

A Preliminary Analysis of Block Island Power Company's Use of Clean Distributed Resources to Provide Power to Its Customers

Technical Report: August 1998

T.E. Hoff
*Pacific Energy Group
Walnut Creek, California*



NREL

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

A Preliminary Analysis of Block Island Power Company's Use of Clean Distributed Resources to Provide Power to Its Customers

Technical Report: August 1998

T.E. Hoff (*presently with Clean Power Research*)
Pacific Energy Group
Walnut Creek, California

NREL Technical Monitor: C. Herig

Prepared under Subcontract No. XAX-6-16817-01



NREL

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at <http://www.doe.gov/bridge>

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: <http://www.ntis.gov/ordering.htm>



Table of Contents

1.	Introduction	1
2.	System Description	1
3.	Energy Production.....	2
4.	System Cost.....	3
5.	Conclusions	5
6.	Appendix	6

1. Introduction

This report is an analysis of the potential for Block Island Power Company (BIPCO) to use renewable energy and clean distributed resources to supply power to its customers. The report is only a preliminary evaluation; it does not make a final recommendation as to the action that BIPCO should take. Rather, its purpose is to indicate whether or not further analysis is warranted.

Block Island is located approximately 10 miles off the coast of the Rhode Island mainland. BIPCO currently supplies power to its customers using diesel generators. For a variety of reasons, BIPCO will make major investments in new capital to provide power to its customers. The two basic alternatives that have been suggested are: (1) to install a submarine cable to provide electricity from the mainland to the island; and (2) to purchase new cleaner power generators. This work evaluates the feasibility of a third alternative: (3) to invest in clean distributed resources.

2. System Description

It is proposed that the clean distributed resources be composed of: energy efficient lights and refrigerators; photovoltaic (PV) systems distributed to where power is consumed; two wind turbines; and commercial and residential cogeneration. The energy efficient lights and refrigerators will reduce electrical consumption. The PV systems will convert sunlight into electricity. The wind systems will convert wind into electricity. The cogeneration units will use fuel to simultaneously produce electricity and also heat for hot water. The investments could be made according to the following time frame.

1999

- Replace 20,000 incandescent light bulbs with fluorescent lights (compact fluorescent lights or the equivalent) in residences, hotels, and restaurants; this corresponds to 2 lights for each person during the peak summer months
- Replace existing refrigerators with high efficiency refrigerators for all year round residential customers
- Install two 500-kW wind turbines (1 MW of wind)
- Install fifty 20-kW PV systems at or near demand service customer premises (1 MW of PV)
- Install six 250-kW cogeneration generators to supply hot water to demand service customers (1.5 MW of cogeneration)
- Operate the existing diesel generators to provide 15 percent of the power sold and to provide emergency peaking power¹

2004

- Install 1-kW cogeneration fuel cells in year round customer residences in place of their water heaters (0.3 MW of residential cogeneration)

¹ This corresponds to less than 350 hours per year of full operation for units #13, #19, and #20 (combined capacity of 3,836 kW).

- Operate the existing diesel generators to provide 5 percent of the power sold and to provide emergency peaking power

3. Energy Production

It is estimated that this system will need to produce 8.3 Million kWh to provide 7.7 Million kWh to the customers.² Table 1 presents the distribution of electricity production (and savings) on an annual basis.

Since the some of the technologies are non-dispatchable, the match between supply and demand on a finer time scale is an important consideration. The data available at the time of the analysis was monthly. Figure 1 suggests that there is a good match between supply and demand on a monthly basis.³

Table 1. Percent of annual energy production and savings by source.

Efficiency	Wind	Commercial Cogeneration	Residential Cogeneration	PV	Diesel Backup	Total
25%	19%	29%	8%	21%	5%	107%

² It is anticipated that the system will have fewer losses because the technologies will be located nearer the customers' premises. 8.8 and 7.7 Million kWh of electricity were produced and sold in 1996, respectively; it is estimated that the use of distributed resources will reduce the system losses from 15 percent to 7 percent.

³ The monthly production of electricity was determined as follows. The energy efficiency savings were assumed to be proportional to the demand since these type of energy efficiency investments tend to have stable reductions throughout the year. The PV output was based on the percentage of horizontal insolation by month from NREL's solar database. The wind output was obtained from Tony Jimenez at NREL. Residential cogeneration was assumed to be constant throughout the year since the heat load is for water heating needs. Commercial cogeneration was the residual of demand minus the other components; no monthly data were available to verify the commercial cogeneration. This pattern of production, however, appears to be reasonable because the demand customers will have hot water demand that is highly correlated with the number of people on the island.

