The Potential for Innovative Energy Facility Development in Rhode Island

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THE POTENTIAL FOR INNOVATIVE ENERGY FACILITY DEVELOPMENT IN RHODE ISLAND

1. Energy Consumption Trends and Energy Use Decision-making in Rhode Island Industry

INTRODUCTION

Energy price increases and threats of supply disruptions during the 1970's have had an important effect on energy use patterns in Rhode Island. A trend of steady growth in total energy use during the 1960's was reversed dramatically after 1972, with current energy use the lowest in a decade. During much of the 1970's, Rhode Island was the target of many proposals for major new energy facilities, including oil refineries, LNG and petroleum storage tank farms, and nuclear power plants. Except for LNG and LPG storage tanks built in Providence Harbor, none of the proposals reached the construction stage. The reason for this is simple. According to the Department of Energy, energy use grew only 1.6 per cent between 1972 and 1978 in New England. A New England Congressional Institute study shows a 6.5 per cent decline in energy use in the region between 1978 and 1980. Personal income per capita grew by 3.9 per cent during the same period,while per capita energy use dropped by 7 per cent. With little growth in demand for conventional fuels in the region there is little need for new energy facilities. Rather than purchase greater quantities of conventional fuels, energy consumers are finding ways to use less, or use different fuels.

The premise of this report is that most major new initiatives in energy facility siting will continue to be made by energy consumers rather than energy suppliers. In addition, opportunities for cogeneration or district heating systems will become more attractive as energy prices continue to rise. Even though considerable progress has been made in conservation and conversion, only the easiest savings have been achieved. Much remains to be done by the industrial, commercial and institutional sectors to achieve a state economy which is less easily disrupted by future energy price increases and global energy politics.

ENERGY CONSUMPTION PATTERNS

Rhode Islanders used an estimated 215 million BTUs per person in 1979, which was the lowest rate in the nation, compared to a much higher national average of 359 million BTUs per capita. Total consumption of energy in the state in 1979 was 199.4 trillion BTUs, the lowest since 1967. Table 1 shows the trend of consumption over the past 20 years. The 1979 consumption was 16.5 percent lower than the peak 238.9-trillion BTU which occurred in 1972. In addition 1979 consumption was only 4.5 percent greater than the level reached twenty years previously in 1960. Each consuming sector reached its peak of use in a different year. Industrial energy use peaked in 1964, transportation in 1971, residential in 1972, and commercial in 1973.

TABLE 1

TOTAL ENERGY USE IN RHODE ISLAND BY SECTOR
TRILLION BTUS

	Residential	Commercial	Industrial	Transport.	Utility*	Total
1960	52.5	35.7	41.5	60.7	20.5	190.8
1961	52.9	33.1	37.4	52.6	20.0	176.1
1962	53.0	37.2	42.6	51.4	19.4	184.3
1963	53.5	35.6	42.5	52.8	19.0	176.4
1964	47.6	35.8	52.5	49.2	15.8	185.3
1965	52.3	29.5	39.9	53.0	18.2	174.6
1966	51.6	28.6	41.1	55.6	17.2	177.0
1967	55.1	34.7	44.8	63.0	19.9	198.1
1968	57.9	40.3	44.3	58.3	19.9	201.0
1969	63.4	44.0	50.0	57.5	21.1	215.2
1970	66.1	49.9	47.5	62.8	21.7	226.3
1971	69.8	58.0	42.5	66.4	19.5	236.9
1972	72.8	59.2	41.9	64.8	17.3	238.9
1973	68.6	63.1	40.7	59.7	15.2	232.2
1974	65.8	52.4	40.1	58.3	15.0	216.5
1975	65.5	49.6	37.3	56.2	10.5	208.8
1976	69.9	52.9	41.8	55.2	6.5	219.6
1977	69.0	54.6	48.8	55.2	6.6	227.6
1978	67.7	54.2	37.2	54.2	8.2	213.3
1979	64.1	43.5	37.5	54.3	8.7	199.0

*not added to Total to avoid double counting electricity use

Source: U.S. Department of Energy

Most conventional fuels do not show a pattern of growth in the 1970s. Residual or #6 heavy oil has dropped dramatically from its peak in 1971. Distillate fuel use is about 22.6 percent lower in 1979 than in 1972, the year of its highest use. Natural gas usage returned to 1971 peak levels in both 1977 and 1979. Electricity consumption remained virtually unchanged between 1976 and 1979, while gasoline use has changed little since 1972.

These facts indicate that Rhode Island is not experiencing runaway growth in energy consumption, and would hardly be the place for a energy company to attempt to increase the sale of its product. It is interesting to note that total employment in the state has increased 16 percent during the 1970s, while industrial and commercial use of energy declined in the same period. A slight loss of population (.4 percent) occurred between 1970 and 1980 while the number of households increased 17 percent.

ENERGY CONSUMERS

During the 1970s both firms and individuals have made a number of decisions and investments to reduce energy usage. Unfortunately, we know little at present about the nature and extent of these decisions. Have all of the easy savings been achieved? How much money are businesses planning to invest to install more efficient equipment and improve structures and processes? How do energy cost increases compare with other costs of production or business? What major changes can be foreseen in the way energy is used in Rhode Island by major consumers in the next five to twenty years?

It is not readily apparent whether it is a few large firms or many small ones which dominate industrial and commercial fuel use. The 1977 Census of Manufacturers provides the most recent information about the number and size of firms. This data has been used to make a rough estimate of whether large or small firms dominate manufacturing energy consumption, and which sectors are the largest energy consumers. This result is then compared with actual 1977 energy use data.

In Rhode Island, 67 percent of all manufacturing employees worked in firms employing 100 or more persons. Firms of 50 workers or more account for 80 percent of all manufacturing employment (See Figure 1). The energy use of the twenty industries in which the Census classified the state's manufacturers, by firm size, was estimated by utilizing BTU per employee data taken from national studies. The mid point of each firm size was multiplied by the number of firms to estimate employment by each firm size. Total estimated energy consumption by firm size for each industry was then computed (Figure 2). The result was an estimated total of 33.5 trillion BTUs in 1977, based on estimated employment in manufacturing of 137,000. This compares to the actual ~~A~~ 1977 industrial energy use of 37.8 trillion BTUs (including electrical generating losses) reported by the Department of Energy, and an average actual 1977 employment in manufacturing of 128,800. The estimates of total employment and energy use utilizing firm size data are reasonably close to actual data sources.

Figure 1 Percentage of Industrial Sector Employment in Each Size Firm, 1977. U.S.Department of Commerce.

