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ABSTRACT

High and wasteful energy consumption practices have become a part of the American life style. The United States, with six percent of the world's population, is responsible for 33 percent of the world's energy consumption. Americans are now faced with shortages of primary fuels, especially natural gas and oil, and with stringency of electric power capacity. To utilize energy in New York State more efficiently, a vigorous program of energy conservation should be pursued. In particular, the people of the State should be convinced that conserving energy is their responsibility. In the interest of educating energy consumers as to what they can do and how the energy utilization of appliances and recommends the apparatus to be used and some steps to be taken to improve energy utilizaticn. (Pages 149-150 may reproduce poorly.) (Author)

Report

of

Ad Hoc Committee on

Appliance and Apparatus Efficiency

to the

Interdepartmental Fuel and Energy Committee

of the

State of New York

June 25, 1973

Acknowledgement

The Chairman of the *Ad Hoc* Committee on Appliance and Apparatus Efficiency wishes to express his appreciation to the Committee members and their sponsoring agencies for their time and resources. The Chairman also wishes to extend his appreciation to Mr. Joseph E. Rizzuto, Co-Chairman of the *Ad Hoc* Committee, and Miss Agnes M. Stiffen, Secretary of the *Ad Hoc* Committee, whose extraordinary efforts resulted in the enclosed presentation.

PARKER D. MATHUSA
Chairman, *Ad Hoc* Committee On
Appliance & Apparatus Efficiency

Preface

This report summarizes the results of a study performed by the *Ad Hoc* Committee on Appliance and Apparatus Efficiency. The *Ad Hoc* Committee, which includes representatives of State agencies, architects, builders, engineers, trade associations and labor unions, was established by the Hon. Joseph C. Swidler, Chairman of the New York State Interdepartmental Fuel and Energy Committee. The objective of the *Ad Hoc* Committee was to provide assistance in meeting the energy dilemma by proposing plans and recommendations for improving the efficiency of household appliances and industrial apparatus.

The *Ad Hoc* Committee had its opening meeting on September 13, 1972, and has met ten times at two week intervals. A wealth of information has been generated or assimilated by the Committee, and the highlights of this information have been included in this report. This report also contains conclusions and recommendations. In some cases these recommendations have been made by the Staff of the New York State Public Service Commission based on information provided by the Committee. Therefore, these recommendations do not necessarily reflect the position of every member of the Committee.

Members of the *Ad Hoc* Committee representing or associated with trade associations served solely as sources of information and took no part in the formulation of conclusions and recommendations as contained in this report.

PARKER D. MATHUSA
Chairman, *Ad Hoc* Committee On
Appliance & Apparatus Efficiency

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Summary and Recommendations

This report represents the work of the Ad Hoc Committee on Appliance and Apparatus Efficiency. The report deals with the energy utilization of appliances and apparatus and steps that can be taken to improve this utilization.

High and wasteful energy consumption practices have become a part of the American life style. The United States with six percent of the world's population is responsible for 33 percent of the world's energy consumption. We are now faced with shortages of primary fuels especially natural gas and oil and with stringency of electric power capacity.

The efficient use of energy in New York State will only be achieved if we pursue a vigorous program in energy conservation. The people must be convinced that an energy crisis exists and that conserving energy is their responsibility. The consumers of energy must then be educated as to what they can do and how they can contribute to promoting energy conservation.

More efficient appliances in general cost more money. In many cases this higher initial cost is eventually recovered in the form of lower annual operating costs. Many appliances however are purchased by builders and landlords who are only interested in the initial cost of an appliance because the operating cost of the appliance will become the responsibility of the homeowner or tenant. Consumers have always focused their attention on lowest initial cost and a major reorientation of their purchasing habits would be required to promote the purchase of appliances based on total initial and operating costs.

1. Labeling of appliances and apparatus with respect to performance is desirable from the standpoint of promoting increased appliance efficiency since it would inspire manufacturers to engineer a product with the maximum reasonable efficiency within the limitations of maintaining safety, durability and a competitiveness. The appliance industry should be encouraged to define a performance factor for all major energy consumptive appliances and apparatus as has been done for air conditioners.

The problem with improving the efficiency of appliances and apparatus is not that manufacturers lack the knowledge or capability to do so but the appliance manufacturers are governed by the economics of competition in the market place. The manufacturer responds to the purchasing practices of the consumer.

Particular emphasis should be placed on establishing a performance factor for refrigerators, refrigerator-freezers and food freezers since this appliance group is responsible for over 25 percent of residential energy consumption in New York State.

It is also recommended that certification of performance factors be accomplished by independent testing agencies and that comparative appliance data be published. Industry's cooperation on a voluntary basis should be solicited.

2. This committee recommends that all New York governmental agencies at both the State and local levels, including authorities and other quasi-governmental units, take the lead in placing increased emphasis on energy efficiency in the purchase of appliances and apparatus. In order to meet this end, it is recommended that the Governor issue a proclamation requesting all public purchasing officials to review their specifications and purchasing practices for appliances and apparatus which consume a significant quantity of energy. Energy efficiency requirements for this equipment should be added or, if existing, re-evaluated taking into consideration the present importance of conserving energy in New York State.

3. A well planned intense energy conservation program is required in order to change the present inefficient and wasteful energy consumption practices in New York State.

The committee suggests the establishment of a central organization to perform the following duties:

Coordinate activities of State agencies and private industry that are performing energy related functions.

Advise and make recommendations to State agencies, corporations and authorities that have regulatory powers affecting the consumption of energy.

Undertake activities to encourage business and industry to maintain high standards and public responsibility in all affairs involving the consumption of energy.

Conduct studies and analyze matters affecting the consumption of energy.

Recommend to the Governor new laws and amendments to laws affecting the consumption of energy.

Collect and disseminate to local community organizations and the general public data regarding energy conservation and encourage energy conservation activities by these organizations.

Assist all local governments in the development of energy conservation activities

Encourage the development of educational programs for children and adults.

4. The Ad Hoc Committee on Appliances and Apparatus recognizes that building insulation is usually the most important factor contributing to the total energy consumption of space conditioning appliances and apparatus. This Ad Hoc Committee recommends that the State Building Code Council or a similar new council:

a) Develop from existing information residential and commercial insulation requirements for mandatory statewide minimum standards for new construction.

b) Impose immediately on new residential and commercial buildings mandatory statewide interim standards, which should not be lower than those prescribed by the United States Department of Housing and Urban Development for federally-assisted housing.

c) Conduct an investigation to determine the feasibility of promoting the upgrading of insulation in refurbished homes.

5. Sub-committees on electric, gas and oil appliances and apparatus have investigated opportunities for improving energy utilization of major energy consumptive appliances. Specific recommendations with regard to Electric. Gas and Oil Appliances are presented below.

a) Electric Appliances

Residential air conditioning contributes approximately 40 percent of the summer peak demand in the downstate area. An increase in the performance of room air conditioners could reduce the impact on peak electric power demand and conserve a significant amount of energy. The *Ad Hoc* Committee recommends that legislation be promulgated with respect to the proposed minimum performance standards for room air conditioners presented in the table below.

Proposed Air Conditioner Performance Standards

Size Btuh		Performance in Btuh/Watt (EER)* 1975	1976	1977	1978	1979
Up to 5,999		6.0	6.5	7.0	7.5	8.0
6,000 to 9,999	115V	7.0	7.5	8.0	8.5	9.0
10,000 and Higher		7.0	7.5	8.5	9.0	9.5
Up to 17,999		6.5	7.0	8.0	9.0	9.5
18,000 to 23,999	230V	6.5	7.0	8.0	8.5	9.0
24,000 and Higher		6.5	7.0	7.5	8.0	8.5

*The test conditions are 80°F room air temperature at 50% relative humidity and 95°F outside air temperature at 39% relative humidity per ASHRAE Publication No. 16-69.

Selection of the proper size air conditioner should be strongly emphasized by all sales personnel and in related advertising. The selection of an air conditioner with a cooling capacity larger than required will result in cooling the space too quickly, hence inadequate dehumidification. Overshooting temperature settings, cycling too often and uncomfortable and inefficient space conditioning will also result.

The following eight recommendations summarize ways to better utilize energy for lighting:

1. Design lighting levels for tasks.
2. Design with more effective luminaires.
3. Use efficient light sources.
4. Use luminaires designed for heat removal.
5. Use high reflectance finishes on ceilings, walls, floor, and furnishings.
6. Provide switches for control of lights in individual areas.
7. Optimize window design for daylighting and air conditioning.
8. Maintain lamps and luminaires.

The recommendations suggested for lighting operation could easily result in a one-third reduction of energy used for lighting. Several of the recommendations apply primarily to new construction and it is in initial design that the greatest opportunity for energy savings exist. Most of the energy savings can be realized by applying the principles involved to existing lighting installations. A sizable portion of the energy wasted is the result of unnecessary lighting levels. This can be corrected at any time by reducing the number of luminaires or fluorescent lamps in the luminaires provided that individual lamps connected to a common ballast are not removed.

The Committee suggests that the State initiate lighting energy savings in State office buildings. The Committee recommends that the State building and operating agencies review the recommendations presented herein and take appropriate action.

The superiority of high pressure sodium vapor lamps has been demonstrated in highway lighting studies. The Ad Hoc Committee recommends that a lighting study be performed for each highway lighting application and include consideration of high pressure sodium vapor lamps. The basis of selection should be total operating and initial costs rather than only initial cost so that appropriate consideration be given to the amount and cost of the energy used.

The Ad Hoc Committee also recommends the use of photoelectric controls on all highway, roadway and parking lot lighting. With the use of this device, lighting is provided only when it is actually needed.

The use of heat pumps in lieu of electrical resistance heating could reduce the average electric space heating energy requirements by approximately 50 percent. Slightly higher initial cost will eventually be recovered by reduced operating costs. In view of the growth in electric space heating predicted for New York State, the use of heat pumps offers a very significant opportunity throughout the State for the conservation of energy.

In order to realize the energy saving potential of heat pumps, it will be necessary to build consumer confidence in the reliability of this device. The first step is for manufacturers to demonstrate confidence in their own product by offering guarantees and low cost service policies.

The increased use of heat pumps in New York State would, to some extent, result in a greater summer air conditioning load, since presently less than 25 percent of electric space heating customers install central air conditioning.

The Committee recommends mandatory minimum standards of performance for all electric water heaters. It is recommended that all water heaters sold for use in New York State be required to meet a standby loss of 4 watt-hours per hour per square foot of tank surface area. This action would result in a 20 percent reduction in electric hot water losses and a significant reduction in the State's energy consumption. Over the long term such an act will be economically beneficial to the homeowner.

The instant-on device should be eliminated from television sets. In the absence of joint industry action, this Committee recommends that legislation be enacted which prohibits the sale in New York State of television sets containing the instant-on feature. It is further recommended that consumers who now own such a set be encouraged to discontinue use of the instant-on device where possible.

The major household appliances (refrigerators, ranges, dishwashers, clothes washers and dryers) are responsible for approximately 40 percent of residential electric energy consumption. Performance standards defining the energy utilization characteristics of these household appliances do not exist in spite of the significance of the energy consumption of these appliances. For this reason it is difficult to compare the relative performance of units presently available or to quantitatively determine the opportunity for performance improvement of these appliances.

Improved insulation techniques for refrigerators and freezers could significantly reduce the energy consumption of this appliance.

In the case of clothes washers and dishwashers, a reduction in the quantity of hot water required could conserve a significant amount of energy. Detailed design suggestions for improving the energy utilization of household electric appliances are presented in the appropriate appliance section.

A significant amount of energy can also be saved by appropriate utilization practices of household electric appliances. Energy conservation suggestions for the use of these appliances are presented in detail in Appendix A

b) Gas Appliances

The thermal efficiencies of gas burning appliances and apparatus are generally high, and significant improvements above the minimum efficiency requirements developed by the American National Standards Institute appear impractical at this time. Many factors which tend to increase thermal efficiencies in gas appliances also result in decreased equipment life, and often result in potential safety hazards. The thermal efficiencies measured in the certification testing of gas burning equipment are presently not made available to the public. Although the opportunity for improvement of these efficiencies is quite small, publicity with respect to the actual efficiencies is considered desirable since it would inspire the manufacturers to engineer a product with the maximum efficiency within the limitations of maintaining safety, durability and a competitiveness.

The utilization efficiency of gas burning equipment, may be as low as 40 percent as a result of incorrect appliance selection or improper or careless operation and maintenance. Promoting higher utilization efficiencies for gas burning equipment is most readily accomplished through education of the people who purchase the equipment and are responsible for its operation and maintenance.

Energy consumption of most residential heating systems could be reduced by approximately 12 percent by maintaining the house temperatures at 68°F, rather than 72°F. An additional three percent fuel savings could also be achieved by lowering the thermostat at night by an additional 3°F.

The consumption of gas by pilot lights does not in all cases result in wasted energy. In some cases heat produced by gas pilots is useful in that it provides heat to spaces requiring heating, thus reducing the heating system requirements. The replacement of gas pilots with automatic ignition devices would, however, result in an average saving of approximately five percent of the gas consumption of new residential gas appliances. Conversion of existing appliances with gas pilots to automatic ignition is considered impractical.

The price of automatic ignition devices must be kept relatively inexpensive so as to encourage the purchase of gas appliances versus electric appliances which might have a lower efficiency in terms of primary energy consumption.
Gas appliance manufacturers have indicated that automatic ignition devices are being developed for ranges and this effort should be encouraged by the State in the purchase of such equipment for State application.

improvements in the manufacturers' designs are virtually impossible because of excess air requirements to insure complete combustion, and the minimum exhaust gas temperature requirements to avoid condensation and provide adequate draft.

Oil fired appliances and apparatus, such as furnaces or boilers, should be required to carry an approval or listing by one or more of the nationally recognized agencies such as Underwriters' Laboratories, American National Standards Institute or The Hydronics Institute. Standards or procedures of these agencies should incorporate a minimum thermal efficiency for listing that must be verified by an independent testing laboratory.

Although the opportunity for improvement of the thermal efficiency of oil fired equipment is quite small, it is believed that proper certification and listing of efficiencies would inspire some improvement on the part of manufacturers, and facilitate a wiser choice of equipment by the consumer.

Selecting the most suitable grade of fuel oil, based on equipment size, is important with respect to both efficiency and air quality.

The size of new oil fired heating units should be based on a realistic estimate of load. Modular boilers should be used.

When two or more boilers are installed they should be sized so that, at minimum load, the smallest boiler will operate at a minimum of 40 percent of its rated capacity.

The use of automatic damper control could reduce the total consumption of gas used by heating appliances by reducing the loss of conditioned air through the exhaust vent system. It is estimated that automatic damper control can reduce gas heating appliance energy consumption by an average of about ten percent. It is recommended that the gas utilities be encouraged to gather field data on the performance of automatic damper control and make known to their customers the potential of this device for energy savings. This device should be considered for new installations where the cost and safety implications are the most favorable.

In many commercial and industrial buildings, conventional blower type unit heaters are used for heating. Replacing these with infrared heating equipment can reduce fuel consumption by 30 percent or more. Better comfort conditions are also generally obtained.

A low utilization efficiency of gas burning equipment is often the result of oversizing the equipment for the application. Oversizing can be avoided by educating the people who are responsible for the sizing and selection of gas heating equipment.

c) Oil Appliances

Boilers are the primary oil fired appliance for both space heating and water heating in New York State. The thermal efficiency of this appliance is generally high, and significant

Proper operation and maintenance of new and existing equipment can result in a fuel oil savings of up to 15 percent.

6. Follow-Up Activities

The Staff of the New York Department of Public Service will continue to develop draft executive orders and legislation based upon the recommendations of this Ad Hoc Committee for consideration by the Interdepartmental Fuel and Energy Committee.

Ad Hoc Committee on Appliance and Apparatus Efficiency

I. Introduction

This report presents the work of the *Ad Hoc* Committee on Appliance and Apparatus Efficiency. The report deals with the energy utilization of appliances and apparatus and steps that can be taken to improve this utilization.

The first questions that might be asked are, why was this study performed, and is there a real need to improve energy utilization in New York State. A short summation of the energy outlook is presented so as to establish the need for action.

The Energy Outlook

For the last few years, there has been growing concern throughout the United States for our ability to meet this country's rapidly increasing energy needs. In short, the use of energy is outstripping production, and as a result we have gone from a period of abundant, cheap energy to a period of growing shortages and rising costs.

Over the past 70 years, national energy use has grown at an average rate of 3.2 percent, although over the 19[illegible] to 1970 period an upturn to approximately 4.8 percent has been noted. This rise in the energy growth rate results from our expanding economy as evidenced by major shifts in energy use patterns and our increased standard of living in terms of appliances and equipment for increased comfort and convenience. Over the 20 years from 1950 to 1970, the electric utility consumption of primary energy which includes coal, gas, and oil, has risen from 16 to 24 percent of the total, indicating an increasing trend towards an electric energy economy.

In 1970 the United States was responsible for one-third of the world's annual energy consumption. The portion of this energy obtained from the various primary fuels is as follows:[1]

Source	% of Total
Oil	44.6
Gas	31.6
Coal	19.7
Hydro	3.8
Nuclear	.3

Over the previous decade, the main shift in the source of supply has been from coal to oil and gas because of State and Federal environmental regulations. In terms of total energy reserves, coal is our greatest energy resource in the United States with approximately three trillion tons in the ground; however, only about five percent of this can be recovered economically utilizing today's technology. Although coal resources are more than ample to meet our needs for quite

1. "Outlook for Energy in the United States in 1985," The Chase Manhattan Bank, Energy Economics Division, June 1972.

some time, new technology is necessary to enable us to produce and utilize it within the governmental restrictions.

The demand for natural gas has increased at an accelerated rate because it contains no sulfur and produces no particulates when burned. Unfortunately, there has been a decline in proven reserves which, for the most part, is due to the high cost of discovering new reserves combined with the controlled price at which the gas can be sold. Because of the long lead time in discovering and developing new reserves, it is unlikely that the gas supply picture will improve during the next decade.

In 1972, the annual consumption of oil in the United States was approximately 5.8 billion barrels of which 28 percent was imported from abroad. By 1980, it is anticipated that the annual consumption will exceed 8.2 billion barrels of which approximately half will be imported. The large increase in oil imports may have a major effect on the United States' balance of payments and will increase our dependence on foreign nations.

Many people believe that nuclear energy has the greatest promise of meeting our energy needs for the long term. However, unless new technology is developed to make feasible the use of breeder reactors or nuclear fusion for the generation of electricity, the nuclear fuel supply situation will become as critical as is the case with other primary fuels. With the required technological breakthroughs, nuclear energy will provide a potential source of meeting our long term energy needs.

Even for the near term, the rate of growth of nuclear plant capacity is not living up to expectations. Considerable difficulties have been experienced in siting these plants and making them operational. There are the problems of safety requirements, radiological hazards and thermal pollution. The lead time for nuclear plants (from conception to operation) is seven and one-half to ten years.

In the long run, new technology will undoubtedly ease the energy picture. Hope for the nuclear fuel supply problem is sought in the fast breeder reactor which produces a usable fuel from natural uranium as it operates. In addition, the high temperature gas cooled reactors are expected to result in greater conversion efficiency, and hence offer a reduced thermal waste problem. These technologies are hopes for the near future, but can not provide for our immediate energy needs.

Both coal gasification and the fuel cell are new technologies which offer the potential to make better use of existing energy resources; however, it is unlikely that either of these processes will be developed sufficiently to alleviate the immediate energy shortage.

Improving Energy Utilization

There are several long term solutions to the energy supply-demand problem. Most solutions involve increasing the energy supply since the social and economic implications of a long term reduction in the demand for energy might be disasterous for the nation as a whole. Steps to solve the nation's energy supply problem are vitally important to our nation's welfare, and they must certainly be pursued with all the vigor deserving of one of our nation's highest priorities.

However, these steps will not significantly improve the energy outlook until at least the beginning of the next decade. In the meantime, we are undergoing a period in which the energy demand might easily overtake the supply capability. An interim measure is required, therefore, to help stretch the energy supply during this anticipated period of shortage. This can be done by improving energy utilization. A program of energy conservation must be pursued promoting the avoidance of waste and the more efficient use of energy.

Chairman Joseph C. Swidler of the New York State Public Service Commission indicated at a Workshop on Total Energy Conservation in Public Buildings that "Energy conservation will do more than extend the life of the hydrocarbon resources. It will dampen the environmental impact that follows unavoidably from supplying and using energy - the air pollution that comes from burning fuels, the thermal pollution of surface waters that comes from generating electricity, the impairment to land that comes from mining coal or drilling for oil. Even after new technologies are developed to lessen the environmental impact of supplying and using energy, energy conservation will still be a weapon in the fight against pollution."

Our society has been indoctrinated into a wasteful consumptive economy of affluence. This is the land of plenty and many people just don't want to believe that energy shortages exist. For years, and in many circumstances, the predominant philosophy in our country has been one of indiscriminate consumption and waste without concern for anything but our own immediate needs and desires. Energy was an abundant and cheap commodity and there was really no incentive to conserve it. Now the energy picture has changed drastically and the people must be induced to adapt to the new set of circumstances. This requires a change in their attitudes and habits. The public must be convinced that there is a shortage of energy and that a sincere effort should be made to eliminate wasteful energy consumption wherever it appears. For the near term it is particularly important that a wiser and more prudent use of our energy resources be practiced. Achieving this end will not be easy and a concentrated effort is required to promote energy conservation in all facets of our society.

On January 6, 1972, Governor Nelson A. Rockefeller established an Interdepartmental Fuel and Energy Committee and named Chairman Joseph C. Swidler of the Public Service Commission as Chairman of this Committee. The Committee was charged with surveying on a continuing basis New York's fuel and energy resources and requirements.

The Governor, in his January 18, 1972 State of New York Message to the Legislature, stated "Equally important in providing an adequate power supply is the need to avoid the waste of electric power and of the primary fuels, coal, oil, and natural gas." The Governor continued by stating "Natural fuel supplies are not limitless. We are already running low in natural gas supplies and becoming more and more dependent on oil imports. Energy conservation will continue to grow in importance. Our efforts to avoid waste may have an important bearing on energy costs and the availability of power in the years ahead." The Governor concluded by requesting Chairman Joseph C. Swidler to continue his efforts in working with the public and private sectors to encourage the design and building of more energy efficient equipment and buildings.

The Interdepartmental Fuel and Energy Committee, under the leadership of Chairman Swidler, established Ad Hoc Committees on:

Energy Efficiency in Large Buildings
Appliance and Apparatus Efficiency
Energy Efficiency in Transportation

The above Ad Hoc Committees were charged with investigating energy conservation in their respective areas and reporting back to the Interdepartmental Fuel and Energy

Committee recommendations for promoting energy conservation in their respective areas.

This report presents the work of the Ad Hoc Committee on Appliance and Apparatus Efficiency. At the opening meeting of this Committee on September 13, 1972, Chairman Swidler, as quoted below, asked the Committee to provide assistance in meeting the energy crisis by proposing plans and recommendations for improving the efficiency of household appliances and industrial apparatus.

"For too many years, we have failed to deal with the waste of energy, ignoring efficiency in appliances and apparatus. We are now faced with shortages of primary fuels, especially natural gas and oil, and with stringency of electric power capacity. It is essential that we move promptly to avoid waste in the uses of energy."

Table I shows the breakdown by user category of the primary energy used in New York State in 1970. The primary energy used by utilities can be also apportioned among the categories of the end user to yield the energy use distribution as is shown on Table II.

Table I

Primary Energy Distribution for New York State in 1970

(Considering Utilities as Users)

User	Trillion-Btu	Percent Of Total
Electrical Utilities	1,103.9	25.7
Residential/Commercial	1,474.9	34.4
Industrial	580.3	13.5
Transportation	1,135.4	26.4
Total	4,294.5	100.0

Table II

(Apportioning Primary Energy Used by Utilities to End Users)

User	Trillion-Btu	Percent Of Total
Residential/Commercial	2,067.6	48.2
Industrial	967.1	22.5
Transportation	1,168.3	27.2
Electric Utilities and Transmission	91.5	2.1
Total	4,294.5	100.0

Table II indicates that approximately 70 percent of the primary energy used in New York State is used in the residential, commercial, and industrial sectors. All the energy used in these sectors is essentially consumed by an appliance or apparatus. A considerable portion of this 70 percent of the total energy used in New York State is consumed in large buildings and hence the investigation of its efficiency of utilization falls under the jurisdiction of the Ad Hoc Committee for Energy Efficiency in Large Buildings. However, items such as motors, lighting and various other appliances which are common to large buildings will be covered by this report without excessive duplication since the Ad Hoc Committee on Energy Efficiency in Large Buildings is focusing primarily on efficiency at the system level rather than at the component level of building design. The work of the Ad Hoc Committee on Appliance and Apparatus Efficiency is offered, therefore, a unique opportunity to investigate the efficiency of utilization of a major portion of the energy used in New York State. The areas where this utilization can be improved, as well as the methods for accomplishing this end, are documented herein. It is fully realized that a task of this magnitude can not be concluded in a brief study. This report, therefore, can certainly not be considered the end, but more realistically, the beginning.

II. A. Electric Sub-Committee Report on Appliances and Apparatus

1. General Data

The electric utility industry is an important consumer of the nation's primary energy resources: coal, petroleum, natural gas, falling water and uranium. The electric utility industry in turn, supplies energy to three major sectors of electric energy consumers: industrial, commercial, and residential. Electric energy consumption in the commercial and industrial sectors is primarily under the jurisdictions of the Ad Hoc Committee for Energy Efficiency in Large Buildings and the Ad Hoc Committee for Energy Efficiency in Transportation. This Committee will focus on energy efficiency in appliances and apparatus used in the residential and commercial sectors.

The distribution of energy supplied by the electric utility industry was examined to obtain a background for the relative importance and potential for energy conservation in the residential and commercial sectors. The 1970 distribution of electric energy consumption by sector is shown below:

1970 Electric Energy Consumption

(From Reports of the Seven Major Electric Utility Companies of New York State)

Sector	kWh (Millions)	Percent
Residential	24,666	34.1
Commercial and Industrial	47,596	65.9
	72,262	100.0

The history of electric energy consumption by sector is shown in the following table:

History of Electric Energy Consumption by Sector

(From Reports of the Seven Major Electric Utility Companies of New York State)

	Residential		Commercial and Industrial		Total
Year	kWh (Millions)	% of Total	kWh (Millions)	% of Total	kWh (Millions)
1967	18,958	31.5	41,165	68.5	60,123
1968	20,639	32.1	43,594	67.9	64,233
1969	22,491	32.7	46,317	67.3	68,808
1970	24,666	34.1	47,596	65.9	72,262
1971	25,777	34.0	50,064	66.0	75,841

The above table indicates that for the five year period from 1967 to 1971, residential energy consumption increased by 36 percent, while total New York State electric energy consumption increased by only 26.1 percent. This trend would indicate that conservation of energy in the residential sector will become increasingly more important in the future.

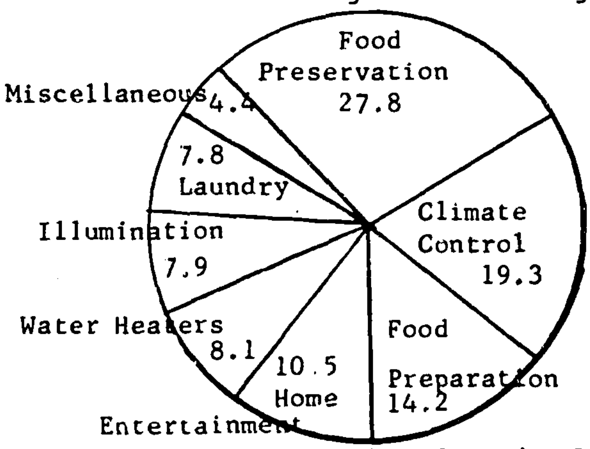
The electric utility industry load in the residential sector is due to many types of appliances and apparatus which may be classified into several major categories. The estimated energy used by each of the major categories of appliances is tabulated below to show its relative importance with respect to energy consumption. The total estimated energy consumed by appliances in 1970 is within four percent of the residential load reported by the seven major electric utility companies for that year, and is within the accuracy of the known statistics.

<u>1970 Electric Energy Consumption by Appliance Category</u>

(New York State)

Appliance Category	kWh (Millions)	Percent
Food Preservation	7,120	27.8
Climate Control	4,926	19.3
Food Preparation	3,620	14.2
Home Entertainment	2,680	10.5
Water Heaters	2,071	8.1
Illumination	2,0[illegible]1	7.9
Laundry	2,005	7.8
Miscellaneous	1,140	4.4
Total	25,573	100.0

The percentage of the total energy used by each category is shown in the following circle diagram.



The categories as shown in the circle diagram are quite broad and were further subdivided to determine where any appreciable energy savings could be achieved.

2. Selection of Appliances and Apparatus for Study

The Sub-Committee agreed that a basic starting point for evaluating the energy conservation potential of an appliance was to initially obtain data for New York State on the number of appliances of that type used, their estimated energy consumption, and the projections for future sales. This approach recognizes that, although the potential energy savings for one appliance might be small, the cumulative energy savings for the aggregate might be of some magnitude.

The Committee's best estimates on appliance energy use are summarized in Table II A-1. The parameters listed for each appliance are: saturation level, average wattage per unit, average annual unit consumption, and total energy consumption in New York State. From this data it is possible to appraise the potential for energy conservation represented by each of the listed appliances.

The Electric Sub-Committee decided after preliminary evaluation to concentrate its efforts on several electric appliances and apparatus that appeared to offer the greatest opportunities for energy conservation. The appliances and apparatus selected were:

a. Room Air Conditioners

b. Unitary Air Conditioners

c. Electric Heat

d. Lighting

e. Refrigerators, Combination Refrigerator-Freezers and Food Freezers

f. Clothes Washers

g. Clothes Dryers

h. Automatic Dishwashers

i. Water Heaters

j. Ranges

k. Television Sets

l. Fractional Horsepower Motors

The above appliances and apparatus were analyzed in detail by members of the Ad Hoc Committee and the analysis is presented in the following sections.

