

Analysis of Policies to Promote  
Weatherization of Homes on  
Martha's Vineyard

by

Amy Faye Philipson

B.S., Massachusetts Institute of Technology  
(1976)

SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE  
DEGREE OF

MASTER OF CITY AND REGIONAL PLANNING

at the

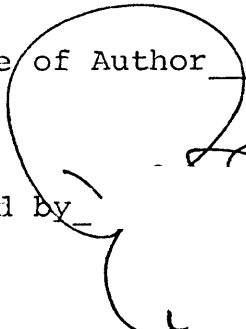
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

December 1980

© Amy Faye Philipson 1980

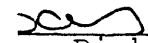
The author hereby grants to M.I.T. permission to reproduce and to distribute copies of this thesis document in whole or in part.

Signature of Author



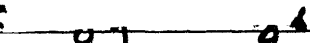
Department of Urban Studies  
and Planning  
October 24, 1980

Certified by



Richard Tabors  
Thesis Supervisor

Accepted by



Chairman, Department Committee

MASSACHUSETTS INSTITUTE  
OF TECHNOLOGY

MAR 19 1981

LIBRARIES

ANALYSIS OF POLICIES TO PROMOTE  
WEATHERIZATION OF HOMES ON  
MARTHA'S VINEYARD

by

AMY FAYE PHILIPSON

Submitted to the Department of Urban Studies and Planning  
on October 24, 1980 in partial fulfillment of the  
requirements for the Degree of  
Master of City and Regional Planning

ABSTRACT

A citizen group advocating energy conservation on Martha's Vineyard was the client. The goal was to determine a policy for promoting home weatherization in order to reduce the demand for home heating fuels and the resultant drain from the Island economy.

A model of the prototypical dwelling units in New England was modified to predict the benefits to the Vineyard homeowner from different levels of weatherization investment. This was used in conjunction with an analysis of to what extent weatherizing should be promoted and to decide what policies might cause the year-round Vineyarders to further weatherize.

With no outside resources, the local Island governments may only be able to adopt a policy to inform Vineyarders of the benefits to weatherization. However, the results of the investment model show that the rate of return an Island homeowner can expect from additional investment is lower than generally expected by the New England household. A plan to inform Vineyarders is less likely to promote more weatherization than similar programs in other areas because Islanders are already aware of the benefits.

If the resources are available, then a rebate program would be most likely to induce further weatheriza-

tion. It significantly lowers the cost to the consumer and targets a group of homeowners who may be missed by the existing set of programs to promote residential energy conservation. Although the program will have an expansionary impact, the effect will be slight. The expansionary effect will increase as energy prices rise more quickly than other prices and as the export percentage of a dollar spent on energy rises.

Thesis Supervisor: Richard D. Tabors

Title: Principal Research Associate

Biography:

The author attended Wellesley College from 1972-1974 and was invited into the honors and tutors program in Economics. She transferred to MIT and received a B.S. in Economics in 1976. Professional experience includes credit research and analysis at Continental Bank, Chicago, Illinois, and economic research at the MIT-Harvard Joint Center for Urban Studies.

## TABLE OF CONTENTS

	page
CHAPTER 1	
Introduction and Problem Statement	7
CHAPTER 2	
Factors Affecting Consumers' Decisions to Weatherize	9
2.1 Information	9
2.2 Lack of Financing	11
2.3 Consumer Choice	14
CHAPTER 3	
Regulations and Incentives: Examples	19
3.1 Regulations	19
3.2 Incentives	26
3.2.1 Subsidized Loans	27
3.2.2 Partial Rebate	37
3.2.3 Tax Credits	41
CHAPTER 4	
Determining a Policy for Martha's Vineyard	47
4.1 A Review of the Alternatives	47
4.2 Impact of an Information/Marketing Program	52
4.3 A Rebate Policy	55
CHAPTER 5	
Benefits of a Rebate Program	59
5.1 Assumptions	59
5.2 Economic Effect of a Rebate Program	61
CHAPTER 6	
Conclusions and Suggestions	64
6.1 Conclusions	64
6.2 Suggestions	65

TABLE OF CONTENTS (Cont.)

	page
APPENDIX I	
A Model of Energy Consumption for Home Heating on Martha's Vineyard	67
A1.1 Data and Assumptions in the Model	70
A1.2 Description of Cases	75
APPENDIX II	
Results from the Model	85
A2.1 Case A Initial Conditions--New England Housing Stock Characteristics	85
A2.1.1 Analysis of Investment Results using Payback Criterion by Age of Unit	85
A2.1.2 Critique of Model and Payback Analysis	90
A2.1.3 Rate of Return Analysis	91
A2.2 Case B Initial Conditions--Martha's Vineyard Housing Stock Characteristics	95
APPENDIX III	
Energy Balance for Martha's Vineyard	97

## CHAPTER 1

### Introduction and Problem Statement

The Energy Resource Group of Martha's Vineyard (ERG) is a non-profit citizens organization formed in the fall of 1976. Island residents created ERG because they perceived a lack of accessible information about energy alternatives. Besides conducting workshops and demonstrations and providing information to the general public, ERG has sought to influence policy decisions. Woodlot management, zoning for windmills, and establishment of an energy planning office for Dukes County are all areas where ERG has affected public policy.

The goal of this thesis is to perform a policy analysis in order to suggest the best method for promoting weatherization on Martha's Vineyard. Chapters Two and Three are a discussion of the major factors affecting consumers' decisions to weatherize, the rationales for government intervention, and existing policies to promote the investments.

An evaluation of the success of the policies is combined with a characterization of the political, social and economic constraints on Vineyard governments. Policy recommendations are the end result.

The Appendix to the thesis includes a description of

REFORM, a model of the impacts of weatherization on the energy demanded for home heating. The model shows the returns a homeowner can expect on his investment. This information is used as a guide to what factors are likely to be most important in the decision to weatherize and hence to test the probable effectiveness of the initial recommendation.

A revised policy is presented in Chapter Four. Then, the costs and benefits of this program on the overall Island economy are calculated.

## CHAPTER 2

### Factors Affecting Consumers' Decisions to Weatherize

What follows is a description of the major factors affecting consumers' decisions to invest in weatherization. Examples of government policies which seek to stimulate weatherization through changes in each of the factors are also included.

#### 2.1 Information:

There is the possibility that consumers are unaware of the benefits to weatherization. Homeowners simply may not realize that insulation and other measures will significantly reduce their energy consumption and at a cost which will still leave them with considerable energy savings.

ERG was originally founded in response to the perception that consumers are unaware of these benefits. The organization provides Islanders with access to information about energy alternatives and conservation. The federal government is in part responding to the same perception with the Residential Energy Conservation Service<sup>1</sup>. The program, administered by the state energy offices, is

---

<sup>1</sup>Massachusetts Residential Conservation Program, Executive Office of Energy Resources, June, 1980.

scheduled to begin this fall when utility customers will be given energy audits upon request and payment of a \$15 fee. The fee may be waived for low-income customers. The utility will conduct the audit, provide assistance in locating reliable contractors, and help arrange financing.

The RCS is an effort to market weatherization and energy conservation in general. If the energy auditor is a good salesperson, he or she will convince the homeowner to weatherize. There are two problems with the program. The first is a tendency to regard the auditor with distrust. He is offering advice on what can be done to reduce energy consumption and who could be hired to make the necessary repairs, installations, etc. He is even offering to help find financing. The consumer may question what the reward to the auditor is. Have any of the possible contractors or financiers attempted to influence the auditor? There exists a policing mechanism in the RCS program but consumers may still be skeptical of information presented by the auditors. The tendency to disbelieve may be strengthened because the auditor could be seen as a representative of the utility. In that case, consumers may question the seller of a product (conservation) which will diminish the demand for his employer's product (electricity).

The second problem with RCS in Massachusetts is that

utilities already have excess capacity<sup>2</sup> and therefore little incentive to promote the program. It will lead to reduced residential demand for electricity, lower receipts, and more excess capacity.

## 2.2 Lack of Financing

Lack of financing is a problem for low income households who want to weatherize. The necessary funds may be completely unavailable from private sources or too costly. Under the rationale that rising energy prices have caused hardship because people cannot afford to make the weatherization improvements, the federal government established a program (National Energy Conservation Policy Act<sup>3</sup>) to provide grants to low income families. Income may be no more than 125 percent of the federally established poverty level. The maximum grant is \$1000 for the purchase of and installation of eligible weatherization materials. The amount may be increased up to \$1600 by the regional Representative to reduce severe shortages of labor. The program is funded through the Department of Energy which in

---

<sup>2</sup>Conversation with Andy McGill, Massachusetts Executive Office of Energy Resources. Also, Wall Street Journal, "Many Electric Utilities Suffer as Conservation Holds Down Demand," Philip W. Shenon, October 9, 1980.

<sup>3</sup>National Energy Conservation Policy Act, Weatherization Grants for Low-Income Families, Office of Weatherization Assistance, Department of Energy, Washington, DC.

turn funds the Community Action Program (CAP) in conjunction with the Community Service Administration.

The winterization effort in Wareham, Massachusetts<sup>4</sup> is one example of the implementation of the federal program. Materials are bought with Department of Energy funds which are channeled through the Housing Assistance Corporation in Hyannis, Massachusetts. The Housing Assistance Corporation is part of CAP.

Wareham's program began in April 1976. At that time CETA workers installed the weatherization measures. They included attic and wall insulation, weatherstripping, caulking, storm windows and doors, insulation of hot water pipes, heating ducts and water tanks, installing attic vents, replacing broken windows, and installing insulating gaskets on electric switches and receptacles. The spending limit on materials was \$125 - \$250. The program has since been revised. Community Development Block Grant funds are used to support the services of one carpenter in addition to the CETA workers. The spending limit on materials has been raised to \$1000. Since 1976, approximately 330 houses have been serviced. No statistics were available on energy savings or cost to the town of Wareham.

---

<sup>4</sup>James O. Brandolini, Community Development Department, Housing Rehabilitation, Town of Wareham, Massachusetts, Weatherization Program.

period between the time weatherization was requested and when it was obtained. The current crew of three workers is able to weatherize three to four homes per week.

There are programs similar to Wareham's throughout New England. A study undertaken by the New England Community Action Program Directors Association (NECAPDA<sup>5</sup>) provides more general information to evaluate the effectiveness of grant programs in achieving weatherization.

The program is aimed at reducing the regressive impact of higher energy prices. Eligibility is determined by income rather than by the condition of the housing, the goal being to provide financing to those who do not weatherize because they lack the funds. According to the NECAPDA, this goal is achieved. Eighty-six percent of the homes weatherized by the program are occupied by persons in families with income below the federal poverty level.

The economic efficiency (rate of return per dollar spent) of the program is more difficult to evaluate. To the extent that the units winterized are in need of more repairs than average because it is more difficult for owners to pay upkeep, the program targets the houses with

---

<sup>5</sup>New England Community Action Program Directors Association, Report of Weatherization Program, Boston, Massachusetts, February, 1979.

the greatest possible rate of return. NECAPDA's survey shows 90 percent of the units benefiting from the program were in need of significant repairs using the DOE method to calculate heat savings based on reports from Community Action agencies, "weatherized homes throughout New England stood to benefit an average of \$400 in fuel savings in the first year"<sup>6</sup> after the investment. That is, actual savings are unknown but are expected to be significant.

Criticisms of the program center on the lack of local control and the complex array of federal agencies involved. Sixty-four percent of the community action agencies contacted would prefer increased flexibility. Among rural and small urban agencies, 87.5 percent prefer more flexibility to accommodate local conditions. The lack of local decision making power led to a situation in Wareham where weatherization was slowed. DOE funds could only be used for materials when installation was the greater cost. Materials could be purchased but not installed.

### 2.3 Consumer Choice

Consumers may understand the benefits to weatherization, be able to afford it, and still not choose to make the investment. Weatherization is expensive, and if it

---

<sup>6</sup>Ibid., Section C.

costs more to invest than it does to pay the heating bill even for one year, consumers are not likely to weatherize. Also, there is no guarantee that savings will be what they are projected to be. Given this risk or perceived risk, the rational consumer may discount the energy savings at a very high rate and decide against the investment.

