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THE QUEST FOR ENERGY SECURITY--SUFFICIENCY IN PUERTO RICO

by

Dr. Juan &. Bonnet, Jr.

Director

Center for Energy and Environment Research

University of Puerto Rico

Presented at the Conference on

ENERGY PLANNING FOR THE U.S. INSULAR AREAS

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THE QUEST FOR ENERGY SELF-SUFFICIENCY IN PUERTO RICO

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incentives and financial arrangements

All the alternatives already developed provide opportunities for

investment in Puerto Rico. We envisage four types of opportunities: (1)

investrent in equipment or systems that will substitute for imported fuels;

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(2) manufacture of such equipment for Puerto Rico and the rest of the

Caribbean and Latin America; (3) creation of new businesses dedicated to the development and supply of alternative fuels from renewable sources; and (4) development of a technology transfer service industry from Puerto Rico

to the Caribbean and Latin America.

CEER studies indicate that, at other prices constant, the increase in oil prices from 1973 to 1979 induced an increase of more than 130% in an estimated producers price index, excluding industry markups, which implies double digit inflation even when there is no increase in other prices. This increase has resulted in an estimated loss of 58,000 jobs and \$1,326 million in production to Puerto Rico. This alone shows that alternative expenditures for indigenous energy alternatives in the short term would result in reduced

future spendings and reduced drain of funds:

Center for Energy and Environment Research

To carry out the research and development needed, and to transfer the technology to the Caribbean and Latin America, there already exists the Center for Energy and Environment Research (CER) of the University of Puerto Rico. Founded in 1987 as the Puerto Rico Nuclear Center (PRNC), and reorganized in 1976 as CEER, it is presently concentrating on research and development in the fields of alternate energy and the environment.

Last year the Center received the U.S. Department of Energy's Exceptional Public Service Award for its scientific research accomplishments. In presenting the award, Or. Alvin Trivelpiece, Director of DUE's Office of Energy Research, declared CEER as having become "the most important Hispanic research

center in the United States," and Puerto Rico as having

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rapidly developed into an ideal laboratory for Caribbean and subtropical energy research."

Through 1961, federal funds supplied CEER with substantial support on

the order of \$2 million yearly. Since then, federal funding has been severely curtailed. In order to compensate partially for the diminishing federal assistance, the University of Puerto Rico has increased its budgetary contribution

tion to CEER, In fiscal year 1983 UPR is providing \$1.3

million, or abo

40% of CEER's total budget. The rest of the funding comes from competitive research grants and contracts awarded by federal and local agencies and by private industries.

The federal government should preserve its leading role in supporting basic research and education in solar related areas at universities.

Advances in long term, high risk yet potentially high payoff areas such as photovoltaics hinge on the scientists and engineers who will devote their talent to these new technologies.

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year CEER was granted a 5-year Indefinite Quantity Contract

(IQC) by the U.S. Agency for International Development (AID). This may serve to facilitate technology transfer activities to the Caribbean region.

CEER has already worked in Panama, Barbados, the Dominican Republic and other Caribbean Basin countries.

Several of CEER's major alternative energy achievements discussed here

are now ready for reliable and economic commercial use. CEEP has developed

the "energy cane and "energy grasses" concept under a five-year grant from the U.S. Department of Energy: it has developed a new type of solar energy collector with industry's participation; it has also established a solar

insolation, wind and microseismic data gathering network; it has designed

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and constructed a large solar air conditioning system, and is developing an energy integrated farm on the south coast of Puerto Rico. CEEK has also carried out DOE-sponsored OTEC research in Puerto Rico, with special empha-

sis on biofouling and corrosion,

Director O11 Substitution Policy

The decrease in energy consumption and the temporary reduction in oil prices due to lower world demand are contributing to the postponement of

concrete actions to find substitutes for oil as our primary energy source in

Puerto Rico. 1

has been aggravated by the substantial reduction in federal allocation: for solar energy research to CER. If we want to assure continued development and a competitive and healthy economic climate, oil

substitution should

be one of our most important public policy priorities.

