12 Oct 1976

The Energy Dilemma of Puerto Rico

Juan A. Bonnet Jr.

Fernando L. Perez

THE ENERGY DILEMMA OF PUERTO RICO

Juan A. Bonnet, Jr. and Fernando L. Pérez
Puerto Rico Water Resources Authority
San Juan, Puerto Rico

Abstract

The energy problems of the island of Puerto Rico are discussed in this paper. The conflict between the need to increase the industrial activity and the need to reduce the almost complete dependency on imported fuel oil is analyzed. Conservation measures and activities to promote the development of our alternate energy sources are discussed. The case of Puerto Rico presents what can happen to a country that depends almost exclusively in foreign oil for its energy production.

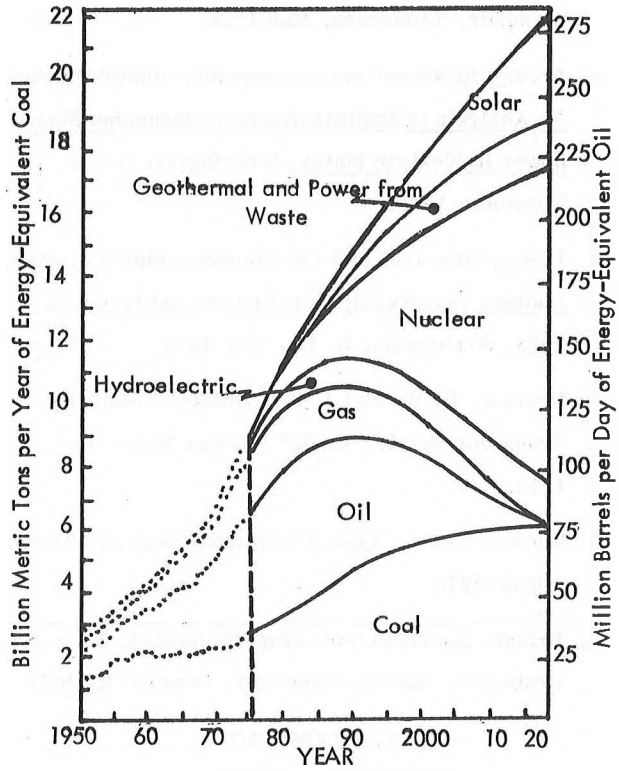
I. INTRODUCTION

The world energy use is presented in the composite curve on Figure 1. This curve was published in the Electrical World of November 1, 1975 in an article by Fremont Felix (1). The curve presents the historical and projected use of energy, detailing its sources. "If the forecast holds true", said Felix "all presently known oil and natural gas will be depleted within a 50 year period."

Other forecasts found in the literature also predict that all the oil and natural gas of the world will be depleted, for all practical purposes, within our life span.

The above forecasts concern us very much in Puerto Rico. We import annually from non-U. S. sources about 106 million barrels of fuel oil. This amounts to about 35 barrels per citizen. Of the total imports, about 64 millions are consumed internally and the balance is exported as petroleum products.

In Puerto Rico, the transportation and the electric power generation depends almost totally on fuel oil or its products. An exception is hydroelectric power, which supplies less than 2% of the electric power generation. This situation will have to continue for the next eight or ten years. The construction of a 600 MW nuclear plant had to be postponed indefinitely and coal burning plants are not attractive for the island. Therefore, conservation and optimization measures will have to be implemented in order to alleviate the fuel problem. In the meantime, we are devoting efforts to promote the development of our alternate energy sources.



WORLD ENERGY USE
Figure 1

Reference (1)

A disturbing thought, however, is that we have to increase our industrial activity to create more jobs for the growing labor force, but this will require a proportional increase in our consumption of fuel oil, an energy source that will be phased out in a limited period of time. As a result, we may get involved in due time in a chaos of unaffordable energy prices created by the fuel scarcity.