There are at least two other reasons why consumers may choose not to weatherize. Energy Future<sup>7</sup>, the report of the Harvard Business School, cites the mobility of the average household as a factor. "By 1970, only 54 percent of all household heads were living in the same houses as 1965. If you think you are going to move in a couple of years, why invest?" The consumer in this case may understand the benefits to weatherization and accept them but calculates that the investment easily may not be recovered by the time he moves. Even if the improvement adds to the value of the home so that it is recouped in the sale, the consumer may earn a better return by putting his money in a money market fund.

Perhaps the most common reason for not weatherizing is that there are many no cost/low cost ways of reducing energy consumption. The return on these is infinite since the cost is almost nothing but a change of habits. Turn-

---

<sup>7</sup>Energy Future Report of the Harvard Business School, Robert Stobaugh and Daniel Yergin, eds, Ballyntine Publishing Co., November 1980, p. 215.

ing down the thermostat, closing shades, closing off unused portions of a house, are just a few of the ways to keep down the heating bill. Many households find taking these measures leaves the proportion of their income spent on fuel relatively constant or that the increase is within acceptable limits. Why undertake a relatively large investment in insulation when it is not necessary? The return is high (payback short) but it is also high for other types of investment that might even be perceived as less risky. At current energy prices, weatherization may not be a compelling or even the most attractive investment for many households.

In all of these cases, consumers are not acting out of ignorance nor are they constrained by lack of funds. They are responding to market prices which should reflect the costs and benefits of weatherization.

One argument for government intervention to stimulate weatherization is that market price is not the true cost of energy. Consumers are basing their decisions on today's prices which are much lower than the long run marginal cost or replacement cost of energy. The government computes the costs and benefits of a weatherization program according to this price and finds the net effect to be positive. Also, a program to weatherize is less risky than an individual's investment. On average, projected

savings will probably be close to the benefits actually realized even though the return to some households may be less.

National security is another frequently cited reason for conservation policies that directly affect consumer choice. Reducing the dependence on imported oil will make the country less susceptible to supply interruptions and price changes. Reducing demand extends the time that the existing domestic supply will last in the event of an interruption. Thus when energy prices rise relative to other prices, there is less disposable income available for other expenditures. This causes a contraction in non-energy sectors and an expansion of the energy sector. But, much of the demand in the energy sector is met by sources outside the economy causing a net drain or a negative balance of payments.

Although national security is not an issue for the attention of the local governments on Martha's Vineyard, an interruption of supply would obviously disrupt the local economy. A certain amount of oil is stored on the Island. As is the case for the country as a whole, reducing demand will lengthen the time that this supply will last.

Most energy on the Vineyard is supplied by off-Island sources. Electricity is generated off-Island by New Bed-

ford Gas & Light Company. Suppliers<sup>8</sup> estimate that twenty cents of every dollar spent on oil stays on the Island. A survey<sup>9</sup> by the Martha's Vineyard Commission found that in general 35 cents of every dollar spent on the Island stays in the economy in the initial round of spending. As expenditures for energy use increase, the Vineyard economy will contract. More is spent in the energy sector relative to other sectors and a higher proportion of what is spent goes off-Island.

Under these rationales, there are many policies which directly affect consumer choice. Rather than providing information or providing the winterization service itself (or grants), the programs prod consumers to weatherize with regulations or incentives. Because there are many variations, the entire next chapter is devoted to the discussion and critique of existing policies.

---

<sup>8</sup>Conversations with Vineyard oil dealers provided this information.

<sup>9</sup>Dukes County Planning and Economic Development Commission, An Economic Base Study of Dukes County, Massachusetts, Fall, 1973, pg. 30. Conversations with planners for the Vineyard Commission suggest that the multiplier is the same or slightly lower than it was in 1973.

## CHAPTER 3

### Regulations and Incentives: Examples

The discussion of regulation and incentive policies includes where possible background on the conditions which led to the adoption of the program and an evaluation of its success.

#### 3.1 Regulations

##### Santa Clara, California<sup>10</sup>

The Board of Supervisors of the County approved an Energy Audit and Conservation Measures ordinance on January 21, 1980. The reasons for the ordinance included findings by the Santa Clara County Energy Task Force that (1) residents are "facing uncertainties in conventional energy resource supplies and the certainty of rapid cost increases as a result of the high expense of new energy production and generation facilities;" (2) retrofit was a "potential growth industry" in the county; (3) certain energy conservation measures were "cost-effective over the lifetime of the device in the average home for both donor and contractor installation."

---

<sup>10</sup>Title C of the County of Santa Clara Ordinance Code, Division C14, Energy Conservation, Chapter I, Residential Energy Audit and Energy Conservation Measures, Santa Clara, California.

The Santa Clara community faces steeply rising energy costs because new facilities are necessary to meet rising demand. The area is growing rapidly and conservation is one way to keep demand within existing capacity. Faced with costs estimated to be "10 percent of median family income by 1985" such an ordinance is not likely to be completely unacceptable. Also, the burden of the ordinance falls most heavily on those who have had no part in its adoption—new residents. The ordinance requires retrofit "prior to resale with minimum energy conservation measures to the extent that such measures are cost effective for a homeowner and applicable to the housing." Although the property owner must comply, the cost of the retrofit can be shifted to the buyer depending on the elasticity of demand. Judging from current housing prices in California it is a seller's market.

The other major reason why the ordinance was passed is that it requires very little weatherization. On a \$100,000 house, the cost might be \$500 to \$600, contractor installed. The incremental addition to mortgage costs is estimated to be less than the energy savings<sup>11</sup>. The ceiling must be insulated to R-19 unless it is already in "ex-

---

<sup>11</sup>Telephone conversation with John P. Cook, Energy Staff, County of Santa Clara, California.

cess of R-7 throughout at least 90% of the existing ceiling area." All doors opening to unheated areas must be weatherstripped, water heaters fitted when insulation blankets to a minimum of R-6, shower fixtures fitted with flow restrictors, and all heating and hot water pipes insulated if they are in unheated spaces. Any broken window or hole in the building envelope where "light may be seen" passing from an unheated and/or uncooled area to a conditioned area must be repaired. There are exceptions to the requirements if the repair is impossible or unaccessible or "unusual hardship" is caused. Appeals may be made to the Code Enforcements Appeals Board.

The ordinance may be extended to include other measures demonstrated to be cost-effective, as determined by the Planning Commission. Cost effective is defined as costs less than benefits over the "expected lifetime of the energy conservation device." Since cost effectiveness depends on the lifetime of the device, the rate of return on the investment may be relatively small, and still be required. In practice, it may be unlikely that any additional requirements can gain acceptance unless they clearly exhibit a high rate of return regardless of the definition of cost effectiveness.

The ordinance can reduce energy consumption only as fast as houses are sold. Sales are dependent on mortgage

availability and interest rates, and demand. Since the ordinance only went into effect October 1, there is no experience to evaluate.

An extra step is added to the sales process by the ordinance because an energy audit is used to determine if the house meets the standards. However, there is no follow-up to check compliance. Civil action may be brought by the buyer or action taken by the county if it is notified of failure to comply. A subsequent buyer may in turn bring an action against the first buyer if the original buyer did not force compliance by the original seller. However, failure to comply may not prevent recording of the deed or contract of sale. The system is administratively easy but does not necessarily result in a reduction of residential energy consumption.

Livermore, California<sup>12</sup>

This city council passed an ordinance in December 1979 similar to Santa Clara's. However, only ceiling insulation to R-19 (when the area is accessible and the existing rating is less than R-7) is required at resale. The same is required upon installation of central air conditioning or when a building is being modified. Modification means any enlargement or alteration of habitable

---

<sup>12</sup>Livermore, California, City Code, Ordinance No. 1003.

areas that exceeds "10 percent of the value of the structure, as determined by the Building Official." The value of the structure means replacement costs based upon the square footage costs in the "Building Valuation Data" published by the International Conference of Building Officials.

The Livermore law levies a penalty or places a burden on residents who increase their consumption as well as on new residents. It still raises the cost of moving to Livermore but may be slightly more equitable since residents also must take some responsibility for increased consumption. The rate of reduction in energy consumption is again determined by sales in the area. There is no provision for expanding the law nor any discussion of cost effectiveness in the ordinance. All of the council members and the mayor concurred in adopting the ordinance, one meeting after it was introduced. That is not surprising since there is pressure to take action to ameliorate the prospects of steeply rising energy costs caused by need for more capacity and this is an action costing current residents very little.

Again the pressure for compliance at point of sale is minimal. There is likely to be more pressure on the buyer to quickly complete the sale than for fear of paying a

noncompliance penalty<sup>13</sup> upon resale.

Davis, California<sup>14</sup>

The Davis building code has been amended to require an inspection of any home prior to resale. In addition to meeting safety standards, the house must have attic insulation to R-19, water heater insulation to R-6, flow restrictors on showers (3 gals/minute), and weatherstripped doors. The seller must comply with the ordinance. Unlike the Santa Clara County and Livermore laws, there is an inspection to determine compliance. Failure to comply may not delay the sale but is an infraction carrying a fine of up to \$250. If there is no retrofit then the buyer can take action to rescind the sale and may recover all fees.

Because Davis has an inspection and may levy a fine on violators, compliance is likely to occur. In fact, ninety percent of sellers do comply<sup>15</sup> and the city's attorney had never received a complaint.

---

<sup>13</sup>The unstated penalty makes the offense a misdemeanor for which there is a fine of \$500 or six months in jail—comment of Davis, California City Attorney.

<sup>14</sup>Davis, California building code ordinance as described by the building inspector.

<sup>15</sup>Telephone conversation with the building inspector, Davis, California.

Los Angeles, California<sup>16</sup>

In 1973 during the oil embargo, Los Angeles cut residential energy use 18 percent. Electric utility customers were required to cut their use of electricity compared with the same billing period of the previous year. The penalty for noncompliance was a 50 percent surcharge on the entire bill.

Although this was not a weatherization program, it is an example of regulation to achieve reduction in energy consumption. It is probably the most economically efficient way to meet the goal since consumers were left to make their own decisions about essential and non-essential uses and even whether to accept the fine. Market prices for weatherization were not distorted and the results were immediate.

The demand for electricity is a derived demand. Electricity is not what is wanted but rather the use of electricity to power a television, food processor, heater, or hair dryer. For most goods, the amount consumed rises as income increases. The same is probably true of electricity. Therefore, higher income people have higher bills. They also are more likely to own electric appliances whose use is discretionary or non-essential. The cut-

---

<sup>16</sup>Energy Future, p. 9.

back may have been less of a burden to them than to low income customers whose use consists of heating and lighting only. This means that the regulation may have been regressive. A remedy to the problem, if it exists, would be to require a percentage reduction rather than an absolute. The 50 percent surcharge would already be progressive if larger bills are an indication of higher income.

Although the program was efficient, quick, and fairly equitable, it probably would not have happened if the situation had not been generally perceived as a crisis. The broad based consensus necessary for its adoption would not have existed.

### 3.2 Incentives

Incentives may be loans at subsidized interest rates, grants, rebates or tax credits. Programs to encourage weatherization using some or all of these methods to affect consumer choices exist in many states and localities. Their success in stimulating weatherization, economic efficiency and equity effects vary considerably depending on the specific structure of the program.

### 3.2.1 Subsidized Loans

#### New York State<sup>17</sup>

The Home Insulation and Energy Conservation Act (HIECA), signed into law in August, 1977, required the nine major electric and gas utilities in New York State to offer energy audits to their residential customers and to arrange for financing of the installation of eligible energy conservation measures. Each utility designed its HIECA program for its specific franchise territory, subject to Public Service Commission approval, but the basic HIECA program characteristics are the same statewide.