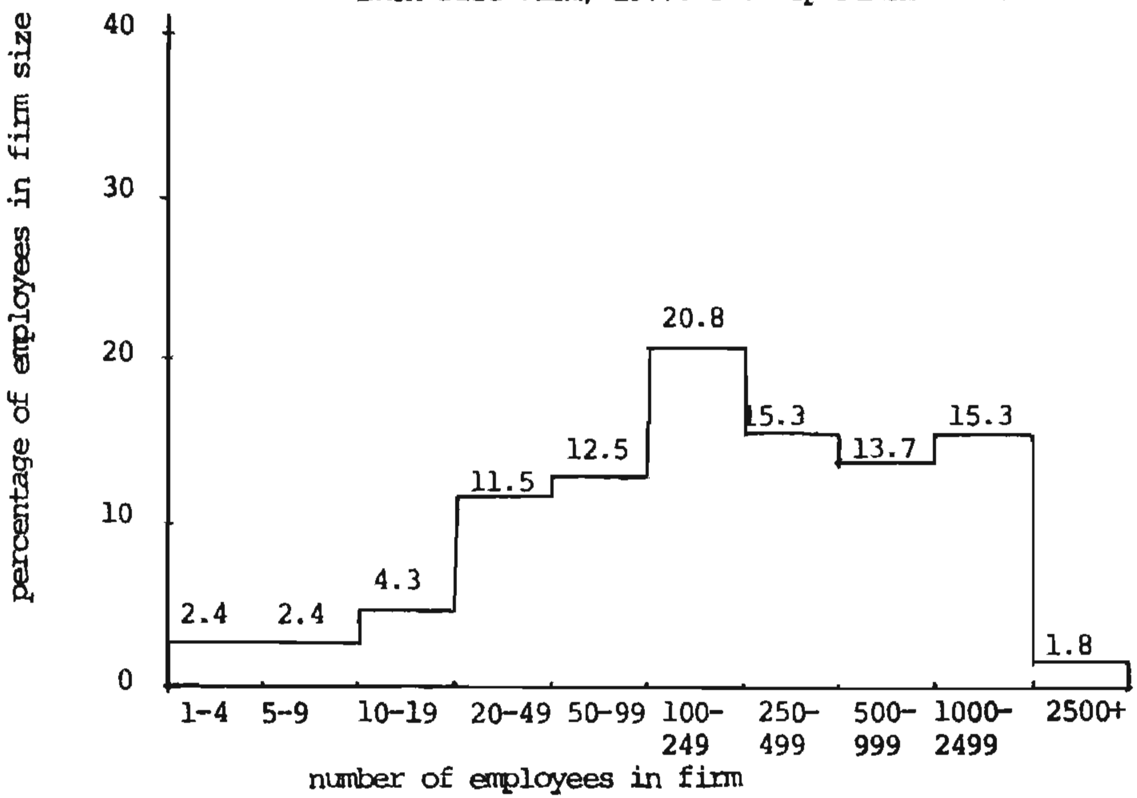
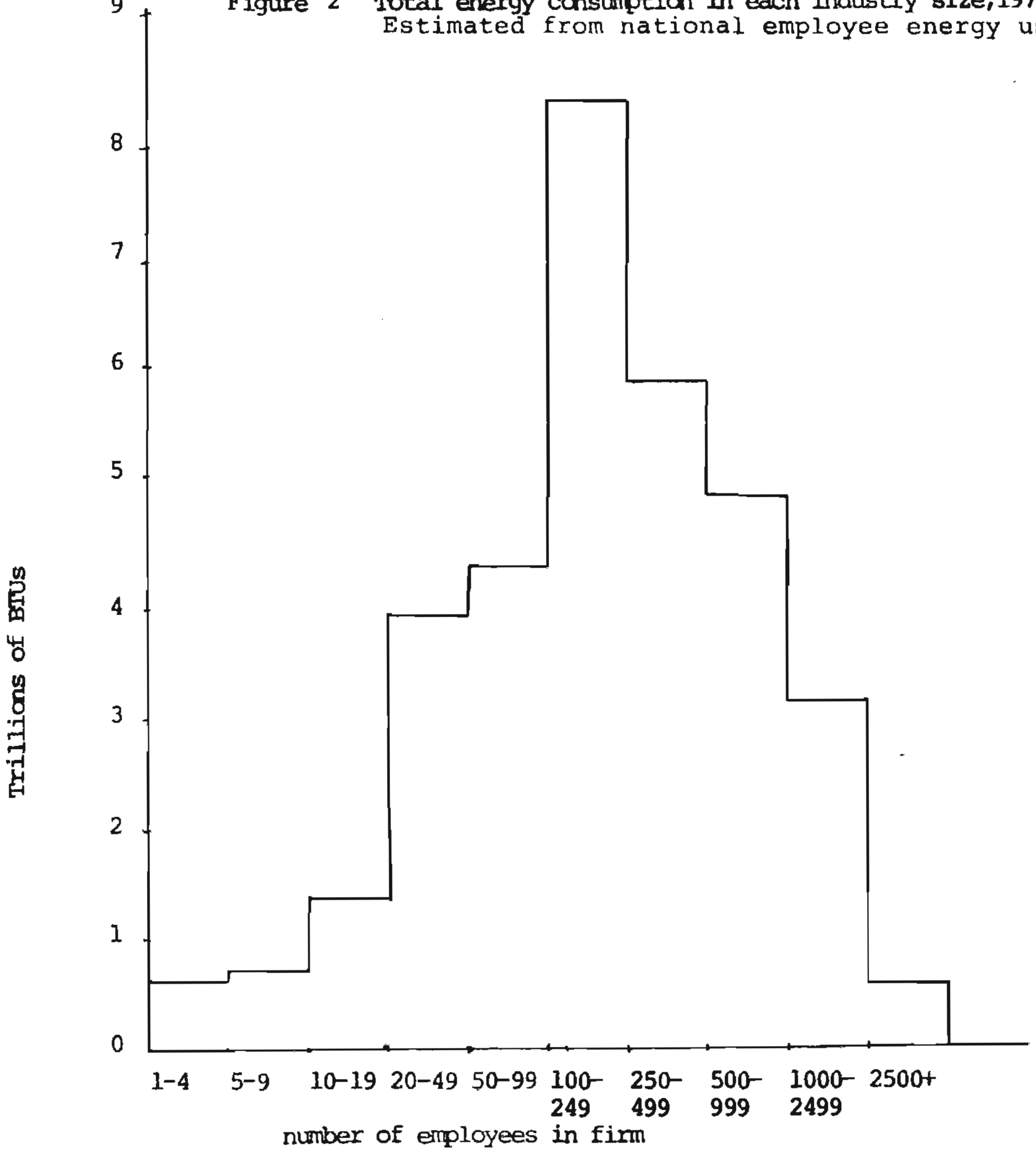


Figure 2 Total energy consumption in each industry size, 1977
Estimated from national employee energy use



As Figure 3 shows, for all industries, two thirds of energy consumption occurs in firms employing 100 or more persons, and 80 percent in firms employing 50 or more workers. According to the 1977 Census, there are just 257 out of 3107 firms with 100 or more employees. These few companies use an estimated 67 percent of all industrial energy consumption. A total of 490 firms employing 80 percent of all manufacturing workers used 80 percent of all manufacturing energy according to these estimates. These companies, plus any new firms entering the state are the most important to the state in terms of employment and energy use problems.

Industrial Energy Conservation Trends

Has industrial energy use declined simply because employment is less, because industry has made a true effort to conserve, or because employment has shifted to less energy consuming activities? There has been significant flux in employment in various sections of the industrial sector over the past ten years. Although total manufacturing employment has increased over time there may have been a decrease in employment in high energy consuming firms causing total energy use to drop without the initiation of energy conservation measures by industry. To test whether energy use is less because of lower employment in certain sectors, data on energy use per employee for 1976 was taken from a study done for the New England Energy Congress. Estimated energy use in each two digit industry was then computed for 1976 and 1979 (See Table 2). Without a reduction in energy use per employee in any industry, an 8.6 per cent increase in energy consumption, from 30.1 to 32.7 trillion BTUs would be expected. However, State Energy Data Report, SEDS, data shows an actual 10.5 per cent decline from 41.9 to 37.5 trillion BTUs.

Figure 3 Percentage Distribution of Estimated Energy Consumption by Firm Size, 1977

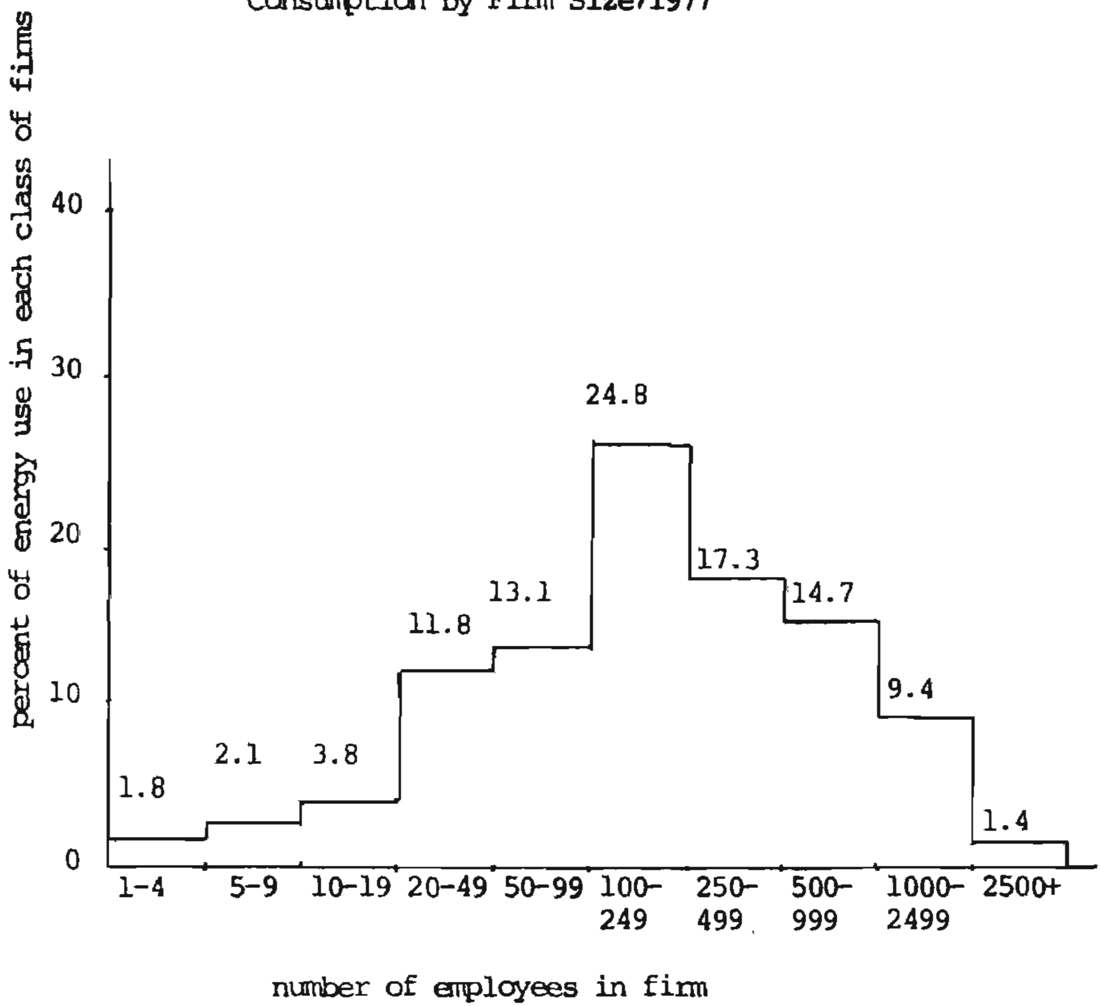


TABLE 2

INDUSTRIAL ENERGY AND EMPLOYMENT TREND ANALYSIS
Expected Energy Use in 1979 Without Conservation

SIC	Name	1976 Employment 10^3	1976 energy use per employee, millions of BTUs	1976 industrial energy use, trillions of BTUs	1979 Empl (10^3)	1979 No Conservation Scenario industrial energy use trillions of BTUs
20	Food	3.6	392.3	1.412	3.4	1.333
22	Textile	12.4	465.0	5.766	12.5	5.813
23	Apparel	3.8	47.2	.179	3.6	0.170
30	Rubber	7.3	224.2	1.636	7.2	1.614
33	Prim. Metals	7.2	361.1	2.599	8.2	2.961
34	Fab. Metals	9.3	193.2	1.796	10.1	1.951
35	Mach.	8.9	114.1	1.015	9.5	1.084
36	Elect	9.7	102.3	.992	11.7	1.197
37	Transp.	5.5	151.2	.831	6.2	0.937
38	Instru	5.0	114.8	.574	5.4	0.620
39	Mis. Mfg. (Jewl)	32.7	93.6	3.060	35.0	3.276
--	Other (SIC 25, 32,26,27,28, 31)	17.5	593.3	10.380	19.9	11.807
		122.9		30.16	132.7	32.763

Therefore, a considerable effort to reduce energy consumption is taking place in Rhode Island industry. (The estimated industrial energy use based on firm size is 27 per cent lower than the SEDS numbers for 1976 and 8 per cent lower than the actual 1979 values. However, the direction of change is probably realistic.)