2. BACKGROUND ON PUERTO RICO

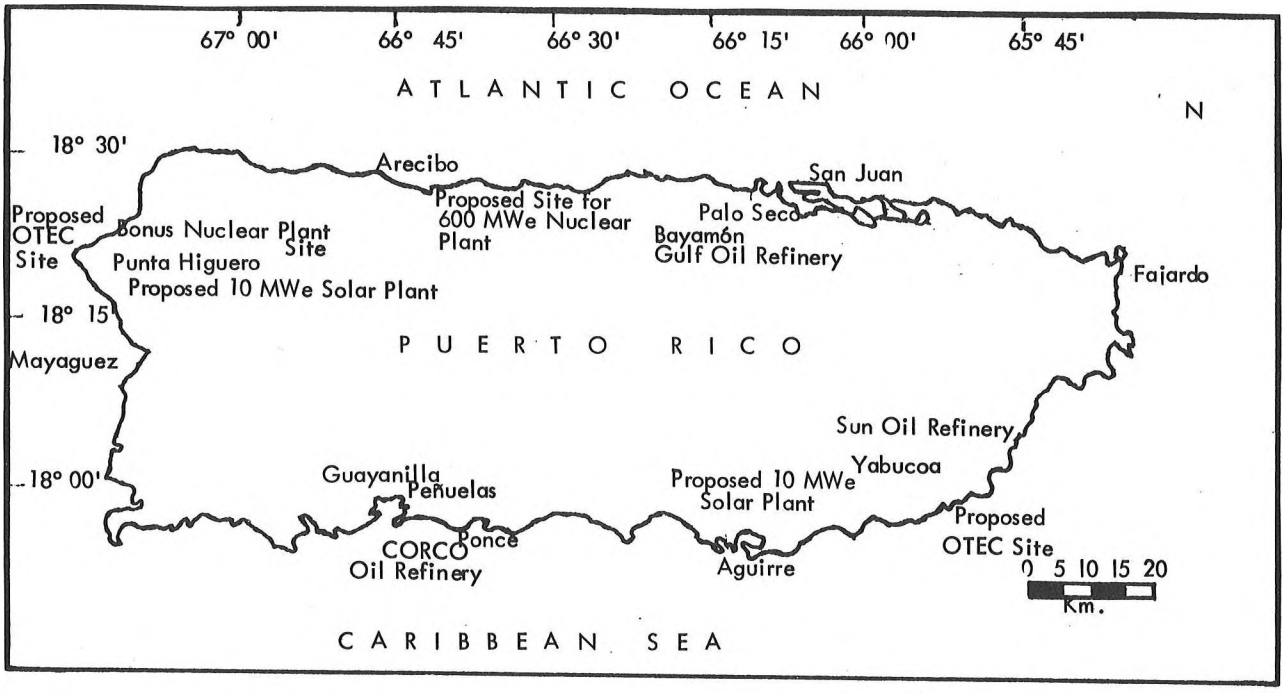
The geographers describe the island of Puerto Rico (Figure 2) as a mountain surrounded by water. It is associated to the United States through a political formula known as Commonwealth. Its population amounts to 3 million people distributed on an area of 8,897 km.^{2}, for an average population density of 337 persons per square kilometer. Birth rate is now decreasing, but it is still at a high value of 23.7 cases per thousand persons annually. The net income per capita is approximately $1,985 annually and the gross national product for the year 1975 was $7,117 millions.

Our economy is affected by the following four basic problems:

(1) High population density
(2) High birth rate
(3) Scarce Natural Resources
(4) Low savings index

Due to these problems we have been motivated to use our main resource - our people - in the most effective manner. This has required to educate our labor force in modern techniques in order to use it more effectively. A basic instrument in this effort was "Operation Bootstrap" a massive program that the local government launched in the year 1940 to industrialize the island while maintaining the most valuable agricultural activities.

Operation Bootstrap was undertaken to turn the economy from a poor agricultural base into a wealthy industrial base. The objective was to increase our income and improve our economy by means of the high industrial wages and the related industrial activity. Low energy prices based on low cost imported oil were offered as incentive to American and foreign industries in order to attract them to Puerto Rico. After two decades, industry was converted in the backbone of our economy, progress reached all social levels and Puerto Rico was called "the showcase of America."