Table II A-1

New York State

Estimated Annual Kilowatt-Hour Consumption

Selected Electric Appliances

1970

Appliance	Saturation	Average Wattage	Estimated kWh Consumed Annually Per Unit	Total (In Millions)
Food Preservation				
Food Freezer (15 cu. ft.)	16.2	341	1,195	1,145
Refrigerator	49.9	250	750	2,213
Refrigerator-Freezer (14 cu. ft.)	25.0	325	1,150	1,700
Fefrigerator-Freezer (Frostless 14 cu. ft.)	24.9	350	1,400	2,062
Climate Control				
Air Conditioner (Room)	28.6	1,400	595	1,365*
Dehumidifier	(5)	257	377	111
Fan (Attic)	(5)	370	291	86
Fan (Circulating)	(5)	88	43	13
Fan (Furnace)	(24)	282	394	559
Fan (Roll-About)	(5)	171	138	41
Heat Lamp (Infrared)	(5)	250	13	4
Heat Pump		11,848	16,003	
Heater (Radiant)	(5)	1,322	176	52
Humidifier	(5)	177	163	48
Oil Burner or Stoker	(15)	266	410	364
Resistance Heaters	1.8	15,000	17,000	1,810
Air Conditioner (Central)	3.2	5,000	2,500	473
Food Preparation				
Broiler	(10)	1,436	100	59
Carving Knife	(5)	92	8	2
Coffee Maker	88.6	894	106	555
Deep-Fat Fryer	(5)	1,448	83	25

Table II A-1
(Continued)

New York State

Estimated Annual Kilowatt-Hour Consumption

Selected Electric Appliances

1970

Appliance	Saturation	Average Wattage	Estimated kWh Consumed Annually Per Unit	Total (In Millions)
Food Preparation (Continued)				
Dishwasher	18.1	800	242	59
Food Blender	36.5	386	15	32
Food Mixer	82.4	127	13	63
Food Waste Disposer	25.5	445	30	45
Frying Pan	56.2	1,196	186	618
Grill (Sandwich)	(25)	1,161	33	49
Hot Plate	24.5	1,257	90	130
Range	21.0		1,175	1,459
Range Self-Cleaning Oven	1.7		30	3
Roaster	(5)	1,333	205	61
Toaster	92.6	1,146	39	214
Waffle Iron	(25)	1,116	22	33
Can Opener	45.5		5	13
Home Entertainment				
Radio-Phonograph	99.8	71	86	508
Television (Black & White)	86.7	237	262	1,343
Television (Color)	37.4	332	375	829
Laundry				
Clothes Dryer	19.9	4,856	993	1,169
Iron (Hand)	99.7	1,008	98	578
Washing Machine (Automatic)	52.3	260	78	241
Washing Machine (Non-Automatic)	5.0	195	59	17

Table II A-1
(Continued)

New York State

Estimated Annual Kilowatt-Hour Consumption

Selected Electric Appliances

1970

Appliance	Saturation	Average Wattage	Estimated kWh Consumed Annually Per Unit	Total (In Millions)
Water Heaters	8.3		4,219	2,071
Illumination	(100)		340	2,011
Miscellaneous				
Clock	(99.8)	2	17	301**
Floor Polisher	(10)	305	15	9
Hair Dryer	(25)	381	14	21
Heating Pad	(10)	65	10	6
Sewing Machine	(25)	75	11	16
Shaver	(25)	14	18	27
Sun Lamp	(10)	279	16	9
Toothbrush	(10)	7	5	3
Vacuum Cleaner	92.0	630	46	250
Bed Covering	49.5	177	147	430
Water Pump	(5)	460	231	68
Total				25,573

( ) Estimated Saturation
5,914,000 Occupied Housing Units in New York State from 1970 Census of Population and Housing.

* 18.4% had one and 10.2% had two or more room air conditioners.

** Assumed that the average home contains three clocks.

a. Room Air Conditioners

Room air conditioners are factory assembled unit packages for climatic control of homes, offices, and other similar applications. Basically, the room air conditioner cools, dehumidifies, cleans, and circulates conditioned air in an enclosed space, room, or zone. Some room air conditioners also have the capability to ventilate and heat a zone as well. Mounting and installation capabilities include window mounting or installation through a special opening in the wall.

Available cooling capacities range from 4,000 to 36,000 Btuh. Popularity in cooling capacities seems to favor the smaller size room air conditioners. According to the Association of Home Appliance Manufacturers (AHAM), the best selling models last year nationally were in the following size cooling capacities:

Popularity Rank	Cooling Capacity Btuh
1	8,000 to 9,000
2	6,000 to 7,000
3	less than 6,000
4	17,000 to 20,000
5	11,000 to 13,000

Energy Consumption

In 1971, 358,000 room air conditioners were purchased in New York State - 100,000 more than either of such warm states as Florida or Texas. The potential electric load of just these new units on the New York system amounts to approximately 430 megawatts. On extremely hot days throughout the State, a rather obvious assumption can be made that this will be an almost 100 percent coincidental load. This burden is even further magnified when one recognizes that the power plants, transmission lines, transformers, and the distribution system are least capable of providing maximum output performance due to the higher ambient temperatures.

Exaggerated summer peak loads are most expensive to electric utilities, due to the fact that this highest level of load exists only for two to three hours for a few days during the summer. Generating equipment must be standing idle all year long just to accommodate a once a year peak, and the transmission and distribution systems must be over designed in order to handle the extra capacity.

The Consolidated Edison system, which has the most exaggerated summer peak load in the State, experienced on July 28, 1970 a summer peak demand of 7,041,000 kilowatts, which was 27 percent higher than the January 22, 1970 winter peak demand of 5,526,000 kilowatts.

The utility's system average load for the winter peak day amounted to 4,326,000 kilowatts which indicates that air conditioners and other temperature affected loads such as refrigerators and freezers can cause system load to be as much as 25 to 30 percent higher than their average load.

The Association of Home Appliance Manufacturers (AHAM) has estimated that the total annual electric consumption of the approximately 2,301,000 room air conditioners in New York State is 1,365,000,000 kWh.

Saturation

According to the 1970 Census of Population and Housing, 18.4 percent of the households (1,091,000) in New York State had one, and another 10.2 percent (605,000) had two or more room air conditioners. Household saturation of room air conditioners has been growing at an annual rate of 4 percent in recent years, although the maintenance of this rate will be tempered to some extent by the concurrent growth in central air conditioning household saturation, particularly in new construction.

New York State, which represents nearly 9 percent of the national population, accounted for approximately 9.5 percent of the 1971 national air conditioner sales. This indicates that the New York State growth in room air conditioner energy load is only slightly greater than the national average. An estimated 25 percent of the annual room air conditioner sales are replacement sales and the approximate life of a unit is 12 years.

Energy Efficiency

The room air conditioner is unique among household appliances because a readily available and rational method for quantifying the energy consumption characteristics of the product in terms of the energy used and the function it performs (an energy efficiency ratio) already exists. Since 1961 the room air conditioner manufacturers have voluntarily submitted their products to an independent testing laboratory retained by the industry trade association for the purpose of testing and certifying to the public the Btuh cooling capacity, wattage, and amperage of each unit. This program, designed to provide accurate information to consumers on the primary product selection consideration (cooling capacity), by happenstance also provides an accurate method for rating energy consumption by dividing the certified Btuh output by the certified watts.

This situation is unique for three reasons, as follows:

1. The room air conditioner, unlike many other appliances, performs essentially one task for consumers; this task (cooling) is relatively easily measured under laboratory controlled conditions; and the system for accomplishing the task is self-contained within the appliance.

2. The industry developed a standard establishing a controlled operating condition that reasonably represents actual consumer use conditions and thereby all operating measurements are based on the same conditions. The AHAM Standard is RAC-1.

3. The industry submits their products to AHAM for certification of performance claims based on independent laboratory testing.

Window air conditioners have a range of energy efficiency ratios of 6.0 to 7.4 Btuh/watt in the 8,000 Btuh cooling capacity models, and 5.7 to 8.5 Btuh/watt in the 10,000 Btuh models. Exhibit II A-1, "Range of Efficiencies of Window Units by Cooling Capacity," indicates the tremendous variation of energy efficiency over the entire cooling range.

The average window air conditioner has an efficiency of about 6.50 Btuh per watt. This corresponds to an electrical consumption of about 1.85 kilowatts per every 12,000 Btuh of cooling.

The range of energy efficiency ratios for the through-wall air conditioners is 6.2 to 7.3 Btuh/watt in the 8,000 Btuh models and 5.6 to 6.6 Btuh/watt in the 10,000 Btuh models as is shown on Exhibit II A-2, "Range of Efficiencies of Through-Wall Units by Cooling Capacity."

Through-wall air conditioners have about a 6.00 Btuh per watt energy efficiency ratio, corresponding to 2.00 kilowatts per every 12,000 Btuh of cooling.

Cost Benefit Analysis

Careful purchasing practices by a consumer when selecting a room air conditioner can yield impressive energy savings. Unfortunately, the only cost a consumer notices is the initial cost. Most consumers never calculate the variations which occur in the operating costs of alternative models in the identical cooling range. Estimated operating costs should be compared since one unit can cost almost twice as much as another to operate due to mechanical design differences resulting in higher electrical consumption.

Exhibits II A-3, "Room Air Conditioners: Present Worth of Power Costs for Downstate New York" and II A-4, "Room Air Conditioners: Present Worth of Power Costs for Upstate New York" enable the discriminating purchaser to determine which model air conditioner is the best buy, as shown in the following example:

A prospective purchaser requires an 8,000 Btuh window air conditioner: Model "X" uses 1,500 watts, Model "Y" uses 1,000 watts. Model "X" costs $150. How much can the purchaser afford to pay for Model "Y" which consumes less power?

A downstate purchaser should turn to Exhibit II A-3. By entering the chart on the left-hand side at "1500" watts and following the curve horizontally to the diagonal guide on the right, and then dropping down to the bottom scale, the purchaser can read "$315" power costs for Model "X". Repeating this procedure for Model "Y", enter the left-hand scale at "1000" watts and determine the power costs of $210 for Model "Y". The difference between the power costs, $105, is the extra amount that could be applied to Model "Y". A purchaser could afford to pay $150 plus $105 or $255 for Model "Y".

An upstate customer using the data on Exhibit II A-4 will find that it would be economical to pay up to $190 for Model "Y", or $40 more than the $150 for Model "X".

Exhibit II A-1

WINDOW AIR CONDITIONERS: EFFICIENCY RANGE BY COOLING CAPACITY

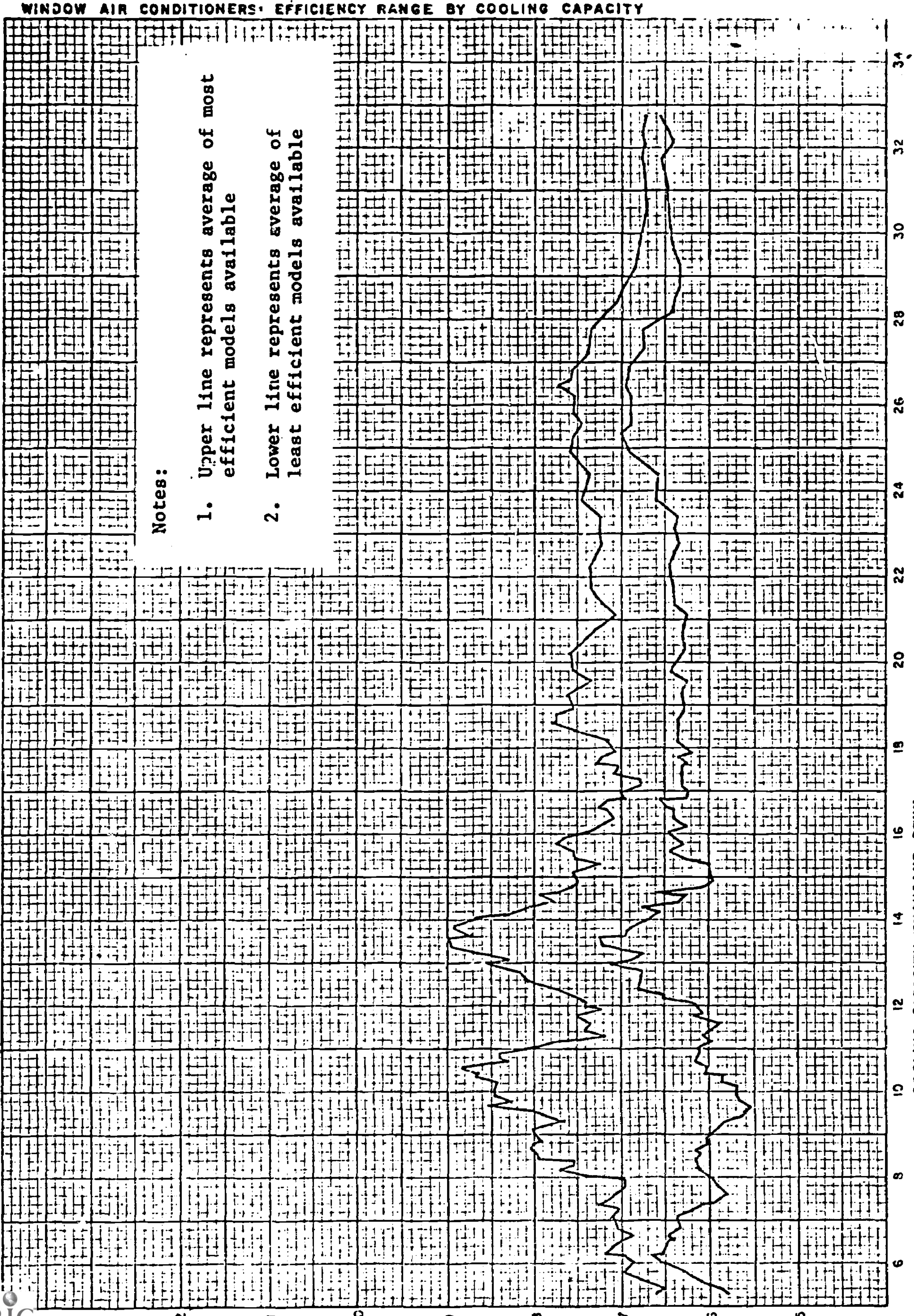


Exhibit II A-2

THROUGH-WALL AIR CONDITIONERS
EFFICIENCY RANGE BY COOLING CAPACITY

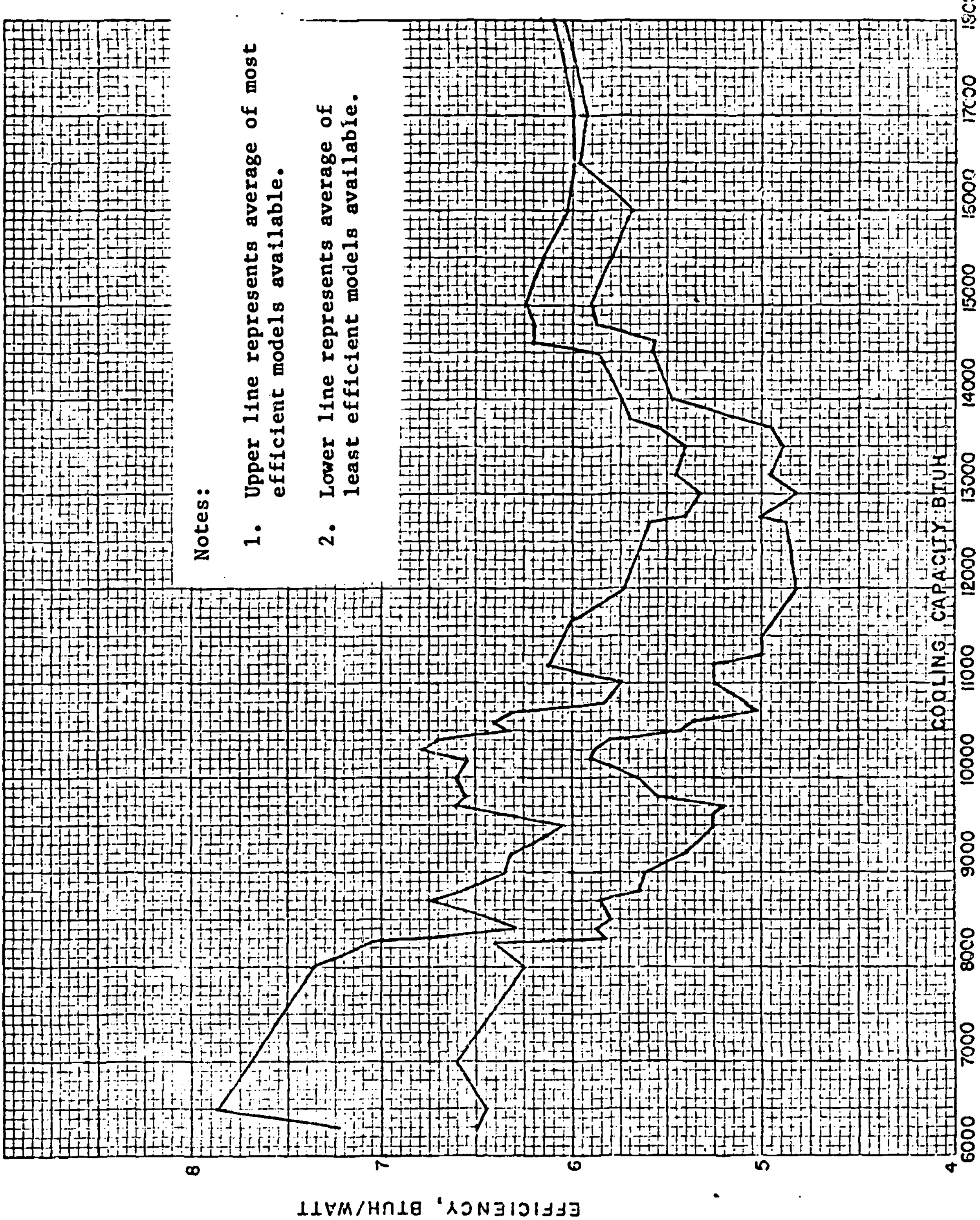
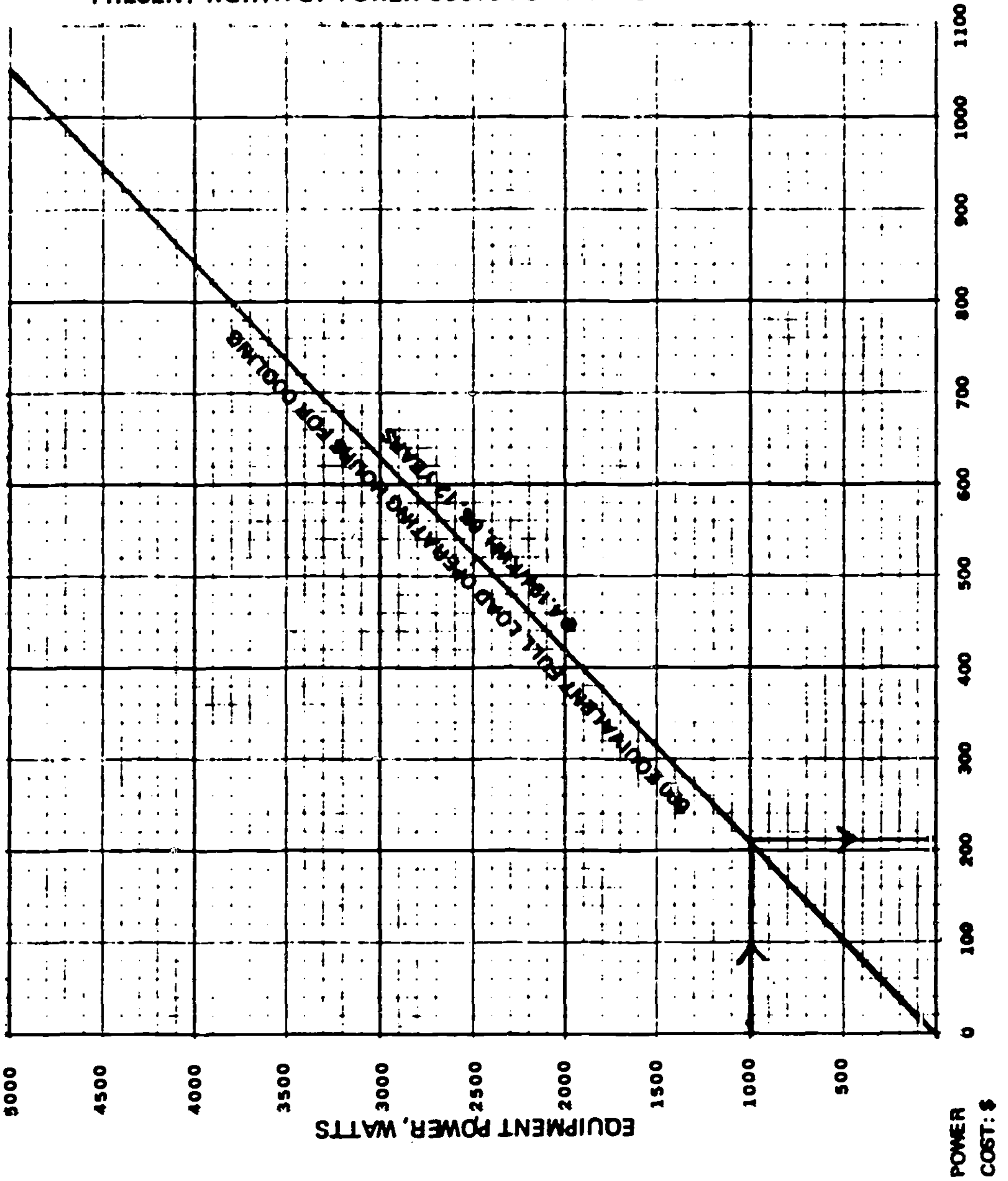


EXHIBIT II A-3

ROOM AIR CONDITIONERS

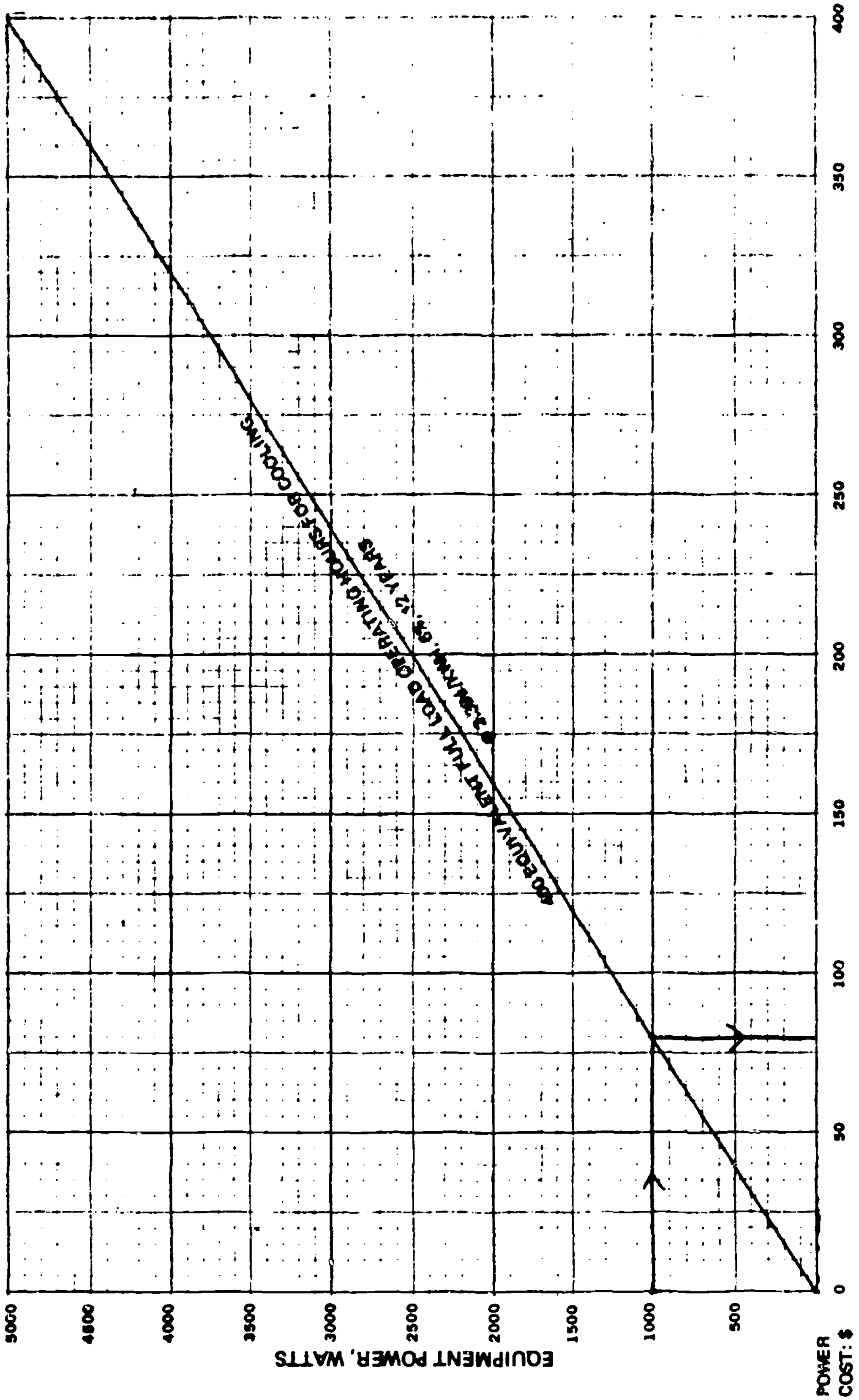
PRESENT WORTH OF POWER COSTS FOR DOWNSTATE NEW YORK



PRESENT WORTH OF POWER COSTS FOR UPSTATE NEW YORK

Exhibit II A - 4

ROOM AIR CONDITIONERS



Design Changes to Improve Efficiency

As previously discussed, the energy efficiency ratio (EER) of air conditioners is stated in Btuh per watt. The ultimate EER is not a fixed value, but is a continually increasing goal. However, the application of new ideas and design modifications, usually accompanied by added costs for manpower and tooling, may not be economically sound when considering the overall competition of the air conditioner manufacturing industry. If the performance of air conditioners is to be appreciably improved so that energy will be conserved, it is the opinion of this Committee that pressure must be placed on the industry by agencies which specify and buy equipment or, if need be, by legislation. The agencies or legislation can impose a schedule of increasing performance factors which is based on reasonable application of state of the art technology. However, the means to achieve these factors must ultimately be the responsibility of each equipment manufacturer.

Room air conditioners have been developed as a plug-in appliance requiring only an electrical connection. The major elements of an air conditioning unit are an evaporator coil, a condenser coil, a circulating refrigerant, a sealed hermetic compressor, two fans, and a single phase electric motor. These components are positioned in the conditioner unit such that the condenser air fan and condenser are located on the outside of the building wall when the room air conditioner is installed.

The compressor, the most important component in an air conditioner, is complex in design, production, application, and performance. The refrigerant, lubrication system, and electric motor are the most important components in the hermetically sealed compressor.

The electric motor used to drive the compressor is the largest component of the compressor assembly and usually determines its size and configuration. In order to satisfy the continuous demand to make equipment smaller and more compact, the compressor size is reduced by using smaller motors for a given pumping capacity. This reduction in motor size is accomplished by using less iron and copper and by improving electrical insulation. However, this modification results in a several percent reduction in efficiency at the design load and voltage.

The compressor can be redesigned so that the efficiency will be increased about five to ten percent at the design point, and possibly as much as 10 to 20 percent at extreme temperatures and voltage conditions. The compression ratio can be increased if provisions are made to prevent undesirable material from entering the cyliner. The motors can be redesigned to improve the efficiency at the design point and provide a flatter efficiency curve with changes in load and voltage. It should be further pointed out that motor inefficiency not only requires more energy input to the motor, but the resulting additional heat due to less efficient operation must be absorbed by the refrigerant and removed by the refrigeration system.

The motor which drives the condenser and evaporator fans uses about 15 to 25 percent of the energy delivered to an air conditioning system. The condenser fan is used to force air over the condenser coil to remove the heat from the refrigerant.

The condenser coil is a heat exchanger used to remove heat from the refrigerant by forcing air across the tubes of refrigerant so that the heat is transferred to the air. The condensing coil has gradually been reduced physically to satisfy the demand for compactness and has resulted in a higher condensing pressure and temperature. The evaporator coil is a heat exchanger used to transfer heat from the air to the refrigerant by forcing the air across the evaporator coil. The evaporator coil has also been reduced physically to meet the demand for compactness and has resulted in reduced compressor suction pressure and temperature. Both of these coils can be increased in physical size and would each increase the air conditioning energy efficiency ratio by about five to seven percent.

The mechanical design and assembly of the enclosure of the components is very important because the arrangement of enclosure panels determines the flow of air through the equipment. Any air that can bypass the coils or leave the system through openings in panels or ductwork will reduce the performance.

It is therefore imperative that the equipment be assembled from rugged material that has been protected against corrosion and vibration that could result in unwanted paths through which the air flow could bypass the coils.

Finally, the electric design of the equipment must be broad enough to permit acceptable performance with the wide voltage ranges that are commonly experienced.

Maintenance and Service

To retain the designed efficiency of a room air conditioner, the unit must be serviced at least once a year. Annual maintenance of a room air conditioner by the owner consists of cleaning or replacing the air filters as necessary, inspecting the plug and cord for cracks and wear, vacumming the accessible parts, lubricating according to the manufacturer's directions, and resealing around the unit where vibration may have loosened the weather stripping.