Three different types of energy audit are available to customers. All three consider ceiling or attic insulation, wall insulation, floor and foundation insulation, hot water insulation, caulking and weatherstripping, storm doors, storm windows, clock thermostats, furnace and boiler retrofits, furnace and boiler replacements, regardless of the fuel used, and heat pumps.

The type A audit is performed by a utility representative in a customer's house. The information is analyzed to determine the payback for the energy conservation measured approved by the Commission. A \$10 fee, waivable if

---

<sup>17</sup>Second Annual Report on Implementation of the New York State Home Insulation and Energy Conservation Act, New York State Public Service Commission, Albany, New York.

the customer's income is below the federal poverty guideline, is charged.

Type B audit requires the customer to collect the data which are analyzed by the utility to determine payback and cost. The fee is not more than \$3.00.

Customers perform type C audits by themselves from a workbook distributed by the utility. The book gives instructions for calculating energy savings as well as installation instructions.

The utility provides the customers with a list of contractors in the area who can install the various measures. These contractors have signed an agreement with the utility to be listed as approved contractors. The requirements for approval include at least one year of experience in working with the measures to be installed, good standing with the Better Business Bureau or its equivalent, satisfactory credit rating, adequate comprehensive insurance, and any required license. In addition, a one-year guarantee on workmanship and materials must be offered.

Each utility has made arrangements with at least two banks in its territory to make loans to customers for energy conservation improvements. The interest rate on these loans may be no more than the utility's overall rate of return--generally between nine and ten percent. Loans

may be written for up to seven years, subject to a minimum monthly payment of \$10.00. They are available only for energy conservation improvements having a payback period of seven years or less but they are available to anyone regardless of credit worthiness. The energy conservation measures to be financed may be installed on a do-it-yourself basis or by a contractor. The minimum amount that may be loaned is \$200; the maximum is \$2,500 for a one-family house, \$3,500 for a two-family house, \$4,000 for a three-family house and \$4,500 for a four-family house.

The utilities' arrangements with the banks vary. Some banks are willing to grant loans directly to customers at an interest rate equal to the utility's rate of return, while others require the utility to guarantee all the loans as a condition of granting them at that rate. And some banks require the utility to make up the difference between its rate of return and the interest rate at which the bank generally lends. During the fall of 1979, three banks in the downstate area withdrew from the program in response to changes in prevailing interest rates. In cases such as these, the utility must make arrangements with other banks to ensure that at least two banks in its service territory are available to provide loans under the program.

HIECA (which was the model for the federal residential

conservation service program<sup>18</sup>) combines subsidized loans with an energy audit service to market the conservation measures. Individual reports from the nine participating utilities were used to compile Tables 3-1, 3-2 and the updated Table 3-3. As of May 31, 1980, approximately 267,000 audits have been completed (A and B) or requested (C) from about 3.8 million eligible dwellings. Twenty-five hundred loans have been requested and twenty-three hundred have been granted. The program has cost the utilities an estimated \$2-3 million which is recouped from the rate payers.

Only 4.3 percent of the people who had an A or B audit during the period June 1978 to September 1979 (Table 3.2) went on to get a loan, while 30.8 percent of those who had an A or B audit installed conservation devices without obtaining financing under the program. A mail survey of 3,000 utility customers who requested audit C workbooks showed 18 percent of the 1229 who returned the questionnaires used at least one of the measures. There is no information on the relationship between loans requested and type C audits requested.

The results of the program do not show a tremendous response from consumers. The Public Service Commission has attributed this in part to a less than enthusiastic

---

<sup>18</sup>The Federal Residential Conservation Service Program will be a similar program to HIECA in all states. (Title II of the National Energy Conservation Policy Act of 1978)

promotion by the utilities. Utilities may find themselves financing oil-burner replacements<sup>19</sup> or discussing conversions to another type of heating fuel during audits. Given these factors and the program goal of reducing demand for their product when over capacity exists, it would not be surprising to find some reluctance to promote the program among utilities.

Reducing the interest rate on a weatherization loan does not appear to make weatherization substantially more attractive. The data also indicate that an energy audit conducted entirely or in part by a utility representative is more likely to result in an investment in conservation than an audit completed by the consumer. The New York State Residential Insulation survey taken in 1977<sup>20</sup> showed that only one percent of the homeowners had refrained from adding insulation because they had been unable to obtain financing. It may be that the marketing effort, aimed at overcoming consumer skepticism or lack of information, is more responsible for the weatherization under HIECA than the loan program.

---

<sup>19</sup> Brooklyn Union, Long Island Lighting Company and Rochester Gas and Electric, arguing that financing oil burner replacements unfairly subsidized a competitive industry, challenged the Public Service Commission's inclusion of oil burners in a court proceeding. On December 6, 1979, the Appellate Division, Third Department, determined that oil burner replacements were properly included in the program, pg. 7-8, 2nd Annual HIECA Report.

<sup>20</sup> pg. 17, 1st Annual HIECA Report.

TABLE 3-1

Summary of Results of Home Insulation and  
Energy Conservation Act Programs  
June 15, 1978 to September 30, 1979

I. Effect of the Program on Conservation of Fuel and Energy

Installations financed through Utilities' Program

Annual savings of gas	43,325 Mcf/yr.
Annual savings of oil	157,593 gal/yr.
Annual savings of electricity	80,507 kWh/yr.

Installations not financed through Utilities' Program

Annual savings of gas	91,672 Mcf/yr.
Annual savings of oil	603,411 gal/yr.
Annual savings of electricity	236,505 kWh/yr.

Total Annual Savings

Annual savings of gas	134,997 Mcf/yr.
Annual savings of oil	761,004 gal/yr.
Annual savings of electricity	317,012 kWh/yr.

II. Cost Savings to Participating Customers

Installations financed through Utilities' Programs

Gas heat customers	\$ 128,449 /yr.
Oil heat customers	\$ 88,480 /yr.
Electric heat customers	\$ 2,822 /yr.

Installations not financed through Utilities' Programs

Gas heat customers	\$ 272,152 /yr.
Oil heat customers	\$ 339,116 /yr.
Electric heat customers	\$ 8,390 /yr.

Total cost savings to participating customers

\$ 839,409 /yr.

TABLE 3-1 (Cont.)

III. Capital Cost to Participating Customers for Installations

Installations financed through Utilities' Programs

Gas heat customers	\$ 668,448
Oil heat customers	\$ 337,723
Electric heat customers	\$ 6,746

Installations not financed through Utilities' Programs

Gas heat customers	\$ 1,680,144
Oil heat customers	\$ 1,833,917
Electric heat customers	\$ 28,874

Total capital cost for installations	\$ 4,555,852
--------------------------------------	--------------

Information on utility loan installation is directly available from utility records. Information on non-utility financed installation is gathered by surveys conducted by the utilities.

Source: Second Annual Report on Implementation of the New York State Home Insulation and Energy Conservation Act, NYS Public Service Commission, June 31, 1980.

TABLE 3-2

## Program Indicators

A & B audits resulting in installation of measures financed under HIECA Act	4.3 %
A & B audits resulting in installation of measures not financed under HIECA Act <sup>1</sup>	30.8 %
C audits resulting in installation of measures <sup>2</sup>	18.0 %
Average cost to utility of A audit	\$ 94
Average cost of financed installation <sup>3</sup>	\$ 1604
Average cost of unfinanced installation	\$ 708
Average payback period of financed installations	5.1 yrs.
Average payback period of unfinanced installations	5.7 yrs.
Total cost of program	
Cost to utilities	\$ 2,911,804
Cost to financing customers <sup>4</sup>	1,012,917
Cost to other customers	<u>3,542,935</u>
Total	\$ 7,467,656

---

<sup>1</sup>Estimate based on utility surveys

<sup>2</sup>Preliminary result

<sup>3</sup>Excluding finance charges

<sup>4</sup>Excluding finance charges

Source: Second Annual Report on Implementation of the New York State Home Insulation and Energy Conservation Act, NYS Public Service Commission, January 31, 1980.

TABLE 3-3

Cumulative Report of HIECA Program  
as of May 31, 1980

Type of Audit	Requested	Completed
A	56,339	47,184
B	12,713	3,796
C	215,535	NA

	Requested	Granted	Amount
Loans	2,501	2,320	\$ 3,640,640

Source: HIECA Implementation Report, Cumulative as of May 31, 1980.

Rochester, New York<sup>21</sup>

The experience of the Energy Audit Project in Ward 19, Rochester, New York, tends to confirm the importance of marketing. The Project was part of a comprehensive neighborhood improvement effort and was a joint venture of the 19<sup>th</sup> Ward Community Association,<sup>22</sup> Rochester Gas and Electric Corporation (PG&E) and the City of Rochester. The City allocated CETA funds for two full-time Energy Auditors to be trained by RG&A and supervised by the Association. Staff and neighbor volunteers used block club meetings, school presentations, door-to-door leafleting, television and newspaper advertising, a booth at the Association's street fair, and articles in the Association's newspaper to publicize the Project, and the availability of free audits.

The audit process itself involved at least two visits to the home. The first visit, which is by appointment, is an interview and inspection. The follow-up visit is a presentation of the audit results and the available loans and grants. If the resident decides to undertake an im-

---

<sup>21</sup>The Energy Audit Project, An Interim Report for the period January-September 1979, 19th Ward Community Association, Inc., Rochester, New York, October 10, 1979.

<sup>22</sup>The 19th Ward Community Association is part of the Community Services Administration community assistance program.

provement, the auditor often is called upon again for advice.

The importance of the marketing process can be seen in the statistics which show the Project area with one percent of RG&E's customers requesting seventeen percent of the audits and twenty-five percent of the loans.<sup>23</sup> Although some homeowners were reluctant to provide information on the type of financing used, six sources of financing were identified. Fifty-one percent relied on personal sources, twenty-five percent used RG&E loans, sixteen percent used grants from the housing improvement program, four percent used housing improvement program loans and another four percent borrowed from the federally funded 312 program. The high percentage of people using personal funds may also be a reflection of the type of improvement made. Weatherstripping, which is among the most inexpensive conservation measures, was the most frequently selected as Table 3-4 shows.

### 3.2.2 Partial Rebate

A rebate is a form of a grant. However, grants are received prior to the weatherization work whereas rebates are reimbursements to homeowners. The Boston rebate pro-

---

<sup>23</sup>Community Solar Options; Changing Your Energy Future, September 29-30, 1980, Chicopee, Massachusetts, comments by Caroline Argust, 19th Ward Community Association.

TABLE 3-4

Types of Improvements	%
Attic insulation	17
Wall insulation	7
Storm windows	19
Storm doors	16
Weatherstripping	31
Caulking	10
Sources of Financing	%
Personal	51
Housing Improvement Program Grant	16
Housing Improvement Program Loan	4
312 Program Loan	4
RG&E Loan	25

Source: An Interim Report of the Energy Audit Project for the period January-September 1979, 19<sup>th</sup> Ward Community Association, Inc., Preservation Program, Rochester, New York, October 10, 1979.

gram allows the homeowner to choose his contractor or install the measures himself. The Wareham winterization program includes installation. The latter program is more restrictive because it is without cost to the recipient. The reimbursement nature of a rebate insures that the work is actually done because the homeowner bears the initial cost.

Boston, Massachusetts<sup>24</sup>

The City of Boston's Housing Improvement Program (HIP) was extended to provide rebates for weatherization as well as repair. Because the funding is part of a Community Development Block Grant, the program must principally benefit low and moderate income persons. Low income homeowners and renters are eligible for free energy audits and rebates of 40 percent. Moderate income homeowners may receive 20 percent rebates and free energy audits. In addition, the City has a requirement that a certain level of weatherization be the result of the investment. Attics must be insulated to R-19, all windows must have storm windows, doors must have storm doors or be weatherstripped, and smoke detectors must be installed. The maximum rebate is \$2,000.

---

<sup>24</sup>Information from Michael Mahoney, Boston City Hall, telephone conversation, August, 1980.

The program began August 1, 1980. There had been only 311 requests for audits or audits and rebates by October 1. This has been attributed<sup>25</sup> to lack of marketing, the minimum weatherization requirements, and the program being introduced in the summer.