THE ISLAND OF PUERTO RICO
Figure 2

SIZE OF THE COUNTRIES IN PROPORTION TO THEIR FUEL OIL CONSUMPTION

Figure 3

Reference (2)

The recent increases in imported fuel oil prices have turned this situation around. Imported oil has now higher prices than domestic oil and the low price energy incentive has vanished. Therefore, a key element in our industrial promotion program, no ionger exists. This represents a threat which we must deal promptly and effectively if we want our economic activity to regain healthy levels.

3. TOTAL ENERGY CONSUMPTION IN PUERTO RICO

In spite of its small size, Puerto Rico ranks high in oil consumption among the other countries of the world. The map on Figure 3 was redrawn from a similar one that appeared in the June 1974 edition of the National Geographic magazine, in which the countries are sized in proportion to their fuel oil consumption (2). Notice that in this map Puerto Rico becomes the biggest of the antilles. It is bigger than Alaska and most countries of South and Central America. With the exception of the United States, United Kingdom, France, Canada and few others, the fuel oil consumption of Puerto Rico is of the same order of magnitude as the fuel oil consumption of the remaining countries of the world.

The petroleum flow pattern of Puerto Rico during Fiscal Year 1975 is shown on Table 1. Indicators of the economic recession are observed in the reduced magnitudes of the figures. For example, total imports and change on inventories were only 106.1 million barrels, instead of the expected 120 millions or over.

The table presents a breakdown by sectors of consumption and used and lost energy in each one. Manufacturing (23.8 million barrels) is the biggest sector followed by the production of electricity (19.1 million barrels) transportation (17.4 million barrels) and others (4.1 million barrels). Exports in the form of petroleum products account for 41.7 million barrels of the total imports.

Table 2 gives and idea of the petroleum industry operating in Puerto Rico. There are three oil refineries. Carribbean Gulf Oil Refinery is located in Bayamón, about ten kilometers to the south east of San Juan. Commonwealth Oil Refinery is in Peñuelas in the south coast. Sun Oil Company is located in Yabucoa in the south east coast. The three refineries have a combined capacity of 283,800 barrels per day. By 1978, the estimated internal consumption will be 200,000 barrels per day, leaving a net exportable capacity of about 75,500 barrels per day.

Table 1

PUERTO RICO PETROLEUM FLOW PATTERN
Fiscal Year 1975

	mmb	%		
Total Imports and change on Inventories	106.1			
Crude				
Naptha				
Other products				
Sectorial Consumption			Used Energy mmb	Lost Energy mmb
Electricity	19.1	18.0	1/	12.4
Transportation	17.4	16.4	4.3 1/	13.1 2/
Manufacturing	23.8	22.4	18.5 1/	8.1 2/
Others	4.1	3.9	7.0 1/	1.0
Subtotal	64.4	60.7	29.8	34.6
Exports	41.7	39.3		
Total	106.1	100.0	46.3%	53.7%

1/ Used electricity imputed in manufacturing and others sectors.

2/ Includes loss in process.

mmb: Million barrels

Note: Lost and used energy developed from U. S. Western States Statistics

Source: Office of Petroleum Fuel Affairs of Puerto Rico

Table 2

Puerto Rican Refinery Capacitites and Net Exportable Capacities in Thousands of Barrels per Day

Company	Actual Capacities	Planned Capacities					Estimated Puerto Rico requirements	Net Exportable Capacity
	1966	1974	1975	1976	1977	1978	1978	1978
Caribbean Gulf, Bayamon	31.5	37.8	37.8	37.8	37.8	37.8	---	---
Commonwealth Oil Ref. Company, Peñuelas	103.5	161.0	161.0	161.0	161.0	161.0	---	---
Sun Oil Co., Yabucoa	---	85.0	85.0	85.0	85.0	85.0	---	---
Total	135.0	283.8	283.8	283.8	283.8	283.8	200.0	75.5

Source: Office of Petroleum Fuel Affairs of Puerto Rico

4. ELECTRIC ENERGY PRODUCTION AND CONSUMPTION

The electric energy production and consumption can be very well described through the activities of the Puerto Rico Water Resources Authority.

The Puerto Rico Water Resources Authority (PRWRA) is public corporation and governmental agency of the Commonwealth of Puerto Rico created for the purpose of developing and utilizing the energy resources of Puerto Rico to generate and distribute electricity at the lowest possible cost. As such, PRWRA is the sole supplier of electric power in the Commonwealth.

