year. The nature of the plants is such that the development of the project can proceed in six stages, each of which represents a plateau of stability and a basis for lengthening the project schedule if necessary.

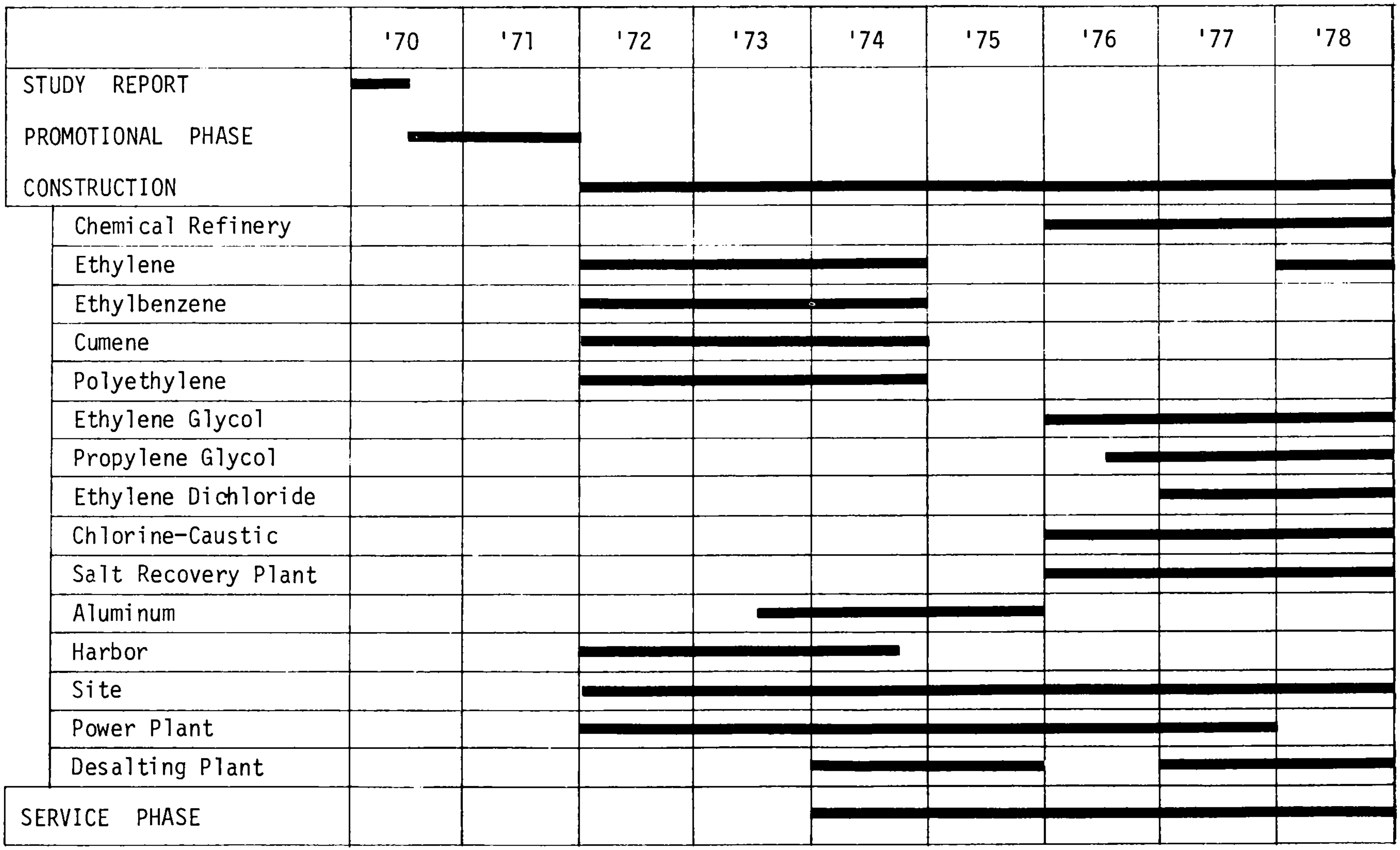
The promotion of the Energy Center can be handled by Fomento, acting for the various governmental agencies of Puerto Rico in a role they have successfully filled in the past in connection with the industrialization program of Puerto Rico. The establishment of contracts between the governmental agencies of Puerto Rico and industry, will be the basis for the governmental agencies to raise money for their portion of the project through the issuance of bonds. The government agencies would finance the purchase of the land and its improvements, the dual purpose power plant, the desalting plant and harbor facilities. Industry on the basis of the same contracts and the indicated profits would raise money for financing the industrial plants. The exact location of the interface between the governmental agencies and industry and the degree of risk to be assumed by each are matters to be worked out during negotiations and will be dependent in part on the organization plan that is adopted.