It is difficult to judge how effective the program will be in promoting weatherization from the short period it has been in existence. As with 100% grants, the program is restricted to those for whom financing may be difficult. However, the partial rebate program assumes that the homeowner can pay for part of the weatherization. Also the homeowner must invest his funds first and then be reimbursed. He can afford some amount of weatherization himself whereas 100% grant recipients presumably cannot. Provided that the rebate is attractive enough, i.e., the energy savings pay back the homeowner's share of the investment in a very short time, rebates will induce weatherization from the eligible group. The art of designing the cost efficient program is to determine exactly what the payback must be to just induce the desired weatherization. The inclusion of the minimum requirements assures the city that the measures likely to have the greatest payback are undertaken first although the cost may deter some poten-

---

<sup>25</sup>Ibid.

tial beneficiaries. Those too poor to make the initial investment or too wealthy to be eligible will not be affected by the program.

### 3.2.3 Tax Credits

Many states and the federal government provide income tax credits for installation of conservation measures and renewable energy systems. Few states have systems for monitoring the impact of the credits but the federal government has recorded the credit taken under the Energy Tax Act of 1978.

Massachusetts does not give tax credits for conservation measures although it does exempt solar systems from property tax for twenty years from the date of installation. There is a personal income tax credit of 35 percent of the cost of renewable energy equipment. The equipment must be installed at the taxpayer's principal residence in the state. Maximum credit is \$1,000. Eligible equipment must use solar energy for space heating or cooling or water heating or must use wind energy for any non-business residential purpose.<sup>26</sup> (In California, approximately 60 percent of the tax credits are for solar heating of swim-

---

<sup>26</sup>Chapter 796, Laws of the Commonwealth of Massachusetts, 1979.

ming pools.)<sup>27</sup> If a federal income tax credit or grant is received by the taxpayer, the state credit will be reduced.

In addition, sales of equipment for residential solar, wind or heat pump systems are exempt from sales tax.<sup>28</sup>

U.S. Energy Tax Act of 1978<sup>29</sup>

The following description of the Act and taxpayer response is included as an example of conservation promoting legislation. State laws are similar.

Clearly, higher income taxpayers are more likely to be induced to invest in weatherization by a tax credit incentive. To benefit from the program, an individual must have enough income to pay taxes and to afford the energy conservation measure.

There are no data on the energy savings from the investment although the cost in lost tax dollars is given by the tables. The information is not sufficient to de-

---

<sup>27</sup> Conversation with Pat Lawson, National Solar Heating and Cooling Information Center.

<sup>28</sup> Chapter 796, Laws of the Commonwealth of Massachusetts, 1979.

<sup>29</sup> Preliminary Statistics of Individual Income Tax Returns, Internal Revenue Service, 1978.

EXHIBIT A

Description of U.S. Energy Tax Act of 1978

The credit was actually made up of two separate parts, one based on qualified "energy conservation expenditures" and the other on qualified "renewable energy source expenditures," with different requirements for each type of credit. The entire residential energy credit was available for qualified items installed in or on the taxpayer's principal residence from April 20, 1977, through December 31, 1985. However, the credit could not be claimed for any taxable year beginning before January 1, 1978; therefore, it was first available for use on 1978 tax returns. A maximum amount was specified for each part of the credit, although a minimum \$10 amount for the sum of both credits was required before any credit was allowed. None of the credit was refundable, but any credit exceeding income tax reduced by all other statutory credits could be carried over to subsequent years through 1987.

The credit for energy conservation property was 15 percent of the first \$2,000 of expenditures, including original installation costs, with a maximum credit of \$300 per residence over the entire period the credit is to

be in effect. The credit was available for each dwelling unit used by the taxpayer as a principal residence; however, the construction of the dwelling unit had to be substantially completed before April 20, 1977, in order

for the energy conservation expenditures to qualify. In addition, the taxpayer had to be the first person to use the property installed and that property had to be expected to remain in use for at least 3 years. Energy conservation property consisted of insulation, storm windows and doors, caulking and weatherstripping, and certain other items (such as an automatic energy-saving setback thermostat, furnace replacement burner, or a meter displaying the cost of energy usage). Data for each of

Table 3-5 shows the response to the tax credit for 1978. The size of the credits taken is reported in Table 3-6.

TABLE 3-5

Returns with Energy Conservation Expenditures  
(All figures are based on samples)

Size of Adjusted Gross Income	Number of Returns with Energy Conservation Expenditures	Amount of Expenditure [\$ in thousands]	Amount of Energy Conservation Credit Before Limitation [\$ in thousands]
Under \$5,000	57,127	44,462	5,588
\$5,000 - \$9,999	436,644	282,704	38,476
\$10,000-\$14,999	641,347	413,676	57,977
\$15,000-\$19,999	1,119,561	696,275	95,939
\$20,000 or more	3,646,109	2,652,978	358,884

From: Table 8—Returns with Residential Energy Expenditures: Expenditures by Type and Computation of the Energy Credit by Size of Adjusted Gross Income, Preliminary Statistics of Individual Income Tax Returns, 1978.

TABLE 3-6

## Returns with Energy Conservation Credit by Size

Size of Credit	Number of Returns with Credit	Amount Before Limitation [\$ in thousands]
Total	5,900,783	557,884
\$ 1 - \$ 99	3,972,410	178,514
\$100 - \$199	1,098,802	152,349
\$200 - \$299	396,686	97,127
\$300 - \$399	432,886	129,873
\$400 - \$499	-0-	-0-
\$500 - \$999	4 <sup>*</sup>	3 <sup>*</sup>
\$1000 and above	-0-	-0-

\* Estimates should be used with caution because of the small number of returns on which it is based.

From: Returns with Residential Energy Credit or Business Energy Credit: Type of Credit by Size, Preliminary Statistics of Individual Tax Returns, 1978

termine where the credit reduced the marginal cost to the homeowner enough to induce the investment rather than simply making a previous decision to invest more attractive. A survey of energy bills before and after weatherization would be necessary to evaluate the benefits of the program.

## CHAPTER 4

### Determining a Policy for Martha's Vineyard

#### 4.1 A Review of the Alternatives

The town governments on Martha's Vineyard may provide financing, incentives, information or regulations to stimulate weatherization on the Island. A program to fund low income homeowners who cannot afford the investments exists. So does a method of providing information and at least one incentive to weatherize (federal tax credit). What then is the best use of resources to reduce residential energy consumption efficiently and equitably, given the economic, political, and social constraints on the Island?

Adding to the low income winterization program is probably not the best use of funds since it already provides a fairly complete service. Also, the amount of money available in local coffers is probably not enough to significantly extend the benefits.<sup>30</sup>

Incentive programs will achieve results but, as section 2.2 showed, it is the specific structure of the program that determines who is likely to benefit and how widespread the benefits will be. The incentive structure

---

<sup>30</sup> Benefits could be extended to more residents by raising the income level which determines eligibility for the program, if there was sufficient funding.

also determines how much more desirable an investment in weatherization is than it would be at market prices. An efficient program would make the investment just attractive enough to induce the maximum weatherization without payments to those who would have weatherized anyway. An equitable program might not be the most efficient. It would be aimed at making weatherization affordable to those who lack financing and might weatherize less homes for a given amount of money. However, these investments might yield a higher return because the homes are initially in worse condition.

Again, local governments probably do not have the funds to establish an incentive program on their own. Most localities must rely on state and federal monies for other than the basic services. These funds usually carry restrictions, which means the locality would not be free to determine the structure of the program.

Although regulation allows the local government to try to affect residential energy consumption without the aid of other levels of government, results depend very much on the attitudes of the residents. The preferences of a local community are reflected in local laws. The emphasis placed on equity versus economic and administrative efficiency will be expressed in the structure of the regulation because community approval is necessary for

passage and cooperation necessary for enforcement.

The mandated curtailment of energy usage in Los Angeles carried a stiff penalty for violation. It was implemented through the utility billing system where detection of a violation was simple. If there was a method to ensure detection and hence enforcement of a retrofit ordinance, then a similar regulation would probably be successful on the Vineyard. However, community approval for a strictly mandated curtailment involving the utility in the detection and penalty process might easily be impossible to achieve.

The other California regulatory schemes rely on the buyer or an institutional structure to ensure compliance. The buyer has little incentive to force compliance in Livermore or Santa Clara County. The sellers' market prevailing in California and in Massachusetts may mean that the buyer will lose the property if he attempts to delay the sale. A mandatory inspection scheme, similar to Davis's, with fines for noncompliance could be established on Martha's Vineyard. However, it requires a major change in an institutional structure that may not be in keeping with Yankee philosophy. Inspection is now available to buyers on request. Making it mandatory may be considered government interference.

A Massachusetts regulation similar to the point of

sale energy code enforcement is the lead paint law. The regulation requires there be no lead paint up to a certain height on the wall (within a child's reach). It is up to the buyer to attain compliance prior to the sale. But the law is never enforced because the only motivation the buyer may have is to protect himself on resales. Assuming a seller's market still exists at that time, the motivation to file a complaint is minimal.

Because of the difficulty in designing an enforceable regulation which will meet with community approval and cooperation, regulation is probably not the best method of reducing residential energy consumption through weatherization.

The local government may be best equipped to dispense information and dispel skepticism about the value of weatherization rather than try to directly influence market prices. Through the educational process, the locality may even be able to tap private sources of funds.

Given the lack of funds and the problems with regulation, it is not surprising that the local government may take the role of promoting weatherization by acting as a coordinator and center for information. Support by the local government can help legitimize the idea of weatherization and lessen the mistrust of energy auditors. Plans featuring a strong outreach effort, community involvement

and identifiable information centers can ensure that local resources are used in the most efficient way—to leverage the communities' use of federal and state funds by insuring that citizens take advantage of all incentives.

The strategies used in Rochester, New York and the Fitchburg, Massachusetts Action to Conserve Energy (two of the most successful plans) featured extensive community outreach and volunteer efforts. Weatherization workshops, neighborhood energy centers, free or reduced-cost kits of materials and volunteer crew assistance involved over 3500 Fitchburg households in low cost/no cost weatherization.<sup>31</sup>

Northampton, Massachusetts is another community which cleverly used various funding sources, including the private sector, to create a successful program. Discount coupons worth 25% of materials cost were made available to anyone who attended weatherization training sessions. Six local businesses agreed to cooperate with the plan and 65-70% of the coupons were redeemed.<sup>32</sup> The City also organized a competition among contractors to lower the cost

---

<sup>31</sup>Massachusetts Local Energy Action Program (LEAP), Case Histories, Booklet 3, prepared as one of a series by Arrowstreet, Inc. under a grant from the Northeast Solar Energy Center as part of the Solar Cities and Towns Program of the U.S. Department of Energy, August 1980.

<sup>32</sup>Telephone conversation with program coordinator, Northampton, Massachusetts.

of insulation. Nearly 70% of the homes in Northampton were built before 1945 and have uninsulated walls and attics. Contractors bid on supplying insulator (on a price per square foot basis) for all interested homeowners in a particular area knowing that the homes are similar. As a result of supplying a large number of houses at once, the residents will save as much as 20%.<sup>33</sup>

A program which does not provide funding but taps private sources and takes full advantage of federal funds can be very successful in promoting weatherization. A plan which markets existing incentives and does not neglect the private sector, so that the system is tailored to the community, is in general likely to have a significant impact.

#### 4.2 Impact of an Information/Marketing Program

Although it appears that an information and marketing strategy is the most likely role for Vineyard governments, given their economic and political constraints, and although it appears from the experience of other communities that such a plan can have significant impact, the question of the likely impact on Islanders' decisions still remains.

The Appendix to this thesis contains a description and critique of a model of the impacts of weatherization

---

<sup>33</sup>LEAP, op. cit.

investments on home heating bills. The model was used to calculate the rates of return a houseowner could expect from various levels of investment in insulation, storm windows, storm doors, and weatherstripping.