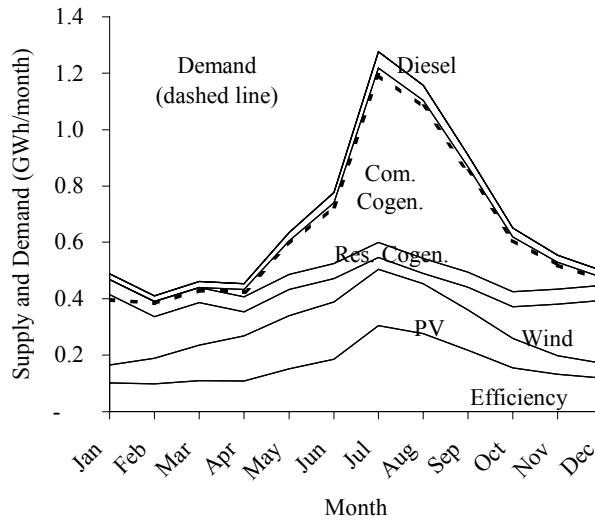


Figure 1. There is a good monthly match between supply and demand.

4. System Cost

Table 2 indicates that this system would have a capital cost of \$8 Million dollars. Including the other annual costs, this translates to a total annual cost of about \$2 Million starting in 1999.⁴ Figure 2 presents the annual cost of the system from 1999 to 2028; two cost estimates for the cable alternative (one included in the BIPCO Power Requirements Study, April 1998 and the other from Booth & Associates, May 1997) are included for comparison.

⁴ The calculations make the following assumptions: the discount rate is 5.75%; there is no inflation with capital costs when the technologies need to be replaced (it appears that the costs of the renewable technologies are declining over time); there is 4% inflation for fuel and O&M costs; property taxes are 0.5% of capital cost; insurance is 0.75% of capital cost; and the base cost for operations is \$929,351. It is also assumed that, while the energy efficiency investments have a 10 year life, BIPCO will need to make the investment in efficiency only once; customers will make the investment in subsequent years.

Table 2. 1999 system cost.⁵

	Efficiency	Wind	Com. Cogen.	Res. Cogen.	PV	Diesel Backup	Total
Capital Cost (\$)	\$500,000	\$1,000,000	\$2,000,000	\$500,000	\$4,000,000	-	\$8,000,000
Size (MW)		1.0	1.5	0.3	1.0	-	
Life (years)	10	15	15	15	30	-	
Elec. Prod. (GWh/y)	2.0	1.5	2.2	0.6	1.6	0.4	8.3
O&M cost (\$/kWh)	-	\$0.02	\$0.05	\$0.05	\$0.01	\$0.02	
Fuel Cost (\$/kWh)	-	-	-	-	-	\$0.08	
Annualize Factor	0.1343	0.1013	0.1013	0.1013	0.0707		

ANNUAL COSTS

Cap. Cost (\$/yr)	\$67,132	\$101,288	\$202,575	\$50,644	\$282,865	\$0	\$704,503
Property Tax (\$/yr)		\$5,000	\$10,000	\$2,500	\$20,000	\$0	\$37,500
Insurance (\$/yr)		\$7,500	\$15,000	\$3,750	\$30,000	\$0	\$56,250
O&M Cost (\$/yr)		\$29,692	\$111,526	\$32,073	\$15,768	\$7,671	\$196,730
Fuel Cost (\$/kWh)		-	-	-	-	\$30,685	\$30,685

Annual Cost	\$1,025,668
Base Cost	\$929,351
Total Cost	\$1,955,019

There are several things to notice in the table:

1. The total capital cost is \$8 Million and the annual cost is starts out at about \$2 Million per year in 1999 (the costs increase slowly over time); these costs are comparable to the cost of power using the submarine cable.
2. While there are O&M costs for the cogeneration, there are no fuel costs. The reason for this is as follows. Customers currently purchase and burn fuel to heat their hot water. Rather than having the customers purchase the fuel for their hot water and BIPCO purchase fuel for its generating units, BIPCO will purchase the fuel for the cogeneration units, run the cogeneration units to generate both heat and electricity, and then sell the heat to the customers. The money that BIPCO will spend on fuel will be offset by the revenue from customers for the hot water because this is the amount customers would have had to spend on fuel without the cogeneration.⁶
3. The two cable cost estimates differ in later years. The major reason for the difference is because the estimate in the BIPCO Power Requirements Study assumes that there is no inflation in electricity costs while the Booth & Associates estimate assumes that there is 4 percent escalation. This emphasizes one risk that BIPCO faces with providing power using the cable: BIPCO may need to increase rates if its suppliers increase its electricity prices. If this happens, the distributed resources will make it increasingly attractive for customers to self-generate and BIPCO could lose customers.