The refrigerant system, drive belts and the thermostat should be periodically checked by a qualified serviceman.

In areas of greater air pollution, more frequent attention to maintenance is necessary because air pollution can cause rapid deterioration of exposed parts.

Conclusions

1. Governmental organizations should be encouraged

to lead the way in modifying their purchasing procedures to require the purchase of more efficient air conditioners.

2. An increase in the efficiency of air conditioners will lessen their impact on peak power demand and conserve a significant amount of energy. This increase in efficiency of new air conditioners might be brought about by educational programs to assist consumers in selecting efficient units or through legislation imposing minimum performance requirements on air conditioners offered for sale in New York State. This *Ad Hoc* Committee believes that mandatory minimum performance standards are the most effective approach in improving air conditioner efficiency within a short time span. A more detailed discussion and recommendations regarding the use of education and minimum standards for increasing air conditioner efficiency is contained in Section III of this report.

b. Central Air Conditioning Equipment

Central air conditioning equipment is used to condition the areas too large to be economically and conveniently air conditioned by room air conditioners. Central air conditioners are used to condition the space of industrial, commercial, and residential buildings. Many different types and designs of central air conditioning equipment are in common use including equipment that is used for seasonal or year-round air conditioning. Central air conditioners can be purchased as preassembled self-contained units, as unassembled matched components, or as unassembled and unmatched components which when combined properly will operate as a system. When components have been designed to be assembled into a system, or are pre-assembled, they are classified as unitary equipment. Units of these types are manufactured in ratings ranging from about 20,000 Btuh to about 2,000,000 Btuh of air conditioning.

The configuration of unitary equipment can vary considerably. Most equipment utilizes air as the medium for cooling the refrigerant; however, packaging characteristics of equipment change, depending upon the application.

Unitary air conditioners with air cooled condensing units are the most commonly used type in residential installations and have therefore been studied in detail by this Committee. These units consist of an air cooled condensing unit comprised of a refrigerant compressor, condensing coil and fan, and an evaporator unit (cooling coil). Refrigerant piping connects the two assemblies. The condensing unit is usually located outside of the residence, whereas the evaporator or cooling coil will be in the duct system, usually immediately downstream from the furnace, within the residence. This equipment configuration is identified by the designation RCU-A-C, Remote Condensing Unit, Air Cooled (coil only) in the ARI Directory of Certified Unitary Air Conditioners and Heat Pumps. Conditioned air is usually circulated by the furnace blower in these installations.

The cooling capacity of the equipment installed depends upon the cooling requirements of the residential structure. The number of residential installations using equipment larger than 60,000 Btuh is quite small. In commercial and industrial installations, equipment ranges upward to 2,000,000 Btuh.

The ARI Directory of Certified Unitary Air Conditioners lists the cooling capacity in Btuh and power input in watts of the certified equipment. The power input includes all power consumed by all electrical components of the unitary equipment. For single package units and for units which include a fan or blower in the evaporator unit, the listed input includes power for the fan or blower to circulate the conditioned air. When the unitary equipment does not include a fan or blower, as in the RCU-A-C type unit, the power input contains no power for the evaporator or cooling coil fan motor. The rated cooling capacity does contain an allowance for the assumed heat released by a fan or blower motor.

Energy Consumption

The energy consumed in New York by unitary air conditioning equipment can be assumed to be a function of the average capacity of the equipment, the number of units, the average Energy Efficiency Ratio (EER) in Btuh per watt, and the equivalent full load hours of operation where installed. This large number of variables makes it difficult to estimate the energy consumed by air conditioners in New York State.

In New York this problem is particularly complex because New York is not a single climate entity. The New York State Office of General Services estimates that air conditioners installed in New York City operate about 600 equivalent full load hours a year and those installed in other areas such as Buffalo, Albany, and Syracuse, operate about 400 equivalent full load hours per year. Furthermore, saturation in the upstate area is likely to be less than downstate because of the milder summer climate.

In 1970, the United States Census determined that 199,651 residential units in New York State contained central air conditioning. Air Conditioner shipments to New York

State have averaged about 4.5 percent of the national market, of which about 70 percent are in areas reasonably represented by the New York City climate, and the remainder in areas represented by the Albany climate. The total number of central air conditioner units estimated to be in New York State at the end of 1972 is 340,000 units.

The sizes of residential central air conditioning equipment range from about 22,000 Btuh to about 60,000 Btuh, with an average size of about 36,000 Btuh. The average EER for these units is 7.2 Btuh/watt and results in an average energy use of 5000 watts per unit. The estimated energy use of the units that were in service at the end of 1972 is 918,000,000 kWh per year. This estimate is based on units which do not include evaporator fans or blower motors. The evaporator fan or blower motor usually requires about 20 percent as much energy as the rest of the air conditioner. If this energy is added to the above, the total energy consumption of residential air conditioners in New York State is 1,100,000,000 kWh and represents more than 3.5 percent of the State's annual residential energy use.

Air conditioners are normally sized to maintain comfort at the design conditions in a given area, and if an extended period of two or three days of unusually hot weather occurs, there will be little, if any, diversity of air conditioner load so that the electric demand of air conditioners will approximate the total installed capacity. The electric demand of the 340,000 air conditioners with an average of 5000 watts per unit is 1,700,000 kW, and if the evaporator fan or blower motor is added, the total is 2,040,000 kW.

In addition, it is estimated that 24,000 central air conditioning units of larger size for use in small commercial and small industrial applications will be shipped into New York State in 1973. These units and existing small commercial and small industrial units will operate at the same time as the residential units and, since there are about 33 percent as many, will increase the unitary air conditioning annual load and peak demand in New York State to 133 percent of the values stated above or 1,224,000,000 kWh and 2,300,000 kW, respectively.

Saturation and Projected Shipments

The 199,651 residential units in New York State which were equipped with central air conditioners represent a saturation level of 3.2 percent. Air conditioner shipments have increased substantially during the last ten years, and this trend is expected to continue. The growth of air conditioner saturation is affected by the rate of residential construction and by the national and regional economic conditions.

Industry estimates, which are normally rather conservative, are collected annually by ARI and are tabulated in the form of six-year projections of domestic shipments. The projection issued early in 1972 was as follows, with

New York State figures being calculated as a percent of domestic shipments, of which about 75 percent are expected to become residential units:

Year	Domestic Shipments (Millions)	Shipments Into New York 4.5% of Total Domestic	Estimated Annual Added New York State Energy Use kWh	Estimated Added New York State Demand kW
1972	2.0	90,000	243,000,000	450,000
1973	2.2	99,000	267,000,000	495,000
1974	2.4	108,000	291,600,000	540,000
1975	2.6	117,000	315,900,000	585,000
1976	2.8	126,000	340,200,000	630,000
1977	3.1	140,000	378,000,000	700,000
		Total	1,835,700,000	3,400,000

Performance

One measure of the operating characteristics of air conditioning equipment is its "energy efficiency ratio," expressed in Btuh of cooling capacity per watt of electrical input. The energy efficiency ratio is analogous to the thermodynamic term "coefficient of performance," which has units of Btu per watt-hour.

The energy efficiency ratio is not a fixed value in that it changes as air conditioner operating conditions change. This is particularly significant in the case of units which utilize air-cooled condensers. As outdoor temperature increases, condensing pressure and temperature increase and the Btuh of cooling effect for each watt of power consumed decreases. Conversely, as outdoor temperature decreases, the performance increases.

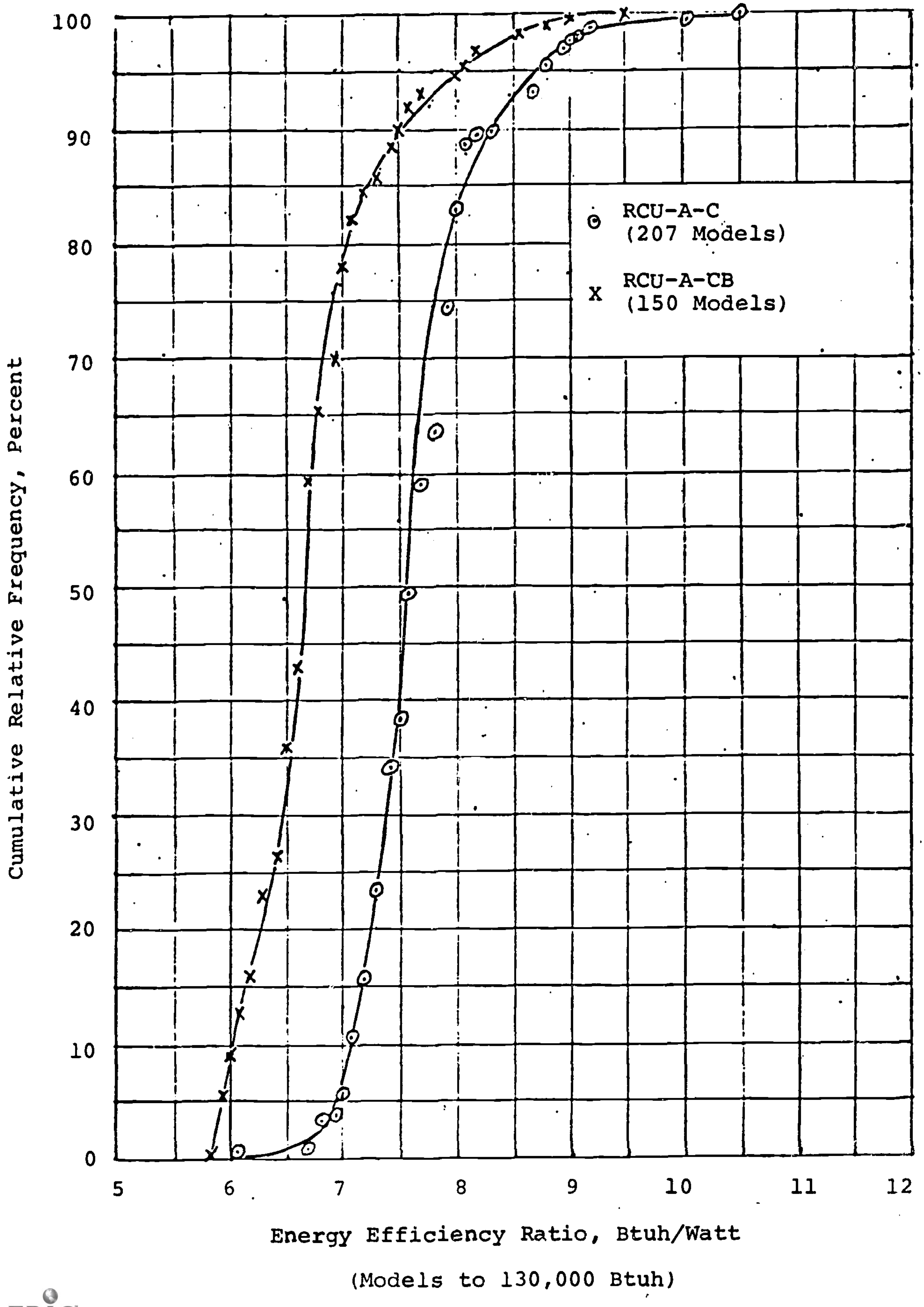
Further discussion of EER will be restricted to that calculated from the rated Btuh cooling capacity and the watts input as published in the ARI Directory of Certified Unitary Air Conditioners and Heat Pumps. These values were all obtained at ARI Standard Rating Conditions which are, for air cooled condensing, as follows:

Air Entering Indoor Coil	80F dry-bulb 67F wet-bulb
Air Entering Condenser Coil	95F dry-bulb
Cooling Coil Air Quantity not to exceed per 1000 Btuh of cooling capacity	37.5 cfm

The performance for all models of two types of equipment certified by a very limited number of manufacturers is shown in the graph of Exhibit II A-5. Both types of equipment utilized remote air-cooled condensing units. One type, RCU-A-C, does not include a fan or blower for circulating conditioned air; this function would normally be performed by the blower in the furnace. The second type, RCU-A-CB, included a blower-coil unit with a fan or blower motor.

The "cumulative relative frequency" shows the percent of units studied whose EER was equal to or less than the value on the ordinate of the graph. For example, 50 percent of the RCU-A-CB units studied had an EER of 6.6 Btuh/watt or less.

Exhibit II A-5



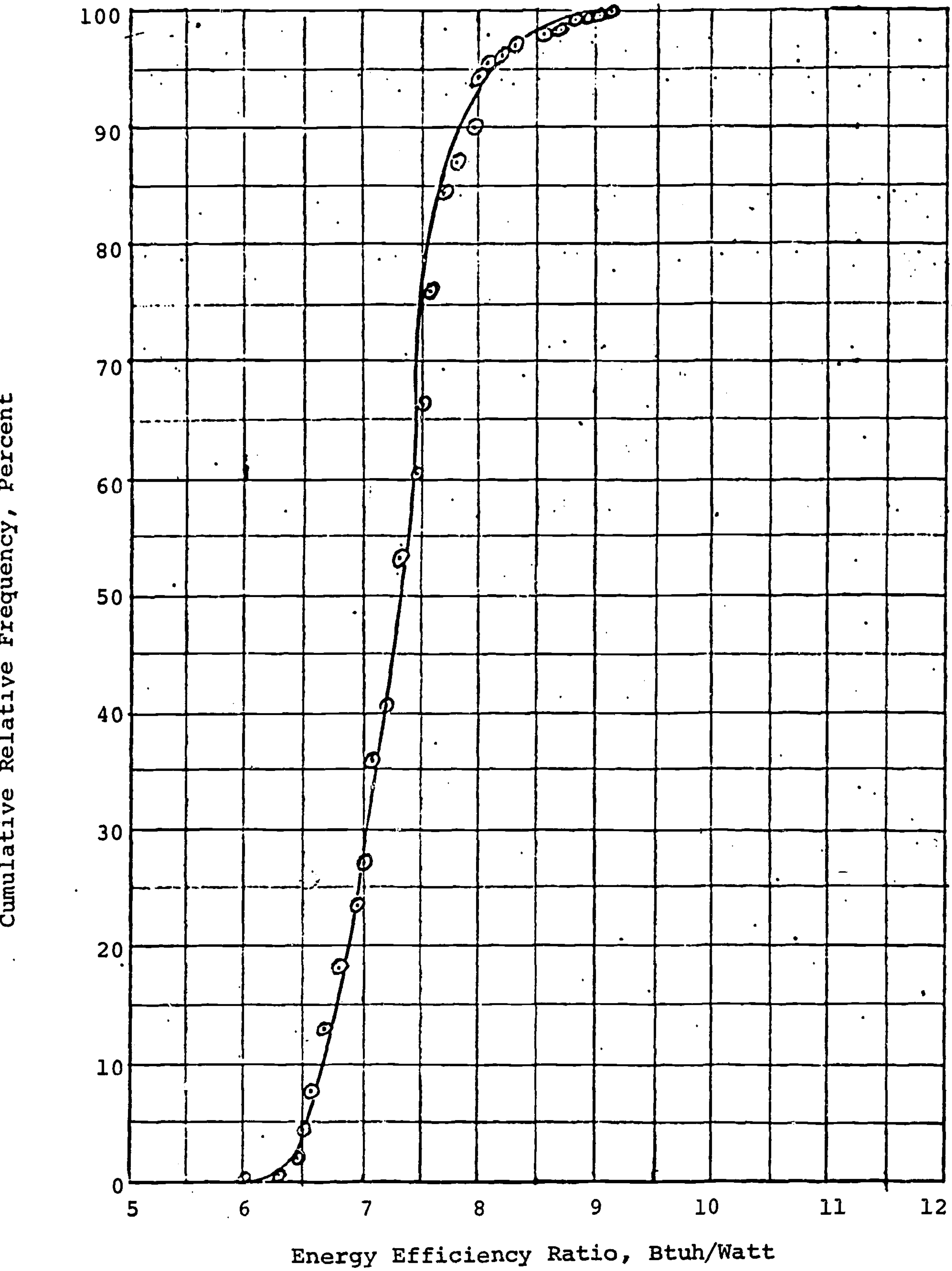
The cooling capacities of the units examined ranged from about 18,000 Btuh to 130,000 Btuh. There were noticeable variations of the energy efficiency ratio in each manufacturer's product, but it did appear that, in a very general way, the smaller units consumed energy less efficiently than did the larger units.

It is probably reasonable to assume that the energy efficiency ratio of the combination of an air conditioning unit (type RCU-A-C) and furnace fan would be very nearly the same as that of an air conditioner which included a cooling coil fan (type RCU-A-CB).

Exhibit II A-6 shows an analysis of the performance factors for 783 models in the cooling capacity range of 18,000 Btuh to 60,000 Btuh. These are the products of 12 manufacturers. All models are of type RCU-A-C, and input to the cooling-coil fan is not considered in determining the energy efficiency ratio.

One provision of the ARI Certification Program for Unitary Air Conditioners is that one-third of each participant's basic models must be tested in an independent laboratory each year. These units are selected by the ARI Engineering Staff, usually after examining submitted test data to determine which units seem most nearly susceptible to failure. Results from independently conducted tests on units thus selected were reviewed by the ARI Staff to get an indication if energy

Exhibit II A-6



(RCU-A-C, 783 models to 60,000 Btuh)

consumption characteristics were changing significantly from year to year. The data, as summarized by ARI and presented below, suggests major changes have not occurred:

Performance Factor	1965	1967	1971
Low	5.8	6.0	6.4
Median	7.3	7.1	7.1
High	9.0	8.5	8.8

It should be remembered that the units tested were selected on the basis that they might not achieve the performance claimed for them. This, in general, however, was found not to be the case

Improved Energy Efficiency Ratio vs. Equipment Cost

The average energy efficiency ratio (EER) of air conditioning equipment is about seven Btuh/watt and can possibly be increased to about 12 Btuh/watt. The improvement in EER is generally accompanied by an increase in cost to the manufacturer, which must eventually be paid by the end user. The actual added cost is difficult to determine. The manufacturers, who have built high efficiency equipment, state that they have not found sufficient purchasers who are willing to pay the added price to justify continued production. The manufacturers feel that research to improve efficiency is not justified because of the lack of sales appeal of the higher cost but more efficient equipment. The total owning and operating cost analysis is relatively easy to calculate for self-contained equipment such as window air conditioners, but is extremely difficult to apply to unitary split system equipment. The cost of split system equipment may represent only 40 percent of the system cost, and the application and installation may have more effect on system efficiency than component test efficiency. Since total owning and operating costs are very difficult to apply to split system equipment, standards for minimum component EER should be established and some form of field installation inspection should be developed to help guarantee acceptable system installation.

If standards are established for minimum EER, equipment having higher EER will gradually become the most commonly produced equipment. Where high speed or semi-high speed production is involved, the standard product can be sold for lower cost than a non-standard product, even though the non-standard product contains less expensive parts. The difference is more than offset by production techniques. If this occurs or is approached in central air conditioning equipment, the equipment with high EER need not be accompanied with an excessively high price.

One of the major problems associated with central air conditioners, even with equipment that has been manufactured as parts of unitary equipment, is that the air conditioners can only condition space after they have been incorporated into an overall system designed and installed by specialists other than the equipment manufacturer. Central air conditioners, unlike window air conditioners, refrigerators, or other appliances can not be simply unpacked, set in place, plugged in, and operated. Central air conditioners must be incorporated into an air conditioning system which is specifically designed to suit the needs of the structure of which it is part. Connecting duct work must be properly configured and sized to convey the required volume of conditioned air. Proper and adequate electrical supply must be provided. Refrigerant piping must be installed without permitting air or moisture in the refrigerant circuit, and in most installations a closely specified quantity of refrigerant must be placed in the refrigerant circuit.

The contractor determines the size and type of interconnecting equipment and is responsible for proper installation. The contractor's action can affect the air conditioning system performance as well as the maintenance requirements. Skill and care in installation and service are essential to efficient and reliable operation.

Essential steps in selection, installation, and operation of a central air conditioner should include the following:

Load Calculation

The design load on the system should be carefully calculated by a professional engineer for a large installation, or by a contractor for residential applications, using industry standards or guides published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), or by Air-Conditioning or Refrigerator Institute (ARI) 230, or Manual J published by the National Environmental Systems Contractors Association (NESCA). Even though the calculations require time and therefore cost money, they are essential if the systems are to provide satisfactory performance.

Equipment Selection

Equipment must be selected that will have the characteristics and capacity to fulfill the requirements of the application. The equipment must have the capacity to maintain tolerable conditions at extreme temperature and humidity conditions. However, the system should not be larger than necessary because it will then, on average warm days, cool the space too quickly, overshoot temperature settings, cycle too often and, in general, provide uncomfortable space conditioning.

Excessive cycling will result in inefficient performance as well as causing excessive wear on the unit.

System Design

The design changes recommended to improve the operating efficiency of room air conditioners also apply to central air conditioning systems. In addition, however, there are other factors unique to a central air conditioning system that must be considered in a study of the efficiency of this device.

The duct system must be carefully designed using industry procedures such as Manual K published by NESCA or ASHRAE Guide and Data Book. The duct system should be located within the conditioned space, rather than in attics or other unconditioned spaces or be adequately insulated to prevent heat gain. System design and equipment selection are mutually dependent and may be done concurrently. Careful design is important, even though it requires time and adds initial cost, and must be done to avoid air turbulences and high pressure drops in ducts that result in inefficient performance.

Dual Voltage Rated Equipment

The electric design of dual voltage rated air conditioners must be broad enough to perform with acceptable efficiency when installed on any electric system for which it is designed. For instance, if a given unit is recommended for use on both 208 and 230 volt systems, the efficiency should not be drastically reduced at either voltage. This however is often not the case. An ARI certified unit of the RCU-A-C type produces 24,000 Btuh with 3,500 watts when applied on a 230 volt system. This same unit is footnoted in the ARI Directory[1] to require 700 more watts to produce 1000 Btuh less or 23,000 Btuh with 4,200 watts when

1. Directory of Certified Unitary Air Conditioners, Air-Conditioning and Refrigeration Institute.

applied on a 208 volt system. The unit energy efficiency ratio reduces from 6.9 to 5.5 Btuh/watt or 20.3 percent when the supply voltage is reduced from 230 volts to 208 volts. This large reduction in energy efficiency ratio (EER) demonstrates that dual voltage rated units may result in a significantly lower EER at one of the rated voltages.

It is recommended that dual voltage rated equipment be listed directly by ARI at each of the rated voltages instead of employing the use of footnotes. Efforts should be made by manufacturers of such equipment to provide high energy efficiency ratios at both rated voltages or if necessary to obtain a reasonable level of efficiency, provide individual equipment for each voltage.

Installation

Installation must be carefully and skillfully done by mechanics following the instructions and recommendations of the equipment manufacturers, designers and contractors. Relatively minor deviations from the instructions and recommendations or unworkmanlike construction can undo the efforts of engineers and designers and will result in unacceptable performance and inefficient operation of the system.

The mechanical assembly of the ductwork and enclosures of coils and other components through which air flows must be properly sealed and free of obstructions which can reduce performance. The ductwork should be corrosion resistant and sufficiently rugged so that the effect of vibration will not result in future system air leakage.

The mechanical assembly of the refrigerant tubing must be such that the refrigerant liquid or gas will not be restricted in flow or trapped in the system. Coils and interconnecting tubing must be arranged so that there are no sharp bends or abrupt changes in cross-section present in which a vapor lock or liquid block can occur causing restriction of the refrigerant flow. Restricted flow will reduce capacity or cause equipment malfunction.

Check, Test and Start

System checking, testing and starting requires highly specialized skills and may include charging the refrigerant circuit, measuring system operating pressures, temperatures, air quantities and electric voltage, and current. These characteristics must be checked or adjusted to their proper operating values to optimize the performance so that satisfactory comfort conditions will result and so that the energy efficiency ratio will be as high as possible.

System Operation

The homeowner and resident must be instructed to use his air conditioning system properly and effectively and should be told what maintenance procedures he can reasonably perform and be encouraged to perform them regularly. He should be instructed that the most economical operation of the system will result from setting the thermostat to the highest point in summer, and the lowest point in winter, that will provide acceptable comfort. He should be sufficiently aware of system operating characteristics so that he will recognize a need for service.

The above steps are essential to obtain an air conditioning system that will provide comfortable conditions at the highest efficiency for the life of the equipment.

Regular Maintenance and Service

Routine maintenance and prompt service are essential to effective and efficient system operation. The refrigeration circuit should be tested at least once a year to assure correct refrigerant charge, proper operating temperatures and pressures, and correct lubrication. Air filters should be changed at least four times a year and the air flow checked at least once a year.

Water Cooled Condensing Units

Several years ago the Eastern Section of the United States experienced a very serious drought for a period of several years. The drought occurred at about the time when many air conditioning units were installed with water cooled condensing units which used purified drinking water for cooling. In an effort to conserve water, many local governments passed ordinances or laws to prohibit the use of water cooled condensing units which used the water once and discharged it into the sewerage system. These ordinances resulted in a change to almost universal use of air cooled condensing units for small installations.

At this time when energy availability is dwindling, the use of water cooled condensing units should be studied. New techniques in the use of water towers have been developed which reduce the required quantity of water. The overall effect on the environment may indicate that additional use of water to reduce the energy required for air conditioning is justified. The estimated savings in energy of water cooled condensing units compared to air cooled condensing units installed in New York City is between 15 and 25 percent. This savings will occur at the time of peak load on the New York electric systems when electric generation capacity is at a premium.

Recommendations

1. State and local government agencies that purchase central air conditioning equipment should be encouraged to lead the way in modifying their purchase procedures so as to require the purchase of more efficient equipment.

2. Air Conditioning and Refrigeration Institute (ARI) should be encouraged to tabulate the energy efficiency ratio (EER) of all models listed in its Directory of Certified Unitary Air Conditioners. This should be done by each voltage to which the manufacturer specifies that the unit may be connected.

3. Manufacturers of unitary air conditioners should be encouraged to improve the EER of dual voltage rated units.

4. Manufacturers of unitary air conditioners should also be encouraged to develop inexpensive monitoring systems that indicate when air conditioning equipment components such as filters, ducts, fans and other components need attention.

5. As stated for room air conditioners, this Ad Hoc Committee believes that mandatory minimum performance standards are the most effective approach in improving air conditioner efficiency within a short time span. A more detailed discussion and recommendations regarding the use of education and minimum standards for increasing air conditioner efficiency is contained in Section III of this report.

c. Electric Heat

The use of electricity for space heating is increasing in the United States. This trend has far reaching implications in terms of conservation of primary fuels, current fuel shortages, the ability of the electric utilities to meet current and projected loads, air pollution considerations and off-peak loading as related to utility electric rates.

Although the greatest consumer saturation of electric space heating is found in the South, significant growth in saturation is predicted throughout the nation in the next decade. The Federal Power Commission (FPC) in the 1970 National Power Survey, indicated that 40 percent of all new dwelling units built in the United States between 1971 and 1980 will be all electric.

Data taken from the 1970 Census indicates that there were 5,913,861 total occupied housing units in New York State. Of these,

a) 3,357,171 unitr or 56.8% have oil heating,

b) 2,237,007 units or 37.8% have gas heating,

c) 104,091 units or 1.8% have electric heating.

New York State has the lowest percentage saturation of electric heat of any state in the nation with the national saturation being 7.7 percent.

The Electrically Heated Residential Dwelling Units Added in 1971 and 1972 for each utility company are shown in Table II A-2. The total number of units added in New York State in 1971 and 1972 are 16,057 and 18,371 respectively. The added units represent approximately a 15 percent increase in 1971 and 1972.

The average annual energy consumption of residential electric heating units in New York State is estimated to be approximately 17,000 kWh. The total energy consumption for electric heating units in New York State in 1970 was approximately 1,770 million kWh. This constituted 6.7 percent of the total residential electrical energy usage or about two percent of the total electrical energy usage in New York State in 1970. These percentages are expected to increase significantly by the end of the decade.

Most of the electric heating installations in New York State use baseboard resistance heaters. An analysis of the types of heating units found in the approximately 10,000 residential electrically heated dwelling units in the Long Island Lighting Company Franchise Area is presented below:

Type of Electric Heating Unit	Percent Of Total
Baseboard	84
Hydronic	5
Warm Air	4
Glass Panel	4
Ceiling Cable	1
Other, Including Heat Pump	2

The total number of residential and commercial heat pump installations in the Long Island Lighting Company Franchise Area is 282. The total number of heat pump installations in New York State is estimated to be about 500. The heat pump, although more energy conserving than electric resistance heating, has obtained only limited application because of initial cost and maintenance considerations. The heat pump is discussed in greater detail later in this section.

The relative merits of electric heating as compared to fossil fuel space heating is a subject about which there is considerable controversy. New York State Public Service Commission Case 26292, "Conservation of Energy in the Consolidated Edison Franchise Area" is presently bringing to light much data and differences of opinion on this subject. The Public Service Commission has also issued a report "A Study of Electric Space Conditioning in New York State" which treats the many aspects of the use of electric heat in great detail. Although a comprehensive treatment of the relative merits of electric heat is not considered within the scope of this report, it is believed that a brief summary of the conclusions of the Public Service Commission report is worthwhile since it gives some perspective on the overall problem.

"Electric resistance heating is highly efficient, but the production and transmission of electricity is not. Thus, less energy is needed at the point of use of electric heat compared with fossil fuel heating, but in the former case more total energy must be delivered to the State." As a consequence, under current construction practices even though more thermal insulation is used in homes heated electrically than in homes heated by fossil fuels, "an increase in electric resistance heating would increase the total amount of energy needs for heating. Energy needs could be reduced if better insulation practices were required in all new buildings. The use of heat pumps and heat recovery systems could substantially reduce energy requirements when heating by electric. These possibilities should be vigorously pursued."

Our computations indicated that increased electric space conditioning saturation would be beneficial from a power system viewpoint. High saturations would reduce the spread between the summer and winter peak, improve annual load factors with a consequent beneficial impact on unit costs, and increase utility revenues. As a consequence such high electric use could be beneficial to the consumer from a rate viewpoint.