Results (Table 4-1) were obtained under two different sets of assumptions. One (Case A) is based on a description of the current weatherization of the New England housing stock. The other (Case B) reflects the responses obtained by an ERG survey of Island residents.

From the ERG survey, it appears that homes on the Vineyard may be better weatherized than homes in New England. As a result, the payback periods or rates of return on the investments are between 2 and 5 years for Vineyard dwellings but less than 4—or 2 years on average—for New England housing in general. If, as seems likely, the ERG<sup>34</sup> survey is a more accurate representation of Vineyard homes, then the significant difference in results from the model suggests that an information program may be of little value. Homeowners on the Island are aware of the benefits of weatherization and have invested up to the point of diminishing marginal returns. The highest return, lowest cost improvements which might be neglected by the unknow-

---

<sup>34</sup>The ERG data do not exactly fit the specifications of REFORM. Therefore, Case B also reflects the judgement of the thesis writer.

TABLE 4-1

Results from REFORM\*

Year of Construction	Initial Level of Insulation and Fuel Type	Number of Units	Case A		Case B	
			Annual Energy Savings when Weatherized to Ideal Level	Amount of Investment	Annual Energy Savings when Weatherized to Ideal Level	Amount of Investment
1965-1979	Base/Electric	564	\$ 901	\$ 2390	21	\$ 901
	Level 1/Electric			1782		
	Level 3/Electric			1185		
	Base/Fossil	679	656	2590	206	656
	Level 1/Fossil			2266		
	Level 3/Fossil			1668		
1940-1965	Base/Fossil	950	692	2558	177	692
	Level 1/Fossil			2267		
	Level 3/Fossil			1783		
pre 1940	Uninsulated Base/Fossil	1215	1442	3050	165	1442
	Uninsulated Level 3/Fossil			1960		
	Insulated Base/Fossil	427	459	1191	328	459

\* For description of model see Appendix I and II.

ledgable consumer have been made.

The success of the Fitchburg and Northampton plans reflects the fact that, on average, homes in New England can benefit from weatherization as is shown by Case A. A similar attempt to leverage Island resources by marketing weatherization will be less successful because the rates of return that Island homeowners can expect from their investments on average are lower.

These results suggest that consumer choice must be directly affected to promote weatherization on the Vineyard. Since regulation is unlikely to be passed, an incentive program which alters the cost-benefit structure is probably the best method for stimulating the investments.

#### 4.3 A Rebate Policy

Suppose the community was able to fund one incentive program designed to its specification without restrictions. The town may take the strategy of offering an incentive which is unlike those currently offered, administratively simple, and likely to produce the greatest results. Current financing arrangements include bank loans, sometimes at reduced interest rates, and tax credits.

The community could offer loans at a reduced interest rate or give a loan subsidy. Administering any type of loan program could be a multiyear commitment and would

involve the locality in a business for which it has no expertise (banking). The cost of providing an incentive to weatherize using loan financing may be greater than with schemes that do not create a long term liability for consumers. That is, consumers may have an aversion to borrowing which must be overcome as well as making weatherization appear more attractive. Also, a program already exists that offers similar incentives.

Grants of 100% would be attractive incentives to most consumers. However, it is not the most efficient use of funds. Weatherization will be induced by lowering its cost. The cost need not be zero to cause reinvestments. Even grants to partially fund weatherization have a policing problem. The government must spend resources making sure grants are used for weatherization. There is no inherent feature of grants to ensure the appropriate use of funds.

Manipulating the property tax is another way to provide a further incentive for weatherization. The other funding source could then be used to make up any shortfall in revenues necessary to support local services. The incentive would be a one time reduction in property taxes based on a reduction in demand. Heating bills for the same period in two consecutive years would be compared. A minimum reduction would be necessary to be eligible for

some credit to promote weatherization other than low cost/no cost measures. The greater the percentage reduction in energy demanded the greater the credit up to a maximum of maybe 70% of the tax bill.

Using a percentage reduction in taxes means larger and more highly assessed properties will receive the greatest credit. Larger houses probably do consume more energy so this would be an efficient strategy. However, wealthier homeowners with more highly assessed properties would also be receiving the most credit. A cut in heating bills could be the result of changing to a renewable resource so the program may not always induce weatherization.

Even though energy audits are available to help consumers determine their likely energy savings and hence tax deduction, the calculation is only approximate. The credit makes the investment "possibly" more attractive. The uncertainty may mean that a larger incentive is necessary, thereby reducing the energy savings that can be induced. Another drawback to the program is that the locality does not know how many homeowners will take the incentive and what the eventual effect will be on tax revenues. There is the possibility that the hypothetical additional funds will be insufficient to cover expenditures for basic services.

A more direct approach to inducing weatherization is

to provide partial rebates. No similar program exists yet the group who might take the incentive is those who could borrow or take tax credits and still don't weatherize. Embedded in the structure is a policing mechanism since homeowners must present bills to be reimbursed. There is no threat to basic services because tax revenue is unaffected. A flat percentage rewards greater investment which might benefit wealthier people more. Putting a maximum on the rebate will lessen this effect. The percentage rebated could also vary with income.

Determining the exact percentage to be rebated depends on the funds available and the current condition of the housing stock. It also depends on what is considered to be enough to induce weatherization but not be considered a "gift" to those who could afford weatherization.

## CHAPTER 5

### Benefits of a Rebate Program

#### 5.1 Assumptions

A rebate program to insulate all 3825 units from the initial conditions of Case B to the ideal level averages \$2056 per unit or about \$7.9 million in total. With a \$300 per unit federal tax credit, the local share of investment would be about \$6.7 million divided among individuals and the government. Again, it is unlikely that such a large investment will be made so assume that the program will be one third as large, or \$2.6 million.

Energy savings average \$690. For the individual with a \$300 tax credit, the net investment will be \$1210. A 30% rebate will lower the net outflow the first year by \$660 or essentially halve it. The investment will be easily recoverable in the second year rather than the third as it would without the rebate. This is the incentive to weatherize.

For a \$2.10 million investment, 1275 houses can be weatherized. Individuals will spend \$1.57 million, the local government will spend \$.67 million, and the federal government will spend about \$.38 million. A survey con-

ducted by the Martha's Vineyard Commission<sup>35</sup> in 1973 concluded that in general 65 percent of a dollar spent on the Island is part of the export economy. Thirty-five cents remains in the Martha's Vineyard economy, making the general multiplier 1.5. Interviews with suppliers show that only 20 cents of each dollar spent for oil remains on the Island.<sup>36</sup> Almost all of a dollar spent on electricity goes off-Island.<sup>37</sup> Interviews with Island contractors and installers showed that materials varied between twenty and thirty percent of a weatherization job. All materials are assumed to be purchased off-Island. With this information and the assumptions of constant prices and all investments being made in one year, the effect of the program on the Island economy can be calculated.

Although the insulation and winterization sector of the economy will expand, the energy suppliers will face a cutback in income. If energy savings are \$660 per unit on average, then total investment savings will be \$.84 million. According to the model (See Appendix for details), savings on oil will be about 94% of the \$.84 million. At

---

<sup>35</sup>Dukes County Planning and Economic Development Commission, pp. cit.

<sup>36</sup>Island suppliers of oil, propane, and electricity all provided information to the author.

<sup>37</sup>Ibid.

20 cents per dollar spent, the Vineyard oil supply sector will contract by \$.19 million initially due to decreased expenditures on oil. The multiplier will cause total contraction to be \$.29 million. A similar effect due to decreased consumption of electricity will cause a \$.03 million contraction (under the assumption that one percent of every dollar spent on electricity stays on the Island). Neither oil nor electricity supply businesses are labor intensive. Their services will still be necessary, although perhaps less frequently used. The effect on these jobs will probably be negligible.

Table 5-1 shows multiplier effects in terms of overall Island income and the initial expansion in jobs for the one year program. There are two different scenarios in the table corresponding to weatherization materials costs of 20 and 40 percent.

## 5.2 Economic Effect of a Rebate Program

The federal government's share of the investment will cause an expansion of the Island economy because it is an infusion of new funds.<sup>38</sup> The energy savings corresponding to \$.84 million of the individuals' investment are a shift from the energy sector to the weatherization sector. This

---

<sup>38</sup>Some of the federal contribution will be from taxes paid by Islanders.

TABLE 5-1

Total Investment: \$ 2.62 million

Expansion due to federal and individual share

$$\$380,000 + \$1,570,000 = \$1,950,000$$

20 percent labor  $\rightarrow .20 \times \$1,950,000 = \$390,000$

At \$20/hr  $\rightarrow 19,500$  hours

At \$1856 hrs/man/yr  $\rightarrow 10.5$  jobs

The multiplier effect =  $1.5 \times \$390,000 = \$585,000$   
 eventual expansion in the economy

40 percent labor  $\rightarrow .40 \times \$1,950,000 = \$780,000$

At \$20/hr  $\rightarrow 39,000$  hours

At \$1856 hrs/man/yr  $\rightarrow 21$  jobs

The multiplier effect =  $1.5 \times \$780,000 = \$1,170,000$   
 eventual expansion in the economy

Expected Energy Savings =  $1275 \text{ units} \times \$660/\text{unit} = \$841,500$

Savings in oil =  $.94 \times \$841,500 = \$791,000$

Savings in electricity =  $.06 \times \$841,500 = \$50,490$

Contraction in oil sector =  $.20 \times \$791,000 \times 1.5 = \$237,300$

Contraction in electricity sector

$$= .01 \times \$50,490 \times 1.5 = \$757$$

40% labor expansionary effect	\$1,170,000	20% labor expansionary effect	\$585,000
Oil sector contractor	- 237,300	Oil sector contractor	-237,300
Electricity sector contractor	- <u>757</u>	Electricity sector contractor	- <u>757</u>
Net effect	\$ 931,940	Net effect	\$346,943

effect is also likely to contribute to the net expansion shown in Table 5-1, because less of the expenditures for weatherization are part of the export economy.

However, the balance of individuals' investment, \$.73 million, and the local government's share, \$.67 million, will be shifts from other sectors to the weatherization sector. As a result, there is not likely to be any significant overall effect on Island income from the shift since the multiplier reduction in discretionary expenditure will be balanced by the multiplier expansion in the weatherization sector. However, individuals may suffer because demand in their sector falls and they cannot shift to the installation sector. The contribution of the federal government insures a slight expansionary effect in the first year which will be lessened to the extent that some of the new jobs are taken by people currently receiving transfer payments. The transfers will be replaced by income from jobs. The difference in amount will be the expansion.

## CHAPTER 6

### Conclusions and Suggestions

#### 6.1 Conclusions

From the ERG survey and the results of the model, it appears the housing stock on Martha's Vineyard may be significantly better weatherized than the average house in New England. The rate of return that an Island homeowner can expect from additional investment is lower than the return generally expected by the homeowner in New England. A plan to inform Vineyarders is less likely to promote weatherization than similar successful programs because Islanders are already aware of the benefits.

If the Island has the resources then, a rebate program would be most likely to induce further weatherization. It significantly lowers the cost to the consumer, shortening the payback and raising the rate of return. Although the program will cause an expansion of the Vineyard economy, the effect will be slight. The potential expansionary impact will increase as energy prices rise more quickly than other prices. It will also increase if the export percentage of a dollar spent on energy rises. However, as energy prices rise relative to prices, the rate of return expected by the individual consumer will also rise. It may become unnecessary to provide any other

incentive to affect consumer choice.

## 6.2 Suggestions

The results in this thesis are based on a description of the year-round owner occupied dwellings. Many of the Vineyard homes are not occupied year round and yet are heated. Another policy area to consider is stimulating weatherization of these dwellings.

An information program with community outreach and involvement is not likely to be very successful because most of the homeowners are usually off-Island. It would be difficult to completely exclude these dwellings from the rebate program discussed in Chapter 5. Undoubtedly some seasonal homeowners would benefit because "seasonal" is difficult to define. The expansionary effect would be greater to the extent that the "season" would be extended. However, the resources needed to fund such a program would be much greater and even less likely to be available to local governments. Mandating weatherization for these dwellings is not possible for the same reasons it is not possible in general. It would be unlikely to be approved.