PRWRA has accumulated many years of experience in the operation and administration of electric power systems. Over 800,000 customers are served in Puerto Rico and the nearby islands of Vieques and Culebra. System load is characterized by a high load factor of over 75% due to the intensive industrial activity. Annual energy sales are over 10,200 million KWH of which about 4,300 million KWH go to the industry and about 3,200 million KWH go to the residences. Commercial consumers account for about 2,200 million KWH and the balance go to other classes of customers.

Since the PRWRA system does not have interconnections with other electrical systems, it must provide a high reserve capacity in order to attain good levels of reliability. Capacity factor is thus low (peak demand is about 1800 MWe and installed capacity is about 4,400 MWe).

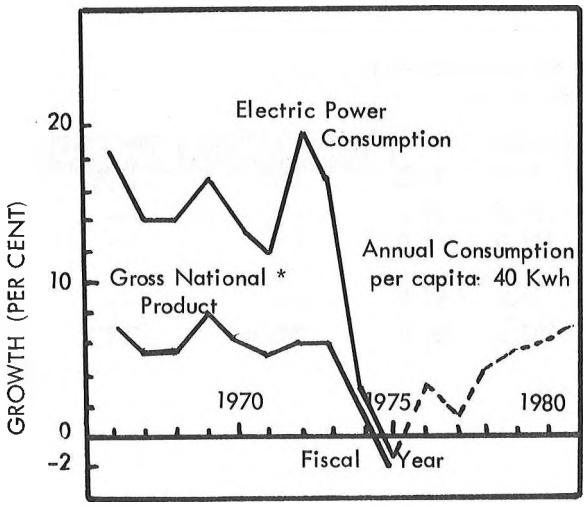
As previously mentioned, power production in Puerto Rico is accomplished, almost in its entirety, by means of oil fired steam electric units, gas turbines, jet units, and less than 2% in hydroelectric units.

The impact of the recent economic recession ant its subsequent resurgence have been self-evident when an analysis is performed on the historical trends of energy sales. During the 1960 decade and the early 1970, the system was growing at approximately 15% annually. This tremendous growth was suddenly halted during the embargo years, decreasing to only a 2.9% in 1973-74 and to the first negative growth in PRWRA's history during 1974-75 of -1.7%. A gradual upswing was experienced during the past fiscal year with an end-of-year increase of 3.7% with respect to the previous year. This recovery has been noticeable since the second half of 1975-76. The first three months of the 1976-77 fiscal year have shown a growth of 5 to 6%. Present indications tend to demonstrate that this growth pattern will be maintained on the average for the next few years.

Electric service in Puerto Rico is now available to over 98% of the people. We can say proudly that we have a totally electrified country. Historically in highly electrified countries, the electric power consumption follows the same trends as the gross national product (GNP) Figure 4 shows that Puerto Rico presents similar trends. There is no doubt that the predicted increase in electric power demand is closely related to an increase in industrial activity. This might imply the addition of new fuel oil generating units in a world of vanishing fuel oil reserves. This will be explained further in the following sections.

5. NUCLEAR POWER

Although we don't have nuclear power plants at present, PRWRA has experience in nuclear power generation. From 1964 to 1967 it operated the BONUS nuclear plant at Punta Higuero in the westernmost tip part of the island. The BONUS plant, a joint venture between the Atomic Energy Commission and the PRWRA, was one of the early demonstration reactors. It had a capacity of 16.5 MWe and was one of the first reactors in the world with an integral nuclear superheater.



* Forecast not Available

GROSS NATIONAL PRODUCT AND
ELECTRIC POWER CONSUMPTION IN PUERTO RICO
Figure 4

At the beginning of this decade, the PRWRA planned to install a nuclear plant in Aguirre, on the south coast. It was a 600 MWe unit scheduled to be in operation during October 1976. Unfortunately the project had to be discontinued several years later due to some uncertain ties in the geology of the site.