Also, in high population density areas, the use of electric space heating may be more environmentally advantageous than local boiler installations on the assumption that the electric generating plants are located in remote areas and that the local boiler installations cannot adequately disperse the stack emissions. Where the local boiler installations are equipped with air pollution control equipment this advantage is minimal. On the other hand, local boiler installations are more advantageous from an energy conservation viewpoint. Thus, in considering the relative merits of electric space heating and local boiler installations, one must balance environmental needs against the need to conserve energy.

On balance, and considering the current electric power supply situation, nothing should be done to stimulate electric load, particularly in the downstate area. Over the longer term, however, electric space conditioning, particularly in highly urbanized areas, might be desirable. Such long term use of electric power is particularly advantageous in view of possible shortages of other fuels and could be quite competitive from an energy conservation standpoint, especially if the potential energy savings from heat pumps and heat recovery systems are realized. In all cases, rates should allow recovery for the cost of service; promotional allowances should not be permitted.

The many unresolved questions with respect to an overall comparison of electric heat as opposed to primary fuel usage cannot be answered by this report. Further study is necessary to resolve the issues. With respect to one and two family homes, electric <u>resistance</u> heating consumes significantly more primary energy than direct heating with fossil fuels, especially if thermal insulating practices are standardized for all homes regardless of the fuel used.

The following suggestions are provided as a guide to using electric resistance heat most efficiently:

Energy Conservation Suggestions with Electric Resistance Space Heating Systems

1. Thermal insulation is the most effective way of reducing consumption with electric heating. Since the 1950's the electric industry has used the "All Weather Comfort Standard" for electric heated and air conditioned homes. This is a guide to good thermal performance values and vapor barrier and ventilation practices. In April 1971, the Federal Housing Administration (FHA) in its Minimum Property Standards No. 300, Interim Revision 51A, has specified maximum heat losses for One and Two Living Units to reduce heat losses in homes using any type fuel to the same level.

2. Weather stripping and caulking around all windows and doors and checking for infiltrating air in these places could reduce electric energy requirements by as much as 15 to 30 percent.

3. Install storm windows or insulating glass. Insulating glass will cut the amount of heat loss through the window areas by one-half.

4. Close the fireplace damper tightly when the fireplace is not in use. A chimney can draw off as much as 20 percent of the heated air in a house during each hour the damper is left open.

5. Close the doors to the attic, basement, or other unheated parts of the home. With an individual room thermostat system, turn down the thermostats in the room not in use to 65°F.

6. Night Setback - Setting the thermostat back at night will reflect a savings in energy use. As an example, Honeywell, Inc., has run a computer simulation test of a heating installation in the New York City area. The data indicates that an eight hour night setback (10 p.m. to 6 a.m.) will result in the following energy savings:

Night Setback	Energy Savings
5°F	8%
7 1/2°F	10%
10°F	12%

Notes:

1. The savings are based on typical New York City temperatures.

2. For a well insulated home, multiply savings by 0.75%; for a poorly insulated home multiply savings by 1.5.

3. Further delay to 8 a.m. on reset has an additional influence on savings because the solar load will aid in returning the house to the desired daytime temperature.

7. Constant changing of thermostat setting increases the use of energy. With convection or radiant heating systems (electric baseboard or ceiling cable), a setting of 70°F is usually comfortable; forced air systems may require a slightly higher setting. Energy costs increase about three percent for every degree that thermostat is raised above the normal setting of 70°F. Higher settings will not make a room warmer any faster.

8. When a house is to be unoccupied for several days, the thermostat should be set lower for this period, say to 55°F.

Table II A-2

New York State

Electrically Heated Residential Dwelling Units

Added in 1971 and 1972

Utility	Year	No. Of Dwelling Units In Apartment Buildings	No. Of New Detached Houses	No. Of Existing Dwelling Units Converted	Mobile Homes	Total 1971	Total 1972
Central Hudson Gas and Electric Corporation	1971	650	950	450	NA	2,050	
	1972	547	980	369	NA		1,896
Consolidated Edison Company of New York, Inc.	1971	1,634	645	92	0	2,108	
	1972	1,000	75	25	0		1,100
Long Island Lighting Company	1971	266	866	781	NA	1,913	
	1972	755	1,402	1,056	NA		3,213
New York State Electric and Gas Corporation	1971	503	1,717	696	NA	2,916	
	1972	1,102	2,218	739	NA		4,059
Niagara Mohawk Power Corporation	1971	5,055	1,096	345	55	6,551	
	1972	5,980	1,105	295	75		7,455
Rochester Gas and Electric Corporation	1971	317	107	79	6	509	
	1972	460	121	67	0		648
						16,057	18,371

Heat Pumps

Although the use of electric heat is increasing in New York State, its use is almost entirely in the form of electrical resistance heating. Heat pumps are capable of delivering more useful heat than the Btuh equivalent of their electrical input. Their use has been essentially limited in New York State because of initial cost and maintenance factors.

A discussion of heat pumps is appropriate since the use of heat pumps, in lieu of electrical resistance heating, would result in an annual average energy savings of approximately 50 percent. In view of the growth in electric space heating predicted for New York State, the statewide energy savings that could be realized through the use of heat pumps is extremely important.

The heat pump is a mechanical apparatus that can either heat or cool a dwelling unit. The heat pump operates on the basic mechanical refrigeration cycle, by transferring heat from one place or source at a relatively low temperature to another at a higher temperature. When used for cooling, the heat pump is operating as an air conditioner. The coil inside the space to be conditioned is used as an evaporator and the outside coil is used as the condenser. When the heat pump is used for heating, the functions of the inside and outside coils are reversed by altering their positions in the refrigerant circuit, usually by means of a four-way valve.

The performance of a heat pump is evaluated in terms of the ratio of the heating effect over the net energy supplied, which is defined as the coefficient of performance (CP).

$$CP = \frac{\text{Heating Effect}}{\text{Net Energy Supplied}}$$

When evaluated over a heating season the coefficient of performance is called the Performance Factor (PF).

In heating, the heat pump supplies the heat equivalent of the electrical input plus the heat taken from the outside air, water or earth. The air-to-air heat pump is the most common type because of its universally available heat source and its simple application to small structures.

Since the minimum heat delivered with a heat pump is the heat equivalent of the electrical input, its minimum possible performance would be equivalent to the use of electrical resistance heating.

The maximum attainable coefficient of performance of a heat pump would be that of a reversed Carnot cycle which is:

$$CP = \frac{T_1}{T_1 - T_2}$$

Where T_1 and T_2 may be taken as the inside and outside coil temperatures respectively.

An actual heat pump in general can be only about half as efficient as an ideal Carnot machine. Coefficients of performance of heat pumps vary with the design and capacity of the units and the temperature conditions under which they are used. Heat pumps with cooling and heating capacities suitable for use in dwelling units typically have coefficients of performance which range from slightly over one with an outside air temperature of 0°F to approximately three at 70°F. The coefficients of performance of larger heat pumps for commercial applications are slightly higher with the coefficient of performance for these units being 3.5 or more.

As shown in the heat pump performance curves of Exhibit II A-7, and Exhibit II A-8 respectively, the coefficient of performance and the capacity of a heat pump decrease with decreasing outside air temperature which unfortunately is an inverse relationship to the actual demand for heat. To compensate for this loss of capacity at low temperatures, heat pump systems also use electrical resistance heaters to supplement the heat output of the heat pump cycle. The heat obtained from the electrical resistance heaters is delivered at an equivalent heat pump coefficient at performance of one; hence, for maximum system efficiency, electrical resistance heating should be minimized.

Heat pump units are generally sized on the basis of required cooling capacity. The associated heating capacity of the heat pump selected is usually within 10 percent of the cooling capacity. The Air Conditioning and Refrigeration Institute (ARI)

EXHIBIT II A - 7
COEFFICIENT OF PERFORMANCE
AIR TO AIR HEAT PUMP

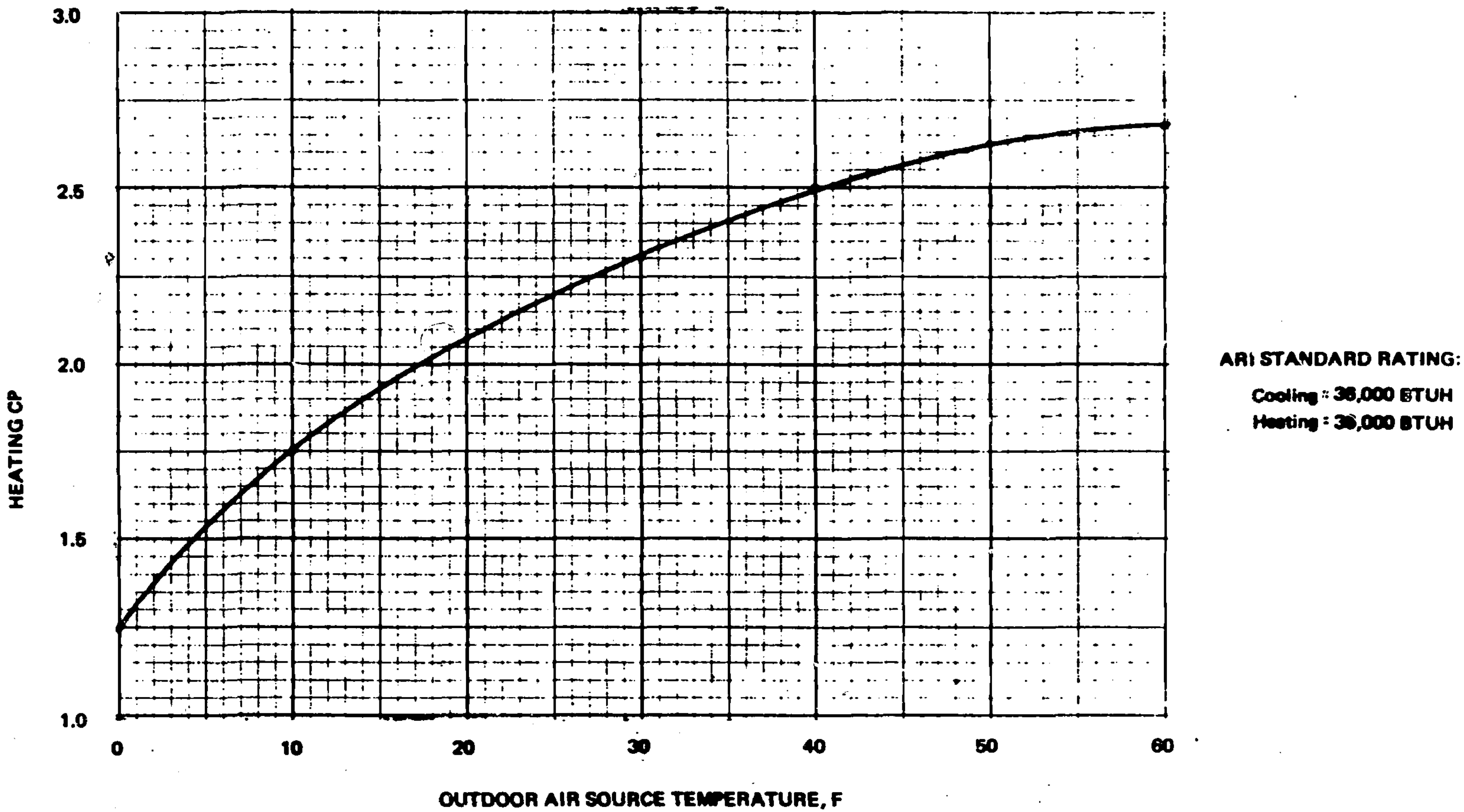
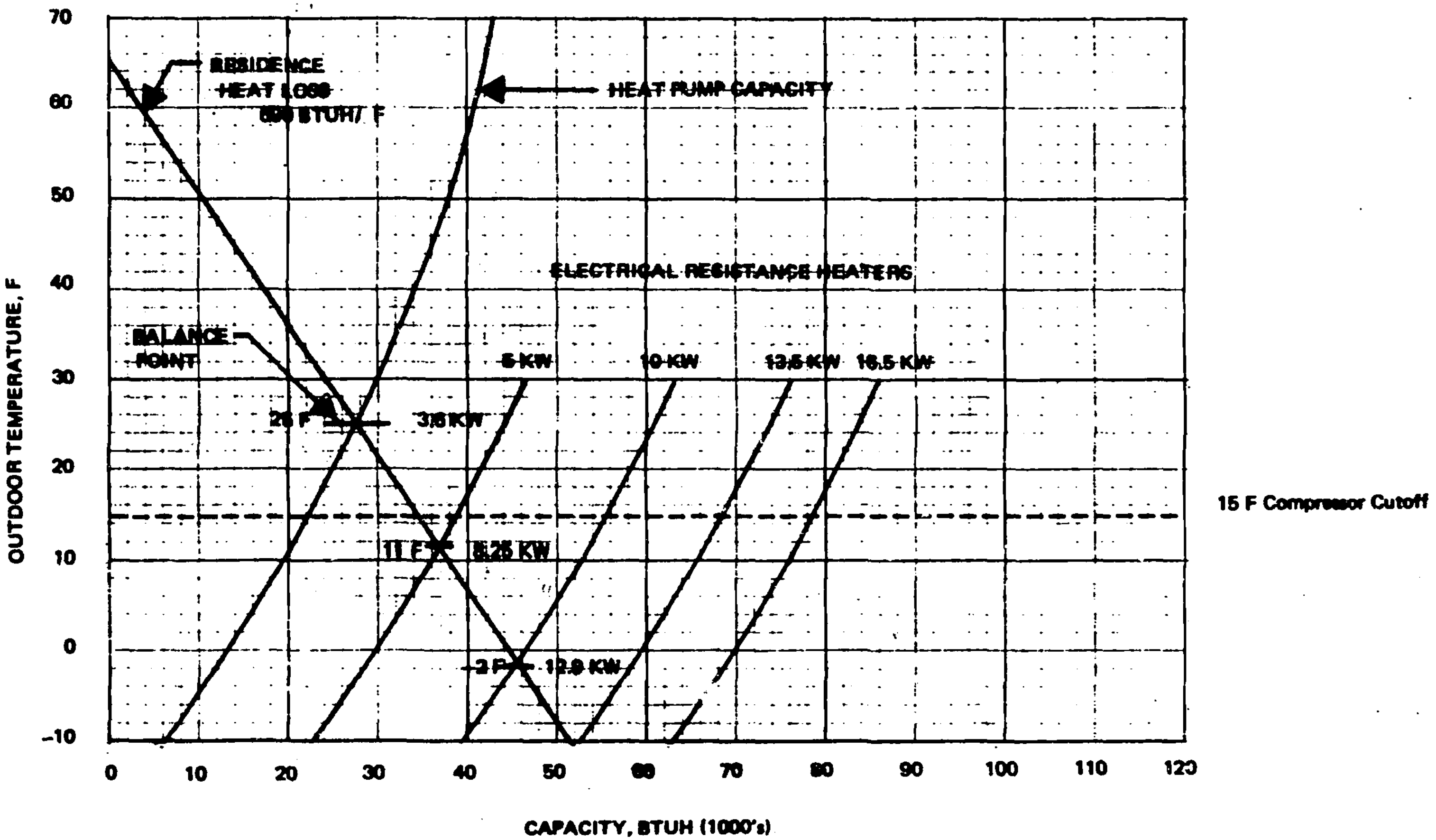


EXHIBIT II A - 8

TOTAL CAPACITY OF HEAT PUMP & SUPPLEMENTAL HEATERS
BASED ON 74F AVERAGE INDOOR TEMPERATURE



Standard heating ratings are specified at an outdoor temperature of 45°F. Some variation in the cooling/heating capacity ratio does exist, thus selecting a unit involves choosing the unit which most nearly satisfies the heating requirement as well as the cooling requirement.

In all New York State climatic divisions the space heating requirements of residential structures exceed the heating capacity available when the heat pump system is selected on the basis of required cooling capacity.

When a heat pump operates in a heating cycle and its outdoor coil surface temperature is below 32°F, frost accumulates on the evaporator coils. The amount of frost and its rate of accumulation depend on the moisture content of the ambient air as well as the difference between the ambient air temperature and the evaporator temperature. The frost must be removed or the heat output of the heat pump will decrease as the frost accumulates. Eventually, the frost would block the airflow over the evaporator coil. Heat pumps have a defrosting cycle to eliminate frost build-up. The actual mechanism of defrosting the outdoor coil is accomplished by reversing the heat pump and heating the outdoor coil with heat from the building. During the defrost period, supplemental heaters are used to offset the building heat losses.

A variety of systems have been devised to initiate defrosting. The most common are listed below:

a) A timer to initiate defrosting at predetermined intervals depending on outdoor air temperatures.

b) A pressure switch which will react to increased pressure drop across the evaporator coil caused by frost build-up.

c) A temperature difference control (thermostat) which will initiate the defrost cycle at a predetermined temperature difference between the refrigerant in the evaporator and the outside air.

The amount of energy consumed in the defrost cycles is a small percentage of the total annual heat pump energy requirements. This percentage does vary with climatic conditions and is estimated to be 0.5 percent on a national basis and an average of about two percent for the New York State area.

During the course of a heating season, a heat pump will be required to operate over a range of outside air temperatures at which it will exhibit different coefficients of performance. The Performance Factor (PF), the term used to describe the performance of the heat pump over a heating season, will have a value dependent upon the heating season temperature profile and the performance characteristics of the individual heat pump.

Calculations were performed by the Committee to determine the variation in performance factor resulting from the difference in climatic conditions experienced in New York City and Syracuse. A ranch type home with a 1,700 square foot livable area having a heat loss rate of 690 Btu/Hr/°F was assumed in making the calculation. The heat pump was assumed to have the capacity and performance characteristics shown in Exhibit II A-8 and Exhibit II A-7, respectively. The heat loss of the residence has been superimposed on Exhibit II A-8, so as to graphically demonstrate the outdoor temperature at which the maximum heat pump capacity is equal to the heating load (balance point), and the outdoor temperatures at which each of the supplemental heaters are being used at full capacity.

The results of the study shown in Table II A-3, indicate that performance factors of 2.3 and 1.8 will be obtained with operation of the specified heat pump under the climatic conditions encountered in New York City and Syracuse, respectively. It is believed that these calculated performance factors are somewhat high. Many existing heat pumps have a low temperature cut-off which prohibits heat pump operation under freezing conditions. At temperatures below cut-off point, heat is supplied entirely by the supplemental heaters, thus lowering the performance factor. Recent improvements in the defrost cycle of heat pumps have resulted in reliable low temperature operation, thus eliminating the need for a low temperature cut-off. This improvement has increased both the reliability and the performance factor of heat pumps.

The use of the heat pump in lieu of electrical resistance heating will result in an energy savings of 57 percent in New York City, and 45 percent in Syracuse. This energy

Table II A-3

Summary of Heat Pump Energy Consumption Data*

For New York City and Syracuse

		New York City	Syracuse, New York
Heat Pump Input	kWh	10,467	11,556
Supplemental Heaters	kWh	854	7,076
Total Input	kWh	11,321	18,632
Total Output**	kWh	25,240	34,173
Performance Factor		2.3	1.8
Heat Pump Energy Requirements as Percent of Energy Requirements for Electrical Resistance Heaters***		43%	55%

* Based on Heat Pump Capacity and Performance Characteristics of Exhibits II A-7 and II A-8, respectively.

** The total output of the heat pump is the heat loss of the dwelling and represents the energy required if electrical resistance heaters are used in lieu of a heat pump.

*** These heat pump energy requirements assume that the air ducting for a central heat pump system is located entirely within the conditioned space. The energy requirements of the heat pump system may be as much as 20 percent higher if the air distribution system is located in unconditioned areas. This effect can be minimized by adequate duct insulation.

savings is seen to be very significant in both the downstate and upstate areas. Therefore, from an energy conservation standpoint, the heat pump is superior to the electrical resistance heater since a significant relative energy savings will be experienced.

The two factors which have tended to discourage increased sales of heat pumps are high initial cost and past maintenance problems. The slightly higher initial cost of heat pumps as compared to electrical resistance heating and air conditioning is eventually recovered by reduced operating costs.

Several years ago, the heat pump was considered an appliance of low reliability and gave prospective purchasers concern with respect to cost of service, as well as inconvenience. These factors, in addition to the higher initial cost of heat pumps than electrical resistance heating, led in many cases to the selection of the latter.

The Edison Electric Institute initiated a Heat Pump Improvement Research Project in 1963. Field data on an improved Westinghouse Electric Corporation residential heat pump design was collected for a three-year period on approximately 150 installations in various parts of the country. The data indicated that an average of 1.13 calls per unit per year were required, with the average time for repair being about three hours.

Defrost is the most serious heat pump design problem. Failure to defrost and unpredictable ice build-up are problems for which improvement is vital to the use of heat pumps. Temperature ranging from the mid-thirties to the low-forties which constitute approximately 25 percent of the heating season in New York State, are probably the most severe for defrosting requirements.

In the selection of space conditioning appliances, the total owning and operating cost must be taken into consideration. The initial cost of a residential heat pump system would be approximately $100 to $300 more than central air conditioning combined with alternate electric heating systems such as electric furnaces, electric duct heaters, or electric baseboard heating. Based on the climatic conditions and the rate structure in the Long Island Lighting Company franchise area, a typical one family residence of 1,890 square feet with electric resistance heating would consume approximately 17,600 kWh at a cost of about $260. The use of a heat pump system with a performance factor of 2.0 would save $130 per year in energy costs. Additional factors to be considered are the increased maintenance costs and shorter system life of the heat pump. These factors are difficult to estimate for the New York area because of the limited number of installations in New York State and the lack of service experience in this area. All data available, however, does indicate that at existing utility electric rates, the cost of energy saved by use of a heat pump in lieu of electrical resistance heating will more than compensate over the life of the system for the somewhat higher initial and maintenance costs. The payback period for recovering the increased initial capital expenditure is estimated to be less than five years throughout the State and will depend primarily on the performance characteristics of the unit selected, climatic conditions in the specific area, and utility electric rates.

Summary and Recommendations

The use of heat pumps in lieu of electrical resistance heating could reduce the average electric space heating energy requirements by approximately 50 percent. Slightly higher initial cost will eventually be recovered by reduced operating costs. In view of the growth in electric space heating predicted for New York State, the use of heat pumps offers a very significant opportunity throughout the State for the conservation of energy.

In order to realize the energy saving potential of heat pumps, it will be necessary to build consumer confidence in the reliability of this device. The first step is for manufacturers to demonstrate confidence in their own product by offering guarantees and low cost service policies.

The increased use of heat pumps in New York State would, to some extent, result in a greater summer air conditioning load, since presently less than 25 percent of electric space heating customers install central air conditioning. However, the use of residential central air conditioning is increasing and the energy consumed during the cooling season would only be less than 15 percent of the energy saved through use of the heat pump.

The use of heat pumps for commercial space conditioning in New York State is extremely desirable since virtually all commercial buildings now being built are centrally air conditioned. In addition, for commercial building, the heating and cooling loads are more nearly balanced and, hence, conform to the heating capability of the heat pump. This minimizes the use of supplemental resistance heaters and increases the Performance Factor of the heat pump.[2] The use of heat pumps for commercial buildings has been covered in the report of the Ad Hoc Committee for Energy Efficiency in Large Buildings.

2. For large residential and commercial applications, heat pumps using a reservoir of water are often used. These heat pumps have higher coefficients of performance and performance factors since these parameters are dependent upon the temperature of the heat source.

d. Lighting

Energy used for illumination is of great interest in an energy utilization analysis since approximately 25 percent of all electric energy sold is consumed for lighting. The amount of energy used for lighting and the efficiency at which the energy is utilized has been the subject of recent concern and controversy. In the past two decades, light levels recommended by illumination engineers have risen substantially. Many people are now questioning the justification for these changes.

Little effort has been made to encourage turning lights off when they are not needed, and in some buildings it is the practice to intentionally leave the lights on at night to create a more favorable building appearance. In the World Trade Center, accessible switches to individually control room lighting have not been provided since essentially all lighting may be under computer control in the distant future. Lighting is presently controlled manually at panelboards on each floor. The relative merits of this system from the standpoint of convenience and energy conservation will be found by experience if the computer controlled lighting system goes into operation.

The energy provided for lighting ends up mostly in the form of waste heat, and usually no effort is made to recover this waste heat and utilize it in the overall space conditioning requirements of the building.

The lighting investigation made by this Ad Hoc Committee and the recommendations provided herein are of a general nature and as such, cover all types of lighting. The lighting devices discussed are used in dwelling units, stores, large buildings, and for parking lot, street and highway lighting. This Committee has duplicated in some small part the work of the Ad Hoc Committee on Large Buildings. However, this duplication is considered to be minimal and is so provided to offer a complete report.

Presented below are eight recommendations for the better utilization of energy used for lighting. They cover design, operation, and maintenance:

1. Design Lighting for Expected Tasks:

In establishing lighting requirements it is necessary to determine what types of activities are expected, their duration, and where they are expected to occur.

The concept of filling the space with high level light is an inefficient lighting approach. It is much more productive to graduate illumination as required by the task at hand, and to keep the surroundings in appropriate balance. Lighting should be provided for the seeing tasks with less light on surrounding non-working areas such as corridors, storage and pedestrian or vehicular areas. An example of the use of task lighting systems is the light in an aircraft cockpit used to illuminate the pilots dashboard containing the engine and flight control systems. There should be the capability to relocate or alter lighting equipment where changes in the use of the space are anticipated.

The Illuminating Engineering Society (IES) recommends values of illumination for visual tasks or a group of tasks in an area. The IES Lighting Handbook[3] sometimes lists locations rather than tasks, however, the recommended footcandle values have been arrived at for specific visual tasks. Also, supplementary luminaires may be used in combination with general lighting to achieve the recommended levels. The general lighting should be not less than 20 footcandles and should contribute at least one-tenth the total illumination level.

Where task positions are fixed and known, the lighting should be designed accordingly. However, task locations are not always known in advance of design so that it often becomes necessary to install task lighting levels at all probable task locations using a general overall lighting system. When this is done, the luminaires should have the capability of operating with controlled operation of the lamps.

Where task lighting is provided, recommendations concerning luminance (brightness) ratios should be considered in determining levels for non-task area lighting.

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3. IES Lighting Handbook, 5th Edition, 1972, Figure 9-80, Levels of Illumination Currently Recommended, Page 9-81.

2. Design with More Effective Luminaires

Select lighting equipment capable of providing proper visibility for performing tasks. This includes selecting lighting equipment designed to avoid veiling reflections and glare.

Luminaire lighting effectiveness depends on how well the light provided enhances the visibility of visual tasks. Light, if not controlled, can reduce visibility by producing veiling reflections (reflections which will partially hide the details of a task and lower the task contrast) and disability glare (light scattered in the eyes producing a haze to look through - such as experienced with oncoming headlights at night).

Well shielded (low brightness) luminaires can eliminate disability glare. Bright unshielded windows near the line of sight can produce significant disability glare.

Luminaires that consume equal wattage and provide equal illumination levels may not provide equal visibility of seeing tasks. Two IES reports have been published covering the evaluation of the visual effectiveness of lighting systems.[4] A computer program is available to simplify the evaluation process. Other programs are under development.

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4. Committee on Recommendations for Quantity and Quality of Lighting of the IES Report No. 4, "A Method of Evaluating the Visual Effectiveness of Lighting Systems," Illuminating Engineering, Vol. 65, August 1970, P. 504.

   Committee on Recommendations for Quantity and Quality of Lighting of the IES Report No. 5, "The Predetermination of Contract Rendition Factors for the Calculation of Equivalent Sphere Illumination," Journal of the IES, Vol. 2, January 1973, P. 149.

It has been found, for example, that polarized light and lighting from the side by luminaires of specific design can enhance task visibility by reducing veiling reflections. By illuminating the working area at an angle beyond the zone causing veiling reflections, the effectiveness of the illumination can be increased to close to 100 percent. Conversely, a heavy concentration of light from overhead and forward of the task can produce a high degree of veiling reflections and may be as little as 25 percent effective.

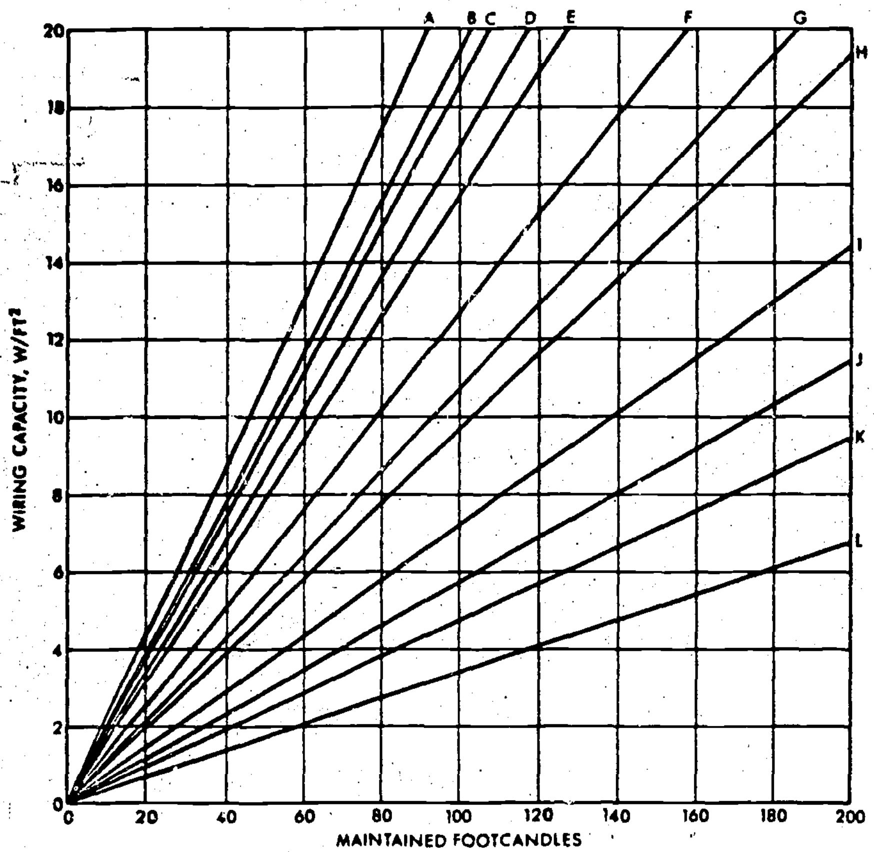
More efficient luminaires produce a greater amount of light on the task with less energy. For example, as shown in Exhibit II A-9, in a given room, incandescent indirect luminaires may require a load of 7 watts per square foot of floor area to produce a 30 footcandle illumination level; but direct fluorescent troffers may only require a load of about 3 watts per square foot to achieve double this level.