⁵ This table includes the cost of the residential cogeneration even though it is not installed until 2004.

⁶ The average efficiency of hot water heating units in the U.S. is around 60 percent. It is assumed that the cogeneration units have a thermal efficiency of 60 percent and an electrical efficiency of 25 percent.

- The system with clean distributed resources may offer customers more rate stability over time because a much smaller portion of the overall cost is due to fuel costs.

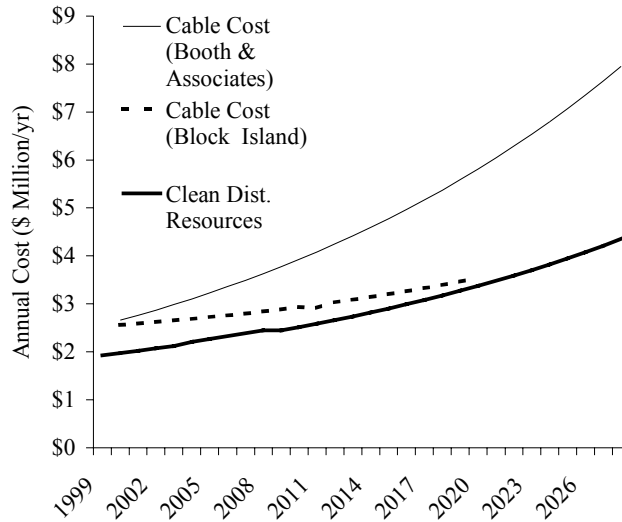


Figure 2. Annual costs.

5. Conclusions

The preliminary conclusion of this work is that a system composed of clean distributed resources has the potential to be a technically and economically feasible alternative for BIPCO. This conclusion suggests that a more detailed analysis of such a system is warranted.

The subsequent analysis should address these, as well as other, issues:

- The costs for the various technologies were estimated in this report. These estimates need to be verified by obtaining bids from suppliers.
- No discussion was included in this report about the impact on rates. That is, while the total cost of this system may be comparable to the cost of the cable based system, less electricity will be consumed. Thus, while the average bills (\$ per year per customer) will remain the same, rates (\$ per kWh) may increase.
- This work assumed that the output from the cogeneration units that supply hot water to the commercial customers will peak in the summer because there will be a high correlation between the use of hot water and the number of people on the island. The hot water usage pattern needs to be confirmed.
- The cogeneration investments assume that customers will be willing to participate; this needs to be verified.
- The analysis assumed that there is a good potential for electricity savings using energy efficiency investments on the island and that customers will allow BIPCO to install the new efficient technologies (at no cost to them). This needs to be verified.

6. While there is a good monthly match between supply and demand, the match needs to be examined on a finer time scale, such as on an hourly basis. It needs to be determined whether or not the wind output plus the PV output exceed demand, particularly during the winter months.

6. Appendix

This appendix describes some of the calculations in more detail.

Efficiency Investments

Suppose that the utility purchases and installs 2 compact fluorescent lights (CFL) for every person on the island. At the peak time, there are about 10,000 people on the island. Table 3 suggests that this would result in the installation of 20,000 CFLs and have a total energy savings of 1.3 Million kWh hours. If each bulb cost \$10 to purchase and \$2.50 to install,⁷ the capital cost of this investment is \$250,000. Since the CFLs have a rated life of 10,000 hours, the bulbs will last about 10 years.

In addition, suppose that the utility purchases a high efficiency refrigerator for each of its year round residential customers. Table 4 shows that this would result in an annual savings of 666,000 kWh. The cost of this savings would be about \$250,000 if each refrigerator cost \$750.

Table 5 suggests that investing in high efficiency lights and refrigerators will cost \$500,000 and save 2 Million kWh or about 26 percent of Block Island's electricity consumption. Due to the type of efficiency investments, it is assumed that the energy savings are proportional to the load throughout the year. We will assume that the utility makes the energy investments once and pays for them over 10 years and then the residents and businesses pay the replacement costs of these units in the future.

⁷ The utility could hire two people for a year at \$25,000 per year per person to install the lights. Each person would need to install 5 lights per hour (or the equivalent of about one house per hour) to accomplish this task.