We should plan now to move Puerto Rico quickly toward the attainment of a degree of energy self-sufficiency that will significantly diminish our dependence on foreign oil. A brief review of past and current efforts to diversify our energy sources should help place the problem in perspective.

The ensuing discussion will take into account possible private industry

involvement in such energy sufficiency endeavors.

The biomass alternatives are the most promising of any plan leading toward energy self-sufficiency for Puerto Rico. Biomass can supply elec

tricity more cheaply than coal or oil. (See Table 1 and Figure 3.) In 1981 CER proposed to revitalize the sugar industry by reorienting it to a supplier of high-test molasses and energy. This proposition is based on solid scientific information generated by the CER energy cane and tropical grasses research and demonstration project during the last five

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years. The final cost analysis for production, including delivery, and energy balances indicates that locally produced biomass is unquestionably an economic and reliable energy resource with multiple benefits when managed specifically as an energy crop. If 7,000 of the acres now planted in sugar Cane were gradually converted to energy cane, Puerto Rico could

(1) Produce more than 13% of its electricity needs from local biomass at a cost lower than that of fuel oil;

(2) Completely eliminate the heavy dependence of its rum industry on imports of molasses. Parenthetically, exports of rum provide one-seventh of the recurring revenues of Puerto Rico's General Funds and

(3) Operate

the sugar cane industry at @ profit.

As an energy alternative available today,

R's bioness program hes been

highly raised by CEER's Senior Scientific Advisory Committee as the "best

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world,

The U.S. National Academy of Sciences in its 1960 report "Energy in

Puerto Rico's Future," concluded that biomass cropping has probably the greatest potential among renewable energy sources. The report further recommended that the Puerto Rican government seriously consider establishing a pilot biomass-fired generating plant with a capacity of perhaps 10-20 megawatts. Three 20 MW units now exist in the San Juan Steam Plant could be converted for this purpose. A sister unit of this equipment was sold to the U.S. Sugar Corporation in Florida and is now being used exclusively for burning bagasse to generate electricity

CEER is preparing a detailed proposal to establish a 20 MW biomass fired generating plant in Puerto Rico. The adoption of biomass will also require a favorable agricultural policy, with a conscious decision to direct sugar cane toward production of bagasse under the "energy cane" management system. Solar-dried

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"Energy grasses" would be a complementary fuel to ensure a continuous year-round supply of power. Biomass could also be developed on the island as feedstocks for our present and future new chemical industries.

When the biomass development project was successfully completed last Year, U.S. Department of Energy funding was terminated. However, biomass has not yet been adopted for use in Puerto Rico even though it constitutes the best available local energy source. The U.S. National Academy of Sciences study found that given vigorous development, biomass could provide 25 to 30% of the island's electricity by the year 2000. Estimates from CEER and the U.S. Office of Energy agree with this (see Table 1).

Consequently, financial arrangements are urgently needed to implement a biomass-fired plant before the sugar industry in Puerto Rico collapses completely. Other Caribbean islands such as Jamaica, the Dominican Republic and Barbados are seriously considering this energy alternative. CER is also conducting experiments with fast-rotation trees, grown in land unsuitable for other purposes, that can be harvested as energy crops. The species *Eucalyptus robusta* has produced biomass yields superior to commercial sugarcane.

Energy Integrated Farm

In Juana O'az, Puerto Rico CEER is conducting an important energy integrated farm project, one of eight such projects in the U.S. This project includes two 70,000 gallon digesters, » biogas-operated electric generator, greenfeed operation of Napier grass, soi?

convention, the

Growing of fish and aquatic plants in the effluent lagoons, and a windmill

for pumping effluent. This one-million-dollar project is funded primarily

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by the U.S. Department of Energy, with additional support from the Puerto

Rico Office of Energy, the private sector and CER.