The energy consumed by Rhode Island industry in 1976 and 1979 can be allocated by fuel type as shown in Table 3. The residual fuel oil consumers are large installations. Data on these consumers was obtained by the Department of Environmental Management because of their air quality regulatory responsibilities. Their list of Major Fuel Burning Installations (MFBI) and the consumption of each excluding Narragansett Electric is shown in Table 4. There is some discrepancy between their data (903 thousand barrels) and that published by DOE in the S.E.D.S. document (881 thousand); however, it is insignificant for these purposes. Of particular note is that 496 thousand barrels of the total of 903-thousand, (or 869-thousand excluding the Narragansett Brewery), is made up of federal, state, or private institutions. Excluding the brewery these institutions consumed 57 percent of the #6 oil in 1979. Residual oil use has declined, while electricity, distillate fuel, and natural gas consumption have increased in the industrial sector according to SEDS.

TABLE 3

ENERGY USE IN RI INDUSTRY BY FUEL TYPE
As reported by the U.S. Department of Energy

	1976	1979
	(trillions BTUS)	
Natural Gas	4.9	5.9
Distillate Oil	1.6	2.3
Residual Oil	8.9	5.3
Electricity - incl. losses	15.4	16.2
All Others	11.1	7.6
TOTAL	41.9	37.5

TABLE 4

1979 Major Residual Fuel Burners

Name	10^3 barrels #6 Oil
U.S. Naval Education & Training	172
Bird & Son	155
R.I. Port Authority	95
Bradford Dyeing	71
R.I. Central Power Plant	56
Colfax Inc	44
Corning Glass	42
Brown Univ.	41
Univ. of Rhode Island	41
Narragansett Brewery	34
Kenyon Piece Dye	34
R.I. Hospital	34
Ladd School	30
Providence College	27
Texaco	27
	903

CONSTRAINTS TO ENERGY CONSERVATION EFFORTS IN INDUSTRY

The free market approach to energy decisions in commerce and industry would simply be that when energy costs become significant the rational manager will take steps to control them, raise his prices to maintain his rate of return, or gradually reduce his margin until, perhaps, it is no longer worthwhile to remain in business. The first reaction is certainly the preferred one, however its probability of happening depends not only on the skill of the manager but also on the size of his business. Often the manager is unable to exercise control over energy use.

In the industrial and commercial sectors of an economy, employment may be centralized so that only a few large facilities employ most of the workforce. Or the structure may be such that there are many small companies each with a few employees. In Rhode Island the mix of firm sizes is somewhat different for each industry. The exact firm size characteristics of each industry can be used to indicate its ability to respond to rising energy costs. For example, a large facility will tend to have staff available to monitor costs and to plan and implement energy conservation measures. The impetus for these measures may come from the company comptroller's office or plant engineering or , in the larger firms, from the energy manager's office. In the small facility, whether a machine shop, jewelry manufacturer or restaurant, the manager usually is preoccupied by day to day operations. The small business owner may be quite knowledgable about the business but ignorant of the techniques of energy conservation. An industrial sector characterized by many small businesses will probably not show as much progress in reducing energy waste as a sector characterized by large facilities.

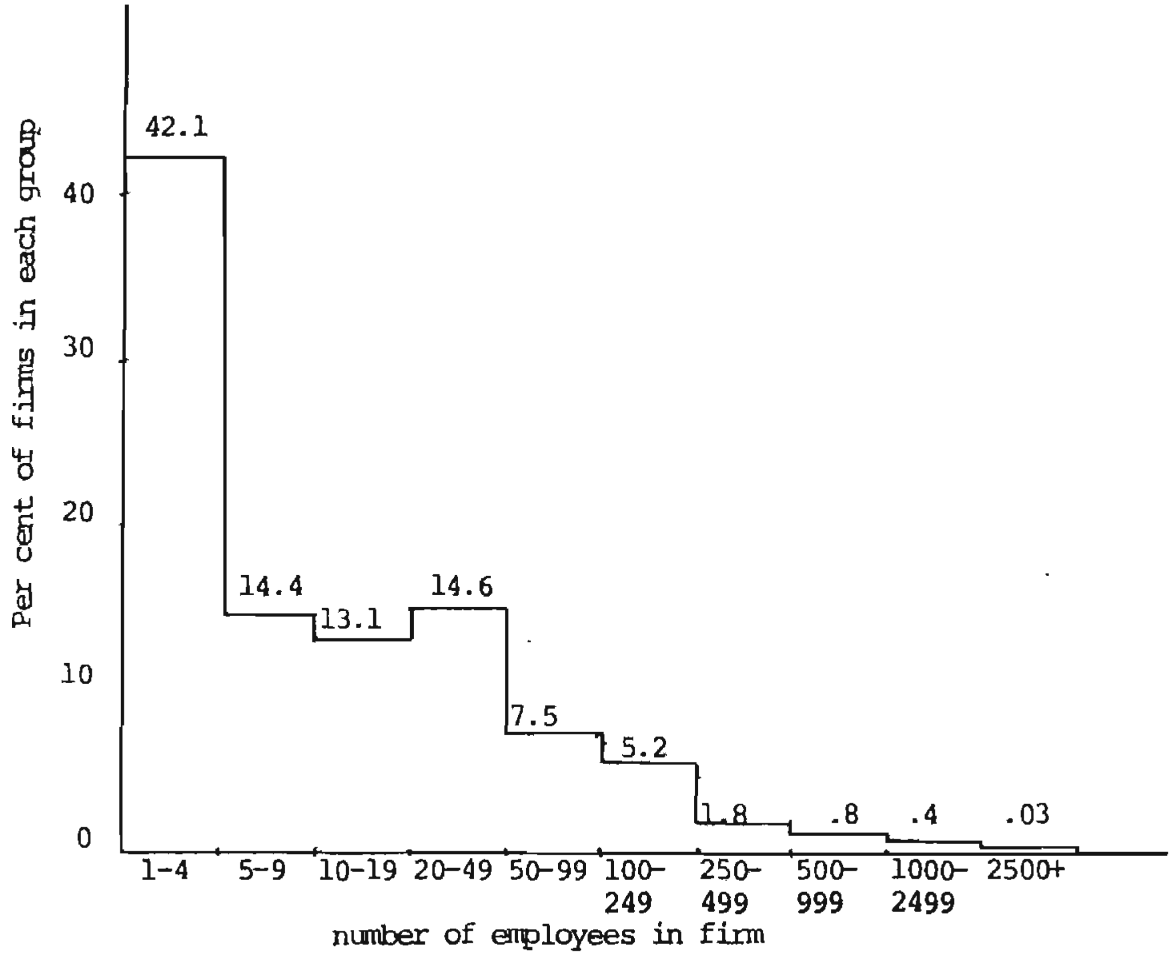
An additional constraint on conservation behavior is the role of energy in the production of a good or service. When energy costs are small compared to total costs, doubling the price may not impose a significant burden on the profitability of the business, and therefore not provide sufficient incentive to reduce energy waste or convert to alternate fuels. On the other hand even a small business may have taken effective steps if energy costs are a significant percent of total costs.

According to the 1977 Census of Manufacturers, there were over 3,300 industrial establishments in the state. Only 257 companies employed over 100 people, and these 257 firms employed two-thirds of our manufacturing work force.(Figure 4) Of these large employers 72 were SIC 39 which includes the jewelry business, 37 were SIC 22 (Textile Mill Products), 21 were SIC 34 (Fabricated Metal Products), 15 were SIC 33 (Primary Metals) and 13 were SIC 30 (Rubber and Plastic). These five industries contained 158 of the 257 establishments with over 100 employees. At that time there were 38 firms with over 500 employees, of which 13 had over 1000 employees. It is in this group that one would expect effective energy management programs to exist.

The remaining 90 per cent of the manufacturing firms in the state,who employ one third of the industrial workers, present a more difficult problem because of the sheer number of establishments as well as the diversity of fields in which they operate.Some 2148 firms, or 65 per cent of the total, have less than 20 employees.

Even those firms which do desire to reduce energy use or lower the price paid for fuel face a final obstacle. The high price of money is a serious constraint to every category of investment in equipment, not just for energy saving measures. When the cost

Figure 4 Percentage of Rhode Island Firms in Size Class, 1977
U.S. Department of Commerce.



of borrowing is high, investment decisions in new plants and equipment are usually defered until management believes that these expenditures will provide adequate returns compared to other investment options available to the company.

The financial decision making criteria of businesses can act as a constraint to energy conservation projects. In many cases a company's investment committee, the body that reviews and recommends proposals for the commitment of company funds, consolidates all proposals for review. Each one is judged by the common denominator of cash return. Energy conservation investments must compete with production equipment, plant expansion and other such proposals for limited company funds. This competition for funds can be a valid way to make decisions as long as financial criteria are used which account for the full value of energy conservation investments. For example,the differential growth rates of energy costs and inflation or money costs may not be accounted for by the method of evaluation used by the firm,producing an inaccurate picture of the benefits of the energy project. In addition if the economy is perceived as soft and interest rates remain high,the payback criteria set by the investment committee may be so rigorous that energy conservation projects with a higher present value but slower payback are filtered out. For instance,when the maximum payback period for an investment is set at 2.0 years then an energy conservation project with a 2.5 or 3 year payback and a higher present value will not be considered by the company's investment committee.

The application of the payback rather than present value criteria by firms means that progress toward reduced firm vulnerablility to fuel cost increases and supply disruptions, which is desireable from the public's view, may be painfully slow. Although in general terms progress has been made at the national level toward industrial energy conservation goals,(see Table 9), energy prices are still frequently cited as a cause of local plant closings. The question of how Rhode Island firms are dealing with increasing energy prices deserves closer scrutiny, in order to detect whether new investments in equipment or material to reduce energy use or switch away from conventional fuels are contemplated, and if not, where opportunities to make such investments, with public encouragement and support, might exist.