Another possible policy is a regulation not necessarily aimed at weatherization per se but rather at insuring that year round residents were given fuel first in the event of a shortfall. Dealers and suppliers may decide to adopt this policy in a crisis because it is in their in-

terests. They can have the same amount of revenue with fewer deliveries and lower costs. A regulation would take the decision of when to implement this policy out of the hands of the dealers, giving the local community more control of the energy supply.

Again, the definition of year round versus seasonal makes any policy very difficult to administer. The local governments may want to investigate a set of different definitions to discover the effects of each in relation to various policies.

## APPENDIX I

### A Model of Energy Consumption for Home Heating on Martha's Vineyard

The New England Regional Commission (NERCOM) has developed a model to predict the energy savings from a set of different investments in weatherization. The Residential Energy Forecasting Model (REFORM)<sup>1</sup> simulates five alternative residential energy conservation scenarios corresponding to five levels of investment for weatherization. The model was originally used to compute energy savings for New England on the basis of meteorological data and a description of the structural/thermal characteristics of the New England housing stock. This thesis uses the same model with data from Martha's Vineyard to predict energy savings for Island homes.

REFORM breaks down the housing stock into five categories—single family detached, single family attached, multi-family high rise, multi-family low rise, and mobile homes. Almost all the dwelling units on Martha's Vineyard fall into one category, single family detached. As a result, this thesis concentrates on policies which will

---

<sup>1</sup>New England Regional Commission, Residential Energy Conservation: Report to the New England Energy Congress, February, 1979.

affect single family homes.

Within each category, homes are further differentiated. The single family category contains a set of prototypical units described by structural characteristics (wall area, floor area, number of stories, etc.). Those characteristics tend to be similar for houses of the same age group using the same fuel. The prototypical units are listed in Table A-1.

By modifying the basic inputs to the model, alternative weatherization levels can be simulated. For example, the results of an investment in insulation can be shown by changing the thermal characteristics of a prototypical unit. Given the wall an R-value of R-9 rather than R-0 and computing the change in energy demanded, gives the energy savings or "return" on an investment in fiberglass batting for wall insulation.

The initial conditions, or description of the current weatherization of the housing stock, is the most sensitive part of the model since it provides the meter against which to measure change in energy demand. Richard Daifuku,<sup>2</sup> the creator of REFORM, developed a set of initial conditions for the New England housing stock which was modified

---

<sup>2</sup>Richard Daifuku's original two papers presenting REFORM are listed in the bibliography and should be consulted for a more detailed description of the model.

TABLE A-1

Prototypical Units Simulated in REFORM  
 Single Family Detached Dwellings

Fuel Type	Year of Construction	Insulation
Fossil	pre 1940	Uninsulated
	pre 1940	Insulated
	1940-1965	n.a.
	1965-1979	n.a.
Electric	1965-1979	n.a.

n.a. not applicable

by the Massachusetts Audubon Society from the results of a survey.<sup>3</sup> This thesis modifies those assumptions in turn when necessary to develop a characterization of the Martha's Vineyard housing stock and tailor the model to Vineyard materials, labor and energy costs.

Information from a questionnaire distributed by ERG supplies much of the data specific to the Island. Twelve hundred questionnaires were distributed to a random sampling of approximately ten percent of the names in the Island telephone directory. About one-third of those sampled responded to the mail survey.

Conversations with Vineyard Commission staff, insulation installers, construction workers, assessors, and architects also provided information.<sup>4</sup>

#### Al.1 Data and Assumptions in the Model

Daifuku used census data on new construction and the results of a survey to build his description of the housing stock. He relied on an "exhaustive" literature search of the construction characteristics of the present housing

---

<sup>3</sup>NERCOM, op. cit., Appendix A.

<sup>4</sup>Vicky DeStephano, Michael Wild, and Douglas Ewing, all of the Martha's Vineyard Commission staff, provided information. A number of insulation installers, construction material suppliers, and contractors on the Island were consulted. Although none of these conversations were strictly confidential, to identify individuals might inadvertently affect the competitive position of a particular business.

stock. From the 1975 census report that 70 percent of all new housing in the Northeast are frame construction and historical data, he assumed all housing was frame. By inspection it can be determined that this is also a good assumption for the Vineyard.

The 1970 census showed that the average house is 1.76 stories and that 90.7% have basements which are unheated. Daifuku derived a prototypical single family dwelling from these statistics—a two story frame structure having an unheated basement.

The year-round dwellings on the Vineyard are usually two-story and have unheated basements. Only the newer homes that are pre-fabricated or slab construction differ considerably from this description. However, they are not usually year-round dwellings. The calculations for energy savings are based only on year round dwellings or about forty percent of the units.<sup>5</sup>

The structural characteristics of each of the categories of single family dwellings are shown in Table A-2. On average, the structural characteristics of year round dwellings on the Island are not inconsistent with the ori-

---

<sup>5</sup>The Martha's Vineyard Commission Water Quality Management Plan of 1977 shows 40% of all Island homes as year round dwellings.

TABLE A-2

Design Parameters for Single-Family  
Detached Structure

	<u>Pre- 1940</u>	<u>1940 -65</u>	<u>Post- 1965</u>
Width x length x height, ft	20 x 30 x 18	21 x 31 x 18	23 x 35 x 18
Floor-ceiling area, ft <sup>2</sup>	1200	1302	1610
Gross wall, ft <sup>2</sup>	1800	1872	2088
Glazing (% of floor area)	12	12	15
Glass area, ft <sup>2</sup>	144	156	242
Sash crack length, ft	182	198	307
Frame crack length, ft	154	166	258
Door area, ft <sup>2</sup>	40	40	40
Door crack length, ft	39	39	39
Net wall, ft <sup>2</sup>	1616	1676	1806
Roof area, ft <sup>2</sup>	662	718	888
End walls of attic, ft <sup>2</sup>	93	103	123
Area of basemt windows, ft <sup>2</sup>	12	13	16
Gross area basemt wall, ft <sup>2</sup>	700	728	812
Net wall above grade, ft <sup>2</sup>	163	169	187
Wall below grade, ft <sup>2</sup>	525	546	609

Residential Space Heating and Cooling in New England 1972-2000, Richard Daifuku, December 1976, Brookhaven National Laboratory.

ginal model specifications.<sup>6</sup> However, there are unique structures among the older Vineyard homes in particular. The model will not adequately represent them and calculation of total energy savings Vineyard-wide may be biased. It is difficult to tell the direction of the bias since the structures are unique. But the effect is not likely to be large since most year round houses are similar to the prototypical dwellings.

The total number of dwelling units was calculated from the report of the 1970 U.S. census and a survey of records of the six Island towns. The census shows 5510 dwelling units in 1970. Of these, 2869 are year round. Table A-3 is a breakdown of year round dwellings by year of construction also from the census. Table A-4 lists the currently reported number of dwelling units by town. The total number of homes is 7924. Therefore, 2414 were built between 1970 and 1979; total year-round dwellings are 1325.

The model is sensitive to the other three characteristics used to describe the current housing stock—the fuel mix, the amount of existing insulation, and the relationship of these two characteristics to the age of the

---

<sup>6</sup>The town assessors and Vicky DeStephano of the M.V. Commission were consulted to determine the structural characteristics of year round Vineyard dwellings.

TABLE A-3

## Year Round Dwelling Units—Dukes County, MA\*

Year Built	Units
1965-March 1970	277
1960-1964	224
1950-1959	478
1940-1949	248
1939 or earlier	<u>1642</u>
Total	2869

\* U.S. Bureau of the Census, 1970.

TABLE A-4

## Number of Dwelling Units by Town\*\*

Town	Number
Tisbury	1568
Oak Bluffs	2263
Edgartown	2242
West Tisbury	700
Chilmark	876
Gay Head	<u>274</u>
Total	7924

\*\* Information provided by assessor, building inspector, or planning office of each town—June 1980.

dwelling. To determine how sensitive the results are to different assumptions about these characteristics, two base cases were developed. Case A follows the assumptions Daifuku used to specify the basic case for the New England housing stock and applies them to data for Martha's Vineyard. Case B draws on the results of ERG's survey to create a different set of initial conditions.

## Al.2 Description of Cases

### Al.2.1 Case A

Daifuku consulted the census to determine the fuel mix of the structures existing as of 1970. Two hundred and seventy-four units on the Island were heated by electricity at that time. REFORM requires the correspondence between age and fuel type to specify the prototypical dwelling units. However, the census does not provide that data. Also, REFORM only calculates energy under this limitation savings for the categories shown in Table A-2. Only homes built in 1965 or later can be heated electrically. Therefore, all of the 274 electrically heated homes reported in the 1970 census are assumed to be built between 1965 and 1970.

In addition, Daifuku assumes that thirty percent of

the units built after 1970 use electric heat.<sup>7</sup> As a result, the total number of electrically heated units is 564 or 45 percent of the housing stock. The rest are heated by fossil fuels.

REFORM calculates energy savings from new investments in weatherstripping, storm doors and windows, and insulation. Unfortunately, data on the current weatherization of dwelling units are scarce. A 1974 report by Petersen<sup>8</sup> served as a basis for Daifuku's assumption that 90 percent of the homes built prior to 1940 have walls insulated to R-8 and 10 percent are uninsulated. However, the Massachusetts Audubon Society found in its survey of New England homes that only 26 percent of all pre-1940 units were insulated.

The Washington Center for Metropolitan Studies<sup>9</sup> surveyed buildings nationally to determine the percent of single family homes with insulation. These were the data

---

<sup>7</sup>J. Lee, Energy Supply and Demand in the Northeast United States, Brookhaven National Laboratory, Upton, NY, 1976.

<sup>8</sup>This information is from a study by S.R. Petersen, Retrofitting Existing Housing for Energy Conservation; An Economic Analysis, National Bureau of Standards Building Science Series 64, U.S. Department of Commerce, Washington, DC, 1974.

<sup>9</sup>Washington Center for Metropolitan Studies' Lifestyles and Energy Surveys—quoted in: Newman, O.K. and Day, D., The American Energy Consumer, Ballinger Publishing Co., Cambridge, MA, 1975, p. 38.

Daifuku originally used to establish the insulation characteristics of the rest of the base case. Massachusetts Audubon's survey again showed different results. The Massachusetts Audubon's data are used in Case A calculations since it is likely that the Martha's Vineyard housing is more similar to the rest of New England's than to a national amalgam.

The Case A base case is shown in Table A-5.

#### Al.2.2 Case B

The Energy Resource Group's survey of Island residents showed 17 percent of the year round houses were heated electrically. Although survey respondents indicated exactly what type of fuel was used, REFORM does not differentiate among oil, propane, wood and solar. In its calculations, all of the houses using these fuels are considered to be heated by fossil fuels.

ERG's data do not easily fit the specifications used to describe the REFORM base case. The survey revealed that 71 percent of the year round dwellings have been weatherstripped, 80 percent have complete storm windows, and 47 percent are well insulated. There is no differentiation by age of structure nor is it clear what "well" versus "adequate" insulation means in terms of the R-values used in REFORM. Based on the response to the questions on storm windows and airleaks shown in Table A-6, and on

TABLE A-5

## Composition of Housing Stock—Case A

Type of Dwelling Unit	Number of Units
pre 1940 U	1215
pre 1940 I	427
1940-1965	950
1965-1979 F	679
1965-1979 E	564

## Initial Conditions—Weatherization Level Zero

	Walls [R- Value]	Ceil- ing [R- Value]	Floors [R- Value]	Storm Win- dows [% of Unit]	Storm Door [% of Unit]	Wea- ther- strip- ping [% of Unit]
pre 1940 U	0	0	0	70	70	25
pre 1940 I	11	9	0	70	70	25
1940-1965	3	7	0	65	65	25
1965-1979 F	7	12	0	45	50	25
1965-1979 E	7	15	0	60	60	30

TABLE A-6

Energy Resource Group Survey Response—  
Year Round Owner Occupied Dwellings

1. Are your windows, doors and building shell tightly sealed to prevent air leaks?

Yes	71.43 %
No	25.00
Don't know	3.57

2. Does your home have storm (or double) windows?

Yes	81.66 %
Only some	6.55
No	11.79

3. In your opinion, how is your home insulated?

Well	47.14 %
Adequately	36.12
Poorly	11.45
Not at all	3.52
Don't know	1.76

the description of the results of the first level of investment (Table A-7), the initial condition for 70 percent of all dwellings is REFORM level one. Some of the units may be weatherized—"well" insulated, all storm windows, and no air leaks. Twenty percent of all homes are assumed to currently be weatherized to level three. Because the Massachusetts Audubon case reflects a survey of New England homes and some ERG survey responses were no insulation, no storm windows, and no weatherstripping, ten percent of the homes on Martha's Vineyard are assumed to be described by the same characteristics as the Case A initial conditions.