old Waste

Energy from municipal solid waste is another viable biomass alternative

for Puerto Rico, whether by direct combustion or by methane generation from landfills. A number of such systems are being studied by our municipalities, including San Juan and Caguas. In fact, the use of solid waste to produce energy in the San Juan metropolitan area has been considered and studied for more than twenty years. It has been determined that 20 Mw electric units are viable right now, provided power can be sold at long-range cost and not at marginal cost. At present, efforts to build the First plant with private funds are being aggressively pursued, and legislative

changes have been proposed to make it financially possible. The proposed changes should be carefully analyzed* to ease the adoption of this viable biomass alternative, which will also solve the waste handling problem of the metropolitan area and stimulate the interest of private involvement in

energy alternative development in Puerto Rico.

Solar Thermal

The use of solar water heaters, of which approximately 20,000 are in operation today in Puerto Rico, solar ponds, and solar air conditioning can help to some degree in reducing oil imports. They are very susceptible to private investment as shown by several solar water heater factories presently in operation on the Island. The use and development of these alter-

natives should be encouraged as much as possible. Different studies indi-

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Calculate that individually each of the above alternatives would supply at most

small percentage of our energy needs; hence, we should move toward some kind

of energy "mix." Also during this year CEER will complete the installation

of a large solar air conditioning project in its Maysquez facilities. The

system consists of 300 parabolic fiberglass solar collectors designed by

CEER and manufactured on site using local manpower, materials and expertise.

When completed, it will provide about 100 tons of cooling to 32,000 sq. ft.

of office and laboratory space.

A solar salt gradient pond to generate process heat at 8 foot process-

ing factory is being designed by CEER. This project will be funded by the

Firm concerned and the P.R. Office of Energy

The relative high capital cost of flat plate solar water heaters

relative to electric water heaters has precluded their faster introduction

in the market. Studies by the Southern Solar Energy Center in Atlanta

indicate that Puerto Rico is fifth among the states in potential for use of

solar water heaters. There is a new generation of water heating systems

that rely on more sophisticated and less expensive materials. Researchers

have developed plastics that are more resistant to scratching and degradation

by the sun's ultraviolet rays and more tolerant of high temperatures.

They weigh less and their cost is as much as 26 percent lower than that of a

conventional solar collector. CER has already installed a small solar

plastic shellom pond with an area of 2 square meters on the roof of a

private school in Mayaguez. The system will supply 135°F water

at the

school cafeteria. A similar larger system is being designed to be installed

at the swimming pool on the Mayaguez Campus of the University of Puerto

Rico. This innovation will make the market penetration of solar heaters on

the Island more attractive.

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There are about 75 locations in Puerto Rico suitable for wind

turbines

Of about 2.5 megawatts each. On the other hand, the 200 KW wind turbine generator (HOD-0) at Culebra is being decommissioned by the U.S. Department of Energy. The UPR Ponce University College is interested in reinstalling it there for educational purposes.

According to Future Energy RED Corp., a Puerto Rican manufacturing firm, they have built and installed 42 Zeus 16 wind turbines on the Island.

They are now in the process of finishing the installation of a 25 MW wind

turbine in a San Sebastián municipal building. This product, locally

designed and manufactured, has been highly rated and featured among other groups

of four on the cover of Popular Science magazine of July 1962. The Zeus 16
machine is 15 percent efficient and has an automatic, centrifugally controlled
variable pitch propeller which can be feathered and withstand winds of
Up to 100 mph. They claim their price is almost half that of U.S. manufac-
turers, The Puerto Rican government is giving @ 50 percent tax deduc-
tion up to \$3006 for each installation

The P.R. Office of Energy estimates that after biomass, wind can make

the greatest oil substitution in Puerto Rico by the year 2000 (see Table 1)

Native Petroleum

Now that "dry rates" for drilling rigs have sharply declined, immediate
attention should be given to petroleum exploration in Puerto Rico. Geo-

logics! investigations using acoustic reflection methods have demonstrated
the existence of interesting geological formations. Very thick layers of

Peat and rich organic sediments are found in all the coastal areas of Puerto

Rico. The effect of fluctuating sea levels through geological times has

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contributed to the formation of extensive deltaic areas such as in the estuary of the Río de Platte River west of San Juan. This area has sedimentary rocks of carbonaceous origin approximately 12,000-feet thick extending from the northern foothills to a considerable distance out to sea. Seismic reflection profile studies were conducted in this area during the 1960s.