After an exhaustive study of the island, the town of Arecibo on the north coast was selected for the installation of the nuclear plant. The operation of the nuclear plant was scheduled for the year 1981, but later due to the electric demand reduction, the project was postponed to 1985. Last December it was postponed indefinitely due to a combination of the reduced electric demand and the increased capital cost of the project. At present we are trying to sell the nuclear plant equipment. This will give us time to develop a new financial strategy to build a nuclear plant in the island when the need arises.

6. COAL

Some studies have been made, and others are under way, to determine the feasibility of burning coal in Puerto Rico.

The probabilities of installing coal fueled plants in Puerto Rico, are very low. Since we don't have coal resources, enormous quantities of the fuel will have to be transported by ships and stored. In addition to this logistics problem, cleaning the exhaust gases from coal burning plants, bring additional problems and costs. Unless oil prices continue rising and coal utilization technology improves, we do not foresee using coal in the near future.

7. CONSERVATION

The Commonwealth Government is implementing a comprehensive program aimed to reduce waste of energy. In addition, lifeline type of laws enacted in 1974 to alleviate the impact of the high costs of energy on low economic income customers have resulted in effective incentives to promote energy conservation. This was one of the first lifeline rate incentives put into operation in the U. S.

According to the law. all residential customers consuming less than 425 Kwh per month. are exempted of fuel adjustment charge for the first 400 Kwh consumed. The Commonwealth Government pays this charge to the PRWRA. During the last fiscal year 515,000 residential customers (almost 70% of residential customers) were favored by this subsidy. The amount subsidized was $29,302,089.

The Consumer Affairs Department of the Commonwealth Government is coordinating an inter-agency effort to implement energy conservation measures. The Office of Petroleum Fuel Affairs of Puerto Rico edited a pamphlet with guidelines and advises to make the most efficient use of the energy by avoiding wasteful practices. These conservation activities continue and a vigorous plan is expected to emerge soon. Consumer education on conservation practices is expected to be a key element of the plan.

Also the PRWRA is carrying out several studies and activities aimed at promoting conservation of energy and resources from the power production stand point. The activities form part of the Utilities Conservation Action Now (UCAN) Draft Plan which was submitted to the Federal Energy Administration on August 13, 1976. (3)

The UCAN plan of the PRWRA is aimed at optimizing the use of the generating facilities and the consumption of fuel. By force it considers the particular characteristics of the electrical system and the needs of Puerto Rico.

Our UCAN Draft Action Plan contains the following objectives, conservation measures, and efficiency measures:

(1) Improve system load factor by providing incentives to shift loads from daytime to nightime use and also determine the optimum load factor for the system.

(2) Increase the capacity factor commensurate with good system reliability.

(3) Encourage growth in kilowatthour sales without incurring in wastefulness.

(4) Reduce the annual peak kilowatt demand growth rate.

(5) Improve system heat rate to reduce fuel oil consumption.

(6) Reform the structural tariff rate.

(7) Promote and advertise efficiency in the use of electric energy.

(8) Carry out solar and solar assisted research.

(9) Develop a Consumer Education Program

(10) Cooperate in solid waste energy and material recovery efforts.

Our system is characterized by having a high load factor as shown on Table 3, but this does not mean that we can operate at high capacity facotrs. The fact that we don't have interconnections with neighboring systems in conjunction with the absence of a pronounced seasonal load variation calls for a large amount of reserve to maintain an acceptable level of reliability. Table 4 shows annual capacity factors of our system from 1971-72 to 1975-76 and forecasts running up to 1985-86.

Table 3

PUERTO RICO

Electric Power System Load Factor

Fiscal Year	System Annual Load Factor (%)
1972-73	78.3
1973-74	77.2
1974-75	77.1
1975-76	75.8
1976-77	75.8
1978-79	77.2
1980-81	78.0
1985-86	78.5

Table 5 presents the actual and forecasted fuel consumptions and total cost. These forecasts will be modified by the UCAN action plan. Some of these objectives will be pursued through a load management demonstration project to be sponsored by the Federal Energy Administration (FEA). (4) This project will operate on an annual grant provided by the FEA that this year amounts to $357,000.