The 70 percent level one, 20 percent level three, 10 percent base assumption was modified slightly for dwellings constructed prior to 1940. REFORM has two sets of specifications for pre-1940 dwellings. One describes the results of investments for the initially uninsulated dwellings and the other describes energy savings for the insulated units. In Case A, these were 26 percent and 74 percent respectively of the pre-1940 units. For Case B, 70 percent are assumed to be level three of the uninsulated units. Thirty percent are assumed to have walls insulated to R-8 and ten percent are completely uninsulated.

The initial conditions for Case B are shown in Table A-8.

TABLE A-7

## Weatherization Levels in REFORM\*

Type of Structure	Walls [R-Value]	Ceiling [R-Value]	Floors [R-Value]	Storm Windows [% of Unit]	Storm Door [% of Unit]	Weather-stripping [% of Units]
Level 1						
pre-1940 I	11	9	0	100	90	100
pre-1940 U	0	0	0	100	90	100
1940-1965	3	7	0	100	90	100
1965-1979 F	7	19	0	45	50	25
1965-1979 E	11	15	0	60	60	30
Level 2						
pre-1940 I	11	19	19	100	70	100
pre-1940 U	0	19	0	70	90	25
1940-1965	3	10	0	100	65	100
1965-1979 F	7	12	19	45	50	25
1965-1979 E	7	15	19	60	60	30
Level 3						
pre-1940 I	11	19	19	100	70	100
pre-1940 U	0	19	0	100	70	100
1940-1965	3	7	19	100	90	100
1965-1979 F	7	19	19	45	50	25
1965-1979 E	11	15	19	60	60	30
Level 4						
pre-1940 I	11	19	19	100	90	100
pre-1940 U	0	19	19	100	90	100
1940-1965	11	7	0	100	65	100
1965-1979 F	7	19	19	100	50	100
1965-1979 E	11	15	19	100	60	100
Ideal						
pre-1940 I	11	38	19	100	100	100
pre-1940 U	11	38	19	100	100	100
1940-1965	11	38	19	100	100	100
1965-1979 F	11	38	19	100	100	100
1965-1979 E	11	38	19	100	100	100

\* Residential Energy Conservation: Report to the New England Energy Congress, February 1979, New England Regional Commission.

TABLE A-8

## Composition of Housing Stock—Case B

Type of Dwelling Unit	Level of Weatherization	Number of Units
pre-1940 U	0	165
pre-1940 U	3	1149
pre-1940 I	0	328
1940-1965	0	177
	1	618
	3	88
1965-1979 F	0	206
	1	723
	3	103
1965-1979E	0	21
	1	148
	3	42

### Al.3 Calculations

With the thermal integrity and the structural characteristics defined, it is straightforward to calculate the energy requirement for a given unit. Daifuku originally computed unit demand in 1977. Massachusetts Audubon recalculated the demands in 1978. This thesis uses the adjusted calculations.

To compute the energy savings, the efficiencies of the heating systems must be specified. The electrical systems are assumed to be 95 percent efficient, and oil furnaces 50 percent efficient.

Vineyard energy and weatherization prices were obtained from the suppliers on the Island. Number two heating oil is \$1.00/136,000 BTUs or about \$1.00 per gallon. Electricity costs \$.08/KWH. The prices of insulation, weatherstripping, and storm doors and windows are listed in Table A-9.

TABLE A-9

Prices of Materials and Labor

Fiberglass Batts (Ceilings and Floors)

Materials

R-11 \$.21/sq.ft.

R-19 \$.33/sq.ft.

R-30 \$.45/sq.ft.

Labor 125% of materials cost

Cellulite Foam (Walls)

\$.80/sq.ft.

Storm Windows

Materials \$6/unit

Labor + Overhead \$24/unit

Storm Doors

Materials \$76/unit

Labor \$49/unit

Weatherstripping

Materials \$.15/linear ft.

Labor \$10.00/window or door

Based on interviews with businessmen, weatherization workers, and insulation suppliers, Summer 1980, Martha's Vineyard.

## APPENDIX II

### Results from the Model

#### A2.1 Case A: Initial Conditions—New England Housing Stock Characteristics

Table A2-1 shows the annual energy savings from each level of investment for each prototypical dwelling. Figure 1 is a plot of the number of years necessary to recoup the investments. All except one are recoverable in four years or less. Most average less than two.

If the choices facing the rational consumer are being modeled by the investment level, and if diminishing returns occur in weatherization as in other investments, the specific actions for the first level of investment (lowest budget constraint) should have the highest return. The highest return should also have the shortest payback. Or, the plots of payback period versus investment level in Figure 1 should slope upward from left to right and then flatten for each type of dwelling.

##### A2.1.1 Analysis of Investment Results using Payback Period

###### 1940-1965 Units:

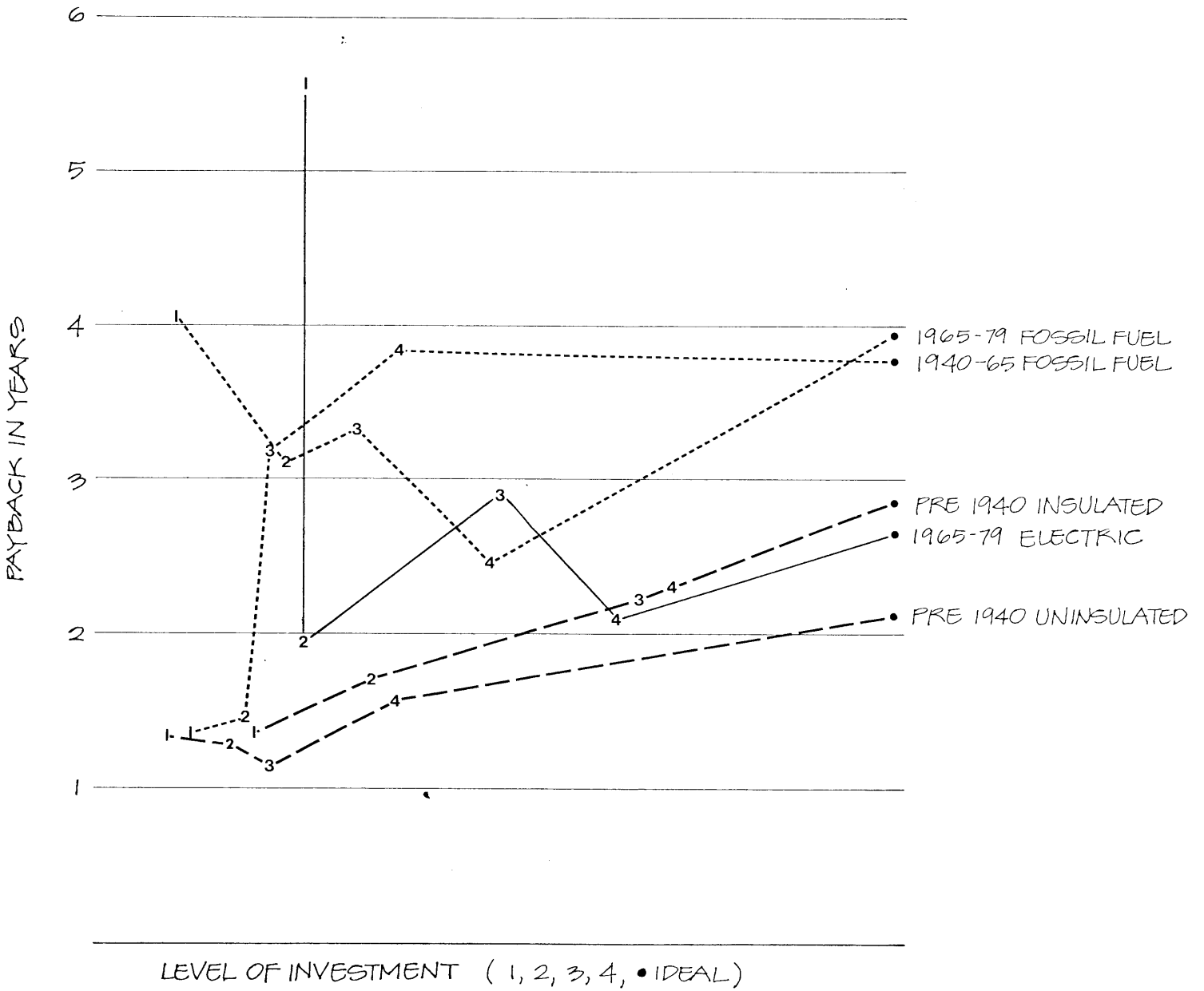
For homes built between 1940 and 1965, Figure 1 shows the declining marginal returns that are expected. The initial insulation tends to have a greater effect on reducing unit demand than additional insulation in the same

TABLE A2-1

	Weather- zation * Cost [\$]	Energy Saved per Unit [MBTUs]	Annual Savings per Unit [\$1.00/ 136,000 BTUs]	Pay- back [years]
pre-1940 Uninsulated				
Level 1	248	25.2	185	1.34
2	496	52.6	388	1.28
3	544	76.8	565	1.14
4	1139	98.0	721	1.58
Ideal	3050	196.2	1443	2.11
pre-1940 Insulated				
Level 1	248	25.2	185	1.34
2	444	35.2	259	1.71
3	889	54.6	401	2.22
4	939	55.6	409	2.30
Ideal	1306	62.4	459	2.85
1940-1965				
Level 1	291	29.4	216	1.35
2	468	43.6	320	1.46
3	775	33.0	243	3.19
4	1318	47.0	345	3.82
Ideal	2558	92.4	679	3.77
1965-present Fossil				
Level 1	231	7.8	57	4.05
2	598	26.2	193	3.10
3	828	34.0	250	3.31
4	1260	70.2	516	2.44
Ideal	2590	89.2	656	3.95
1965-present Electric				
Level 1	607	41.3	109	5.57
2	598	13.1	306	1.95
3	1205	17.7	414	2.91
4	1561	32.0	750	2.08
Ideal	2390	38.4	901	2.65

\* Cost is amount required to weatherize from initial condition to indicated level.

FIGURE 1



area of the house. Raising the R-value of a wall from R-0 to R-7 will cause a proportionately greater reduction in unit demand than raising the value from R-7 to R-14. Essentially, this graph does show diminishing marginal returns (or increasing payback period) to weatherization investments.

1965-1979 Units:

The payback graphs for homes built between 1965 and the present do not clearly reflect diminishing marginal returns. In fact, investment level one has a longer payback than level two, particularly for the electrically heated home. Even so, this can be explained as an effect of diminishing returns.

The specific purchases in each level of investment were originally chosen to correspond to budgets of \$250, \$500, \$1,000, \$1,500, and unconstrained.<sup>10</sup> Level one was about half as expensive as level two. Now, both investments involve approximately the same outlay but the return to level two is greater (payback period shorter). The investment from the initial condition to level one raises the R-value of the walls from R-7 to R-11 for the electrically heated home and the R-value of the ceiling from R-12

---

<sup>10</sup>The levels of investment and the actions taken in each were determined by Massachusetts Audubon Society for their report to the New England Energy Congress, 1979.

to R-19 for the fossil fueled dwelling. Both of these investments are additions to a relatively substantial amount of existing insulation. The weatherization from the initial conditions to level two changes the R-value of floor insulation in both structures from R-0 to R-19. The floors were completely uninsulated and this new insulation decreased unit demand by more than the additional wall or ceiling insulation. Although diminishing returns are not a result of an increase in total spending on weatherization for level two versus level one, diminishing returns are still evident in the results of increased outlay for one aspect of weatherization.