The illustration in Exhibit II A-10 shows how the redirection of light through a system removing it from the glare zone can raise its effectiveness from 25 percent to almost 100 percent so as to achieve optimum visibility of detail.

3. <u>Use Efficient Light Sources</u>

The various lamps available today have different characteristics. Efficiency of lamps, which is stated as lumens output per watt input, ranges from less than 10 lumens per watt to over 100 lumens per watt as shown in Table II A-4.

Exhibit II A-9



Approximate wiring capacity to provide a given maintained level of illumination in a room of 2.5 Room Cavity Ratio by means of the following:

A - Indirect, incandescent filament (silvered bowl)

B - Direct, incandescent filament (with diffuser)

C - Direct, incandescent filament (dawnlight)

D - General diffuse, incandescent filament

E - Direct, incandescent filament (lens)

F - Direct, incandescent filament (industrial) Indirect, fluorescent (cove)

G - Indirect, fluorescent (extra high output)

H - Direct, fluorescent (extra high output) (louvered)

I - Direct, fluorescent (louvered)

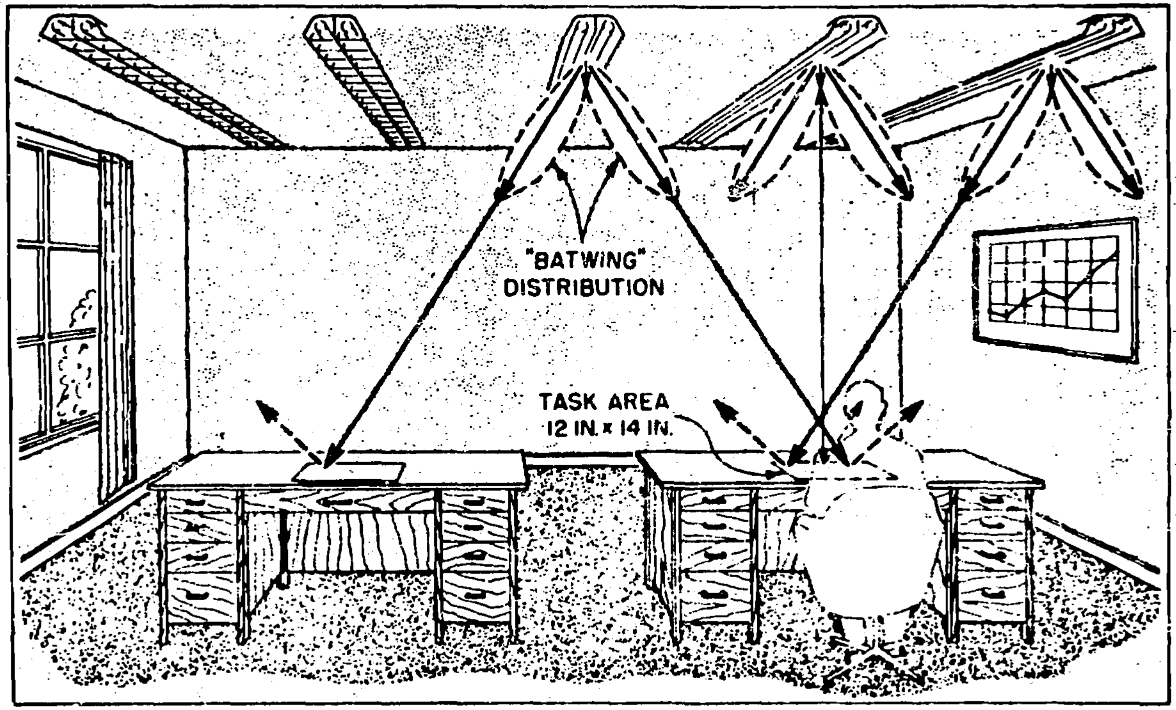
J - Luminous ceiling, fluorescent

K - Direct, fluorescent (lens) Direct, HID (mercury)

L - Direct, Semi-Direct, fluorescent (industrial)

(IES Lighting Handbook, 5th Edition, 1972, Page 16-9)

Exhibit II A-10



Optimum visibility is achieved with light brought in from the side. Near normal illumination tends to cause glare and veiling reflections.

Table II A-4

Lighting Efficiency of Various Light Sources

Light Source	Initial Lumens	Lumens/Watt Lamp Only	Lumens/Watt Lamp And Ballast	Ratio As Compared To 100 Watt Incandescent
25 Watt Incandescent	235	9.4	NA	.54
100 Watt Incandescent	1,750	17.5	NA	1.00
1000 Watt Incandescent	23,740	23.7	NA	1.35
20 Watt Fluorescent*	1,230	61.0	49	2.8
40 Watt Fluorescent**	3,200	78.0	70	4.0
112 Watt Fluorescent***	9,150	81.0	73	4.17
400 Watt Mercury Vapor	23,000	57.0	51	2.9
1000 Watt Mercury Vapor	63,000	63.0	58	3.3
400 Watt Metal Halide	32,000	80.0	68	3.9
1000 Watt Metal Halide	100,000	100.0	93	5.3
400 Watt High Pressure Sodium Vapor	47,000	117.0	104	5.9
1000 Watt High Pressure Sodium Vapor	130,000	130.0	122	7.0

* 24" Cool White - 2 Lamps Per Ballast (Pre-Heat Start)
** 48" Cool White - 2 Lamps Per Ballast (Rapid Start)
*** 96" (800 ma) Cool White - 2 Lamps Per Ballast (Rapid Start)

Higher wattage General Service (GS) lamps are more efficient than the lower wattage lamps. Therefore, using fewer higher wattage lamps may save power. For example, one 100-watt GS lamp produces more light than two 60-watt lamps (1750 lumens vs. 2 x 860 lumens = 1720 lumens).

For the same wattage, GS lamps (750 to 1000 hours life) are more efficient than Extended Service (ES) lamps (2,500 hours life). For example, a 100-watt GS lamp produces 17.5 lumens per watt input while a 100-watt ES lamp produces 14.8 lumens per watt input. For equal lighting results in this case, 17.5 percent more lamps and power are required when using the ES lamps.

ES lamps are used where maintenance labor costs are high or where lamps are located in nearly inaccessible locations.

The choice of light sources is limited by the application and not all light sources are appropriate for a specific lighting task. Characteristics that are normally considered in lighting selection include esthetics, size, light source color, initial cost, and the cost of operation and maintenance. The relative importance assigned to each of these characteristics usually depends upon the application.

Residential lighting is accomplished entirely by incandescent and fluorescent lighting. Although fluorescent lighting has approximately three to five times the efficiency of incandescent lamps, as shown in Table II A-4, the use of fluorescent lamps has been limited in residential use because of initial cost, color rendition, and the physical size and appearance of fluorescent fixtures.

On the other hand, the illumination of office buildings is accomplished almost entirely by fluorescent lighting. Some incandescent lighting is used in this application, but it is the exception, rather than the rule, especially in new buildings. High intensity discharge (HID) lamps could be applied in office buildings, but they have been used primarily for exterior lighting applications such as for parking lots, street and highway lighting. A more extensive discussion of street and highway lighting is presented later in this section of the report.

4. Use Luminaires Designed for Heat Removal

Recognize and control heat from lights. Heating and cooling systems should be designed to use lighting heat emitted from lights to reduce heating energy and to control lighting heat for minimal effect on cooling loads.

By using luminaires having air or water heat transfer capabilities, some heat from luminaires can be removed from the lighting fixtures and rejected externally to the building instead of allowing it to enter the occupied space in warm weather. Conversely the heat can be utilized in the occupied space in cold weather. By integrating the lighting and air conditioning systems, the cooling and heating system requirements can be reduced.

5. Use Light (High Reflectance) Finishes on Ceilings, Walls, Floors and Furnishings

Dark finishes absorb light that could otherwise be utilized. Excessively light finishes can cause glare. Follow the IES reflectance recommendations presented below.[5]

Surface	Recommended Reflectance
Ceiling Finishes	80-90%
Walls	40-60%
Furniture	25-45%
Office Machines and Equipment	25-45%
Floors	20-40%

The upper limits of reflectance have been selected to avoid excessively bright surfaces which can be uncomfortable or reduce visibility by producing disability glare.

As illustrated in Exhibit II A-11,[6] high reflectance finishes can increase the utilization of light. In the example shown, by repainting ceiling, walls and floor and refinishing furniture, the average illumination level was increased from less than 10 foot candles to over 40 footcandles.

6. Light Areas Only When Required

Flexibility in the control of lighting should be provided by the lighting design. Separate and convenient

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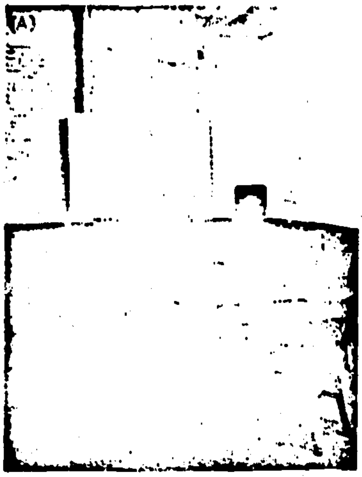
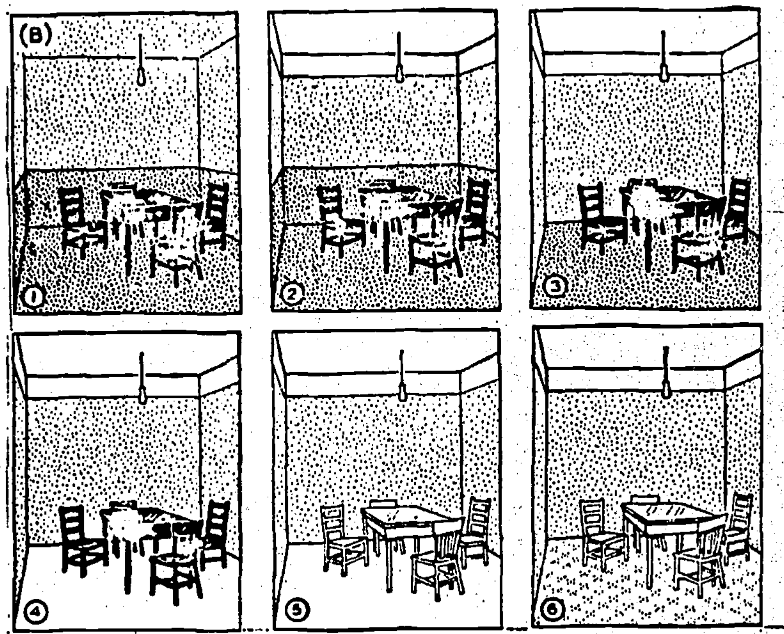
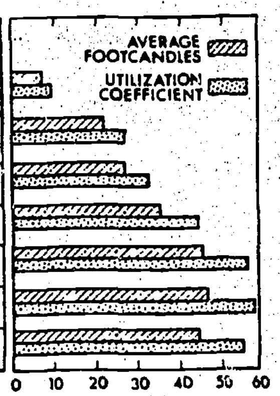
5. IES Lighting Handbook, 5th Edition, 1972, Page 11-5.
6. IES Lighting Handbook, 5th Edition, 1972, Page 5-17.





STEP	CEILING HEIGHT	CEILING COLOR	CEILING ρ*	WALLS COLOR	WALLS ρ*	FLOOR COLOR	FLOOR ρ*	FURNITURE COLOR	FURNITURE ρ*
START	12 FT	WHITE	30						
1	10 FT		65	WHITE AND GRAY	40	DARK RED	12	DARK OAK	
2	10 FT		85						28
3	10 FT	CREAM	85						
4	10 FT		85	GREEN	72	WHITE	85		
5	10 FT		85					BLOND	50
6	10 FT		85			WHITE AND RUSSET	70		

* REFLECTANCE



(D)

Effect of color scheme on appearance, coefficient of utilization, and illumination level in a small room in an industrial area. (A) Test room before changes in color scheme. (B) Step by step changes. (C) Test room with light walls, ceiling, floor, and furniture. (D) Variation of illumination and utilization coefficient with color scheme.

switching or dimming devices should be installed for areas that have different use patterns.

Where the lighting has been designed to provide a higher light level than deemed necessary for current tasks, the light level can be corrected by reducing the number of luminaires in use. This can be ideally accomplished if switches have been provided for this purpose, or their installation is still economically feasible. However, if switching is not available, a reduction in the light level can still be accomplished by removing the fluorescent lamps from luminaires, provided that individual lamps connected to a common ballast are not removed.

When a working or living space is empty, secure and not used for display or observation, there is no need for lighting. In this case it is always more economical to turn off incandescent lighting and, where off-time is more than a few minutes, fluorescent and high-intensity discharge lighting should be turned off.

In areas where adequate daylighting is possible, photoelectric control systems can be utilized to turn off the electric lighting and operate draperies and venetian blinds.

Educational programs, as described in Section III of this report, should be instituted that will remind occupants to turn off lights as they leave an empty room or when daylighting is adequate.

7. Optimize Window Design for Daylighting and Air Conditioning

Windows should be designed and utilized so as to optimize both lighting and heating effects. Daylighting should be utilized as practicable to produce the required illumination either alone or with an artificial lighting system.

The levels of illumination recommended by the IES are not based on electric lighting exclusively. The IES publishes a Recommended Practice of Daylighting[7] and includes daylighting design data in its IES Lighting Handbook[8] as a guide to the utilization of daylight. It is pointed out, however, that because of the wide variation in daylight (from several thousand footcandles down to zero), an adequate artificial lighting system should be provided.

The requirements for good lighting design can be achieved by skillful application of daylighting techniques.[9] These techniques include:

a) Redirecting available light for better interior distribution and utilization, such as with venetian blinds.

b) Limiting the brightness of fenestration to within comfortable limits (the same criteria as used for electric sources) by using devices such as: shades, screens, blinds, and low transmission glazing.

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7. "Recommended Practice of Daylighting", Illuminating Engineering, August 1962.
8. IES Lighting Handbook, 5th Edition, 1972.
9. "Recommended Practice of Daylighting", Illuminating Engineering, August 1962.

c) Controlling solar radiation entering a space, by utilizing such means as reflective glass coatings and sun screening, to reduce air conditioning requirements.

8. Maintain Lamps and Luminaires

Select luminaires with good cleaning capability and lamps with good lumen maintenance. Select a lighting servicing plan to minimize light loss during operation and thus reduce the number of luminaires required.

Studies have shown that good lighting maintenance procedures provide better utilization of the lighting system. For example, a study of a fluorescent lighting system, where different maintenance procedures were used, showed that (see Exhibit II A-12):

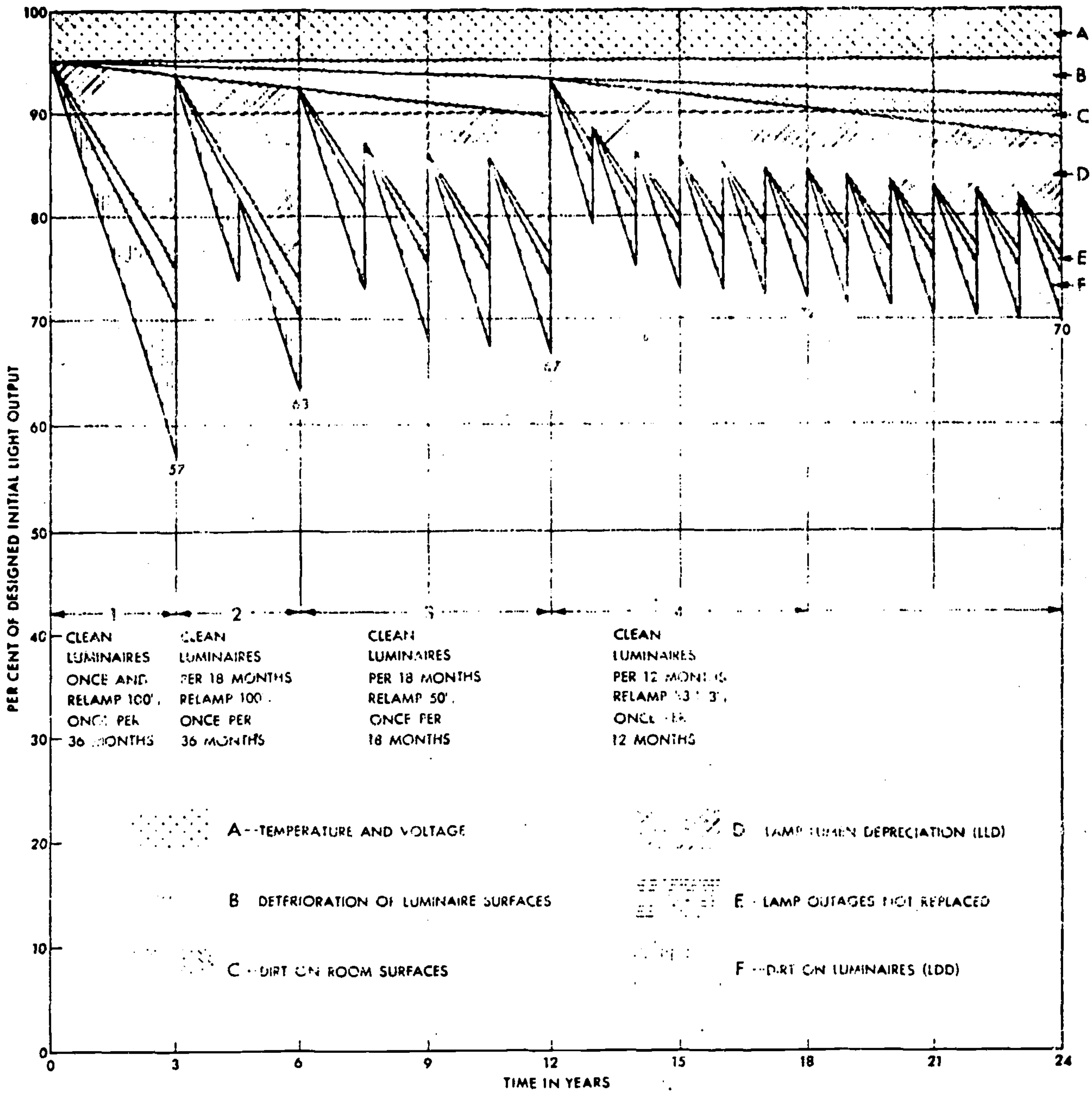
a) When luminaires were cleaned and relamped once every three years, the illumination had dropped to 60% of the initial level after three years.

b) When luminaires were cleaned every one and a half years and relamped every three years, the illumination had dropped to 68% of the initial level after three years.

c) When luminaires were cleaned once a year and one third of the lamps replaced once a year, the illumination had dropped to 78% of the initial level after three years and to 75% even after 12 years.

Therefore, adoption of a better maintenance program allows the illumination engineer to recommend a smaller number of luminaires to be installed to achieve the same lighting level in the space.

Exhibit 11 A-12



Six causes of light loss. Example above uses 40-watt T-12 cool white rapid start lamps in enclosed surface mounted units, operated 10 hours per day, 5 days per week, 2600 hours per year. All four maintenance systems are shown on the same graph for convenience. For a relative comparison of the four systems, each should begin at the same time and cover the same period of time.

In designing new lighting systems more attention should be given to maintenance procedures. The tenant or owner should be aware of the maintenance procedures considered in the design.

Instructions covering operation and maintenance should be posted. These initially should be based on the design criteria, but may be modified later as more efficient, newer replacement equipment is installed. As activity locations change, modify the lighting system and instructions accordingly.

Lighting information for building owners and tenants should be provided. All illuminated spaces should have a set of instructions covering the operation and maintenance of the lighting (electric of daylight), both for maximum utilization of power and for economic considerations.

Summary and Recommendations

The following eight recommendations summarize ways to better utilize energy for lighting:

1. Design lighting levels for tasks.
2. Design with more effective luminaires.
3. Use efficient light sources.
4. Use luminaires designed for heat removal.
5. Use high reflectance finishes on ceilings, walls, floor, and furnishings.
6. Light areas only when required.

7. Optimize window design for daylighting and air conditioning.

8. Maintain lamps and luminaires.

The eight recommendations offer opportunity for savings in energy expended for lighting and air conditioning without sacrificing visual performance or comfort. It is important to note that for air conditioned buildings, for each watt reduction in lighting there is an additional one-half watt reduction in air conditioning power requirements because of the reduced lighting heat load.

Not all of the above recommendations will necessarily result in a savings in dollars expended for materials and services. An overall cost to benefit analysis over the expected life of the installation is required to determine the relative savings.

The recommendations provided herein, if carried out, could easily result in a one-third reduction of energy used for lighting. Several of the recommendations apply primarily to new construction and it is in initial design that the greatest opportunity for energy savings exist. Most of the energy savings can be realized by applying the principles involved to existing lighting installations. A sizable portion of the energy wasted is the result of unnecessary lighting levels.

Where the lighting has been designed to provide a higher light level than deemed necessary for current tasks, the light level can be corrected by reducing the number of luminaires in use. This can be ideally accomplished if switches have been provided for this purpose, or their installation is still economically feasible. However, if switching is not available, a reduction in the light level can still be accomplished by removing the fluorescent lamps from luminaires, provided that individual lamps connected to a common ballast are not removed.

The Committee suggests that the State initiate lighting energy savings in State office buildings. The Committee recommends, therefore, that the State building and operating agencies review the recommendations presented herein and take appropriate action. The benefits of any action taken by the State agencies can then be used as an example to the private sector and the general public.

Highway Lighting

Differences of opinion on the relative value of highway lighting has hampered the acceptance of firm national standards. The guidelines most widely used by the various state highway departments are published by the American Association of State Highway Officials (AASHO) in their booklet, An Information Guide for Highway Lighting.

The American National Standard Practice for Roadway Lighting has also been approved as a Proprietary Standard by the American National Standards Institute (ANSI Standard D12.1-1972) under the sponsorship of the Illuminating Engineering Society. It presents a new format for classification of roadways: a new table of illumination levels; a new method for defining classifications of luminaire light distributions with respect to the roadway area coverage and classifications for the control of glare. Information is provided on lighting fundamentals, computation methods and application design data for special situations. This standard also provides means for measuring and evaluating illumination, brightness, glare and visual tasks. A condensed presentation of the American National Standard Practice for Roadway Lighting is included as part of the IES Lighting Handbook.[10]

Industry development and general experience on lighting of streets and highways has resulted in a reasonably well developed technique for the design of lighting systems. For a given condition to be lighted and a known level of light to be provided, the accepted methods permit ready analysis of different alternates in lamps, luminaires, mounting height of luminaires, longitudinal luminaire spacing, power consumption, and cost comparison data to determine a preferred design.

The "design" of a highway lighting installation is a process of utilizing known photometric characteristics of a selected lamp and luminaire in a somewhat trial-and-adjust

10. IES Lighting Handbook, 5th Edition, 1972, Section 20, Roadway Lighting

process of assumed luminaire locations on the roadway for which is made a calculation of the average amount, or level, of illumination and distribution of light over the roadway area. For each lamp-luminaire combination there are manufacturer's photometric data which include isofootcandle charts showing the "contours" of various horizontal footcandle values over the area illuminated by that unit. Combinations of these, with certain horizontal overlap, can be used theoretically to determine luminaire positions to produce the desired average amount of light over a given pavement area and distribution thereof.

The actual amount of light when measured on the roadway may vary from calculated figures from the manufacturer's charts, depending upon variable installation factors such as voltage, individual lamp output, alignment of luminaires, etc. Nevertheless, the values for average amount of light and variation of light level are usually chosen on the basis of what appears satisfactory on actual highways in relation to these values computed from the manufacturer's charts. The present design values outlined in the AASHO Guide and the ANSI Standards have been stated in terms of calculations from manufacturer's chart values. Thus the lighting "design" is as shown on the charts for laboratory conditions with due consideration to empirical factors for lamp depreciation and luminaire dirt accumulation. While the pattern and amount of light on the pavement may be suitable for the conditions, it may be different from that named as the design level of illumination or uniformity ratio when measured by field instruments such as footcandle meters.

Level and Uniformity of Illumination

The level and uniformity of illumination along a highway depends on several items including: the type and lumen output of light sources, luminaire equipment, mounting height of luminaires, mast arm length, spacing and arrangement of lighting poles. The same average level can be obtained by different installation arrangements, such as a few high-output light sources or a greater number of low-output sources. A factor of concern in comparison of such alternate systems is the uniformity of light over the whole of the travelled way to be lighted.

Luminaires are available in a wide range of types and sizes. Lighting systems using high-efficiency and large lumen lamps can be designed to provide a satisfactory level and uniformity of illumination. Higher luminaire mounting heights offer a number of advantages and should have full consideration when selecting design criteria. There is increasing use of mounting heights of over 40 to 50 feet.

Light Sources

The subject of light sources is simplified when limited to the street and highway lighting field because of the relatively few types that are applicable. There are roughly 10,000 different types and wattages of lamps manufactured while only three types with a few standard wattages of each type are generally used for highway illumination. These three types, mercury vapor, metal halide, and high pressure sodium vapor, are grouped as high intensity discharge (HID) lamps.

Mercury Vapor: The 400 watt mercury vapor lamp has been the most widely used source for highway lighting. With the trend to higher mountings there has now developed an increasing usage of the 1,000 watt mercury vapor lamp. Progress on lamp designs has resulted in longer lamp life (estimated life of 24,000 hours), better lumen maintenance throughout lamp life, and better color rendition characteristics.

Metal Halide: Metal Halide lamps are basically mercury lamps to which metallic halides have been added. This results in a 50 percent increase in lamp efficiency, a color rendition characteristic comparable to Improved Color mercury vapor lamp, and good optical control capabilities. At present, the life and maintenance characteristics of this lamp are not as favorable as mercury vapor lamps.

High Pressure Sodium Vapor: The high pressure sodium lamp, is the first source of white light having a lamp efficiency of approximately 130 lumens per watt for the 1,000-watt lamp (twice the efficiency of the mercury lamps). The high efficiency of this lamp is combined with a good color rendition characteristic, high lumen output maintenance throughout lamp life, and good optical control capabilities.

Incandescent: The filament (incandescent) lamp is used for traffic signals, but has almost been discontinued for street and highway service.

Fluorescent: The fluorescent lamp is still used for tunnel, underdeck, and low rail lighting and some street and highway lighting. Some fluorescent lamps are used for sign lighting.

Lamps: Lamps represent only a part of the overall cost of a lighting system. However, the choice of the lighting source has a significant effect on the economics of the system.

Luminaires: Many different types of open and enclosed luminaires are available for roadway lighting. The luminaire contains an optical assembly consisting of a reflector and refractor to gather the light emanating from the lamp and achieve a particular light distribution on the roadway surface. Some luminaires are adjustable to select various lateral and vertical light distributions and vertical control above maximum candlepower, while others are designed to give a single distribution.

Economic and Energy Conservation Considerations

The selection of lighting equipment is made so as to obtain the desired lighting results with the lowest total annual cost including installation, operation and maintenance. The relative energy consumption characteristics of the lighting systems under consideration affect the selection to the extent that energy costs influence total annual cost.

The results of four typical lighting studies are presented in Exhibits II A-13 through II A-16. These Exhibits compare initial cost, total annual operating cost and total energy consumption for the alternative lighting sources considered in each of the four studies. A review of the four studies indicates that high pressure sodium vapor lamps generally had the lowest annual energy consumption in addition to being the least expensive from both the initial and total annual cost standpoints.