9 of

2 nuclear plant by the Puerto Rico Electric Power Authority. Various interesting formations indicating the presence of dark spots in the reflection profiles (possibility of gas and fluid phases) were discovered. The most outstanding one had an estimated volume of 225 cubic kilometers. Even

with a 1% content of extractable oil, this would be classified as a huge

formation (above 16 billion barrels)

Drills at this location would have to penetrate below sea floor for approximately 26,000 to 11,000 ft, water depth where drilling rigs or drilling ships would be located does not exceed 206 feet, which is well within limits of present drilling technology. A positive drilling program in Puerto Rico would result in the lessening of our dependence on foreign oil to a significant degree and would consequently strengthen our energy position. We should find out now whether there is commercially exploitable oil or gas in Puerto Rico. Federal assistance would facilitate undertaking this task.

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Another alternate source which could produce large amounts of energy is ocean thermal energy conversion (OTEC). However, OTEC has been virtually discarded for Puerto Rico, in spite of the fact that some of the best research has been carried out on the island and that we have some of the

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world's best sites. CEEC studies on corrosion and biological growth: an OTEC Plant components were successfully completed and resulted in the longest OTEC study ever conducted at an actual site, Puerto Rico's technical expertise in this area is nationally recognized. Studies made independently

by PREPA and CEEF indicate that an MTEC plant would be, after O nuclear Slant, the most economic alternative for Puerto Rico in the 1990s. (See Figure 3.)

Newari has been favored over Puerto Rico in obtaining federal grants for OTEC development because of its greater political influence as a state because of substantial Hawaiian government appropriations for its development, but Hawaii and California are moving fast to replace their energy dependence on oil in spite of sharp reductions in federal funds for

their energy research

Renewable Energy

The Puerto Rico Water Resources Authority (PRURA) recognized the need to diversify its energy sources as early as 1960. With the collaboration of the U.S. Atomic Energy Commission and the Puerto Rico Nuclear Center, PRURA developed, constructed and operated the experimental BONUS nuclear power reactor in Rincón. Thus, Puerto Rico generated electricity from a nuclear reactor before any other Latin American country. The BONUS plant is a good example of an early high technology project successfully conducted in partnership between the federal and Commonwealth governments. By early 1970 Puerto Rico was ready for the installation of a commercial nuclear power plant. A 600 MW nuclear unit was proposed for Aguirre and scheduled for

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operation in October 1976. Unfortunately, the project had to be discontinued some years later due to uncertainties in the geology of the site. After an exhaustive study of the island, a new site near Arecibo was selected and environmental studies approved by the Federal regulatory agencies. In December 1975 the project was postponed indefinitely due to a combination of factors, including increased capital cost and social and political reverberations,

At present there are over 200 nuclear reactor power plants operating satisfactorily throughout the world. The United States stands at the crossroads of decision on the nuclear option. If commercial nuclear power is to have a future it must be economic, safe and acceptable to the public. Some basic obstacles such as long term radioactive waste disposal, regulatory uncertainties, high construction costs, and public misconceptions of safety risk assessments must be surmounted. Steps are being taken at the Federal level to resolve these uncertainties; when they are solved, new nuclear power plants will blossom again. That would be the right time for U.S. manufacturers of nuclear power plants to develop and construct smaller units, such as 200 to 300 Mw, suitable for the international market, which is now controlled by foreign manufacturers. A federal/state/public consortium is recommended to develop site specific nuclear power plants. This option should not be discarded for possible future use in Puerto Rico since

it continues to be the cheapest way to produce electricity (see Figure 1).