Table 4

PUERTO RICO

Electric Power System Capacity Factor

Fiscal Year	Capacity Factor (%)
1971-72	63
1972-73	59
1973-74	48
1974-75	40
1975-76	33
1976-77	32
1978-79	35
1980-81	38

Table 5

PUERTO RICO

Barrels of Fuel Consumed in Electric Power Production

Fiscal Year	Fuel Consumed (Barrels)	Cost ($ millions)
1975-76	20,693,000	243.6
1976-77	20,663,000	285.5
1977-78	21,354,000	317.4
1978-79	22,628,000	368.9
1979-80	24,076,000	435.2
1980-81	25,739,000	510.3

8. ALTERNATE ENERGY SOURCES

There are several studies and projects being performed on alternate energy sources. Few of them, if any, can have an immediate impact on the energy situation of Puerto Rico, but we will continue them expecting future reward.

8.1 ENERGY AND MATERIAL RECOVERY FROM SOLID WASTE

A study for the San Juan Metropolitan Area was performed by the Energy Research Institute of the Puerto Rico Water Resources Authority (ERI-PRWRA). Seven alternatives were considered. Table 6 is a summary of cost analysis. (5)

This study demonstrated the feasibility of recovering energy and materials from the solid waste of the San Juan Metropolitan Area. The solid waste to be produced by 1980 can be used as fuel for a 71.8 MWe plant that can generate about 558,316 MWH of electric energy per year. Fuel saved will be about 927,435 barrels of oil per year. Table 7 presents the results of a desirability analysis of all the alternatives studied. The alternative ranked in the first place was "Unprocessed Solid Waste Fueled Electric Plant--No Material Recovery." Although this alternative is not the most economic, it obtained the highest ranking, in part because it is based on the use of water-wall incinerators, which is a technique proven for many years in Europe and other places. Pyrolisis, the most economic alternative, was ranked 6 and recommended for future study because of the little operating experience acrued by this process and the uncertain market for pyrolysis gas at present.

8.2 OCEAN THERMAL ENERGY CONVERSION(OTEC)

A study of the characteristics of the Punta Tuna site is being performed by a team from the Department of Marine Sciences of the University of Puerto Rico. The team is headed by Dr. Donald Atwood. The site is about four kilometers south east of Yabucoa. The National Science Foundation sponsors this project. The study has preliminarily indicated that Puerto Rico possess some of the best locations for developing this energy concept. Consequently, the Puerto Rico Energy and Environmental Research Center intends to expand studies at this site.

Figure 5 provides data on the temperature differences at the site. (6) At depths of about 1000 meters, temperature differences of about 25°C can be found in relation to surface temperature. We believe that on the long run, OTEC has a great potential for our island.

8.3 SOLAR COOLING AND HEATING

The Department of Natural Resources of Puerto Rico is heading an inter-agency team with the objective of providing solar air conditioning and water heating to a typical industrial building. ERDA provided recently a grant of about $500,000 for this study. (7)

Table 6

SUMMARY OF COSTS OF SEVEN ALTERNATIVES FOR ENERGY AND MATERIAL RECOVERY FROM SOLID WASTE OF THE SAN JUAN METROPOLITAN AREA

Systems	Capital Costs Dollars	Operation Costs $/ton	Revenues $/ton	Net Cost* $/ton
Unprocessed Solid Waste-Material Recovery	69,014,100	20.70	15.37	-5.33
Unprocessed Solid Waste-NO Material Recovery	66,834,100	18.32	13.46	-5.36
Unprocessed Solid Waste-Existing Turbo-Generator Material Recovery	57,414,100	18.79	13.16	-5.63
Unprocessed Solid Waste-Existing Turbo-Generator No Material Recovery	42,234,100	16.42	11.25	-5.17
Pyrolysis System-Material Recovery	40,809,400	15.96	14.15	-1.81
Pyrolysis System-No Material Recovery	38,629,400	15.57	12.96	-2.61
Composting	18,723,500	9.38	3.02	-6.36

* The negative sign indicates that the operation costs are higher than the revenues. The net cost must be charged as a dumping feed to the users.