Summary and Recommendations

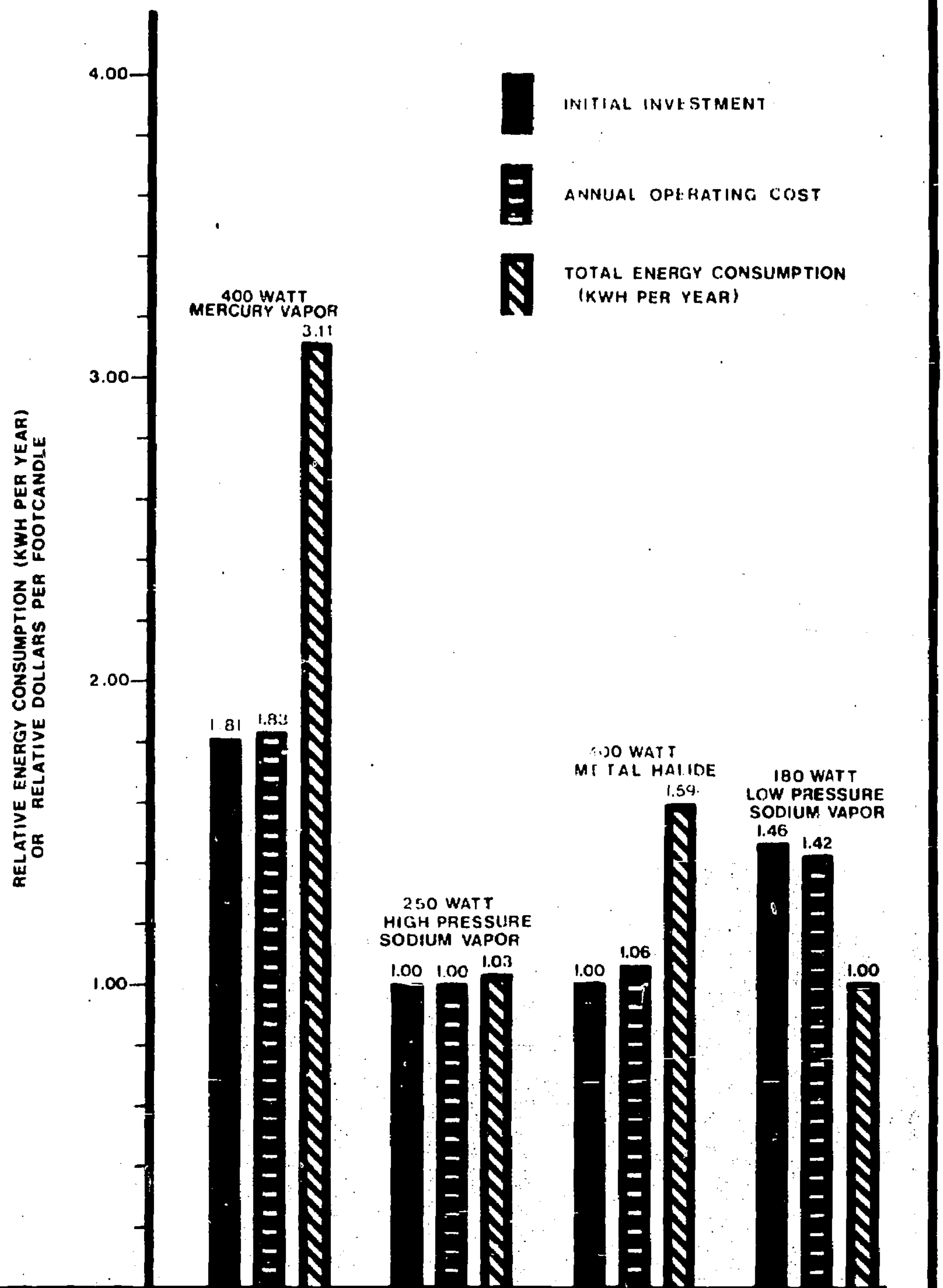
The superiority of high pressure sodium vapor lamps has been demonstrated in four highway lighting studies. The

Ad Hoc Committee recommends that a lighting study be performed for each highway lighting application and include consideration of high pressure sodium vapor lamps. The basis of selection should be total initial and operating costs rather than initial cost so that appropriate consideration be given to the amount and cost of the energy used.

The *Ad Hoc* Committee also recommends the use of photoelectric controls on all highway, roadway and parking lot lighting. With the use of this device, lighting is provided only when it is actually needed.

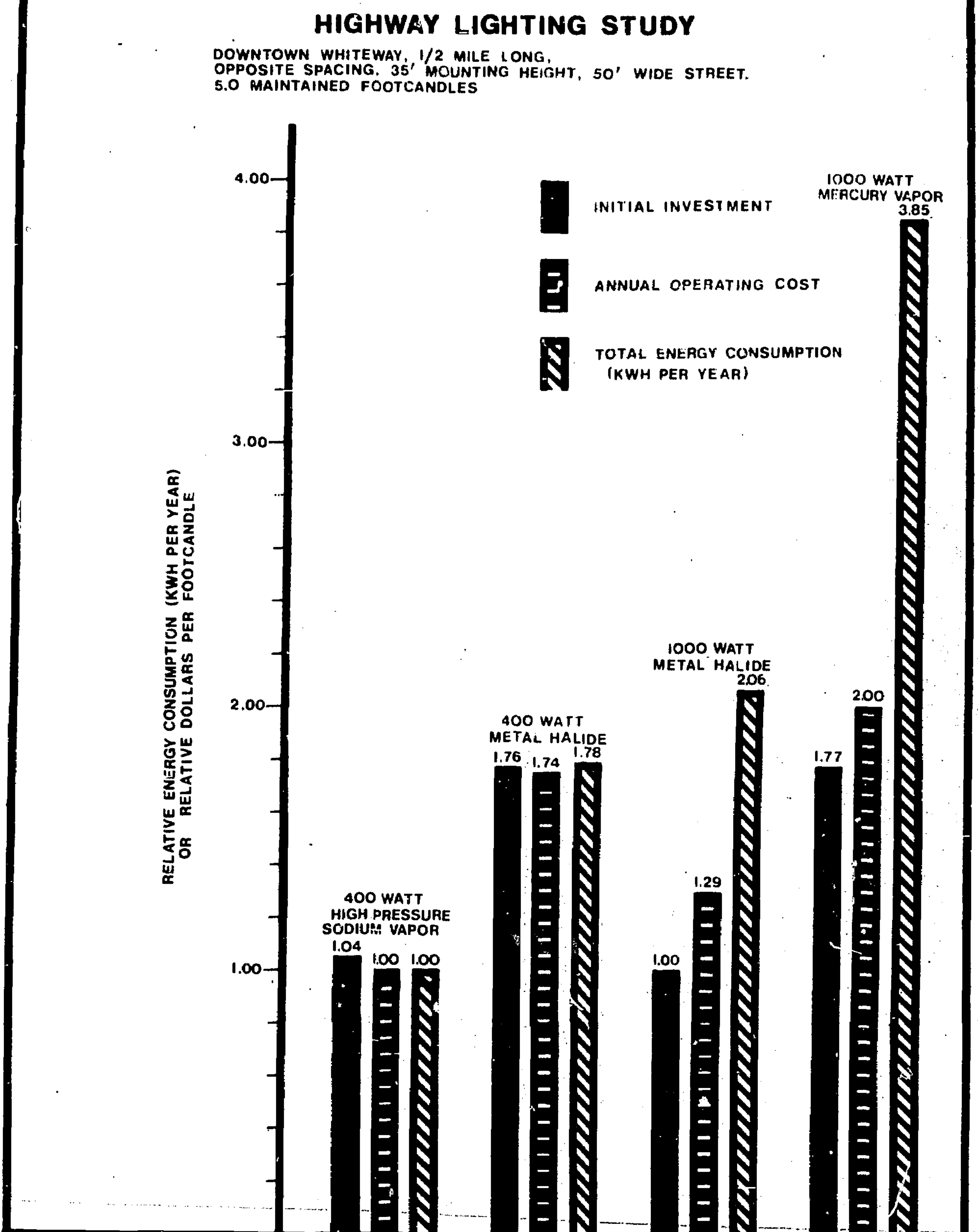
HIGHWAY LIGHTING STUDY

TRAFFIC STREET, 40' WIDE, 1 MILE LONG, 1 MAINTAINED AVERAGE FOOTCANDLE



	400 Watt Mercury Vapor	250 Watt High Pressure Sodium Vapor	400 Watt Metal Halide	180 Watt Low Pressure Sodium Vapor
TOTAL INITIAL INVESTMENT	$ 23,149	$ 12,811	$ 12,854	$ 18,653
TOTAL ANNUAL OPERATING COST	$ 3,983	$ 2,176	$ 2,312	$ 3,100
TOTAL ENERGY CONSUMPTION (KWH/YR)	85,818	28,267	43,723	27,556

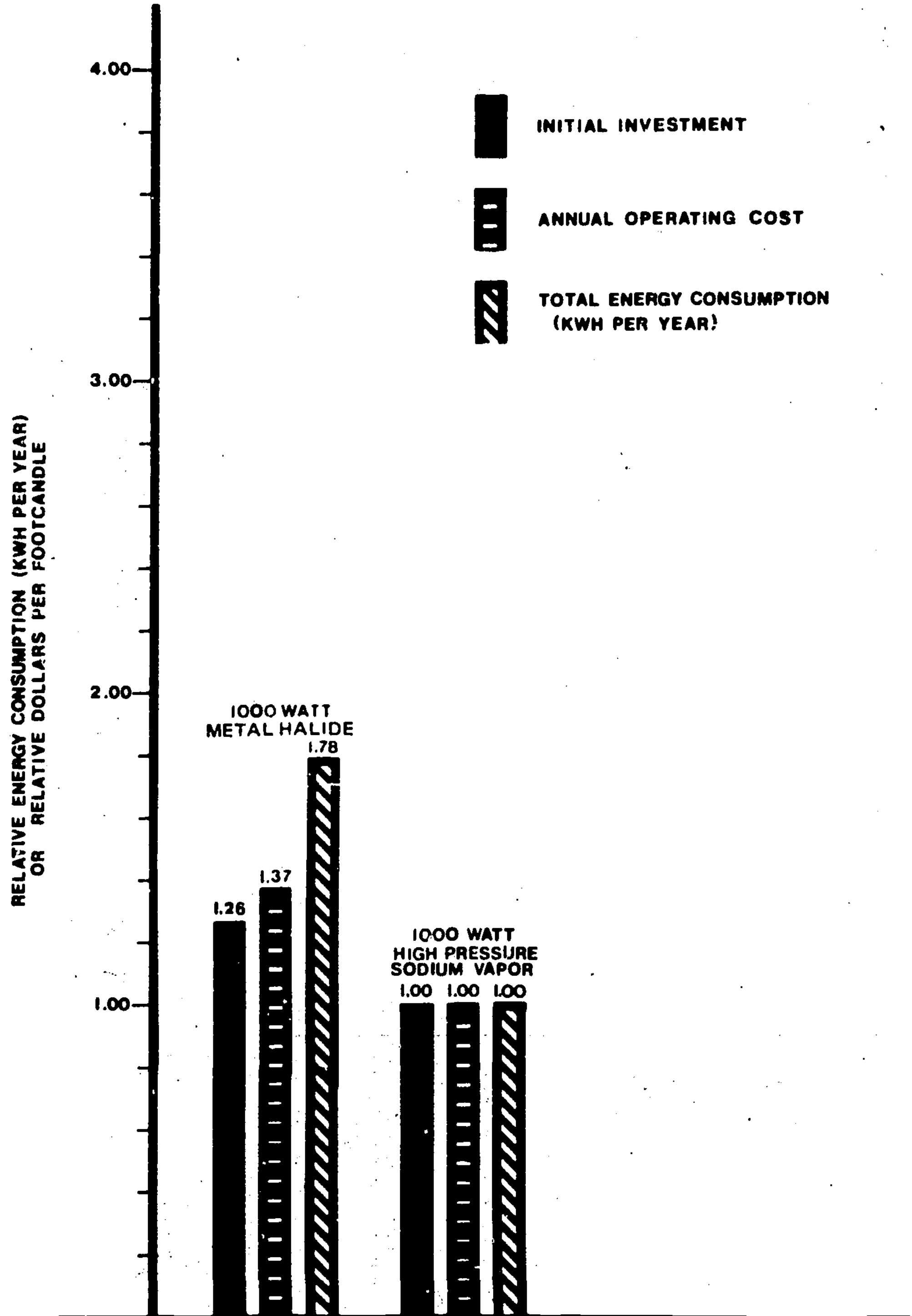
Exhibit II A-14



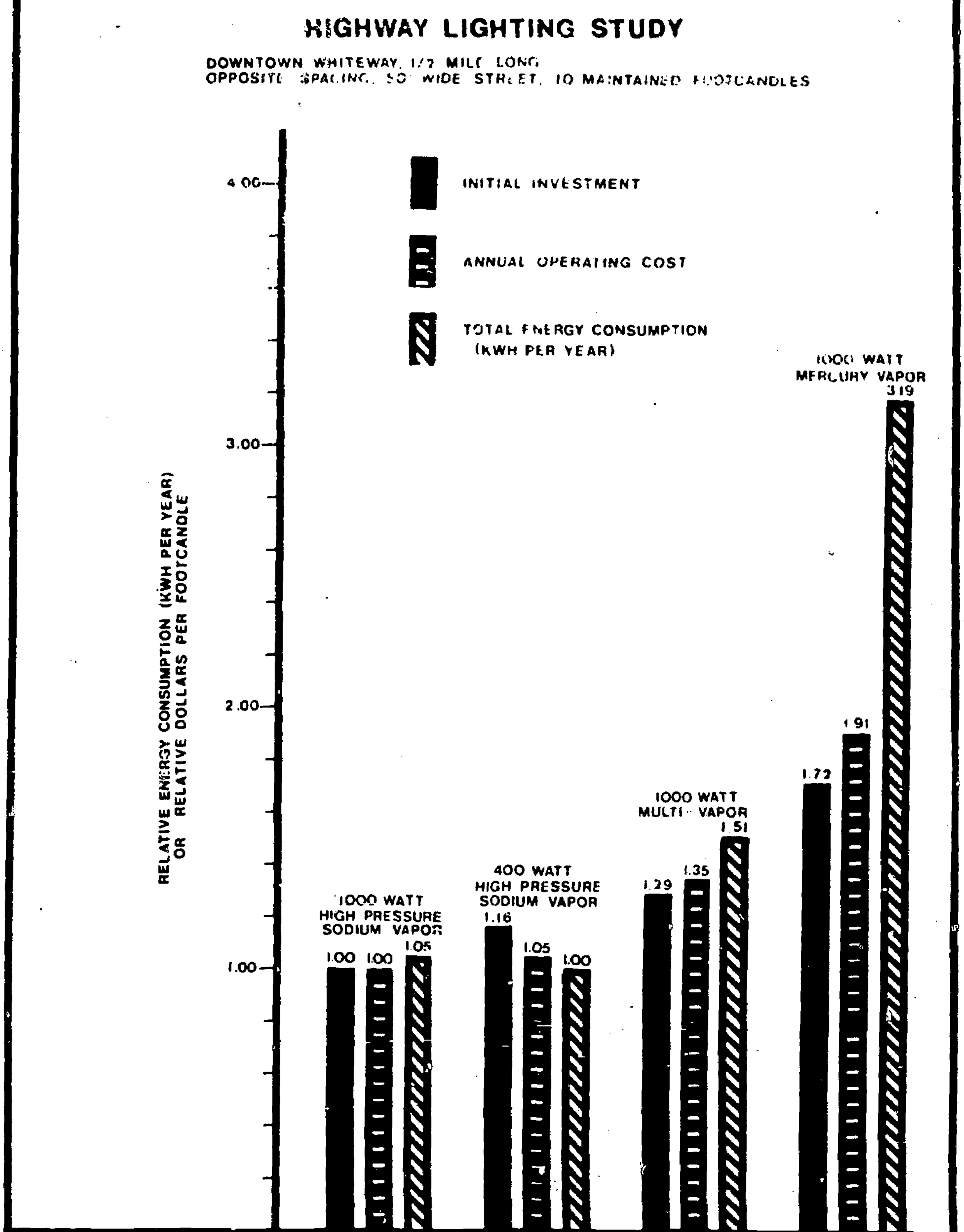
	400 Watt High Pressure Sodium Vapor	400 Watt Metal Halide	1000 Watt Metal Halide	1000 Watt Mercury Vapor
TOTAL INITIAL INVESTMENT	$ 4,865	$ 8,264	$ 4,694	$ 8,321
TOTAL ANNUAL OPERATING COST	$ 732	$ 1,271	$ 944	$ 1,462
TOTAL ENERGY CONSUMPTION (KWH/YR)	13,262	23,647	27,374	50,994

HIGHWAY LIGHTING STUDY

HIGHWAY INTERCHANGE – 260,000 SQUARE FEET PER POLE BASIS,
100' MOUNTING HEIGHT,
1–1.2 MAINTAINED FOOTCANDLES



	1000 WATT METAL HALIDE	1000 WATT HIGH PRESSURE SODIUM VAPOR
TOTAL INITIAL INVESTMENT	$ 9,392	$ 7,437
TOTAL ANNUAL OPERATING COST	$ 1,547	$ 1,129
TOTAL ENERGY CONSUMPTION (KWH/YR)	25,920	14,545



TOTAL INITIAL INVESTMENT	$ 2,696	$ 3,136	$ 3,485	$ 4,648
TOTAL ANNUAL OPERATING COST	$ 604	$ 632	$ 814	$ 1,156
TOTAL ENERGY CONSUMPTION (KWH/YR)	14,010	13,350	20,216	42,537

e. Refrigerator, Combination Refrigerator-Freezer and Food Freezer

The appliances required to preserve food, the refrigerator, combination refrigerator-freezer and food freezer, merit particular attention because, as a group, they make the greatest contribution to the State's residential electric energy consumption. According to data compiled by AHAM, these appliances account for over 28 percent of that energy consumption. A refrigerator or refrigerator-freezer is found in virtually every home in the State; 16.2 percent of the homes also contain a food freezer. In 1971, 368,221 refrigerators and 46,047 freezers were purchased in New York State. The service life of these products is approximately 15 years, but new fashion trends and product features appear to be accelerating the replacement cycle.

1) Energy Consumption

The average refrigerator unit is rated between 250 and 350 watts, operates between 3000 and 4000 hours per year, and uses 750 to 1400 kWh of electrical energy each year. The 1970 United States Census determined that 5,902,000 refrigerators or combination refrigerator-freezers are in service in the State. The total energy consumed anually by these appliances is estimated to be 5,975,000,000 kWh.

The average freezer is rated at 340 watts, operates 3500 hours a year and uses 1195 kWh of electrical energy anually.

The 960,000 freezers reported to be in New York State by the 1970 Census consume an estimated 1,145,000,000 kWh of energy each year. The total annual energy consumption by all of these food preservation appliances was 7,120,000,000 kWh in 1970.

AHAM certifies net general refrigerated volume, net refrigerator volume, net freezer volume and net shelf area of upright freezers. AHAM also certifies net refrigerated volume of chest freezers.

Consumer information sheets for these products contain little energy consumption data. In fact, there is currently no standard test method for obtaining such data. The appliance industry recently developed for the AHAM Standard HRF-1 a section that provides a method for the measurement of power consumption under defined operating conditions. However, this has not yet been adopted as a standard method.

AHAM is developing a method for establishing an "energy factor for refrigerators and freezers, similar to the "energy efficiency ratio" developed by the industry for room air conditioners. This energy factor provides a basis for comparing the relative energy efficiency of refrigerators and freezers in terms of electricity used, storage volume, and refrigerator and freezer section temperature maintenance capability.

In the absence of an industry standard for measuring energy consumption or efficiency, the consumer cannot realistically expect to find much assistance in advertising information. The following guidelines, however, could be of some help.

The volume of space that must be refrigerated has a significant effect on power consumption. Consumers should choose a refrigerator or freezer that is the proper size for their family's needs. Purchasing a unit larger than needed means the consumer pays, initially for storage capacity that is not needed, and subsequently, for the electricity required to keep unused space cool. Conversely, purchase of a unit that is too small for the family requirements can lead to the purchase of a second compact, or used refrigerator for secondary storage. This results in paying too much for the storage space and consuming much more power than necessary.

The type of defrost system affects the energy consumption. There are three basic types of defrost systems:

Manual Defrost - in which the initiation and termination of the defrost cycle is done manually.

Semi-Automatic Defrost - in which the defrost cycle is manually initiated and automatically terminated.

Automatic Defrosting (including "no frost" or "frost free") - in which the initiation and termination of the defrost cycle is automatic.

The automatic defrost system utilizes internal resistance heaters which increase the total energy consumption. A manual defrost unit's power consumption may be increased if the owner does not defrost requlary. A manual defrost system if used properly, will use less energy than the automatic defrost unit.

A refrigerator with a separate exterior door for the freezer section may consume less power than a unit of the same size with a single exterior door. No cool air is lost from the refrigerator section or freezer section when the other door is opened

A chest-type freezer will be somewhat more energy efficient than the upright freezer because cool air will tend to stay within the top-open unit. When the door of an upright freezer is opened, cool air will settle out allowing warm air to enter the freezer.

The location of the freezer section of a refrigerator-freezer will have some effect on energy consumption. A refrigerator with the freezer section mounted on the bottom will consume less energy than one with the freezer section mounted on the top.

The manufacturer could improve the efficiency of food preserving appliances through a number of design changes. The recent design of refrigerators and freezers is based almost entirely on customer appeal and first cost considerations, with little or no consideration of energy consumption. A new design approach is required which gives higher priority to energy efficiency. New designs in regard to the insulation, the compressor, the evaporator and the condensor will probably be most productive.

Insulation is probably the most important component in determining the energy consumption of refrigerators and freezers. The insulation is a major factor in providing a unit with large usable cooled space and small external physical size. These two considerations are very important sales features and leave little room for insulation. If insulation is to be upgraded, standard tests and requirements for energy efficiency must be established. A recent development by a refrigerator manufacturer is a patented molded one piece double cavity plastic liner made of insulating material which is a thinner and better temperature barrier than is currently used by the industry. The liner makes possible the use of a smaller compressor system and results in a reported 30 to 50 percent reduction in energy requirements.

Compressors have been designed to provide optimum performance at rated voltage when installed in the unit with standard temperature conditions maintained. Compressors are tested to assure that operation is not hazardous under prescribed voltage and temperature conditions. Compressors have been designed and tested in the past without considering energy requirements. Applications of compressors for future equipment should be made with energy requirements a major consideration; and, since variations in voltage and temperature are normal, procedures should be established to provide a guide to improve the energy consumption efficiency over the range of conditions encountered.

Evaporator and condenser coils have been selected with first cost and design point optimization as primary goals. Design and application of these coils should be studied and changes made where energy considerations indicate that energy savings are possible.

(2) Recommendations

There are a number of steps the consumer may take to reduce the energy consumption of refrigerators and freezers. Opening of the door should be kept to a minimum. The unit should not be overloaded. The temperature control should be set according to the instruction manual and the family's needs. The unit will require two to four percent more energy for each degree below the "normal" temperature range.

The consumer should also defrost manual-defrost refrigerators regularly since an accumulation of ice and frost causes the appliance to run longer. The condenser coils should be cleaned every three to six months in accordance with the "use and care manual." Gaskets around the door should be kept in good repair to keep cool air in and warm air out.

Section III of this report discusses the formation of an agency on energy control. That agency should engage itself actively in a consumer education program. The program should advise the consumer in such matters as the efficient use of electrical appliances, particularly food preservation appliances. The agency should also work with groups such as AHAM and with appliance manufacturers to establish standards of equipment performance which consider the need for energy conservation.

f. Clothes Washers

The 1970 Census figures indicate that over 57 percent of the homes in New York State are equipped with clothes washers for home laundry use. Almost 90 percent of the washers in use are the automatic type and 10 percent are the wringer type. The service life of a typical automatic washer is approximately ten years. In recent years, more than half of the units sold are replacements for older wringer units and less modern automatic washers.

(1) Energy Consumption

The average automatic washer is rated at 260 watts; the average wringer type washer is rated at 195 watts. The annual energy consumption for these machines is estimated to be 78 kWh for the automatic type and 59 kWh for the wringer type. With 3,091,000 automatic washers and 295,000 wringer washers in the State, the total energy consumed annually by these washers is 258,000,000 kWh. This represents one percent of the total residential electric energy consumption.

Most automatic washers employ a one-half horsepower motor to drive the agitator, to pump water, and to drive the tub during the spin cycle. We note that less energy is required to remove water from the wash load during the spin dry cycle than is required to remove the same quantity of water in an electric dryer. Thus, for those homes with an automatic dryer, no net energy gain results from shortening the spin dry cycle.

Energy consumption figures for automatic washers are deceiving, in that much more energy is required to heat the water than is required to operate the entire wash cycle. A clothes washer uses 14 to 41 gallons of water per cycle. To heat that water from 40°F to 160°F requires the equivalent of 3.9 to 11.5 kWh of energy. This is considerably more than the 0.2 kWh required per cycle to operate the washer. The energy consumption of water heaters is discussed in Section II,A,2,i. of this report. The subject is introduced in this section only to emphasize that the greatest energy savings in the use of automatic washers will be achieved by a reduction of the water heating requirements.

A reduction in water heating requirements has come about by recent trends toward more wash-and-wear clothing which requires much less hot water in laundering. These fabrics also require less heat in drying and eliminate the need for ironing which results in a significant energy savings for the complete laundering cycle.

Specification sheets for automatic washers usually contain very little information on energy consumption. This is not surprising since the energy requirement varies widely among the different wash and rinse cycles recommended for different types of wash loads. Because there are a variety of cycles and wash loads, it has also been difficult for the industry to develop a comprehensive performance test standard. Recently the industry approved such a standard, HLW-1, which provided definitions for standard loads. However, there is still no standard method to quantify washing results; nor is there a standard "energy efficiency rating," such as that applied to room air conditioners.

(2) Recommendations

The most effective action the consumer may take to reduce energy consumption during clothes washing is to limit the amount of hot water used. This can be accomplished by choosing lower water temperatures for the wash cycle and by selecting a lower water level for small loads. Additional energy savings can be realized by using a shorter wash cycle where it is appropriate to do so and by avoiding use of the washer for partial loads.

The manufacturer can assist the consumer by providing uncomplicated controls which allow flexibility in water level and cycle selection. Since efficient use of the machine depends upon proper operation, a clear set of operating instructions should also be provided to the consumer.

g. Clothes Dryers

According to the 1970 Census figures, 19.9 percent of the homes in New York State have an electric clothes dryer. This figure is increasing about one percent each year. Only one-third of current sales are for replacement units. The estimated service life of an electric dryer is fourteen years. Gas dryers, which are found in 9.7 percent of our homes, are discussed in Section II. B. 3. D. of this report.

(1) Energy Consumption

The heating elements of electric dryers are rated from 4800 to 5600 watts. Dryers also include a motor, generally one-third horsepower, rated from 150 to 300 watts. The estimated annual electric energy consumption for each dryer is 993 kWh. With a total of 1,175,000 electric dryers in the State, the total energy consumption is 1,169,000,000 kWh. This amounts to 4.6 percent of the State's residential electrical energy consumption.

There is, at present, no AHAM standard for the measurement of clothes dryer performance. However, the industry is preparing a standard which is expected to provide for a measurement of load drying efficiency based on power consumption. The new standard will not provide for a comparison between gas and electric dryers.

(2) Recommendations

As was mentioned in the discussion on clothes washers, less energy is used to extract water in the spin cycle of an automatic washer than would be required to remove the equivalent amount of water in an automatic dryer. The home maker should, therefore, take full advantage of the washer's spin dry cycle before placing clothes in the dryer. It is also wise to avoid underloading or overloading the dryer. Under-loading can be wasteful of the heat produced, while overloading lengthens the drying time and places an added burden on the drive motor It is recommended that the lint filter be kept clean to avoid interference with air circulation. Finally, the home maker should try to keep the drying time as short as possible and the temperature as low as possible.

The manufacturer may be able to improve dryer efficiency through design modifications. It would be beneficial, for instance, to include a mechanism which automatically shuts off the machine when the clothes are dry. Some models do have such a mechanism which is activated by a built in moisture sensing device It would appear that, if widely adopted, this approach could result in a significant saving of energy.

h. Automatic Dishwashers

As reported by the 1970 Census, automatic dishwashers were found in 18 percent of our homes. The machines accounted for one percent of the State's total residential electric energy consumption. These percentages are expected to increase since the automatic dishwasher is one of the fastest growing segments of the appliance market. In 1971, consumers in New York State purchased 116,414 units, of which 75 percent represented new installations.

(1) Energy Consumption

It is common practice to operate the automatic dishwasher after the evening meal. Because of this practice, the dishwasher is probably a significant contributor to the electric system peak demand.

The average load requirement during the operating cycle of an electric dishwasher is 800 watts. With an average of 302 hours of operation per year, each machine consumes 242 kWh annually. As of 1970, there were a total of 1,072,000 automatic dishwashers in New York State, which resulted in a total annual electrical consumption of 259,000,000 kWh.

The load requirement of an automatic dishwasher varies considerably during the operating cycle. The greatest load occurs when the heaters operate. Most dishwasher models have only a drying heater, but some models also include a water heater for an extra hot or "sanitizing" wash cycle. Specification sheets for individual models list heater wattages, but most do not list the kWh consumption per cycle. The consumer is, therefore, unable to compare models on the basis of energy consumption.

There are no performance standards or certification programs for dishwashers; and, since there are so many variables, such as water quality and dish cleanliness, it is unlikely that meaningful tests and results can be specified.

(2) Recommendations

Significant reduction of the energy consumption by automatic dishwashers will require the cooperation of the dishwasher manufacturers. As a first step, each manufacturer should list the energy consumption per cycle. This action, hopefully, would lead to competition among manufacturers to reduce the load requirement. It may be possible, for example, to reduce the energy consumed per cycle by shortening the drying time. The use of a fan for improved air circulation during the drying step could speed drying and permit a further net reduction of the energy required. The manufacturer, of course, must consider many other factors in the design of an automatic dishwasher. It is hoped, however, that with more attention given to energy consumption, the manufacturer will be inclined to incorporate energy saving features in his machines.

i. Water Heaters

Although electric water heaters are found in only 8.3 percent of the homes in New York State, they account for 8.1 percent of the State's total residential electric energy consumption. It is appropriate, therefore, that we consider this item in our survey of electric appliances used in the home.

(1) Energy Consumption

Electric water heaters for home use generally have a capacity of from 30 to 120 gallons, and a rated input of up to 12 kW. The elements of electric water heaters in almost every case are inter-locked for non-simultaneous firing; therefore, the maximum input is usually 6 kW or less. According to the Edison Electric Institute (EEI)[11] the average annual energy consumption by a hot water heater is 4219 kWh. With a total of 514,485 units[12] in New York State, the total energy consumed annually by all such units in the State is 2,071,000,000 kWh.

Energy losses of electric water heaters are almost totally limited to standby type losses, either through the casing or through piping. Heat traps and insulated hot water lines can effectively reduce the piping losses.

The minimum performance requirements for electric water heaters are described in "The American National Standard for Household Automatic Electric Storage-Type Water Heaters," C72.1-.972.