Four organization plans for the Energy Center are developed as shown in Exhibit 9-2, three of which are recommended

EXHIBIT 9-1

PUERTO RICO ENERGY CENTER STUDY

PROJECT SCHEDULE



as applicable. Two of these plans (Plans A & B) call for all industries of the Energy Center to be party to a management agreement that will be the basis of contracting with Fomento for the complete development of the Puerto Rico Energy Center. Coincident with the agreement, contracts must be executed with PRWRA to construct the dual purpose power plant to supply power and steam, with PRASA to supply water and brine from the desalting plant, with the Ports Authority to build the harbor facilities and with the Land Administration and PRIDCO for the lease of the land. All contracts would include provisions for future growth of the industries in the Energy Center.

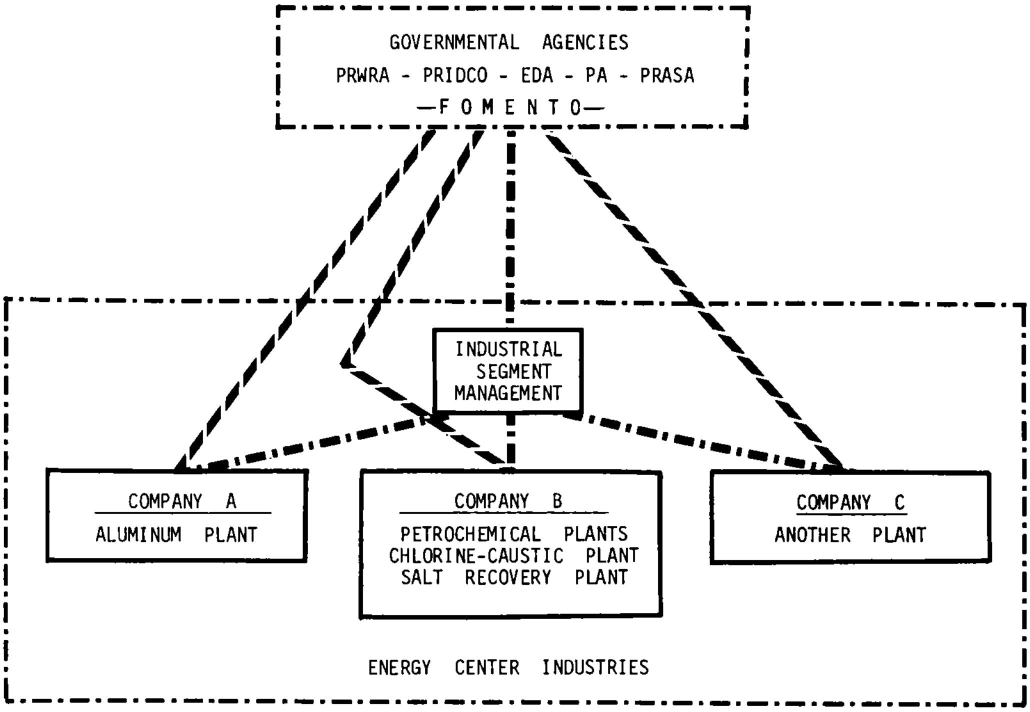
Plan A calls for two industrial organizations to be the initial signators of the management contract, namely, an aluminum company and a petro-chemical organization that would build the petro-chemical, chlorine-caustic and salt recovery plants. This plan would develop the full economic potential as set forth in this study.

Plan B is similar to Plan A except that three separate organizations build (1) the petro-chemical plants, (2) the chlorine-caustic and chlorinated hydrocarbon plants and (3) the salt recovery plant. This plan reduces the capital investment of the participants and would develop the full economic potential. However, the chances of reaching simultaneous agreement between so many industries and government agencies are poor so that it may not be possible to promote this plan.