Table 7

DESIRABILITY RANKING OF SEVEN ALTERNATIVES FOR ENERGY AND MATERIAL RECOVERY FROM SOLID WASTE OF THE SAN JUAN METROPOLITAN AREA

Process	Average Overall Weighted Score for each Process	Desirability Rank	Net Cost* ($/ton)
Unprocessed Solid Waste Fueled Electric Plant - No Material Recovery	0.799	1	-$5.36
Unprocessed Solid Waste Fueled Electric Plant - Material Recovery	0.770	2	-$5.33
Unprocessed Solid Waste Existing Turbo-Generator No Material Recovery	0.767	3	-$5.17
Pyrolysis System No Material Recovery	0.722	4	-$2.61
Unprocessed Solid Waste Existing Turbo-Generator Material Recovery	0.718	5	-$5.63
Pyrolysis System Material Recovery	0.703	6	-$1.81
Composting	0.540	7	-$6.36

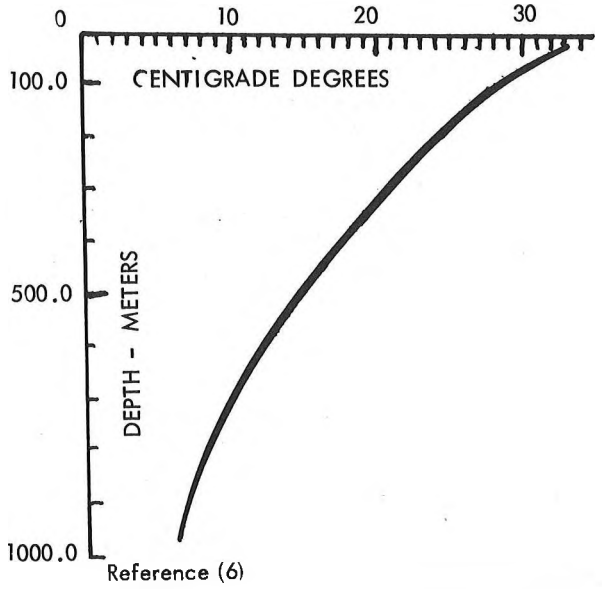
* The negative sign indicates that the operation costs are higher than the revenues. The net cost must be charged as a dumping fee to the users.

8.4 IMPACT OF SOLAR HEATING AND COOLING ON ELECTRIC UTILITIES

The Puerto Rico Water Resources Authority is conducting a study of the financial and technical impact on a Public Utility that may be caused by the intensive use of solar cooling and heating by the subscribers. This study is conducted with a $32,500 grant from the National Science Foundation.

The preliminary results obtained in this study indicate that for solar water heating, the observed delay in the requirement for additional generating capacity is about one year while the reduction in production costs is in the order of three per cent. The effect due to solar space cooling was greater than for the water heating case, but not to a great extent.

Regarding the transmission system, it was determined that the expected reduction in peak demand due to solar heating/cooling would permit a delay of about three years in the projected schedule of improvements to the transmission system.



PUNTA TUNA OTEC SITE TEMPERATURE-DEPTH PROFILE

Figure 5

8.5 WIND TURBINE GENERATORS (WTG)

The Energy Research Institute of the Puerto Rico Water Resources Authority (ERI-PRWRA) prepared a proposal that was accepted for the first phase of the candidate site selection by the ERDA. The site proposed was the Island of Culebra. Measurements indicate that wind speeds over 8 mph may be observed annually over 85% of the time in Culebra. This condition guarantees sustained wind power for a modern WTG.

Seventeen out of over sixty proposals were accepted for the first phase, which covers 18 months of meteorological studies on site. Four of the seventeen sites will be selected for receiving wind turbines that may range from 125 KWe to 1500 KWe.

8.6 PROPOSALS FOR 10 MWe PLANT

The ERI-PRWRA submitted two proposals to the ERDA for the installation of a 10 MWe solar plant at either one of two sites: Punta Higuero and Aguirre. The proposals are now being evaluated by the ERDA.

Calculations indicate that the annual average insolation is over 6 kwh per square meter per day on either of the sites presented. Measurements taken at other sites confirm that these are typical insolation rates in Puerto Rico. We believe that in the future, big solar plants will be operated at several places in the Island, in particular the south west coast, where greater solar radiation potential is available.