11. 1970 National Power Survey, Table 3.3, P. I.3.9
12. Detailed Housing Characteristics - New York, United States Department of Commerce, HC(1)-B34NY

This standard sets a limit on standby energy losses during operation of the heater of 6 watt-hours per hour per square foot of external surface area. The SEE (Southeastern Electrical Exchange) and EEI (Edison Electric Institute) specifications specify a standby loss limit of 4 watt-hours per hour per square foot of tank surface area.

The vast majority of electric water heaters sold in New York State are of a grade referred to as the builders line. These water heaters usually have standby losses in excess of 5 watt-hours per hour per square foot and are guaranteed for only 5 years. The top of the line models usually have standby losses of slightly less than 4 watt-hours per hour per square foot and are and are guaranteed for 10 years. The top of the line models are about 25 to 30 dollars more expensive but, this added cost can be recovered in 2 to 4 years based on the reduced energy cost resulting from the lowest heat loss. After this initial payback period the top of the line water heaters will have more than half of their guaranteed life remaining.

In spite of these very distinct advantages, the cheaper units greatly outsell the more efficient units. One of the main reasons for this is that builders are quite naturally concerned with their own initial costs rather than operating costs which are paid by the homeowner. It appears that the only real remedy for this situation is mandatory minimum standards of performance for all electric water heaters.

(2) Recommendations

The Committee recommends mandatory minimum standards of performance for all electric water heaters. It is recommended that all water heaters sold for use in New York State be required to meet standby loss of 4 watt-hours per hour per square foot of tank surface area. This action would result in a 20 percent reduction in electric hot water losses and a significant reduction in the State's energy consumption. Over the long term such an act will be economically beneficial to the homeowner.

j. Electric Ranges

Most households in New York State have gas ranges. Nevertheless, electric ranges contribute almost six percent of the State's total residential electric energy consumption. The 1970 Census showed that 1,242,000 homes in New York State (21 percent) use electricity for cooking. Annual sales of electric ranges are approximately 96,000; the estimated service life is approximately 15 years.

(1) Energy Consumption

The average annual energy consumption for an electric range is difficult to determine because the wattage requirements of current models depend upon the number and ratings of surface elements, ovens and broilers. A range may contain two to four surface elements with ratings from 1250 to 2760 watts, one or two ovens with ratings from 1500 to 4500 watts, and one or two broilers with ratings from 1800 to 3800 watts. Thus, the total rating for electric ranges varies from 8900 to 20,900 watts. In most specification sheets for electric ranges, electrical consumption data is presented as the "total connected load." This is the load when all surface units, oven elements and other energy consuming features are operating at the maximum setting at the same time. This is not, of course, a normal operating condition.

AHAM has estimated that the average energy consumption by an electric range is 1175 kWh per year. The self-cleaning feature of an oven, assuming one cleaning cycle per month, consumes about 60 kWh annually. However, because of the improved insulation in self-cleaning ovens, about 50 percent of this energy is saved during normal operation. The estimated total annual electrical consumption by ranges in New York State is 1,462,000,000 kWh. Of this total, about 3,000,000 kWh are due to operation of the self-cleaning feature.

The amount of heat loss from an electric range is a useful criterion in the evaluation of the appliance's efficiency. UL Standard 858 imposes limits on the external surface temperatures of electric ranges and thereby indirectly helps to assure a moderately high operating efficiency. This standard is presently being revised; the maximum external surface temperature for self-cleaning ovens is being revised downward. This action will result in a still more energy efficient insulation system for the self-cleaning oven.

ANSI Standard C-71.1, Section 10.2 requires a minimum surface unit efficiency of 55 percent for surface elements and Section 11.2 establishes a maximum heat loss for ovens. Consumers presently have no knowledge of the relative efficiency of electric ranges and there is little or no incentive for manufacturers to exceed minimum requirements.

The efficient utilization of energy in an electric range is achieved by maximizing heat transfer between the source of heat (resistance wiring) and the food mass being cooked, while minimizing extraneous heat losses. The primary sources of heat loss in an electric range are: (1) unused heat in the oven (heating the oven space in addition to the food), (2) oven heat leakage, and (3) heat loss from range surface units.

It should be noted that heat is produced in the resistance wiring with an efficiency of about 96 percent. Therefore, there is very little energy wasted in the production of heat from electricity. The lower overall efficiency of the appliance is primarily the result of the heat losses previously described.

(2) Recommendations

The consumer can make more efficient use of the electric range in several ways. The use of proper cooking utensils can reduce heat losses from surface units. Utensils should be flat bottomed and should be sized to match the surface unit. Ranges contain good reflective surfaces between the heating elements and the range structure. These reflecting surfaces should be cleaned periodically to maintain their reflective properties. Savings can also be realized by avoiding wasteful operation of the heating elements. Preheating, for example, could be minimized. The appliance could be turned off a few minutes before cooking is complete. The appliance should, of course, be turned off when not in use. Finally, in preparing a meal, it may be possible to conserve energy by using a portable appliance to prepare a specific dish. In some cases, the portable appliance requires less energy than does the range.

Design improvements by the manufacturer could help to reduce heat losses. To this end, the industry standard should be updated to require reduced heat losses and improved efficiency. An industry certification program combined with listing and labeling of appliance efficiency would encourage efficiency.

k. Television Sets

Television sets, according to the 1970 Census, are found in 96 percent of New York State households. These sets account for more than eight percent of the State's total residential electric energy consumption. While nearly every home already has a television set, the increased use of higher energy consuming color television sets is expected to further increase the energy consumption. Nationally, as of January 1, 1973, 60 percent of the households had color sets. By the end of 1973, this figure is expected to be about 70 percent. On the average, a color television set consumes twice as much energy as a black and white set. Therefore, the electric consumption by television sets should increase significantly in the next few years.

(1) Energy Consumption

In 1970, more than 7.6 million television sets were in use in New York State and consumed about 2,172,000,000 kWh. This consumption figure would be much higher were it not for the recent introduction of solid state components which have substantially reduced the power requirements per set. The average power rating for black and white sets decreased from 160 watts in 1968 to 150 watts in 1972. During the same period, the average power rating for color sets decreased from 340 watts to 250 watts.

About 25 percent of the television sets have an "instant-on" feature which provides instantaneous sound and picture. This feature, which has a power rating of 5 to 40 watts, operates continuously when the set is turned off. Hence, even with a modest wattage rating, the use of this feature results in a large increase in the energy consumption of the television set. In some cases, the annual energy consumption of a set is more than doubled. The State-wide impact of the instant-on feature is difficult to assess because of uncertainties in the average wattage rating of the feature and the fraction of all sets in which the feature is currently used. Sales of sets with the instant-on feature are increasing each year. It appears, that this single feature could contribute as much as one percent to the total State residential electric energy consumption.

(2) Recommendations

Television manufacturers should be encouraged to accelerate the change-over program from vacuum tubes to solid state components in black and white sets as well as in color television sets to help reduce the energy consumption per set. The instant-on feature should be eliminated from television sets. In the absence of joint industry action, this Committee recommends that legislation be enacted which prohibits the sale in New York State of television sets containing the instant-on feature. It is further recommended that consumers who now have the instant-on feature on their television sets discontinue its use where [po]ssible.

1. Fractional Horsepower Motors

The electric motor is the heart of many appliances and apparatus that are under review by this Committee. There are a variety of types and sizes of electric motors, each with specific characteristics; however, all are of relatively high efficiency when operating under design conditions. Appliances and apparatus can maximize the electromechanical energy conversion by matching the needs of the system with the appropriate motor.

Efficiency is usually the most important of the many characteristics considered in the selection of a motor for a specific application. However, there are some instances where the full load efficiency may not be a measure of the required electric energy. Exhibit II A-17 contains a list of motor characteristics that must be considered to assure proper selection.

Most household appliances employ single-phase fractional horsepower motors in the one-tenth horsepower through one horsepower range. Single-phase motors are also used in commercial and industrial appliances and apparatus, especially as portable or cord-connected equipment.

The following section will review the range of popular motors and their specific application which maximize both system and motor efficiency.

Exhibit II A-17

I. Power Source

A. Voltage
B. Frequency
C. Phase

II. Horsepower

III. Speed

A. Constant Speed
B. Multi-Speeds
C. Variable Speed
D. Absolute Constant Speed (Synchronous)

IV. Torque

A. Starting
B. Running
C. Maximum

V. Reversibility

VI. Duty

A. Continuous
B. Intermittent
C. Varying

VII. Ambient Conditions

VIII. Enclosure and Cooling Method

A. Open
B. Enclosed
C. Explosion-Proof

IX. Mounting Arrangement and Mechanical Configuration

1. <u>Induction Type Single-Phase Motors</u>

Single-phase motors of the induction type are the most common. These motors are used because of their simplicity, dependability, and constant speed characteristics. Sub-types of induction motors include the following:

a) Shaded-Pole

Shaded-pole induction motors are used in a wide variety of applications which require a motor of one-quarter horsepower or less. They are simple in construction, low in cost, and extremely rugged and reliable because they do not require a commutator, switch, collector rings, brushes, governor or contacts of any sort. Their torque characteristics and applications are similar to those of a permanent-split capacitor motor, except that they have a lower efficiency and a lower power factor. They are used in rotisseries, fans of all kinds, humidifiers, slide projectors, photocopy machines, vending machines, advertising displays, etc.; all of which require intermittent duty motors.

b) Split-Phase

Split-phase motors are among the most important and most widely used for all types of single-phase motors. They are used in washing machines, oil burners, blowers, centrifugal pumps, woodworking tools, business machines, bottle washers, churns, automatic musical instruments, buffing machines, grinders, machine tools, and many other applications. They are most widely used in ratings from 1/20 horsepower to 1/3 horsepower, and have medium efficiency, ranging from 45 to 75 percent. Their other characteristics include high starting torque, high starting current, low slip from synchronous speed, and a relatively high ratio of horsepower to material.

c) Capacitor-Start

Capacitor-start motors are the most popular in heavy-duty general-purpose applications which require high starting and running torques. They are available in ratings from 1/8 horsepower through one horsepower. Capacitor-start motors have higher starting torque with lower starting current than the split-phase motor, and have the same efficiency range.

Split-phase and capacitor-start motors are the real work-horses of appliances, since they are available in several synchronous speeds, multi-speed windings, dual voltage, and many combinations of starting and running characteristics.

d) Permanent-Split Capacitor

Permanent-split capacitor motors are similar to the split-phase and capacitor-start motors except that the starting windings are designed to be continuously energized through a capacitor instead of being energized only during starting as in the other motors. The permanent-split capacitor types have the highest efficiency of induction type motors, ranging from 55 to 85 percent. Their other characteristics are an extremely low-starting torque, medium-starting current, lower running current, low slip from synchronous speed, adaptable to speed control, and the highest ratio of horsepower to material. The low-starting torque limits their use to equipment such as direct drive fans, hermetic motor compressors, and other easy-to-start machinery. Air conditioner units utilize this type of motor to minimize the motor heat since any motor heat results in a reduction of the unit's effectiveness and capacity. In addition, since there is a maximum limit of input current for for cord-connected appliances when plugged into normal household outlets, the low running current of these motors permits larger horsepower rated appliances to be used on such outlets. Generally speaking, they are not suitable for belted applications or for any other continuous-duty applications requiring substantial locked-rotor torque.

e) Capacitor Start-Capacitor Run

Capacitor start-capacitor run motors incorporate the desirable characteristics of the capacitor start and the permanent split capacitor motor. It can be a permanent split capacitor motor with an additional capacitor used to provide considerable additional starting torque with only a nominal increase in line starting current. These motors are available in fractional through six horsepower size and are used where high starting torque, low running current and high efficiency is required. Many applications such as air conditioner compressors require a starting torque that is too high at low line voltage to effectively use a split capacitor motor. However, when a starting capacitor is added to increase the starting torque of the motor the application becomes successful.

The disadvantages of this motor are the addition of a capacitor and relay which must be selected properly to prevent relay malfunction and early life motor failure.

2. Universal Motors

Universal motors are characterized by their ability to operate with substantially the same performance on direct current and on alternating current frequencies up to 60 Hz. They develop more horsepower per pound than other alternating current motors, principally because of their high speeds. These motors are series-wound and have series characteristics on both alternating and direct current, except when governors or other means are used to control their speed. Power ratings vary from 0.1 horsepower to one horsepower for continuous-rated motors and even higher for intermittent-rated motors. They are usually designed for full-load operating speeds of 4000 to 16,000 rpm in the larger horsepower ratings and up to 20,000 rpm or more in the smaller ratings.

Their characteristics include extremely high-starting torque, low-starting current, a variable speed which decreases as greater and greater loads are demanded, and medium efficiency ranging from 45 to 75 percent. Universal motors are used in vacuum cleaners and portable tools. Vacuum cleaners utilize the high speed to obtain high performance with small diameter impellers. Portable (hand-held) tools such as electric drills, sanders, and circular saws require high output horsepower with minimum size and weight. Gears are used to adjust the output speed to the required value. No other type of single-phase motor could be used for these devices.

The disadvantages are high noise level, brush maintenance and sparking. Radio and television interference suppression is generally required. This type of motor would be very undesirable for continuous-duty application, such as furnace blowers, and the speed variation would be unsuited to many uses, such as laundry equipment.

3. Polyphase Induction Motors

Polyphase induction motors are usually integral horsepower motors (above one horsepower). This type of motor has the best reliability and highest efficiency, ranging from 55 to 90 percent. However, in fractional horsepower sizes, the efficiency is lower in three phase motors than in single phase motors and most of the fractional horsepower motors are single-phase. Many single-phase fractional through five horsepower motors are used instead of polyphase motors in residential air conditioners because polyphase alternating current is not available.

4. Direct Current Motors

Direct current fractional horsepower motors have been increasing in use due to the growing demands for adjustable-speed drives, using low cost silicon rectifier control modules. These motors are usually shunt-wound, with or without a stabilizing winding

The efficiency of these systems depends upon the type of control module used, and the speed range for the particular application.

5. Synchronous Motors (Reluctance Type)

Reluctance synchronous motors are similar in construction to induction motors except the member carrying the secondary circuit has salient poles without direct current excitation. They start as induction motors and operate normally at synchronous speed. These motors are often used in textile applications and other applications requiring 'synchronous' speeds. They are not suited to general application, and usually have lower efficiencies than conventional induction type motors.

6. Summary

All alternating current, single-phase motors have some similar performance characteristics. The range of efficiencies for the various types of motors is the result of two factors. First, the lower horsepower motors (i.e., .1 horsepower) are inherently less efficient than the higher horsepower motors (i.e., 1 horsepower). Second, the lower speed ratings (850 rpm) are less efficient than the higher speed ratings (3400 rpm). The same is true of the universal motors.

All single-phase motors have similar inherent characteristics related to input power; namely, that the power input is not fixed at one value like many static devices, but varies with the demand for output torque. Thus, if a saw is pushed harder more power is required.

Another inherent characteristic of motors is the change of efficiency as a function of load. At higher loads than rated, the efficiencies can be slightly higher; and at lower loads, the efficiencies can be considerably lower. Therefore, the establishment of a given efficiency is often difficult. A motor used predominately at a given load should have a high efficiency at that load and a motor used at a wide range of loads should have a flat efficiency curve.

In a continuously operating device such as an air conditioner, the motor efficiency should be carefully maximized, since the complete unit, and hence the motor, is judged on the ratio of Btuh output to the watts input to the compressor. In these cases, the most efficient type permanent-split capacitor or capacitor start-capacitor run motor is used. Most furnaces are also equipped with a permanent-split capacitor type motor where direct drive blowers can be used.

Many motors are used for very short periods of time and for a limited number of hours per year. Examples of such motor applications are can openers, garbage disposers, electric lawnmowers, electric saws, drills and hand-held kitchen appliances. Even in these instances, the motor efficiency should be as high as possible since any savings in energy is desirable.

Although higher speed motors generally have higher efficiencies, the exclusive use of higher speeds is not necessarily more effective. Where speed changing machinery (such as gears) is added to obtain the necessary lower speed, the additional power losses of the speed changing machinery could result in a lower efficiency than that of a low speed motor and direct drive. Therefore, it is necessary to consider the overall efficiency of the appliance, not just the motor efficiency.

II. B. Gas Sub-Committee Report on Appliances and Apparatus

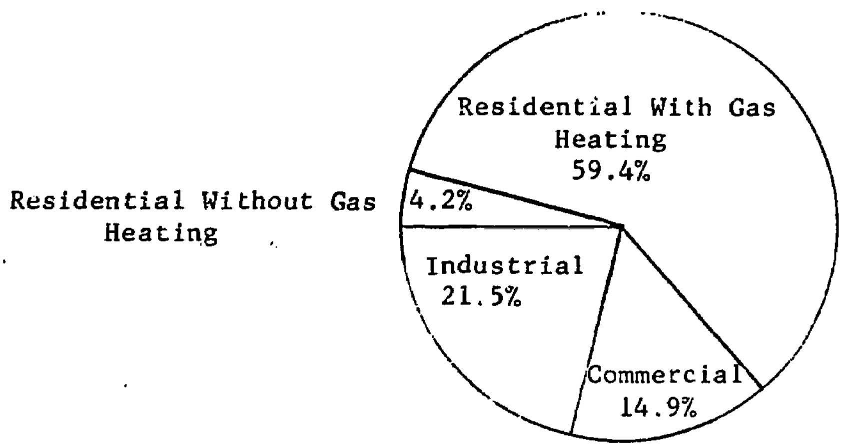
1. General Data

As a first step in ascertaining the opportunities for increasing the energy utilization characteristics of gas appliances and apparatus, the gas consumption statistics for New York State were compiled and are presented herein.

The gas consumption[1] in New York State in 1971 was approximately 544,433 million cubic feet. This total gas consumption is divided among four major market areas as follows:

Market Area	Million Cubic Feet
Residential With Gas Heating	323,718
Residential Without Gas Heating	22,601
Commercial	81,289
Industrial	116,825
Total	544,433

The percentage of total consumption of each market area is shown below:



1. This does not include the gas consumed by interruptible customers.

It is apparent from the above diagram that almost two-thirds of the gas consumed in New York State is used by residential customers and that most of this gas is used in houses having gas heat.

The gas consumed in the residential market is used almost exclusively for four services: Space Heating, Water Heating, Cooking and Clothes Drying. The quantity of gas consumed for each service and the respective percentage of the total residential load of each service is as follows:

New York State Gas Consumption for 1971

Service	Gas Consumption Million Cubic Feet	Percent of Total Residential Load
Space Heating	233,325	67.4
Water Heating	76,191	22.0
Cooking	32,913	9.5
Clothes Drying	3,890	1.1
Total	346,319	100.0

Residential gas air conditioning and incineration have not been considered by this Ad Hoc Committee because of the low sales volume of appliances for these purposes, and the negligible quantity of gas consumed by them in New York State.

The present number of residential gas appliances in New York State for each of the four services is shown in Table II B-1. Also shown in this Table is the approximate number of each type of appliance sold in New York State in 1971.

Table II B-1

New York State 1971 Gas Appliance Summary

Type of Appliance	Units in Service	Annual Sales
Space Heating	2,237,000	102,270
Hot Water Heating	2,485,200	130,806
Cooking	4,186,100	153,351
Clothes Drying	572,400	43,335

2. Efficiency Standards for Gas Appliances

The American gas industry has sponsored national standards for its equipment and has established independent testing laboratories for certification of gas appliances. The standards sponsored by the industry are designed primarily to ensure safety, but also ensure durability and a reasonable operating efficiency of the appliance or accessory when properly installed and in actual use. Most gas appliances and apparatus are designed and constructed to meet these standards of efficiency and performance established by the American National Standards Institute (ANSI). Gas appliances and accessories, the designs of which have been found by the American Gas Association (A.G.A.) Laboratories to comply with the applicable national standards, are certified by the laboratories. A directory of Certified Appliances and Accessories is published by the American Gas Association Laboratories. On a national basis, almost 95 percent of the gas appliances have received A.G.A. Certification, but this percentage is only about 50 percent for New York State because of the very low degree of compliance for gas appliances sold in the New York City area.

Sub-Committees, under the supervision of American National Standards Committee on Performance and Installation of Gas Burning Appliances - Z21, are constantly engaged in the preparation of specifications covering new types of gas equipment, and in reviewing and revising existing standards in line with the latest developments in industry. A new and revised set of standards for each type of gas appliance and accessory is issued and approved as an American National Standard on the average of once every two years.

The ANSI Standards for gas appliances are tabulated in Table II B-2. The efficiency requirements for several of these gas appliances have also been listed below as a convenient reference.

Gas Appliance	ANSI Efficiency Requirements
Domestic Ranges Top Burners	48% up to 14,500 Btuh 45% 14,500 Btuh and up
Hot Plates and Laundry Stoves	40%
Storage Water Heaters	70%
Side Arm Water Heaters	65%
Boilers	75%
Furnaces - Forced Air	75%
Furnaces - Gravity	70%

The present system employed by A.G.A. in the certification of gas appliances is to list in its directory equipment which meets the standards without any reference to the actual performance of the equipment. There is no distinction made between a heating appliance which barely meets the minimum efficiency requirement of 75 percent and an appliance which may in fact have an actual efficiency in excess of 80 percent. An attempt by the Ad Hoc Committee to obtain this data was unsuccessful, and the data is intentionally withheld from the public. This Committee has been informed that the A.G.A. Laboratories certify only that heating appliances meet the minimum requirements established by standards and that the release of information showing that any particular appliances exceed the minimum would involve the Laboratories in activities affecting competition. Therefore, the Laboratories withhold such information from manufacturers who submit their products to the Laboratories for standard certification. It should be pointed out, however, that any manufacturer who wishes to determine and advertise the efficiency of his product is free to employ an independent laboratory to test his equipment for efficiency. They should be encouraged to do so.

It is believed that the maximum increase in thermal efficiency possible may be only about 5 percent over the minimum A.G.A. efficiency standards. It is felt, however, that withholding this information from the public is not in their general interest, nor does it tend to promote energy conservation. This is an area where government intervention or laws might be used to promote the purchase of more efficient appliances. Although the energy savings gained may be small, publicizing gas appliance efficiency would be another step in making the consumer energy conservation conscious.

Table II B-2

ANSI Standards for Major Appliances

Standard Designation		Date Approved by ANSI
Z21.1-1972	Household Cooking Gas Appliances (revision and redesignation of Z21.1.1-1967 and Z21.1.2-1966)	Jan. 12, 1972
Z21.5.1-1972	Gas Clothes Dryers, Volume I, Type 1 Clothes Dryers	Jan. 12, 1972
Z21.5.2-1968	Gas Clothes Dryers, Volume II, Type 2 Clothes Dryers, Including Addenda Z21.5.2a-1969 and Z21.5.2b-1971	Dec. 17, 1971
Z21.10.1-1971	Gas Water Heaters, Volume 1 Automatic Storage Type Water Heaters with Inputs of 75,000 Btu per hour or less, including Addenda Z21.10.1a-1972 and Z21.10.1b-1972	Apr. 6, 1972
Z21.10.3-1971	Circulating Tank, Instantaneous and Large Automatic Storage Type Water Heaters, Approval Requirements for Gas Water Heaters, Volume III, including Addenda Z21.10.3a-1972 and Z21.10.3b-1972	Dec. 17, 1971
Z21.13-1972	Gas-Fired Low-Pressure Steam and Hot Water Boilers	Feb. 17, 1972
Z21.17-1969	Domestic Gas Conversion Burners, including Addenda Z21.17a-1971	Dec. 17, 1971
Z21.34-1971	Gas-Fired Duct Furnaces	Dec. 17, 1971

Table II B-2
(continued)

ANSI Standards for Major Appliances

Standard Designation		Date Approved by ANSI
Z21.43-1968	Unvented Gas-Fired Infrared Radiant Heaters, including Addenda Z21.43a-1971 and Z21.43b-1972	Mar. 9, 1972
Z21.47-1971	Gas-Fired Gravity and Forced Air Central Furnaces, including Addenda Z21.47a-1972	Feb. 17, 1972

3. Discussion of Efficiencies of Major Gas Appliances

In the following analysis, repeated reference will be made to both thermal efficiency and utilization efficiency. It should be kept in mind that these efficiency ratings are quite different. All available gas appliances have a rather narrow band of thermal efficiencies; i.e., all residential gas heating appliances have a thermal efficiency between 75 and 85 percent. Utilization efficiency, on the other hand, may vary from a low of 40 percent to a high of 78 percent. It is possible, therefore, to install a 75 percent thermally efficient heating appliance in a system and obtain a 70 percent or higher utilization efficiency. It is also possible to install an 85 percent thermally efficient heating appliance and achieve a 40 percent utilization efficiency. The thermal efficiency or appliance efficiency is established with the appliance operating at steady-state conditions. The thermal losses are determined and subtracted from 100 percent, thus giving the thermal or appliance efficiency rating. This is the only way in which one appliance can be compared to a similar appliance of a different manufacturer. When a heating unit is installed in a system, it is inoperative much of the time and standby losses occur. With this in mind, it is obvious that the largest gains in energy conservation can be achieved through improving utilization efficiency, as opposed to increasing thermal or appliance efficiency.

(a) Boilers and Furnaces

American National Standards Z21.13 and Z21.47 covering gas fired boilers and furnaces, respectively, provide for minimum appliance efficiencies of 75 percent. If this equipment burned gas 24 hours per day, its utilization efficiency would also be at least 75 percent. However, because this type of equipment burns gas at full load on an average of five hours per day during the heating season, standby losses result, thereby reducing the utilization efficiency to a range of approximately 60 to 70 percent.

Gas conversion burners are commonly used in existing central heating systems as replacements for coal or oil firing equipment. Gas conversion burners are not approved by A.G.A., but are given an A.G.A. listing based on design and construction standards. Efficiency of operation depends on the installation, setting the proper gas input and the overall system efficiency.

In any discussion of gas appliance efficiency, it must be kept in mind that because the heating value of natural gas is always stated in terms of its gross heating value, it is only possible to recover 92 percent of its heat. The reason for this is that 8% of the heating value is represented by the unrecoverable latent heat contained in the water vapor produced in the combustion process. Therefore, a boiler or furnace which is 82 percent[2] efficient is already within ten percent of its maximum efficiency.

Let us now consider various ways of increasing the efficiency of a boiler or furnace. One way would consist of a reduction in the amount of excess air for combustion. This will result in an increase in the efficiency of the appliance, but only at the risk of causing incomplete combustion which is always accompanied by the formation of carbon monoxide. This presents a safety hazard because of possible leakage of exhaust gases inside the dwelling from poor duct connections in the vent systems. To preclude this possibility, A.G.A. Standards limit the carbon monoxide content of the exhaust gases to 0.04 percent, which can only be accomplished with the use of a reasonable quantity (usually about 50 percent) of excess air. It is concluded by A.G.A. that reducing the quantity of excess air to improve efficiency must be rejected for safety reasons.

Another way to increase the thermal efficiency of the heating appliance would be to lower the temperature of the fuel gases by increasing the amount of heat transfer surface in the boiler or furnace. This, also, will increase the thermal efficiency, but only at the risk of excessive amounts of corrosive condensation caused by cooling the products of

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2. Many furnaces and boilers attain this efficiency where jacket radiation losses are considered useful in heating the house.

combustion below their dew point. The dew point temperature of the products of combustion will depend upon the hydrogen content of the gas, the moisture content of the air used in combustion and the quantity of excess air used. A reduction in flue gas temperatures also tends to reduce the natural draft required to vent the products of combustion. Therefore, substantially reducing flue gas temperatures is unacceptable for standard heating equipment, unless expensive venting materials (such as stainless steel) which are unaffected by corrosive condensation are used. As previously mentioned in this section, there is little incentive on the manufacturer's part to increase thermal efficiency above minimum standards, especially when increased product costs are involved, since only standard minimum efficiency information are available to the consumer.

A third way would be to increase the insulation thickness of the furnace or boiler jacket. This would reduce the amount of heat lost by radiation, presently estimated at five percent. However, this five percent radiation loss from the jacket escapes into the furnace room or basement. Most heating engineers believe that such heat, from units located within the building being heated, is not wasted but is useful in heating the house. Therefore, the value of adding insulation to a furnace or boiler jacket is questionable.

There are also ways of increasing the utilization efficiency of a heating plant as contrasted to the thermal (steady-state condition) efficiency of a boiler or furnace.

One way would be to undersize the boiler or burner so that it operates for longer periods of time. The resultant decrease in standby losses would result in a slightly higher utilization efficiency. Another way is to have different flame sizes for various heat outputs.

There are, of course, other obvious ways of increasing the utilization efficiency of hot water heating systems. For instance, the use of well-insulated, small-diameter, thin-walled copper tubing to conduct hot water from the heater to faucets or radiators would improve the system efficiency when compared to uninsulated large-size, heavy-walled steel pipe. The reason is that the hot water stored in the piping, as well as the piping itself, cools to room temperature when the appliance is not in use. The use of thin-walled, small-diameter tubing reduces the amount of energy needed to fill the system with hot water again when heat is called for. Insulating the piping minimizes the loss of heat when the system is hot.

Many room space heaters are inefficient since combustion air is taken from the living quarters. This type of space heater is illegal in dwelling units in New York City because it is considered a safety hazard. Sealed combustion room heaters are, however, permitted.

(b) Gas Water Heaters

The gas automatic storage water heater is most commonly used to supply domestic hot water. Some fuel savings might be realized by installing a tempering tank to raise the water temperature to room temperature prior to water entering the water heater. This would apply equally to electric water heaters. Fuel savings could vary from 0 to 20 percent, depending on a variety of conditions.

The American National Standard covering residential gas water heaters (Z21.10.1-1971) limits the heat input required to produce a "daily quota" of hot water. This daily quota is a function of the heat input rating of the water heater in Btuh and the storage capacity in gallons. The requirements of the standard are equivalent to a minimum utilization efficiency of about 50 percent.