2. Cost Savings Strategies for Large Energy Users: Fuel Switching, Cogeneration and District Heating

INTRODUCTION

Energy conservation programs for firms and individuals begin first by reducing the energy demand of buildings, processes and activities through insulation, improved controls and new equipment. The second step for the energy user is to consider measures that will stabilize or reduce the cost of the energy utilized. These inevitably involve modifications to equipment or even larger capital expenditures to install completely new and often innovative fuel conversion facilities.

Firms which need heat or process steam may be able to reduce the cost per million BTUs of that steam by installing new equipment to burn a cheaper fuel. If the new system is large enough, electricity can be cogenerated with steam for even greater savings. However, unless the energy user is large, it may not be able to use the total output of even the smallest sized alternative fuel combustion units. If there are enough energy users nearby, a district heating plan could be implemented to enable several smaller firms to obtain a cost savings otherwise impossible for them to achieve. A district heating plan could be implemented based solely on conventional fuels by running one or two industrial boilers efficiently rather than several inefficiently.

Each location and firm presents a unique circumstance where one or more of the elements of energy price reduction could be implemented. In practice, it is difficult to distinguish clearly among the concepts of fuel switching, district heating and cogeneration since two or all three may be feasible in a specific setting. The important common link is the requirement that a coordinated, systematic approach be taken in all phases of the project. The cost of capital and the payback criteria of the firm are important determinants of whether a fuel cost reducing investment is made. In addition cooperation among firms or between government agencies, energy users and energy suppliers is essential.

Within the context of energy supply in the United States, the technology for obtaining fuel cost savings may seem new or even exotic, although Europe offers numerous examples of successful, well established cogeneration and district heating projects. The most innovative aspect of achieving fuel cost savings will be the development of new ways to plan, finance, and manage projects. Firms and government will have to work together to assemble all of the pieces of a complex proposal in a way which no single firm is likely to initiate on its own.

FUEL SWITCHING

The simple answer to saving money on fuel is to purchase a lower priced alternative. However, using cheaper fuels could involve tradeoffs such as additional pollution control equipment, new furnaces, cumbersome handling procedures and operating inconveniences. Most important, the inevitable requirement is that a facility manager must take the initiative to study, plan, design, construct and operate a new fuel conversion system.

Coal once was a common power generating industrial, institutional, and even household fuel. Cleaner, more convenient and cheaper petroleum supplanted coal by the 1960s in virtually every use category. At present, the Brayton Point Power Station in Somerset, Massachusetts is the primary example in the region of a major conversion of furnaces and boilers to coal. Institutions such as Providence College have studied or are planning to use coal as a primary fuel. The technical challenge and expense of converting existing furnaces to coal, combined with the fact that its price has risen greatly along with petroleum and the absence as yet of a large scale coal distribution network explains why firms and institutions have not rushed into coal conversion.

Conversion to a coal-oil mixture, which is a variation of fuel switching to coal, is considered to be economically limited to boilers which produce more than 100,000 pounds of steam per hour, or the equivalent of the total energy use in the largest industrial clusters considered in this study (Applied Technology Center 1980, Williams 1978).

An abundant native energy resource with potential as a low priced fuel is solid waste. A wide range of approaches can be found in this country and overseas in Europe and Japan in the use of energy in resource recovery systems. If the primary goal of resource recovery is to dispose of solid waste, in many cases irrespective of the costs of operation, the plant will be designed to maximize the reliability and minimize the cost of waste disposal, and incidentally produce energy products that may or may not be marketable in a given area. This is characteristic of several American resource recovery facilities that were developed early in the 1970s (e.g. Chicago, Illinois and Harrisburg, Pennsylvania) although many of these systems are now being converted to recover the energy productively for steam and electricity. If the primary goal of resource recovery is the production of energy, then the plant will be designed to maximize the reliability of energy production, regardless of the costs of disposing of wastes. This is particularly characteristic of many European facilities which have been developed by cities which were already in the energy production business. In fact, in Denmark, the Netherlands and West Germany more than 90 percent of the waste-to-energy systems were installed in municipalities involved in the energy business in some way already. Often European municipal governments considered the delivery of energy services to be part of the overall service that they must provide to their constituencies generally in the form of steam or hot water district heating systems. The costs of such facilities are comingled between waste disposal, energy costs, and other municipal expenditures, and a clear accounting of expenditures for each aspect of the facility's operations has generally not been required. This is partly due to the institutional arrangement that is common in Europe where the resource recovery facility is constructed by the municipally-owned public utility. Individual industrial and institutional sites which generate large amounts of waste may find it economical to burn refuse and recover energy for themselves using new off-the-shelf equipment.

Resource recovery may offer unique energy conservation opportunities by the generation of electricity at dedicated waste-to-energy plants. The development of resource recovery systems allows the inclusion of the necessary subsystems (turbine/generators, etc.) to provide electrical generation from refuse burning plants. Optimum resource recovery occurs where there is a good match between the solid waste stream and energy needs of the energy market. The ever increasing ability of resource recovery systems to achieve higher qualities of steam may therefore provide increasing opportunities for economic cogeneration plants (i.e. higher pressures and temperature).

Finally, other solid fuels such as wood or wood byproducts and peat may be available in sufficient quantity near a potential user to justify installation of specialized furnaces.

COGENERATION OF ELECTRICITY AND STEAM/HOT WATER

The generation of electricity in conjunction with steam production in industrial plants is not new. Large steam plants such as the one built by the Navy at the present Quonset/Davisville Industrial Park have an unused capability for generating electricity. The advent of large central power stations and the growth in non-industrial electricity demand was accompanied by a declining role for industrial cogeneration as a share of total U.S. electricity supply, down to 4 percent in 1976 (Williams,1978). About 20 percent of all fuel used in the U.S. ends up as wasted heat from power plants. Recent analyses (Williams, 1978, HDR, 1982) show that cogeneration of electricity is cost competitive with any new power generation source. Institutional factors, such as excess power generating capacity and disadvantageous backup power and buy-back rates of utilities prevent the private investments needed to capture the energy lost to the environment. Cogeneration also includes sales of low pressure steam from power plants to industrial customers. The proximity of the two power stations in Providence to a large industrial cluster provides a unique situation with some potential for development.

The technology involved in the generation of electricity is straightforward and off-the-shelf. The basic equipment required is a steam turbine and generator in addition to a furnace and boiler. The steam turbine is utilized to produce rotary motion or usable shaft power. In cogeneration, the power is utilized to "turn" a generator and thereby produce electricity. At the same time, the energy content (thermal value) is available for subsequent use or condensation. The energy conversion process in a turbine occurs in two ways. First, steam entering a turbine is expanded through a stationary nozzle thereby transforming the steam's heat energy to velocity. Rotary motion is accomplished by allowing the expanded steam jet to strike blades on a turbine wheel thereby making the wheel revolve. Turbines may be either single stage or multi-staged depending on specific design conditions (steam flow, pressure, etc.). Generally multi-staged turbines are more efficient. However, this greater efficiency is accomplished at significantly higher cost. Numerous turbine configurations are available. These may allow steam to be extracted from the turbine stages at varying pressures and quantities.

Steam turbines may generally be divided into two basic categories. These include:

- Condensing Turbines
- Non-condensing (Back Pressure) Turbines

Each of these types of turbines are available in a wide variety of sizes. Condensing turbines will exhaust steam at less than atmospheric pressure, which means that the exhaust steam cannot be used for further purposes, while non-condensing (or back pressure) turbines will exhaust steam at pressures higher than atmospheric pressure. This means that the steam leaving the back pressure turbine could be used to perform other work. Normally the pressure of back pressure turbine steam exhaust is determined by the specific steam pressure needs of the ultimate user.

There is a third type of turbine, the extraction turbine, which employs characteristics of both the condensing and back pressure types. Extraction turbines can be employed when steam flows are substantial or if system economics warrant the additional expenditure associated with this more expensive equipment. These turbines allow a portion of the steam flow to be "extracted" at the industry's required temperature/pressure while allowing any remaining steam flow to be carried all the way to condensing in order to maximize electricity production.

In many industrial and institutional facilities steam is the sole energy form produced for use. Waste-to-energy plants often only sell steam as well. The addition of cogeneration capabilities requires the addition of a turbine/generator set which will allow the steam produced to be used to generate electricity. Primary components of this additional equipment include:

(1) The steam turbine which is normally designed and sized for available steam flow conditions and back pressure requirements;

(2) The generator which translates the turbine's rotary kinetic energy to electric energy; and

(3) The switch gear which allows connection of the turbine/generator to the existing electricity distribution system

Numerous manufacturers exist for turbine/generator equipment since this form of equipment has been in use for many years. Significantly, there are no major modifications required of standard turbine/generator equipment for inclusion in resouce recovery facilities.

Turbine/generator manufacturers produce a wide variety of systems. Some are constructed on skids and shipped to the site, while others are field erected. In general, the actual space requirements are quite minimal compared to the area needed for resource recovery system equipment. Installation of a turbine/generator set (or even several) will typically not require a separate building, merely the addition of extra area in the vicinity of the boiler outlet line. However, the location of a turbine system within a resource recovery facility should be compatible with steam flow configurations and should further be sensitive to the maintenance and environment (dust, etc.) necessary for proper turbine operation. This may require positioning in a separate room depending on the system design.

Cogeneration opportunities are usually subdivided into two categories--back pressure applications and condensing applications. In the back pressure application, the steam product at the fuel combustion facility is at a greater quality (pressure and temperature) than that which is required for the market and/or internal steam needs. Coincidental electrical production is accomplished by passing the higher quality steam through a back pressure turbine which drives a generator. The turbine inlet pressure and temperature will generally be a function of the ability of any fuel burning technology to economically and reliably achieve higher pressures and temperatures.