9. CONCLUSION

Puerto Rico must continue developing its socio-economic and industrial activities. This will increase substantially our present energy requirements. Also Puerto Rico must move vigorously to get rid of the Island's dependence on foreign oil. In order to meet the increase in energy needs during the next decade nuclear power is the best choice, but we can not afford its high capital cost. As a result, we might be forced to install new oil plants. This is our energy dilemma, as scenario that may be duplicated in the continental United States if it continuous increasing its dependency on foreign oil.

Our immediate hope to alleviate this problem are the conservation measures. On the intermediate run we must use the imagination and develop a new financial strategy to be able to afford nuclear power plants. On the long run, we may be able to obtain benefit from ocean thermal energy conversion and solar plants. Also we will continue working on projects of smaller impact like wind turbine generators and energy recovery. Puerto Rico must maintain all its energy options open.

REFERENCES

(1) Felix, Fremont - Point-of-use efficiency gives electric energy an edge in generating high per-capita GNP, Electrical World, November 1, 1975.

(2) Grove, N. and Kristof, E. - Oil - The Dwindling Treasure. National Geographic June 1974 Vol. 145, No. 6

(3) Utilities Conservation Action Now (UCAN) - Plan of the Puerto Water Resources Authority, August 13, 1976.

(4) An Experiment to Determine Optimum Load Factor Through Direct and Indirect Load Management - Evaluation - Puerto Rico Water Resources Authority and Environmental Corp. - Proposal to the Federal Energy Administration, April 19, 1976.

(5) System Analysis Study of Energy and Material Recovery from Solid Waste of the San Juan Metropolitan Area - Energy Research Institute of the Puerto Rico Water Resources Authority, March 1976.

(6) Interim Report on Ocean Thermal Energy Project - University of Puerto Rico, Department of Marine Sciences, December 1975.

(7) A Cost Effective Solar Energy Cooling System Study for Standard Fomento Factory in Puerto Rico - Proposal submitted by Department of Natural Resources of Puerto Rico to ERDA, May 1975.

(8) Impact of Solar Heating and Cooling on Electric Utilities - Preliminary Conclusions of the Study by the Puerto Rico Water Resources for the National Science Foundation under contract APR 75-18301.

JUAN A. BONNET, JR.

Juan A. Bonnet, Jr. was born on April 27, 1939 in Santurce, Puerto Rico. He received a B. S. in Chemical Engineering from the University of Michigan in 1960. In 1961 Mr. Bonnet received an M. S. in Nuclear Engineering from the University of Puerto Rico, Mayaguez Campus. From June 1961 to February 1962 he received on the job training in radiation safety and nuclear reactor operation at Arconne National Laboratory. From 1962 to 1967 Mr. Bonnet occupied several supervisory positions at the BONUS Nuclear Plant in Puerto Rico. In 1971 he received a PhD in Nuclear Engineering from the University of Michigan. At present is Assistant Executive Director for Planning and Engineering of the Puerto Rico Water Resources Authority.

Also Mr. Bonnet is a Board Member of the following: Southern Interstate Nuclear Board, The Interamerican Confederation of Chemical Engineers, The Puerto Rico Engineering, Architect, and Surveyors Association, and The Puerto Rico Institute of Chemical Engineerins. He is past president of the Puerto Rico Chapter of The Health Physics Society and a member of the Energy Committee of the Pan American Union of Engineering Associations. He has wide experience in Energy and Environmental matters and has lectured and published several papers in the United States and abroad.

Also he serves as consultant in these matters to other Puerto Rico Government Agencies.

FERNANDO L. PEREZ

Fernando L. Pérez was born in Ponce, Puerto Rico on July 12, 1936. Mr. Pérez received his B.S. in Electrical Engineering from the University of Puerto Rico, Mayaguez Campus in the year 1960. From 1960 to 1964 he worked as Power Distribution Engineering in the Puerto Rico Water Resources Authority (PRWRA). From 1964 to 1967 he occupied several technical positions at the BONUS Nuclear Plant in Rincón, Puerto Rico. In 1968 he received an M.S. degree in Nuclear Engineering from the University of Puerto Rico, Mayaguez Campus. From 1969 to 1974 he was appointed supervisor of the Electrical Research and Development Department at the Planning and Research Division of the PRWRA. At present Mr. Pérez is Technical Director of the Energy Research Institute of the PRWRA.