The longer payback period for level three (versus level two) is an indication of both decreasing returns with overall investment increasing, and the diminishing returns for the same expenditures as level one. The drop back to a shorter payback for level four is again representing an investment in an area where there was no previous weatherization (storm windows and weatherstripping). Although the amount spent is greater, the increase represents storm windows and weatherstripping where there was none. Rather than adding another layer of weatherstripping over an existing one or covering a window with a second storm window, level four is "new" weatherization. The payback period for level five is long because it is the

greatest initial outlay and because all of the aspects of weatherization are exhibiting diminishing returns.

#### Pre-1940 Units:

Units that were initially insulated show a clearly defined trend of diminishing returns to increasing weatherization. These homes are fairly well insulated, weatherstripped, and have storm windows. Although additional weatherization does increase energy savings, the increase in savings is less than proportional to the increased investment, i.e., payback period lengthens.

The uninsulated structures do not begin to show diminishing returns until level four. Insulating the ceiling, storm doors and windows, and weatherstripping all save proportionally more energy than the increase in investment. However, floor insulation, wall insulation, and additional ceiling insulation have a diminishing marginal return.

#### A2.1.2 Critique of Model and Payback Analysis

REFORM does not compute the energy savings from a full menu of possible conservation methods. Also, the higher levels of investment do not always include the same actions as the lesser amounts. The definition of marginal return to an additional dollar of investment is unclear when spending more does not include the same purchases and

when the choice of possible investments is constrained. This is part of the reason why the graphs do not always have the expected shape. It appears that the selection of actions in each level of investment did not assume that consumers will choose the options on the basis of rate of return. Either, there was no consideration of what would be the "best" investment under each budget constraint or relative prices have changed enough to change the ranking of actions by return.

#### A2.1.3 Rate of Return Analysis

By manipulating the calculations for each investment level, it is possible to determine the rates of return for some of the actions. Table A2-2 shows these costs, energy savings, and rates of return. There is a fairly clear picture of diminishing marginal returns except in instances where a relatively inexpensive addition to existing insulation has a lower return than a costlier form of new weatherization. An example is \$230 of increased ceiling insulation for fossil fuel heated homes built since 1965 having a lower return than \$432 spent to put up storm windows and weatherstripping. This seeming violation of diminishing returns arises because the menu of possible weatherization investments is still incomplete. The ideal set of energy savings and cost calculations would show the cost of each marginal reduction on energy consumed for

TABLE A2-2

## Savings from Measures—Disaggregated\*

	Cost [\$]	Δ from Initial Condi- tions (except where noted)	Savings		% Return on In- vest- ment in One Year
			MBTUs	\$	
<u>1965-1979 Electric</u>					
Ceiling & Storm Doors	829	R-23, 40%	6.42	151	18
Walls	607	R-4	4.63	108	18
Floor	598	R-19	13.05	306	51
Storm Windows & Weatherstripping	356	40%, 70%	14.32	336	94
<u>1965-1979 Fossil</u>					
Ceiling & Storm Doors	953	R-26, 50%	19.0	140	15
Ceiling	230	R-7	7.8	57	25
Floor	598	R-19	26.2	193	32
Storm Windows & Weatherstripping	432	55%, 75%	36.2	266	62
<u>1940-1965</u>					
Walls	1089	R-8	21.8	160	15
Floor	483	R-19	17.6	129	39
Ceiling & Storm Door	445	R-12 25% to to R-31, 35%	9.4	173	39
Ceiling	249	R-12	14.2	104	42
Storm Windows, Doors & Weather- stripping	291	35%, 25% 75%	29.4	216	74

TABLE A2-2 (Cont.)

	Cost [\$]	Δ from Initial Condi- tions (except where noted)	Savings		% Return on In- vest- ment in One Year
			MBTUs	\$	
<u>pre-1940 Insulated</u>					
Storm Door	50	20%	1.0	7	15
Floor	446	R-19	19.4	143	32
Ceiling	245	R-10	11.0	81	33
Storm Windows & Weatherstripping	198	30%, 75%	24.2	178	90
<u>pre-1940 Uninsulated</u>					
Storm Windows & Weatherstripping	198	30%, 75%	.25	4	7
Floor	446	R-19	10.35	152	34
Ceiling	446	R-19	26.05	383	36
Walls, Ceiling, Storm Doors	1911	R-11, R-19 to R-38 20% to 30%	49.10	722	38
Storm Doors	50	20%	12.35	182	92

\* There may appear to be violations of the law of diminishing marginal returns because some measures cannot be disaggregated and because less costly investments may be additions to existing insulation.

each form of weatherization. The consumer would know that the first \$50 spent on storm windows caused a certain energy savings versus \$50 spent on weatherstripping. The next \$50 spent on those same items would also generate energy savings but maybe slightly less. In the case where spending less than a certain amount is not useful (spending \$50 on wall insulation probably makes no sense since for it to have any effect probably requires insulating more than 58 square feet of wall), the return is zero for less than that minimum expenditure. With a table showing the energy savings and cost of each measure, the choices of a consumer using cost effectiveness as a decision rule can be determined.

Even with the limitations of the model, it is clear that the paybacks are short and the rates of return high for investments in weatherization. When similar calculations were performed in 1978 for all the New England states, paybacks averaged five years. In large part this reflects the rapidly rising cost of energy. For instance, the 1978 cost per million Btu of oil was \$3.70. Now it is \$7.35. Labor and material costs of weatherization have not inflated nearly as quickly so the investments have become more attractive.

A2.2 Case B: Initial Conditions—Martha's Vineyard Housing Stock Characteristics

Payback periods for investments to bring the housing stock from Case B initial conditions to the ideal are between 2 and 5 years. The better insulated homes have a longer payback to the investment in general which is expected given diminishing marginal returns. If Case B is a more accurate description of the housing stock, then it is less surprising that consumers are not demanding weatherization services. However, the estimated benefits are still substantial and rising energy prices are likely to reduce the actual payback.

TABLE A2-3

## Case B Results

Type of Dwelling	Initial Condition	Cost to Ideal	Annual Savings	Years to Pay-back
1965-1979 E	0	\$ 2390	\$ 901	2.65
	1	1782	792	2.25
	3	1185	485	2.44
1965-1979 F	0	2590	656	3.95
	1	2266	578	3.79
	3	1668	406	4.11
1940-1965	0	2558	692	3.70
	1	2267	463	4.90
	3	1783	334	5.34
pre-1940 U	0	3050	1442	2.12
	3	1960	878	2.23
pre-1940 I	0	1191	459	2.59

### APPENDIX III

#### Energy Balance for Martha's Vineyard

An energy balance showing all inflows and outflows of energy in the Vineyard economy was constructed from information of dealers and suppliers. It also shows oil as providing more than 90% of the heat.

TABLE A3-1

## Energy Balance

## Percentage of Fuel Consumed by Use

Fuel	Annual Island Usage	BTUs [10 <sup>6</sup> ]	Residential			Com- mer- cial	Transportation			Government		
			Heat	Other Cooking Water	Seasonal		Pleasure	Commer- cial	Other	Other	School	Hospital
Diesel	.5 M gals.	7,000				1.00						
Wood	2889 cords	72,225	1.00									
Gasoline	5 M gals.	600,000					.09	.01	.90			
Electri- city	65810 MWM	224,610	.24	.36	.10	.25						.05
Oil	6 M gals.	871,140	.75	←	.24	→					.04	.02
Propane	12000 tanks (284,000 gals.)	19,655	.06	.14		.80						

## BIBLIOGRAPHY

Ashworth, John, et al. The Implementation of State Solar Incentives: A Preliminary Assessment. Golden, CO: Solar Energy Research Institute, 1979.

. The Implementation of State Solar Incentives: Financial Program. Golden, CO: Solar Energy Research Institute, 1979.

Arrowstreet, Inc. Massachusetts Local Energy Action Program. Boston: Northeast Solar Energy Center, 1980.

Batelle, Columbus Labs. Integrated Energy Plan for Riverside, California, Volume II, (Draft).

Community Energy Self Reliance, Proceedings of the First Conference on Community Renewable Energy Systems, University of Colorado, Boulder. U.S. Government Printing Office, 1979.

Consumer's Union. Money Saving Guide to Energy in the Home. Mount Vernon, NY: 1978.

Daifuku, Richard. Residential Space Heating and Cooling in New England 1972-2000. Upton, NY: 1976.

Daifuku, Richard. Simulation Model of Residential Space Heating and Central Air Conditioning in New England 1970-2000. Boston: New England Regional Commission, 1977.

Dukes County Planning and Economic Development Commission. An Economic Base Study of Dukes County, Massachusetts. Oak Bluffs, MA: 1973.

Federal Register. Residential Conservation Service Program. U.S. Government Printing Office, November 7, 1979.

Future Studies Program. Franklin County Energy Study: A Renewable Energy Future. Amherst, MA: University of Massachusetts, 1979.

Internal Revenue Service. Preliminary Statistics of Individual Income Tax Returns. U.S. Government Printing Office, 1978.

- Keyes, Dale L. Energy as an Influence on Future Patterns of Development. Arlington, VA: Energy and Environmental Analysis, Inc., (Draft).
- Lee, J. Energy Supply and Demand in the Northeast United States. Upton, NY: Brookhaven National Laboratory, 1976.
- Massachusetts Executive Office of Energy Resources. Massachusetts Residential Conservation Service Program. Boston: 1980.
- The Martha's Vineyard Commission. Water Quality Management Plan of 1977. Oak Bluffs, MA: 1977.
- McGregor, Gloria S. Energy Conservation in Urban and Regional Planning: The Davis Experience. Davis: Community Development Department, 1980.
- Morris, David. Planning for Energy Self-Reliance: A Case Study of the District of Columbia. Washington Institute for Self-Reliance, 1978.
- National Energy Conservation Policy Act. Washington, DC: U.S. Government Printing Office, 1978.
- New York State Department of Public Service Office of Research. The Effectiveness of the C-Audit Workbooks. Albany, NY: 1980.
- New York State Public Service Commission. First Annual Report on Implementation of the New York State Home Insulation and Energy Conservation Act. Albany, NY: 1979.
- \_\_\_\_\_. Second Annual Report on Implementation of the New York State Home Insulation and Energy Conservation Act. Albany, NY: 1980.
- New England Regional Commission. Residential Energy Conservation: Report to the New England Energy Congress. Boston, MA: 1979.
- \_\_\_\_\_. Tapping the Conservation Wellhead. Boston, MA: 1980.
- Petersen, S.R. Retrofitting Existing Housing for Energy Conservation: An Economic Analysis. Washington, DC: National Bureau of Standards, U.S. Department of Commerce, 1974.

Polenske, Karen. Output Income and Employment Input-Output Multipliers. Washington, DC: U.S. Department of Transportation, 1977.

Ridgeway, James. Energy Efficient Community Planning. Emmaus, PA: The JG Press, Inc., The Public Resource Center, 1979.

Rowan, Ruth E. Industry Employment Projections: An MIRO Model Simulation. Cambridge, MA: Department of Urban Studies, Massachusetts Institute of Technology, 1976.

Shenon, Philip W. "Many Electric Utilities Suffer as Conservation Holds Down Demand." Wall Street Journal, October 9, 1980.

Stobaugh, Robert. Energy Future Report of the Harvard Business School. New York, NY: Random House, 1979.

Tabors, Richard. Energy in Cities. (Draft).

Urban Systems Research and Engineering, Inc. Impact of the New England Regional Commission's Low Income Winterization Program. Cambridge, MA: 1978.