The specific quality of steam which is required by the primary energy market will determine the pressure drop which can be allowed in the design of a cogeneration turbine/generator system. For example, if an industry were to serve as a market for process steam and the industry requirements were for saturated steam at 150 psig, the turbine would be designed so that outlet steam pressure would be provided at required market conditions. If the furnance/boiler facility were able to provide super heated steam at 600 psig, electricity could be generated by allowing the steam from the boiler to flow over a back pressure turbine which would exhaust steam at the market's pressure requirements.

DISTRICT HEATING

In large institutions and industrial operations, large central furnaces and boilers supply steam and hot water to the buildings of a complex through underground pipes. Lower cost fuels such as Number 6 oil, coal and solid waste can be burned efficiently in these facilities with a potential cost savings over Number 2 oil or electricity in individual building furnaces. Many firms cannot get these cost savings because their individual energy demand is too low to make the capital investment worthwhile. On the other hand, energy recovery projects involving solid waste require consumers of the steam or hot water produced. Such operations may have difficulty locating adjacent to a large energy user with year round steam demand. A heating district with several interconnected small users could provide a good market for steam from the resource recovery proposal. Districts can also be formed simply so that a few firms with large underutilized boilers can be operated at full capacity efficiency, shipping the surplus heat to adjacent operations in the district.

District heating itself is not a new idea to the United States. An extensive operation run by Consolidated Edison exists in New York City. At the turn of the century even Providence had a small system. Practical experience is much broader in Europe where nations such as Sweden actively encourage the development and expansion of such systems, including heating of homes and apartment buildings. Active planning efforts exist in several U.S. cities aided by the Department of Housing and Urban Development. A nearby example is Lowell, Massachusetts where a large solid waste energy recovery plant is being linked to a heating district, with active encouragement by local public officials. Expansion plans include several unconnected firms and a proposal to supply heat to the numerous triple decker apartment buildings. A radius of one half mile is considered the economical extent of a steam distribution network. Hot water can be sent much farther. In addition to technical feasibility and private sector involvement, district heating depends on the consistent support of public officials to overcome the barrier of inertia which can impede securing the cooperation of potential participants.

In Rhode Island, industrial or institutional facilities which already are served by a district heating system are good candidates for fuel switching, since demand is likely to be large enough to justify capital investments. In addition clusters of industrial or institutional energy consumers which desire lower or stable energy costs provide potential locations for building new district heating systems combined with a central furnace/boiler using a lower cost fuel.

3. CASE STUDIES OF OPPORTUNITIES FOR SITING FACILITIES WHICH REDUCE ENERGY COSTS TO USERS

Two case studies are presented here as examples of the technical, financial and organizational issues involved in the establishment of cost saving energy facilities. The first is the Aquineck Island Resource Recovery Plant, which is a typical example of a medium sized waste-to-energy facility service an existing district heating system. The second case study examines the potential linkage of cogeneration at Quonset/ Davisville and Aquineck Island Resource Recovery to the need for additional capability by the Newport Electric Company.

AQUIDNECK ISLAND RESOURCE RECOVERY

In FY 1980 the U.S. Navy in Newport spent over $6-million for steam. Purchasing steam derived from the Aquidneck Island communities' garbage could save the Navy about $350-thousand per year at current prices. Obtaining steam from garbage rather than petroleum also would provide a service to the island communities by reducing their future disposal costs and, in addition, could provide capacity-shy Newport Electric Co. with an additional 500 kw of generating capacity if a cogeneration system were employed.

<u>The Steam Customer - U.S. Navy</u>

The U.S. Navy installation currently burns over 156-thousand barrels of oil annually to make steam. There are two operating steam plants on the 1,000-acre USN installation, one at Coddington Cove (COVE) and one at Coasters Harbor Island (CHI). The larger plant, CHI, has four boilers and can produce steam at the rate of 300-thousand pounds per hour. The other, COVE, has two of three boilers operating and can produce 150-thousand pounds per hour. On an annual basis 645-million pounds of steam are generated at these plants and 450-million pounds utilized by the facilities. The consumption of electricity is approximately 70-million kwh per year and it is purchased from Newport Electric Co. The Navy makes up about 18 percent of Newport Electric's system load. The additional four frigates proposed for the facility will expand operations by 10-15 percent, according to the projected increases in personnel, boil fuel, electricity and waste generation. Future growth in the Navy presence could boost this demand even higher.

The Fuel Suppliers-Aquidneck Island Communities

The 1980 population of Aquidneck Island was about 60,800. The population and its waste generation can be broken down as follows:

	1980 Population	Waste Tons/Year
Newport	29,266	32,809
Middletown	17,251	7,744
Portsmouth	14,256	6,620
Total	60,773	47,173

The relatively large per capita production of waste by Newport is due to the inclusion of commercial, institutional and light industrial waste, in the landfill figures. The garbage collected by haulers in Portsmouth and Middletown is taken to the Portsmouth Transfer Station, which is owned by the town, where it is compacted and loaded onto large trucks for hauling to the state landfill in Johnston, the old Silvestri landfill. The garbage collected by haulers in Newport is taken to the Newport Transfer Station, which is privately owned, for preparation and hauling to the state landfill in Johnston, an 88-mile round trip.

The costs of refuse collection and disposal are quite large. For Newport alone in the year ending April 1982 refuse collection costs $421-thousand, or over $13 per ton. In the same time period refuse disposal cost $590-thousand, or over $18 per ton. This latter figure includes the state tipping fee of $4.50 per ton at Johnston, as well as transportation and transfer station costs. So transfer and haul alone would be over $13.50 per ton from Newport to Johnston. The transfer and haul costs for the other two towns is estimated to be comparable with Portsmouth somewhat less and Middletown more.

The towns have been informed by the R.I. Solid Waste Management Corporation (RISWMC) that a central facility is planned for the processing and energy recovery of 1500 tons per day, and it will be located at the Johnston landfill. The towns should expect to pay $15 per ton as a tipping fee in the first year of operation. As pointed out above, the present Newport disposal fee of $18 per ton includes $4.50 for tipping and $13.50 for transfer and haul. With the operating of the proposed Johnston plant, Newport faces a future disposal fee of over $28.50 per ton. The disposal fee added to the collection fee yields a future total waste disposal of over $42 per ton.

Considering these costs a regional facility in Newport to process Aquidneck garbage charging the same tipping fee, namely $15 per ton, would be of value to the towns because of the savings in transportation costs between Aquidneck and Johnston. It appears that these transportation costs are $4-5 per ton. Additional savings may be realized by analyzing the necessity of continuing the operation of the Newport and Portsmouth Transfer Stations. In any case, the transportation costs associated with the trip (44 miles one way) to the state landfill provide a savings opportunity in considering a local small scale plant.

Table 5 shows the "per day" monthly waste tonnage from the Aquidneck communities; the tonnage converted to steam; and a comparison of waste derived steam and steam demand by the Navy installation. On an annual basis the waste derived steam could provide about 35 percent of the Navy demand, or 230-million pounds of the 645-million produced. The supply-demand match is a good one. Even in the peak waste production month of August, steam from waste would provide two-thirds of the Navy steam demand, when at its lowest level. So the Navy could take all the steam the plant produces.

There will have to be some incentive for the Navy to plan a long term commitment for waste derived steam. In most cases the steam customer signs on to obtain a discount from petroleum derived steam. For the sake of this discussion we can assume a 15 percent discount from the $10 per thousand pounds that is presently being paid by the Navy. This $1.50 per thousand pounds when multiplied by the 230-million pounds of steam which could be produced by the resource recovery plant, results in a $345-thousand per year energy savings for the Navy.

Project Costs Estimates

The following facility cost data are based on a 200 ton per day plant in Portsmouth, New Hampshire. The costs have been escalated 19 percent to cover inflation between May 1980 and June 1982. The annual rates used in this escalation are 1980 - 10 1/2 percent; 1981 - 8 percent; and 1982 - 6 percent. The waste flow for the three towns of Aquidneck Island range from 171 TPD in August to 102 TPD in February, and average 147 TPD on an annual basis. Therefore the assumption of a 200 TPD plant implies a redundancy of 36 percent for this project, and are allowance for expansion.

TABLE 5
Aquidneck Resource Recovery

	Monthly Landfill ÷ 26 Tons/Day (6 day week 4 1/3 week mo.)							
	78-80 Newp.	79-80 Ports. & Middl.	Daily Total 3 Towns	Daily # steam (5000#/ton)	Hourly (÷ 24) # steam	Hourly (+ 1b) # steam	M & W 10^6 lb Monthly # steam	Exported U.S. Navy 10^6 lb Monthly # steam
Jan	79	40	119	595,000	24,800	37,200	15.47	79.7
Feb	67	35	102	510,000	21,300	31,900	13.26	89.7
Mar	104	41	145	725,000	30,200	45,300	18.85	56.6
Apr	106	44	150	750,000	31,300	46,900	19.50	53.8
May	112	52	164	820,000	34,200	51,300	21.32	45.1
Jun	112	52	164	820,000	34,200	51,300	21.32	39.2
Jul	114	53	167	835,000	34,800	52,200	21.71	33.8
Aug	118	53	171	855,000	35,600	53,400	22.23	32.7
Sep	108	49	157	785,000	32,700	49,100	20.41	35.5
Oct	99	46	145	725,000	30,200	45,300	18.85	48.6
Nov	100	44	144	720,000	30,000	45,000	18.72	66.4
Dec	95	42	137	685,000	28,500	42,800	17.81	65.0
							229.45	645.1
							35 1/2%	

Capital Cost Estimates - 200 TPD

Furnaces	$1,935,765
Boilers (2)	1,361,401
Ash Removal Eq	211,445
Baghouse	412,335
Feedwater Treatment	178,500
Scale and Appurtenances	43,296
Building & Site*	2,184,840
Total Hardware	$6,327,586

*Building: 34,000 square feet @ 53.55/ft^2 including process electrical mechanical and structural = $1,820,700

site: at 20% of building = $364,140

An additional 15 percent might be budgeted for contingencies and 10 percent for legal, organizational and management cost during construction, so that total direct costs for a 200 TPD plant may be $7,910,000 or almost $40,000 per TPD in 1982-dollars. Financing costs can add an additional 30 percent to installed capital costs so that the 200 TPD project can total $10.3-million.