Coal

In 1979 studies were started by the Puerto Rico Electric Power Author

ity (PREPA) to determine the feasibility of building @ 900 MWe coal anç of?

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Fired power plant. Environmental siting studies for this project were conducted by the UPR Center for Energy and Environment Research (CEFR). In September 1981 PREPA decided to discard the plant project due to various factors, including a downward trend in energy sales and lower forecast of peak loads.

In order to reduce its dependence on petroleum, PREPA is presently evaluating the conversion of two 450 MWe steam units at Aguirre for dual coal and oil firing. It has also announced that it has cancelled construction of additional generating facilities during this decade. CEE has proposed to PREPA an evaluation of burning coal-water slurries in existing vertical fire boilers. The main advantage of coal slurries for Puerto Rico is that they can be treated and transported as a liquid fuel. Boiler and

plant modifications represent 2 modest additions) investment when compared

to the cost of

boilers for solid coal! Environmental impacts are also

greatly reduced with coal-water slurries when compared with use of solid coal. This is a very promising alternative which is already being tested by some utilities in the United States

Once a decision to proceed is made, it would take six to seven years.

before a new large coal boiler unit can be put into operation. Coal-water slurries can be tested in present FWR boilers within one year. It is worth noting that some cement plants in Puerto Rico are already switching from oil to coal. We have to do the same thing for the production of elec

tricity.

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Technology Transfer: Proposal

As we have seen throughout this paper, Puerto Rico has made significant advances in the development of alternative, renewable energy sources. We are now ready to share these developments with our Caribbean Basin and Latin American neighbors. CER is in an advantageous position to undertake such a task. In fact, we have already taken some steps in this direction, though mostly in specific projects and sites rather than in general programs of regional scope.

A good example of the latter is the project "Development of Alternative Energy Science and Engineering in the Caribbean" carried out by CEER with joint sponsorship of the Association of Caribbean Universities and

Research Institutes (UNICK), the U.S. National Science Foundation, the Exxon

Education Foundation, and the Caribbean Development Bank. Two workshops--one on wind energy in Barbados and the other on biomass in Puerto Rico--have been held under this project. A third workshop, on solar energy, will be held at the University of Florida in Gainesville early next month, and a fourth one, on tropical dry forests, is being planned for the Dominican Republic in the fall. More than one hundred persons who are active in various science and technology activities in their respective Caribbean

countries «111 bene#it from this projec.

I am convinced that the time is right to formulate a broad plan to institutionalize science and technology transfer activities so the Caribbean and Latin America, Such @ project should be a collaborative undertaking involving the academic and scientific community, the Caribbean and federal governments, donor groups and foundations, and the private sector.

The institutional setup could be modeled after the East West Center for

eye

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Cultural and Technical Interchange established in the University of Hawaii

Under the provisions of P.L. 86-872 of May 14, 1960.

The Hawaii center, naturally, has a Pacific orientation and scope. The proposed Puerto Rico center would foster science and technology activities and technical interchanges primarily within the Caribbean Basin but also more broadly within the Western Hemisphere. The UPR Center for Energy and Environment Research has the capability, technical resources and expertise to form @ basic nucleus for the formation of the proposed science and technology transfer center. It also has the interest and willingness to contribute its share in the design and planning aspects as well as in the

Implementation of actual projects and programs.

I earnestly hope that this proposal will elicit sufficient interest in Washington and in Puerto Rico to commence serious planning to make it a reality. We at CEER-UPR stand ready to do our part.

Concluding Remarks

We expect the energy situation in Puerto Rico to continue without major changes this year. The reduction in oil prices will be a relief for our economy. We are looking forward to the revision of the Energy Policy Plan by the Pu

erto Rico Office of Energy, to the Report of the Energy Commission of the Puerto Rico Legislature, and to the federal government's Comprehensive Energy Plan for Puerto Rico required by P-L. 96-187. Meantime, local industries will continue taking steps to reduce their energy demands by using energy more efficiently. Some, like the cement plants, are switching to coal, while others are building their own cogenerating facilities and using other energy alternatives. A study by an energy consultant from California indicates that there are 347 PREPA customers with cogeneration potential.