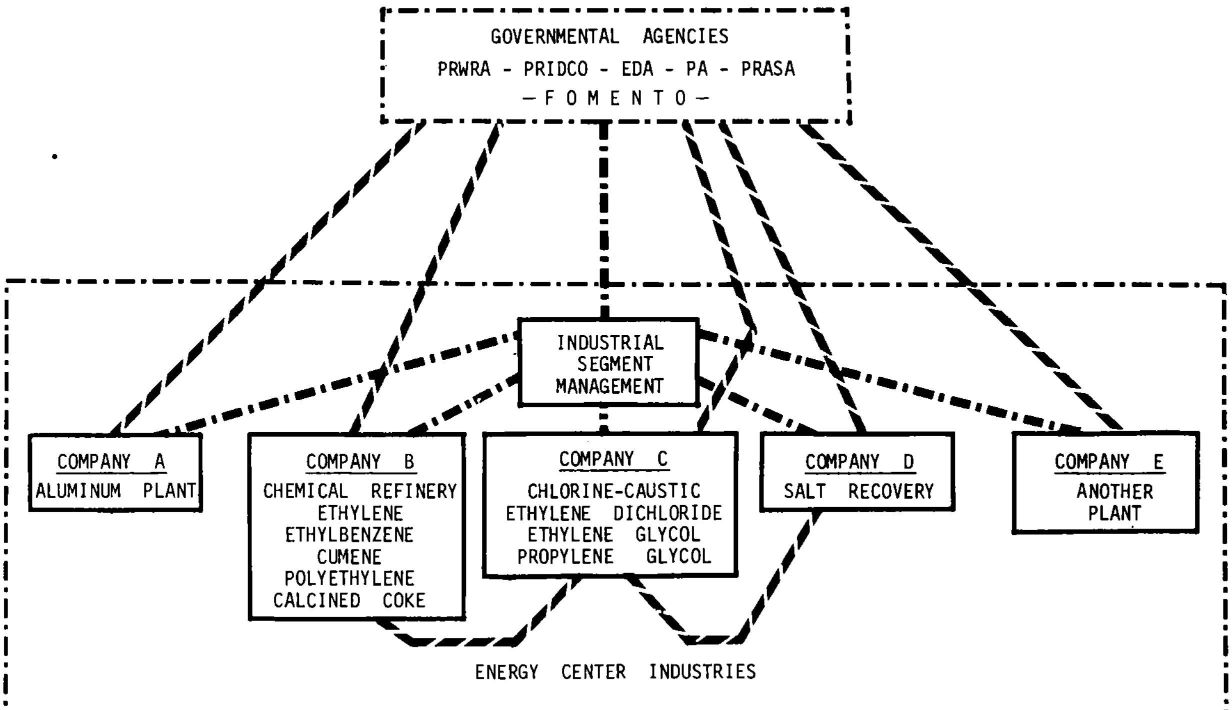
Plan C calls for Fomento to play the central role in the development of the Energy Center and to enter into separate agreements with an aluminum producer and a petro-chemical organization, with the latter building the petro-chemical, chlorine-caustic and salt recovery plants. This plan adheres closely to past practice in Puerto Rico and gives maximum flexibility in promotion. It develops most but not all of the economic benefits indicated in the study.

Plan D is similar to Plan C but calls for separate ownership of (1) petro-chemical, (2) the chlorine-caustic and chlorinated hydrocarbon plants and (3) the salt recovery plant; the last three being related only by arms-length purchase contracts. The economics as given in this report do not apply to this type of organization. This plan is not recommended unless the risks to the governmental agencies were most carefully appraised, understood and found acceptable.

The recommended plans for implementation are believed to be practical and indicate that the prospects for promoting the Energy Center in Puerto Rico are good.