Annual Expenses and Revenues

The annual expenses incurred by the facility are obtained by adding operation and maintenance costs and the debt service payments. The annual revenues come from energy and material sales, interest earnings on funds set aside for bond obligations, and from tipping fees, charged for dumping at the plant.

Operating and Maintenance Expenses - 200 TPD: An estimate of $20 per ton can be used to calculate operating and maintenance costs on an annual basis in 1982 dollars, so for a plant that processes 47-thousand tons per year, O & M would be $940-thousand.

The Labor Cost segment of O & M for this size plant can be broken down as follows:

	200 TPD (24/day - 7 day/wk)
1 Manager	$ 25,400 per year
5 Foremen	103,900
5 Primary Operators	92,400
5 Secondary Operators	80,800
2 Mechanics	36,900
1 Scale Operator/Secretary	13,800
Labor	$353,200
+ 25% Fringe	88,300
Total Labor	$441,500

In addition to the labor charges, conventional fuel charges, residue hauling and disposal costs, local taxes must be included in the O & M calculations

In plant electricity consumption is approximately 25 kwh per ton of waste processed. Fuel oil or gas for secondary chamber ignition averages 1.8 gallons per ton processed, and fuel for the tractors and trucks averages 0.3 gallons per ton. Costs of these items are estimated as follows:

- electricity: 25 kwh/ton *0.08/kwh *47000 tons = $94,000
- fuel oil: 2.1 gals/ton *$1.00/gal * 47000 tons = $98,700
- ash residne haul and disposal: Ash is 30% of raw

  .3 * 47000 tons * $13/ton = $183,300
- payment in lieu of taxes ($0.5/ton)

  $0.5/ton * 47000 tons = 24,000

  $400,000
- management, supplies and miscellaneous 100,000

  $500,000

On the assumptions that the plant would not be operational until 1984, the O & M expenses can be escalated at 6 percent per year, so that instead of $20 per ton will be initially $22.50 per tone of waste processed.

Debt Service Expenses: The estimated installed capital cost of the 200 TPD plant is $10-million. For the sake of this discussion it is assumed that the private sector has become involved in the financing of the project. A 25-75 percent equity debt split is a likely situation. Therefore $2.5-million is the equity contribution. A revenue bond issue of 15 year term at 15 percent is assumed as the debt. A bond issue if $11.6-million is required to provide adequate net funds to the project.

The annual debt service expense, including payments of interest and principal, total approximately $2-million, or $42 per ton of waste processed.

Energy Revenues: The plant will be assumed to be designed to produce both steam and electricity. The 47,000 tons of waste can be converted to steam at the rate of 4300 pounds of steam per ton of waste. Assuming a 10 percent loss then 181,890,000 pounds of steam are produced each year.

The customer, the U.S. Navy, is presently (1982) paying a little over $10 per thousand pounds for steam. As mentioned previously a discount of 15 percent means steam from the resource recovery plant is sold at $8.50 per thousand pounds in today's market to the U.S. Navy. This price becomes $9.91 in 1984 if escalated at 8 percent, or $38.40 per ton of waste.

Before being piped to the U.S. Navy, the steam will be sent through a back pressure turbine and electricity generated for sale to Newport Electric Company. At an actual water rate of 65 pounds per kilowatt hour, some 2.8 x 10^6 kwh can be generated from the steam produced. Pricing the electricity at 6-cents (1982) and escalating this rate at 8 percent produces revenues of $196-thousand in 1984, or $4.15 per ton of waste.

Total energy revenues, starting in 1984, are estimated to be $42.55 per ton of waste processed.

Other Income: It is expected that there will be a requirement for one year's debt service funds to be held in reserve. This type of requirement is often insisted upon by bond counsel to reduce the risk to the bondholder. The debt reserve fund is assumed to be invested at 14 percent and, if untouched, will provide an annual investment income plus provide the final year's debt payment. The $2-million in reserve will provide $280-thousand in income, or $5.95 per ton of waste processed.

Tipping Fee Revenues: Revenues from tipping fees can be calculated as the residual income needed to balance the previously discussed expenses and revenues. The estimated revenues totaled $48.50 per ton, with $42.55 from steam and electricity and $5.95 from interest income. The estimated expenses were $64.50 per ton, with $22.50 from O & M and $42 from Debt Service. Therefore $16 per ton is the required tipping fee in 1984 ($48.50 plus $16 equals $64.50). If it is assumed that the tipping fee escalates at the same rate as O & M expenses, namely 6 percent, then in 1982 dollars the tipping fee is $14.25 per ton of waste processed.

AN INTEGRATED COGENERATION/DISTRICT HEATING/LOW COST FUEL SYSTEM

The Aquidneck Island Resource Recovery proposal could serve as one element of an integrated plan for supplying Newport Electric with additional baseload capacity which it will soon need. Steam users at the Newport Naval Base and Quonset Point/Davisville could be supplied by lower cost fuel, including solid waste energy recovery at Newport and both coal conversion and a similar solid waste plant at Quonset Point. Surplus steam would be used to generate electricity for yet another energy purchaser, Newport

Quonset Industrial Park

The 800-acre facility has been flagged as the prime industrial park in the state. Governor Joseph Garrahy has personally singled it out to receive prime focus for rehabilitation and development. Presently it houses the largest employer of Rhode Islanders namely the Electric Boat Division of General Dynamics Corporation. At this plant, employing over 5,000, the hull sections of the Trident submarine are fabricated.

The steam plant at Quonset was built in 1942 by the U.S. Navy. It was designed as a cogeneration district heating system and supplies steam through many miles of pipe embedded in concrete to various parts of the facility. The original steam plan was equipped with four (4) Combustion Engineering boilers each rated at 90,000 pounds of steam per hour at 390 p.s.i.g. Associated with these four boilers were two (2) KVA (2500 KW) Westinghouse backpressure turbine generators. In 1955 the U.S. Navy added a fifth boiler, a Riley-Stoker rated at 165,000 pounds of steam per hour. Site preparation had been carried out to expand the electrical generation capability also. All five boilers were designed to burn oil or pulverized coal, although presently oil is being used. At present (the C.E. boilers were derated to 65,000 pounds) the boilers are capable of producing over 400-thousand pounds of steam an hour; however, today's actual production averages about 10 percent of that capability on an annual basis. Peak production (January and February) is about three times this average. The two generators of 5MW capacity total lie idle, and electricity at the facility is purchased from Narragansett Electric Co.

The largest steam customer at the facility is Electric Boat, consuming 80-85 percent of that produced by the plant. The price paid for steam by the state's largest private employer at the state's prime industrial park is over thirteen dollars per one thousand pounds of steam (over $13 per 1000 lbs. steam) is higher than that paid at the Newport Naval Base. Table 6 shows the monthly energy consumption by fuel type at Electric Boat for a recent year. The following table converts the annual energy consumption to a common denominator, barrels of oil.

Fuel	Annual Amount	Conversion to BTU	BTU
Electricity	53.0×10^6 KWH	10,500 BTU per KWH	556.5×10^9
Steam	221.8×10^6 lbs.	1,300 BTU per lb.	288.3×10^9
Distillate	10.5×10^9 BTU	---	10.5×10^9
Propane	7.2×10^9 BTU	---	7.2×10^9
			862.5×10^9

862.5×10^9 BTU at 6×10^6 BTU per Barrel = 144,000 barrels of oil/year

At the present time serious consideration is being given to evaluating the feasibility of converting the steam plant to coal, to upgrading the steam distribution system, and to incorporating the cogeneration of electricity at the upgraded plant. The Governor's intent is to offer discounted steam and electricity to clients at the Quonset facility thereby lowering their energy costs.

Newport Electric Company

The Newport Electric Co. has foreseen a capacity shortage in the near term. According to a Stone and Webster report done for them it was recommended that they seek 15-20 MW by 1985-6 to accommodate increased demand in their service area.

Efforts are underway by the Energy Coordinating Council to arrange for hydroelectric power from the Power Authority of the State of New York (PASNY)

TABLE 6

1979 ELECTRIC BOAT-QUONSET ENERGY CONSUMPTION

Month	Electricity	Steam	Distillate	Propane
January	5.0×10^6 KWH	47.3×10^6 lbs.	1.1×10^9 BTU	0.6×10^9 BTU
February	4.5	44.0	1.0	0.6
March	4.5	40.3	1.0	0.5
April	5.1	22.9	1.0	0.5
May	4.2	6.6	0.8	0.5
June	4.3	3.5	0.7	0.4
July	4.2	2.7	0.7	0.6
August	3.7	2.9	0.8	0.6
September	3.7	2.9	0.8	0.8
October	4.6	3.8	0.8	1.0
November	4.0	14.5	0.8	0.8
December	5.2	30.4	1.0	0.3
YEAR TOTAL	53.0×10^6 KWH	221.8×10^6 lbs.	10.5×10^9 BTU	7.2×10^9 BTU
Monthly Avg.	4.4×10^6 KWH	18.5×10^6 lbs.	0.9×10^9 BTU	0.6×10^9 BTU

at Niagara and St. Lawrence to be imported to Rhode Island as a "neighboring state." The capacity to be made available apparently is 8 MW. This 8 MW is planned for Newport Electric Co., and will therefore provide part of their estimated needs for 1985-6.