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A change in federal policy would also be very helpful. At the present time, the federal government does not spend money on alternate energy sources which in its judgment are ready for commercial operation. An implicit assumption of this policy is that the research and development has been completed, and that all investors have to do is build a plant and start making money. However, this assumption does not always hold true. There are many things about new processes which cannot be learned at a desk, in a laboratory or even in a pilot plant using commercial type equipment. Sometimes substantial learning may continue even with the second and third commercial units.

The U.S.

National Academy of Sciences in its study "Energy in Puerto

Puerto Rico's Future? concludes:

Puerto Rico, in dealing with its own energy problems, should grasp

its opportunity to become an international energy laboratory.

Seeing on testing scenarios especially appropriate to the

sovereign-dependent tropical and subtropical regions of the world. The

island's geographical position and its established energy research

and development facilities enhance this potential, which should

be called to the attention of agencies and institutions with investment to make in accelerating developments overseas, In this paper we have identified alternative energy sources for Puerto Rico such as energy cane, energy crasses, solar thermal systems, solid waste, and fT exploration, a1] of which are commercially viable and suitable for private investment, This conference should consider how to help bring these development potentials to prospective investors. Also, as

already mentioned, there are other energy alternatives that need further research and development. We have ideal conditions to pursue these for the well-being of both Puerto Rico and Caribbean Basin countries. But to do it the federal assistance that has been reduced must be restored.

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A general, broad energy consensus is needed in Puerto Rico so that plans and actions for oil substitution alternatives on a large scale may be implemented as soon as possible, Plans to implement alternative energy

sources should be translated into action promptly. If not, in a few years

Our people will suffer from our present inaction, oil is vanishing steadily and continues to be @ very political]. unstable energy source. Puerto Rico cannot afford to wait or relax until tomorrow. Prudence and economics

dictate that we move toward energy self-sufficiency as rapidly as possible.

Yours,

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TABLE 1

POTENTIAL OF RENEWABLE ENERGIES IN PUERTO RICO
{COMPARISON OF PROE-NAS-CEER STUDIES}

A. Contribution to Electrical Needs in Percent (%) of Total Electrical Use. Estimates of Puerto Rico Office of Energy (PROE), National Academy of Sciences (NAS) and CEER Studies

?Source YEAR 1990, YEAR 2000

percentage of Annual Production

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- NAST ceERY fate! NAST GEER?

Biomass 17.2 10.4/3.2 13.8 wl 30/9.9 8.8

Wing 8 8/2 SF 12 Lee

Protovoltaics O50 - 37 07.0

orec 00 (0.0 3 69 1.3.6 287

Hvaro. ne 74 1.07.6

Solar Water Heater

Identia 8 2.0/1.1

Industeie) water

eater 1 3.9/2.3 77

8. Contribution to Non-Electrical in Percent () of Total Electrical
Use. Estimates of Puerto Rico Office of Energy (PROE), National
Academy of Sciences (NAS) and CEER Studies

Industrial Heat V7.0 2/L17.9* | 15.08 3.8/2.3 15.7%

Ethanol 31 1.23. 237 | 20.7/13.4 26.5

1, Maximum potential based on Scott & Arrenstien (Ref. 12).

2. Optimistic/conservative projections based on high energy demand growth assumption. (See Ref. 17)

3, See Iriarte (Ref, 10),
includes 2 cogeneration component.

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FIGURE 1

TOTAL LEVELIZED GENERATION COSTS OF ALTERNATIVES
FOR ELECTRICAL ENERGY PRODUCTION IN PR

E

1985 1990 1998 2000-2005 2010-2018 2020

YEARS

NOTES. | WIND ENERGY ALTERNATIVE ASSUMES NO STORAGE FOR THIS

COMPARISON,

2 ALL COSTS ESCALATED 5 1/4% PER YEAR, EXCEPT OIL, AT 9%

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