Table 3. Annual electricity savings from fluorescent lights.

	Number of people ⁸	Number of lights per person	Annual hours of operation ⁹	Savings per light per hour (kWh/hour) ¹⁰	Total savings (kWh)
Year Round Residential	800	2	1,460	0.07	163,520
Summer Residential	1,700	2	487	0.07	115,906
Visitors	7,500	2	975	0.07	1,023,750
Total					1,303,176

Table 4. Annual electricity savings from high efficiency refrigerators.

	Number of residences ¹¹	Annual savings per refrigerator (kWh) ¹²	Total savings (kWh)
Year Round Residential	333	2,000	666,000

Table 5. Energy efficiency cost and savings.

	Savings	Installed Cost
Lights	1,303,176 kWh	\$250,000
Refrigerators	666,000 kWh	\$250,000
Total	1,969,176 kWh	\$500,000

⁸ There are 1,017 residential customer accounts. It is estimated that there are about 333 active accounts in the winter (average of 2.4 people per house).

⁹ The annual hours of operation is based on the following: 4 hours per day for year round residential customers, 4 hours per day from June through September for Summer residential customers, and 8 hours per day from June through September for visitors (i.e., in hotels, restaurants, etc.)

¹⁰ This savings is based on a 30 Watt fluorescent replacing a 100 Watt incandescent.

¹¹ This assumes that there average number of people per house on Block Island is the same as the Rhode Island's average of 2.4 people per house.

¹² This assumes that the existing refrigerators consume about 2,500 kWh per year and that the new refrigerators will consume 500 kWh per year.

PV and Wind Output

Table 6 presents the estimated electricity output from PV and wind units on Block Island. The data are presented in units of kWh per kW of investment.

Table 6. Monthly electricity production for PV and wind

	PV Output (kWh/kW)	Wind Output (kWh/kW)
Jan	63	250
Feb	91	148
Mar	126	150
Apr	160	85
May	189	93
Jun	204	82
Jul	200	41
Aug	178	36
Sep	144	80
Oct	104	112
Nov	65	183
Dec	53	224

Cogeneration

Assume that the population of Block Island is 800 people for 8 months of the year and 10,000 for 4 months of the year. Assume that the average person uses 10 gallons of propane per month for water heating. This suggests that about 464,000 gallons of propane are used per year on Block Island for water heating. Since the average gas water heater in the U.S. has about a 60 percent thermal efficiency, these units could be replaced with cogeneration units that have 60 percent thermal and 25 percent electric efficiency and would produce electricity with no additional consumption of fuel. If BIBCO could provide all of the hot water needs of its customers, it would produce about 3.1 Million kWh per year as well as the heat for the hot water.¹³

¹³ 3.1 Million kWh = 464,000 gallons of propane * 91,220 BTU's/gallon * 0.000293 kWh/BTU * 0.25

Prepared by:
Thomas E. Hoff, Ph.D.

Presently Employed by:
Clean Power Research
10 Glen Court, Napa, California 94558
phone: (707) 224-9992 email: tomhoff@clean-power.com
Internet: www.clean-power.com

August 5, 1998

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE January 2000	3. REPORT TYPE AND DATES COVERED Technical Report; August 1998	
4. TITLE AND SUBTITLE A Preliminary Analysis of Block Island Power Company's Use of Clean Distributed Resources to Provide Power to Its Customers; Technical Report; August 1998			5. FUNDING NUMBERS C: XAX-6-16817-01 TA: PV008102	
6. AUTHOR(S) T.E. Hoff		7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Pacific Energy Group 32 Valla Ct. Walnut Creek, CA 94596		
8. PERFORMING ORGANIZATION REPORT NUMBER			9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401-3393	
10. SPONSORING/MONITORING AGENCY REPORT NUMBER SR-520-27513			11. SUPPLEMENTARY NOTES NREL Technical Monitor: C. Herig	
12a. DISTRIBUTION/AVAILABILITY STATEMENT National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report is an analysis of the potential for Block Island Power Company (BIPCO) to use renewable energy and clean distributed resources to supply power to its customers. The preliminary conclusion of this work is that a system composed of clean distributed resources has the potential to be a technically and economically feasible alternative for BIPCO.				
14. SUBJECT TERMS photovoltaics ; renewable energy ; clean distributed resources			15. NUMBER OF PAGES	
17. SECURITY CLASSIFICATION OF REPORT Unclassified			16. PRICE CODE	
18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified		19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	