During mid-March 1982 the Public Service Company of New Hampshire announced that Newport Electric had "experssed an interest" in buying into Seabrook I nuclear plant. It was determined by conversations with the company that they were seeking an additional 5 MW of capacity from the Seabrook Plant. this additional capacity was expected to cost approximately $10 million.

With the 8 MW from PASNY and 5 MW from Seabrook, Newport Electric would attain its 1985-6 recommended capacity. At present Newport Electric's peak is approximately 85 MW and its base load is 35 MW. Although Newport has some peaking units, its bulk power is purchased from Eastern Utilities Associates (EUA) the parent of Blackstone Valley and Montaup Electric. EUA has filed for registration with the S.E.C. for a public offering of 900-thousand shares of stock, to be handled by Kidder Peabody and Blyth Eastman Paine Webber. The funds are intended for a $50 million coal conversion project at Montaup and for the rehabilitation of a hydroelectric facility in Pawtucket.

Aquidneck Island Resource Recovery

As pointed out previously the Aquidneck Island Resource Recovery Plant would produce an average of 735-thousand pounds of steam per day (147 tons x 5,000 lbs. steam per ton). If the U.S. Navy is the steam customer they plan to accept steam at 165 p.s.i.g. into their distribution system. Therefore the resource recovery plant would be designed to produce steam at that pressure. The cogeneration of electricity and steam implies higher initial steam pressures. The higher pressure steam passes thru the turbine-generator system, producing electricity, then is exhausted at the steam customers desired pressures. The higher the initial, or inlet, pressure and the lower the exhaust pressure, the more energy is available to turn the turbine. Planning for higher pressures, of 400 to 500 p.s.i.g., early in the process adds relatively little to the overall cost of the resource recovery plant. Then the addition of a backpressure turbine set to the system adds perhaps 5 percent to the overall cost. The output from such a system would be approximately 500 KW, or 0.5 MW, and could be added to Newport Electric Co. capacity.

Integrating the System Elements

These three projects can be viewed as elements of a complete energy producing and consuming system. This integrated view may lead to benefits for two significant companies in the state, as well as enhance the progress towards a full development of Quonset Industrial Park, and enhance steps towards resource recovery in the state.

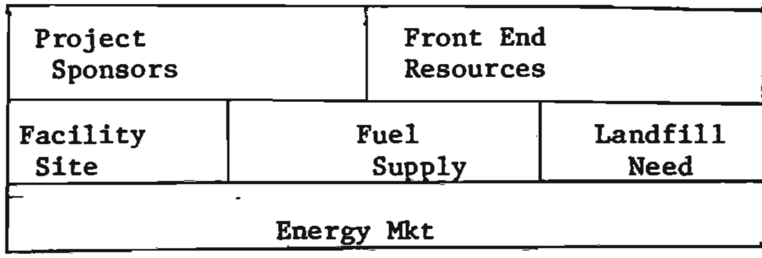
At present Electric Boat is the prime consumer of steam and electricity at Quonset. According to the preceding table they average 4-5 million kilowatt hours a month. Dividing their monthly consumption by the hours in a month indicates their average capacity requirements, namely 700 KW. Their peak capacity requirement is unknown at present, but may be of the order of 1 MW or more.

As mentioned previously there are two (2) 2500 KW backpressure turbine-generators lying idle at Quonset. This 5 MW of capacity was on-line in the past and will be evaluated by the study of the Governor's Office. At the present time 1 MW can be reserved for Electric Boat requirements. This indicates that 4 MW of capacity are not presently required at Quonset. This 4 MW is of no interest to Narragansett Electric, whose service area includes Quonset, because they presently have surplus capacity, having turned down an offer to take over the Quonset Plant.

In the previous section it was pointed out that Newport Electric Co. is seeking 15-20 MW by 1985-6, and that 8 MW may be supplied by PASNY. Since Newport Electric has expressed interest in 5 MW from Seabrook I, rather than the remaining 7-12 MW, it is reasonable to assume their approach to demand growth is somewhat more conservative than the Stone and Webster projection. It is clear that the 4 MW at Quonset could supply 80 percent of Newport Electric current estimate of needed capacity. Newport Electric's needs could be considered in the present day planning at Quonset. The 4 MW of power if it were theirs could be "wheeled" through the Narragansett Electric service area to Newport, or perhaps sent by cable across the head of West Passage to Conanicut Point on Jamestown Island, part of Newport Electric's service area. If and when the Quonset Industrial Park requires the additional capacity this could be met by expanding capacity at Quonset, provided this expansion potential is included in the planning process now underway. Of additional interest is the observation that General Dynamics owns coal resources in Virginia, which may be of consideration in the coal conversion planning for Quonset. Thus two Rhode Island companies could benefit from this suggested expansion in planning for the future of Quonset.

Project Building Blocks-Making It Happen

Underlying the development of any successful integrated energy facility project are six building blocks, all of which must be present to insure viability. Assembling the building blocks can be a very delicate process.



The most basic components are; one, an assured source of fuel. The solid waste flow, for example, must be guaranteed; two, an assured site for the facility within a reasonable distance of the energy customer, because steam cannot be transported great distances; and, three, an assured market or customer for the steam. But to carry out the organizing and negotiating processes necessary to the three basic components there must exist an entity termed project sponsor, or the driving force behind the project. The sponsors must have at their disposal the required front-end resources to cover the costs of feasibility studies, permits, procurement efforts, etc.

Energy Market: This is probably the single most important element in determining whether a project will succeed. A market for the recovered energy product--steam, electricity, or both--must be identified and then contractually committed. The earlier this commitment can be obtained the better. In the case of Aquidneck Island, meetings have been held with the U.S. Navy as the potential steam customer, and they have shown a mild interest. Meetings have also been held with Newport Electric and they have expressed interest in the project in general and the possibility of 500 KW of capacity from cogeneration, in particular. However, no firm commitments exist as of November 1982.

Facility Site: Obtaining a site on which to build the facility is a critical project component. The difficulties in obtaining a site within a reasonable distance of the market often are not fully appreciated. This component was not secured by the R.I. Solid Waste Management Corp. so that it was driven from Cranston to Warwick to Johnston. The last site was secure but had no steam customer thereby forcing the plant to produce only electricity via condensing turbines. In the case of Aquidneck Island the Navy has space but has reservations about permitting a plant on the land.

Fuel Supply: A resource recovery project should be viewed as any other product manufacturing enterprise. A critical element is the raw material for the plant, in this case solid waste. Coal or coal-oil mixture must be readily available if those fuels are to be utilized. As with any business enterprise it is essential to know how much of the raw material is available for processing. This means determining the quantity and quality of solid waste available through documented weighing programs and then obtaining long-term commitments for the delivery of the waste to the plant site. In the case of the Aquidneck Island project landfill weighing records have been analyzed over a two-year period from the standpoint of tons per month from each of the towns. The quality of the waste has not been sampled but is assumed to be within the normal range of municipal waste.

Landfill for Residue and Backup: Implementing a waste-to-energy project does not eliminate the need for a landfill. About 30 percent of the weight and 10 percent of the volume of input to the plant will leave as ash or residue which requires landfilling. Landfill capacity also is required for periods when the system is down for scheduled or unscheduled maintenance. In the case of the Aquidneck project the Johnston landfill owned by the State is the ultimate site, however, being over forty miles away makes transportation costs high.

Project Sponsor: There is a need for an individual or agency to accept responsibility for developing and implementing the project. There must be a single committed coordinator to keep the development process moving.

Depending on the ownership and financing approach of a particular project, the coordinating role may be played by an industry, system vendor, municipality, or special authority. In all cases, without such a sponsor, the inevitable technical pitfalls and institutional barriers will unnecessarily delay or terminate the project. In the case of the Aquidneck project the project sponsor is not decided. It could be the private sector or a municipality but will not be the special authority, the RISWMC, as might be expected. The Rhode Island Port Authority would sponsor any development at Quonset Point/Davisville.

Front-End Resources: Often difficult to muster are the financial resources needed to initiate the project, before the contractural commitments have been obtained and financing secured. Nevertheless front-end money for in-house staff and consultants are both critical to a project's ultimate success. In the case of Aquidneck Island front-end money has not been arranged as of November 1982. Ways of raising it are being investigated and some expenditures are being made on an individual basis from institutional overhead. The Rhode Island Port Authority would be responsible for securing planning funds for any development at Quonset Point/Davisville. Other interests such as Newport Electric, The Solid Waste Management Corporation or municipalities might also be expected to participate.

4. The Location of Clusters of Major Industrial Energy Users in Rhode Island

INTRODUCTION

Industry accounts for 31 percent of the work force and 18.8 percent of energy use in Rhode Island. The estimate in Chapter 1 showed that only 257 firms probably account for two thirds of the total used in the industrial sector. Throughout the nation a number of innovative techniques are being employed or are under study to help industry reduce energy costs as a component of the cost of manufacturing products. These include a combination of conservation, fuel switching, including alternative fuels, cogeneration of steam and electricity, and district heating. In Rhode Island, 34 firms which are still in operation were reported to be major users of No. 6 heavy boiler fuel in 1979. This type of fuel use is generally viewed as being potential for retrofitting to a coal-oil mixture or an alternative fuel such as solid waste. At the very least, they could be considered potential candidates for purchasing steam from an energy recovery facility. Several of the firms using large amounts of residual fuel oil are located within clusters of other major industrial firms in the state. These clusters would be potential locations for efforts by industrial energy consumers to construct innovative energy facilities.

GEOGRAPHIC DISTRIBUTION OF INDUSTRIAL FIRMS

Firms with 100 or more employees were identified using the Rhode Island Directory of Manufacturers and their location mapped on U.S.G.S. quadrangle sheets. A total of 310 industrial facilities were included. The distribution of firms and total employment in each community is shown in Table 7. About 75 percent of the industrial work force is included in these companies.