ORGANIZATION PLAN A



ORGANIZATION PLAN B

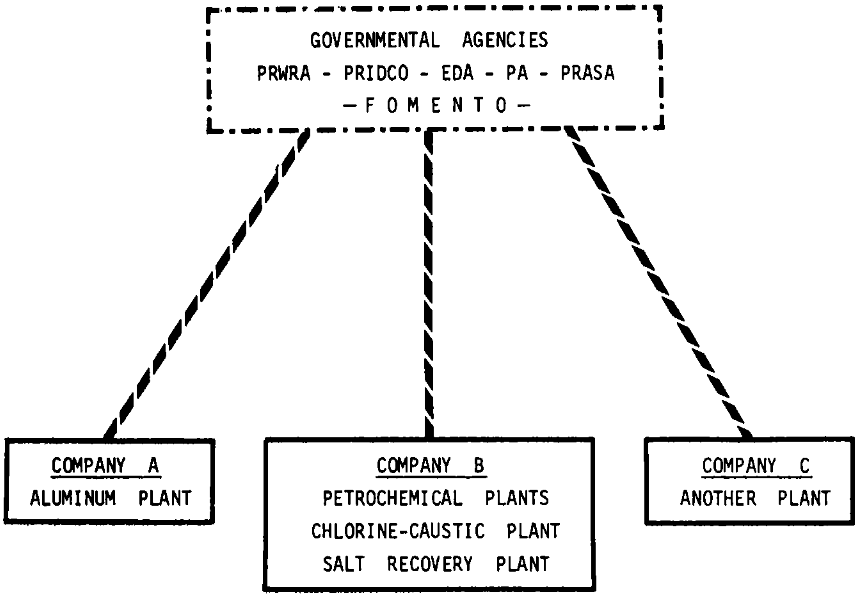
ENERGY CENTER ORGANIZATION PLANS

KEY

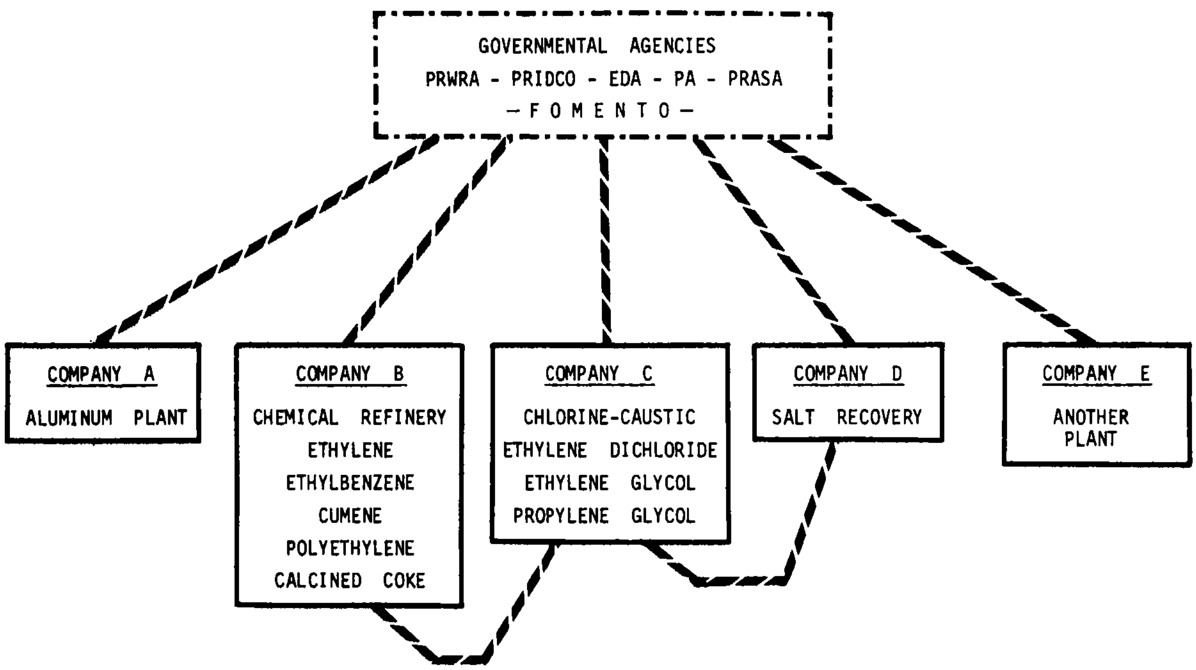
PURCHASE CONTRACTS

MANAGEMENT CONTRACTS

EXHIBIT 9-2



ORGANIZATION PLAN C



ORGANIZATION PLAN D

ENERGY CENTER ORGANIZATION PLANS

KEY

PURCHASE CONTRACTS

MANAGEMENT CONTRACTS

EXHIBIT 9-2

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