TABLE 7

Distribution of Firms of 100 or More Employees, by Municipality

Municipality	Number of Firms	Total Employment in Firms
Barrington	1	190
Bristol	4	910
Central Falls	10	3443
Coventry	3	1000
Cumberland	7	1499
Cranston	21	7360
East Greenwich	3	1780
Exeter	1	100
East Providence	19	6333
Hopkington	2	275
Johnston	6	935
Lincoln	12	3423
Middletown	1	250
Narragansett	1	150
North Kingstown	3	7100
North Providence	5	1375
North Smithfield	5	1950
Pawtucket	44	11137
Portsmouth	3	2575
Providence	82	20018
Richmond	2	598
Scituate	1	325
Smithfield	5	1030
South Kingstown	1	120
Warren	7	3013
Warwick	22	8211
Westerly	6	1207
West Warwick	12	3115
Woonsocket	21	4518
	310	93940

Using the criteria that steam can be piped economically with a zone having a radius of about .5 miles, clusters of firms with this characteristic were located and mapped. This yielded 10 clusters which contained 1000 or more employees, as listed in Table 8 and shown in Figure 5. These clusters represent about 25 per cent of the state's total employment in manufacturing, but only two per cent of the total number of firms. The largest cluster is Quonset Point/Davisville. Three of the remaining nine are in Providence. Cluster 2 is very close to the two power plants operated by Narragansett Electric, as well as Rhode Island Hospital and other large office buildings. All but one of the clusters is the locus of a facility using residual (number 6) oil.

ENERGY USE IN INDUSTRIAL CLUSTERS

Estimates were made of the energy use in each industrial cluster in order to determine the upper boundary of the market for district steam or hot water, cogeneration or alternative fuels. The first approach taken was to use energy use per employee coefficients for the firms in various two digit Standard Industrial Classifications (SICs). This yielded the results shown in Table 9 for the five largest industrial clusters. The total of 3.0 trillion BTUs represents 8 per cent of the 1979 Rhode Island industrial energy use of 37.5 trillion BTUs reported by the federal Department of Energy. It was consumed by only 1.6 per cent of the total number of firms.

By way of comparison, a district steam plant fired by refuse derived fuel is slated for construction in Lowell Massachusetts. It will consume about 2.9 trillion BTUs of refuse fuel per year and its total steam output for sale will amount to 1.5 trillion BTUs,based on an 850 ton per day rate of fuel use. A total demand for the steam has been determined to be .700 trillion BTUs, including .029 trillion already on line, two more firms with commitments to use .220 trillion, and a potential market of .458 trillion

TABLE 8

Major Industrial Clusters (Firms located within a circle of .5 mile radius)

LOCATION	NUMBER OF FIRMS	EMPLOYMENT
1. Quonset Point/ Davisville	1	± 5000
2. I-95/I-195 (Prov.)	12	4787
3. Huntington Park (Prov.)	15	4095
4. Hillsgrove (Warwick)	10	3823
5. Pawtucket/Central Falls	9	3140
6. Warren	7	3013
7. Woonsocket	10	2884
8. Pawtucket	4	2653
9. Atwells Ave./Broadway (Prov.)	6	1900
10. State Airport (Lincoln)	7	1338
	81	32633

FIGURE 5
Location of Large Clusters of Industry, 1000 or More Employees
See Table 8

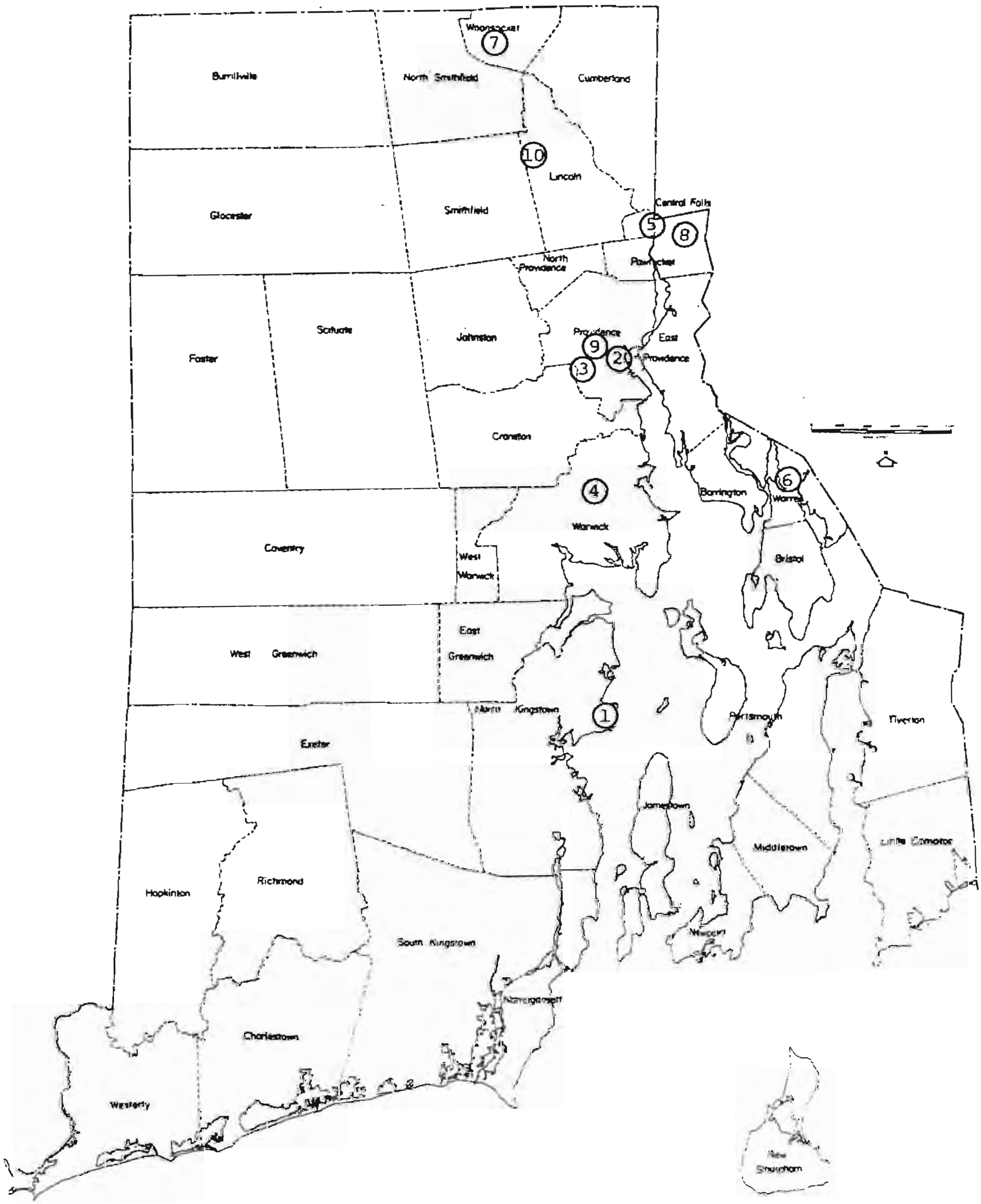


TABLE 9

Estimated Energy Use in Industrial Clusters Based on National Energy Use Coefficients and Employment Levels

	Number of Firms	Total Estimated Energy Use (10^{12} BTUs)
1. I95/I195 Interchange (Providence)	13	.889
2. Huntington Park (Providence)	15	.390
3. Hillsgrove (Warwick)	10	.826
4. Pawtucket/Central Falls	9	.462
5. Warren	7	.429
	54	3.012

BTUs. The remaining steam, about .800 trillion, would be used to generate electricity.

The estimates of energy use in the five major industrial clusters (Table 7) tentatively suggest that one or more of these areas might be a likely site for a district heating, cogeneration, or fuel switching proposal designed to reduce costs for industrial firms. In order to determine whether the basic approach taken to identify potential sites for an innovative energy facility development was realistic a survey form was sent to all firms in the three largest clusters listed in Table 9. The results of the survey are shown in Table 10.

Overall, Rhode Island firms are using less than half as much energy per employee as the national average of two digit SIC firms. Of the 14 firms responding, it was expected that total energy use would be 1.097 trillion BTUs, but in fact energy use was only .428 trillion BTUs. As Table 8 shows, wide discrepancies exist in some classifications, such as SIC 26, paper products, reflecting the diverse activities which can be placed in a two digit SIC. Other local industry groups, such as SICs 27,28,34,36 and 39 match more closely the national average. The five jewelry firms (SIC 39) varied widely in ther energy use per employee, but the average of the group, 71.5 million BTUs per worker, matched the national value of 93.6 million BTUs surprisingly well. The approach taken to identify the clusters can therefore be viewed on the whole as reasonable, supplying energy use estimates accurate within a factor of two, with energy use consistently being overestimated when national factors are applied. Further examination of the feasibility of district heating, fuel switching and cogeneration in these clusters is certainly warranted.

TABLE 10

INDUSTRIAL ENERGY USE SURVEY

CLUSTER#, FIRM CODE	SIC	National per employee energy use,	Actual per employee	TOTAL esti-mated	TOTAL actual
		millions BTUs		trillions BTUs	
2. I-95/I-195 Interchange					
a.	26	1731.9	21.7	.173	.002
b.*	22	455	172.4+	.273	.103+
c.	38	114.8	12.1	.144	.015
3. Huntington Park					
a.	39	93.6	123.2	.037	.036
b.	39	93.6	42.1	.011	.005
c.	27	71.6	67.0	.008	.008
d.	39	93.6	5.2	.023	.001
e.*	39	93.6	94.0+	.074	.075+
f.	39	93.6	25.9	.023	.006
4. Hillsgrove					
a.	36	102.3	16.5	.076	.012
b.	34	193.2	156.0	.009	.007
c.	25	117.6	58.0	.058	.029
d.*	36	102.3	74.3+	.165	.120
e.	24	-	51.4	-	.002
				1.097	.428

*includes just Number 6 oil use
from a 1979 state survey

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