The two main factors that determine the utilization efficiency are the recovery efficiency and the standby losses. The recovery efficiency is the efficiency at which the water is heated over the required temperature range at full input rate. However, water heaters are practically never used continuously and hence standby losses occur. These losses represent gas burned to maintain water temperature over periods when no hot water is being drawn from the tank. The utilization efficiency of the average gas water heater is approximately 64 percent.

Gas automatic storage water heaters typically employ 1" of glass wool thermal insulation around the tank to reduce the standby heat loss. Additional tank insulation could reduce the standby loss significantly and would increase the utilization efficiency by three to five percent. Present residential gas water heater standards require approximately 70 percent recovery efficiency to meet the daily quota specified in the standard. Any improvement in recovery efficiency or any reduction in standby loss would improve the utilization efficiency.

Recommendations

It is recommended that manufacturers be encouraged to take steps to improve the utilization efficiency of their gas water heaters. Industry standards should be promoted which specify a lower standby loss and an increased utilization efficiency. Labeling of water heater efficiencies should also be encouraged.

(c) Gas Ranges

The American National Standard for Household Cooking Gas Appliances (Z21.1-1972) provides for a minimum top burner thermal efficiency of 48% for burners having rated inputs up to 14,500 Btu per hour. No finite specification is included in this standard regarding a minimum thermal efficiency for gas range ovens. However, maximum permissible surface temperatures are specified, thus limiting permissible oven heat loss.

The efficiencies obtained in actual cooking operations depend, of course, on the cook and what is being cooked. Obviously, the size of the utensil and the flame size will affect the efficiency obtained. Likewise, the amount of food placed in the oven will largely determine the oven efficiency. Little more energy is needed to bake four pies simultaneously than only one pie. The utilization efficiency of a gas range, including top burners and ovens, is approximately 37% (See Table II B-3), reflecting the fact that top burners and ovens are seldom used at their full capacity or highest efficiency.

Existing apartment houses have the least efficient gas ranges. Fuel waste is caused by misadjusted burners and pilots. Overfiring is common. Gas inputs are usually considerably higher than recommended by the manufacturer. This could be corrected by having the manufacturer pre-adjust the air and gas mixtures for burners and pilots. Variation in inputs in the field could be eliminated by requiring gas pressure regulators on all new ranges.

Consumer education in matching flame size to pan size would have the most immediate effect in increasing range efficiency and would also be desirable from a safety point of view.

(d) Clothes Dryers

American National Standard Z21.5.1-1972, covering residential gas clothes dryers, provides for a maximum gas consumption of 2,500 Btu per pound of water evaporated, which is equivalent to a drying efficiency of 44.5%. It is believed that most gas clothes dryers manufactured today operate at a higher efficiency, the average approximating 50% (See Table II B-3).

Practically all gas dryers manufactured today are equipped with electric ignition, thus eliminating energy waste due to gas pilot consumption.

Drying clothes is largely a matter of circulating large quantities of warm air through clothes as they are rapidly tumbled in a rotating drum. If the temperature of the air could be increased, drying efficiency would also be increased.

However, in order to prevent damage to delicate fabrics, gas dryers are limited to a maximum temperature of 240 degrees. With this limitation, there does not seem to be much likelihood of an improvement in drying efficiency.

(e) Inter-Relationships

It is interesting to note how the various household appliances are related, one to the other. For instance, if the horsepower rating of washing machine motors were to be reduced in order to save energy, the spin cycle would not extract as much water from the clothes as before. More energy would have to be used by the gas clothes dryer which would exceed the energy saving accomplished by using a smaller motor in the washer.

Table II B-3

Energy Efficiencies for Residential Gas Use

	Utilization Efficiency (a)	Ultimate Efficiency (b)
Space Heating	60%	55%
Water Heating	64%	59%
Cooking	37%	34%
Clothes Drying	50%	46%

Energy efficiency data from Stanford Research Institute; Gas Engineers Handbook; and Consumers' Research. (a) Utilization efficiency refers to the efficiency of fuel use within the home. (b) Ultimate efficiency includes the efficiency with which energy is delivered to the home (transportation, processing, conversion, etc.)

4. Opportunities for Energy Saving

In the previous section, various aspects of increasing gas appliance thermal efficiency were discussed. The greatest opportunities for energy savings are in the improvement of the utilization efficiencies of gas appliances. Since standby losses have a significant impact on utilization efficiency, two areas involving standby losses which have recently received much publicity have been reviewed by this Committee. They are:

(1) Gas Pilot Energy Consumption

(2) Automatic Damper Control for Gas Heating Appliances

These subjects are discussed in Sections 5 and 6, respectively.

A brief description of infrared heating is covered in Section 7, since it offers the possibility of significant energy savings when used in special heating applications.

It is worthwhile to note that the Gas Industry is sponsoring many research and development projects related to the efficiency of gas appliances and apparatus. A list of these projects together with the name of the organization assigned project responsibility is presented in Table II B-4.

Table II B-4

Industry Sponsored Research and Development Projects Related to Gas Appliance and Apparatus Efficiency - Project Responsibility

(a) Home Climate Control

1. Pivoting Tip-Vane Compressor - Battelle Columbus Laboratories
2. The Technical Feasibility of the Solid Adsorption Cooling System - Institute of Gas Technology
3. Evaluation of Existing Recommendations for Conserving Energy Fuel Sources - Institute of Gas Technology
4. New Working Fluids for Rankine Cycle Residential Air Conditioning Systems - Allied Chemical Corp.
5. Natural Gas Home Air Conditioning - Gates Rubber Company
6. Total Comfort Program - Eaton Corp.
7. Thermal Refrigeration - K. Johnson Company
8. Free Piston Stirling Engine Driven Gas Fired Air Conditioner - Ohio University
9. Basic Research in Heat Transfer - Dynatech Corp.

(b) Home Appliances

10. Design of Domestic Appliances to Use Gas at Elevated Pressures - A.G.A. Laboratories
11. Improved Design of Flush (Direct Vent) Terminals for Sealed Combustion System Appliances
12. Providing Outdoor Combustion Air Directly to the Combustion Chamber of Vented Gas-Fired Heating Appliances - A.G.A. Laboratories

13. Development of a Central Heating Furnace with Ultra High Efficiency - A.G.A. Laboratories

(c) <u>Large Uses - Commercial</u>

14. All Steel Infrared Burner and Radiating Surface - Bettcher Manufacturing Corporation

(d) <u>Large Uses - Industrial</u>

15. Optimization of the Use of Oxygen in a Gas-Fired Glass-Melting Furnace - Institute of Gas Technology

The areas of selection, operation and maintenance of gas appliances are potentially very valid areas for energy savings. Selecting an appliance of the right type and size is very important in obtaining a high utilization efficiency. Operating the appliance in an efficient manner is also very important in minimizing the consumption of energy. In addition, the fact that a gas appliance was certified to meet minimum efficiency requirements does not insure that this efficiency will be retained over the life of the appliance. Adequate maintenance of gas appliances must be provided to maintain maximum performance over the life of the equipment.

Appendix A to this report deals with selection, operation, and maintenance aspects of major gas appliances related to the conservation of energy. The information presented covers gas appliances for use in the residential, commercial, and industrial areas.

The only practical way to implement the energy conservation suggestions dealing with selection, operation and maintenance of gas appliances is through a program of education. Programs for educating the public are covered in Section III of this report.

5. Gas Pilot Consumption

There appears to be considerable disagreement concerning the pilot consumption of gas appliances and apparatus. For instance, the Gas Appliance Manufacturers' Association (GAMA) estimates the average pilot consumption per gas range on a national basis to be 500 Btuh. The United States Department of Housing and Urban Development estimates gas range pilot consumption to be 450 Btuh, and the Brooklyn Union Gas Company has conducted field surveys that indicate the average consumption to be 350 Btuh. The differences in the consumption estimates are probably due to the fact that the number of pilots per range varies from two to five and the input per pilot will differ from one range model to another.

Another area of controversy with respect to gas pilot consumption is the apportionment of the gas energy consumed into useful heat and wasted energy. In the case of a range, the gas pilot consumption may be considered to supply useful heat for approximately nine months of the year, since during this period pilot heat contributes to meeting the heat load requirements of the dwelling. For the remaining three months, the range pilot heat, in addition to not being useful, may result in additional energy being expended for air conditioning to remove this heat. The percentage of New York State residences having central air conditioning is about 3.2 percent, but it is believed that many of the residences with central air conditioning also have electric ranges. Some residences with gas ranges have room air conditioners. It is estimated that about five percent of the residences using gas ranges have their pilot heat removed by some form of air conditioning during the summer months. Assuming an average room air conditioner energy efficiency ratio of 6.8 Btuh per watt, an additional one-half Btuh of energy must be consumed to remove each Btuh of gas pilot waste heat.

The Estimated National Pilot Consumption of Residential Appliances is presented in Table II B-5, together with the assumptions on which the estimate was based. The national pilot consumption estimates of Table II B-5 were then used to formulate the New York State estimate for gas pilot waste energy presented in Table II B-6. It should be noted from Table II B-6 that the percentage of total national residential sales of natural gas that is used for ignition only is 5.07 percent, and this percentage is assumed to be the same for New York State. By applying this percentage to New York State residential gas sales, it was determined that 17,850 million cubic feet of natural gas were wasted for ignition only in New York State during 1971.

The quantity of gas wasted for ignition only in New York State is immense! It would be capable of meeting the gas consumption requirements of approximately 62,500 new one family homes employing gas for space heating, hot water heating and cooking. Although the total quantity of gas wasted by pilots is quite large, it is made up of small contributions of over 9,000,000 gas appliances and apparatus in New York State. From the standpoint of cost of implementation, difficulty of enforcement and safety considerations, it is unrealistic to even consider conversion of gas pilots to electric ignition for appliances already in use in New York State.

An assessment was made as to the annual energy wasted by the gas pilot consumption of the additional new residential gas appliances that are shipped into New York State each year. The assessment was made based on the 1971 appliance shipments presented in Table II B-7. The results of this assessment were then used to estimate the residential natural gas savings over a ten year period that would be gained by requiring all gas appliances shipped into New York State after January 1, 1974, to be equipped with electric ignition. The total ten-year savings is estimated to be 10,400 million cubic feet of natural gas as shown in Table II B-8.

Although the quantity of natural gas that could be saved by requiring electric ignition in new appliances is significant, there are several other factors to consider before making any overall recommendations.

The initial cost of an appliance is most often the primary factor in its selection. This is especially true of the selection of appliances for rented dwellings where the cost of operation of the appliance becomes the responsibility of the tenant. If requiring electric ignition on a gas appliance tended to increase the competitive advantage of the comparable electric appliance, then the overall effect on energy consumption must be carefully considered. Because of the relatively low conversion efficiency of primary fuels into electric energy, in many cases the comparable gas appliance is considerably more efficient in terms of consumption of primary fuel. Under the conditions as described above, requiring electric ignition on a gas appliance might end up with a negative effect in terms of promoting energy conservation.

It is interesting to note that practically all new gas clothes dryers are manufactured today with electric ignition. Discussion with a leading manufacturer of gas clothes dryers has indicated that the cost of providing electric ignition was somewhat less than the cost of providing a gas pilot for a clothes dryer. Based on simple economics the gas pilot on new clothes dryers is very nearly extinct.

Incidental to the economic decision is the fact that over half the annual energy consumption of a clothes dryer with a gas pilot is wasted in the form of gas pilot heat. A typical clothes dryer pilot wastes over 5,000 cubic feet of gas each year at an annual cost to the consumer of about $7.50.

Some electric ignition systems employ the use of a glow coil which is essentially an electrical resistance heater designed to reach elevated temperatures and cause ignition when energized. The Committee has been advised that in some cases the glow coil may be powered continuously in order to extend coil life. In such cases the use of primary energy for this device may exceed the energy requirements of gas pilots. It is hoped that the gas appliance industry will find a suitable alternative for gas pilots that will reduce or completely eliminate the energy wasted in this area.

For years, consumers have been urged to leave gas heating system pilots on through the summer because it was believed that pilot heat would prevent condensation and corrosion in the furnace. In systems having air conditioning integral with the heating system, the opposite happens. Air passing over the heat exchangers keeps them cool and hence moisture in the products of combustion of the pilot condenses in the heat exchanger and stack. The heat of the pilot is also added to the system air conditioning load. In non-cooling systems, the pilot heat may keep one section of the heat exchanger warm but not the entire furnace.

Pilot burners in many heating systems today are difficult to ignite. In most residential installations, the homeowner would not consider extinguishing the pilot in the spring and re-igniting it in the fall because he does not want to bother, is afraid of it, or cannot figure out how to do it. It is believed that the main reason utilities promote continuous pilot operation in furnaces is that they cannot reasonably provide the manpower to relight pilots in the fall. The only hope of completely eliminating this problem is the long-term approach of incorporating automatic electric ignition in all new gas heating systems. An alternate solution, not as desirable, but less costly, is to provide a manually operated electric ignition system which would ensure the capability of seasonal startup by the homeowner.

For the short term, it is recommended that utilities be urged to distribute information as to the benefits of turning off gas pilots for the summer months and instructions as to how to accomplish it. This information should be provided in Spanish as well as English. In cases where the utilities are still requested to light pilots, the homeowner should be instructed by the serviceman as to how to light the pilot so as to avoid future "turn-on" calls.

Conclusions and Recommendations With Respect to Gas Pilot Consumption

1. Field conversion of gas appliances from gas to electric ignition is impractical because of cost, safety and difficulty of implementation.

2. Gas pilots should be eliminated from new clothes dryers since a suitable alternate is available at a cost that will not price the gas appliance out of the market.

3. In the case of furnaces, boilers, and room heaters, pilots should be turned off during the non-heating months. During the heating season, pilot gas provides useful heat to the house.

4. Little energy can be saved by replacing pilots with electric ignition in the case of water heaters, since 75 percent of the pilot gas is useful for heating the water and/or maintaining the water temperature at the thermostat setting.

5. Little energy can be saved by replacing pilots with electric ignition in the case of gas ranges because pilot gas helps to heat the house during the heating months of the year. However, as central air conditioning becomes more widespread, the importance of eliminating gas pilots in ranges will be increased.

6. Further and more concentrated efforts are required of the gas appliance industry to develop a safe low cost ignition system for gas appliances and apparatus. Unless progress is made in the near future towards eliminating wasteful pilots in gas appliances, appropriate actions should be taken by government to insure the elimination of this wasteful consumption of gas.

Estimated National Pilot Consumption of Residential Appliances[1]

Appliances	Number in Use as of December 31, 1970	Unit Pilot Consumption in Btu/Hr	Pilot Consumption In Millions of Cubic Feet Per Year: Total	Used For: Heat And Ignition	Used For: Ignition Only
Ranges[2]	39,840,000	500[3]	174,000	120,000	54,000
Water Heaters[4]	31,964,000	750	210,000	157,000	53,000
Central Heating Units[5]	20,529,000	850	152,000	85,000	67,000
Other Heating Units[5]	39,386,000	850	290,000	163,000	127,000
Clothes Dryers[6]	7,140,000	850	28,000	None	28,000
Incinerators	700,000	850	5,000	None	5,000
Central Air Conditioning	280,000	850	2,000	None	2,000
Outdoor Cooking & Lighting	4,890,000	None	None	None	None
Refrigerators	450,000	None	None	None	None
TOTAL	145,179,000		861,000	525,000	336,000

1. Includes appliances burning liquefied petroleum gases.

2. Range pilot provides useful heat in residences for nine months each year at efficiency of 92 percent. In residences with both central air conditioning and gas ranges, gas pilot output would represent heat to be removed by air conditioning on days on which A/C equipment is operated. The air conditioning penalty is estimated at 1,087 millions of cubic feet, but has not been included in the table.

3. Consumption shown is national average. New York State consumption is believed by Brooklyn Union Gas Company to be below the national average.

4. Water heater pilots: 75 percent of pilot gas is useful in heating water and/or maintaining water temperature at thermostat setting.

5. Furnace pilots: during heating months 75 percent of pilot gas provides useful heat to residence. If occupants could be persuaded to shut off pilots during three summer months, the saving would amount to 110,000 million cubic feet per year.

6. Approximately 50 percent of dryers are not equipped with continuous burning pilot.

Table II B-6

Estimated Natural Gas Used for Ignition Only

In New York State During 1971

Line		
(1)	Residential Natural Gas Customers in United States at End of 1970 (Millions)	37.5 (75%)
(2)	Residential LP*Gas Customers in United States at End of 1970 (Millions)	12.1 (25%)
(3)	Total Residential Gas Customers in United States at End of 1970 (Millions)	49.6 (100%)
(4)	Natural and LP* Gas Used for Ignition Only in United States During 1970 (See Table II B-5)	336,000 Million c.f./yr.
(5)	Natural Gas Used for Ignition Only in United States During 1970 (75% of Line 4)	252,000 Million c.f./yr.
(6)	Total Residential Sales of Natural Gas in United States (1971)	4,971,690 Million c.f./yr.
(7)	Natural Gas Used for Ignition Only Expressed as a Percent of Total Residential Sales of Natural Gas - Line (5) Divided by Line (6)	5.07%
(8)	Sales of Residential Natural Gas in New York State in 1971	352,083 Million c.f.
(9)	Natural Gas Used for Ignition Only in New York State During 1971 - 5.07% of Line (8)	17,850 Million c.f.

*Liquified Petroleum

Table II B-7

Estimated Pilot Consumption of New Residential Gas Appliances

Shipped Into New York State During 1971

	Number Of Appliances	Unit Pilot Consumption in Btu/Hour	Pilot Consumption in Million of Cubic Feet Per Year: Total	Used For: Heat And Ignition	Used For: Ignition Only
Ranges	153,351	500	670	462	208
Water Heaters	130,806	750	860	645	215
Warm Air Furnaces	32,115	850	239	134	105
Vented Wall Furnaces	1,993	850	15	8	7
TOTAL	318,265		1,784	1,249	535

Note: Clothes dryers are not included because practically all gas dryers manufactured today are equipped with electric ignition devices.

Gas-fired incinerators and air conditioners were omitted because the sales in New York State are negligible.

Table II B-8

Estimated Ten Year Savings of Residential Natural Gas by Requiring All Gas Appliances Shipped Into New York State After January 1, 1974 to be Equipped with Electric Ignition

Year	Millions of Cubic Feet Of Natural Gas Saved By Use of Electric Ignition On New Gas Appliances Sold in New York State	
	All Gas Appliances	Gas Ranges
1974	268	104
1975	803	312
1976	1,338	520
1977	1,873	728
1978	2,408	936
1979	2,943	1,144
1980	3,478	1,352
1981	4,013	1,560
1982	4,548	1,768
1983	5,083	1,976
Total Ten Year Saving	26,754	10,400

Note: The above summary is based on the estimated gas pilot consumptions of Table II B-7 and assumes that gas appliance sales will remain at the present level over the ten year period.

6. Automatic Damper Control

The vent system of a gas-fired heating appliance is utilized to exhaust the products of combustion from the appliance to the outside atmosphere. Venting the appliance is required, however, only when the burner is on and combustion products are being generated. When the burner goes off, a considerable quantity of air continues to escape through the open vent system due to natural convection and the positive pressure differential within the dwelling. If the heating appliance is located in the living quarters or finished basement, conditioned air will be lost through the vent system resulting in a high fuel penalty. If, on the other hand, the heating appliance is located in an unheated area, only unconditioned air will be lost. However, the cooling of the appliance by the cold air passing through it represents a heat loss which must essentially be made up during the next heating cycle. This loss of air through the open vent system can be eliminated by means of an automatic draft control device which closes the vent system when the main burner is not on.

Devices for automatic draft control are available under several trade names, two of which are Vent-O-Matic and Damp-A-Matic. Both of these devices contain an automatically actuated damper plate placed in the vent system. The damper plate is opened a fraction of a second before the main burner is ignited, allowing the products of combustion to be safely vented away. The draft control system is interlocked to the heating appliance's gas valve to prevent ignition of the main burner until the damper plate has moved to a safe (open) position. When the heating appliance main burner goes off, the damper closes automatically. Air is prevented from escaping through the vent pipe.

The amount of fuel saved by installing the device has been the subject of considerable controversy. Manufacturers have claimed a savings of 20 to 30 percent. The Gas Appliance Manufacturers Association estimates a savings in the three to six percent range. One test that was made on a warm air furnace in the field by the Brooklyn Union Gas Company showed an annual heating savings of ten percent. The wide range of efficiencies either estimated or tested is undoubtedly due in part to installation conditions.

The amount of fuel saved by automatic damper control is greater when the appliance is located in a heated area. The savings is also greater for boilers supplying both heat and hot water.

Some concern has been expressed with respect to the safety of using a damper control device. It has been suggested that a thermal switch be installed at the draft hood or barometric damper to sense combustion gas spillage in the event of a failure of the automatic damper interlock. The thermal switch would open, thereby shutting off the burner. The switch should be of the manual reset type requiring the attention of the homeowner or serviceman to restart the burner.

The Washington Gas Light Company, which has its own testing laboratory, tested the Vent-O-Matic device in 1969 and issued a detailed report on its findings. The study determined that if the gas valve interlock switch failed in a closed position, combustion could take place with a closed damper. It also indicated that this single point failure was unlikely for the microswitch used, and made no recommendations for additional safety protection. We understand that testing of the Vent-O-Matic device in the field under actual conditions of operation is now being performed by the Washington Gas Light Company.

Furnaces with factory installed automatic damper control have already been certified by the American Gas Association. If this device were to be field installed by unqualified personnel, there would be greater possibility of it being a safety hazard than if the device were installed as an integral part of the equipment and was factory wired. However, a task force has been established by the American National Standards Institute (ANSI) to draw up standards for field installed units.

The incorporation of automatic damper control devices on new gas heating appliances would increase the consumer cost of the heating appliances by approximately $50 to $75. Field installation of an automatic damper control device would undoubtedly double the cost. The time required to recover the cost of this device by reduced fuel consumption would be approximately two to five years depending on whether it was factory installed, the type of heating appliance on which it was used, and whether the appliance was located in a heated space.

Recommendations with Respect to Automatic Damper Control

Based on the information available to this Ad Hoc Committee, it is believed that automatic damper control will result in an average fuel savings of close to ten percent and hence, it is certainly considered a worthwhile design innovation.

Additional field data should be obtained for different types of installations so that a more accurate appraisal of the device can be made. This data could be most easily obtained by the gas utilities, and it is recommended that the Gas Division of the Department of Public Service encourage their participation in this area. The field test data thus obtained would permit economic evaluation of this device under the various types of installation conditions. Where favorable, the utilities could then encourage installation of the device by publicity enclosed in their billings.

The use of this device should be highly encouraged for new installations where the cost and safety implications are the most favorable. However, unless a mandatory requirement is imposed on heating appliance manufacturers for incorporating automatic damper control, a favorable response is not expected. Builders are the primary customers for new heating equipment, and too often their only concern in purchasing equipment is first cost. For this reason, it is recommended that if additional field testing of automatic damper control devices verifies meaningful fuel savings, a mandatory requirement for automatic damper control be imposed for all heating appliances manufactured or offered for sale in New York State.

7. Infrared Heating

A brief discussion of infrared heating has been included in this report because the use of this apparatus can result in significant energy savings in special applications.

Infrared heaters are designed to operate at elevated temperatures which maximize their radiant energy output. With this type of heater the energy released by combustion of the gas is transferred to the space to be heated primarily by radiation rather than convection as in more conventional heating units. Typical applications of this device are for heating garages, factories, foundries, airplane hangers, gymnasiums, swimming pools, loading docks and racetrack grandstands. Use of this apparatus is dependent upon relatively high ceilings (about 20 feet) so that the radiant field of view can be relatively large and the high temperature device will be well out of reach so as not to present a safety hazard. A complete discussion of the technical aspects of infrared heating is available in the ASHRAE 1970 Guide and Data Book.[3]

It is believed worthwhile, however, to explain why infrared heaters generally utilize less fuel for comfort heating than do conventional type heaters for the applications mentioned above.

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3. American Society of Heating, Refrigerating and Air Conditioning Engineers, 1970 Guide and Data Book, Chapters 17 and 32.

The heat loss of a building is determined by the following:

1. Heat loss through the walls, windows and doors.

2. Heat loss through the roof and floor.

3. Heat loss due to infiltration or mechanically induced air changes.

In each case, the total heat loss is proportional to the temperature difference inside and outside of the building. Therefore, the lower the inside temperature, the lower the heat loss. In convection heating the temperature of the air is the prime factor in keeping the people comfortable. The air in the building and all the air passing through the building must be heated to some predetermined comfortable temperature. In order to maintain a comfortable temperature at chest level, the discharge air temperature from the heater must be in excess of the chest level temperature. This is since hot air rises, causing stratification.

In most industrial applications this comfort temperature is 65°F. The air temperature, therefore, at the ceiling will be in excess of 65°F. In spaces 20 feet or more in height, the ceiling temperature could exceed 100°F. This high temperature just below the ceiling increases the ceiling heat loss. Ventilators in the roof discharge air at a high temperature. Infiltration and wall heat losses are also high.

With infrared heating, the air temperature is not appreciably raised directly by the radiation from the heater, since air is a poor absorber of radiant energy. The infrared energy is absorbed by the floors, the equipment and the people within the area. All these items in turn create minor convection currents which raise the ambient temperature of the air somewhat.

The feeling of comfort in an infrared heated building is equal to the ambient temperature plus the ERF (Effective Radiant Field). In order, therefore, to maintain a comfort condition of 65°F, the ambient temperature will always be less than 65°F. The amount below 65°F would vary from job to job depending on the thermal construction and number of air changes of the building. This lower ambient temperature results in less heat loss by infiltration and exhaust, and less heat loss through the walls and roof, because the temperature difference between the inside and outside is less. The roof loss is much less since with the lower ambient temperature less stratification takes place so that the air temperatures at the roof are much lower than in convection heating.

In infrared heating applications, it is customary to install 85 percent of the calculated heat loss of a building. In many buildings the savings are even greater than indicated by this 15 percent reduction. The savings mentioned here are a comparison of infrared heating versus other direct fired equipment such as unit heaters. When a comparison is made between infrared heating and steam unit heaters, the annual energy savings can go as high as 50 percent.

II. C. Oil Sub-Committee Report on Appliances and Apparatus

1. General Data

Space heating and hot water heating are the major applications of oil consuming appliances and apparatus that fall within the jurisdiction of this Ad Hoc Committee.

As determined in the 1970 Census of Housing,[1] of the 5,913,861 occupied housing units in New York State, 3,357,171 or 56.8 percent were heated by oil. Of these 2,600,343 housing units had oil domestic hot water heating. The balance of the housing units that employed oil for space heating had domestic hot water heating using another fuel, or in some cases had no domestic hot water heating at all.

Table II C-1 shows the breakdown of refined petroleum products supplied to the residential and commercial sectors of New York State in 1970.[2]

Table II C-1

Refined Petroleum Products Sold to the Residential & Commercial Sectors in 1970

	Trillion Btu's	Percent
Distillate	549.5	56.4
Residual	375.7	38.5
Kerosene	36.7	3.8
Liquified Petroleum Gas	12.6	1.3
Total	974.5	100.0

1. 1970 Census of Housing, Detailed Housing Characteristics - New York, United States Department of Commerce Publication HC(1)B34 NY, April 1972
2. Consumption of Energy in New York State 1960-1970, New York State Department of Public Service, Office of Economic Research Report No. X, February 21, 1972.

The fuel oil used for small installations such as one and two family homes is primarily Fuel Oil Grade No. 2, Distillate. It is also used in some larger installations, but in general the larger installations will use Fuel Oil Grades 4,5 and 6, which are termed Residual Oils. The residual oils are cheaper but require somewhat more complex heating equipment and preparation to burn efficiently. Historically, there has been a major difference in price between the fuel oil grades, but any variances have been narrowed by the recently high demand for low sulfur fuels. New York City now restricts the use of fuels burned to those with a maximum sulfur content of 0.3 percent. Because of this restriction, the price of the No. 6 fuel oil that can be used in New York City has changed from about 1/3 the price of No. 2 fuel oil (four years ago) to within 10% of the current price.

In New York State, oil space and domestic hot water heating is accomplished primarily with the use of boilers. For small installations such as used in one and two family dwellings, domestic hot water is obtained by means of an immersion coil in the boiler. A separate oil fired domestic hot water heater is rarely installed initially because its first cost is higher in price than an immersion coil type or comparable gas fired or electric hot water heaters. Oil domestic hot water heaters comprise only about one percent of the residential installations, and are sold primarily in custom houses or installations where the immersion coil in an oil fired boiler is found inadequate or requires replacement.

Hot water heating with an immersion coil has both advantages and disadvantages as compared to separate oil fired units for space and water heating. During the winter season, combining the space heating and water heating load in a single boiler undoubtedly results in a lower energy requirement than operation of separate units. In the summer, however, the combined system is not as efficient, since the boiler must be run at a relatively light load for domestic hot water heating only. This drawback is often further compounded by the practice of oversizing the boiler solely for the purpose of selecting a boiler with a higher capacity immersion coil for hot water heating. However, some compensation for the adverse effect on efficiency of the oversized boiler can be made by the use of a smaller nozzle size on the oil burner. To a great extent, the high winter efficiency and low summer efficiency for an immersion coil tends to result in a reasonable year-round average efficiency, comparable to individual oil fired units. Exact sample data for this comparison, however, is not available.

The four main factors which determine the efficiency obtained in oil fired heating appliances are:

1. Appliance Design
2. Fuel Oil Selection
3. Boiler Size Selection
4. Operation and Maintenance

The above four factors are discussed in Section 2, 3, 4, and 5, respectively. These factors must all be given adequate consideration, since neglect of any one can offset correct application of the others.

Although the emphasis in this section of the report is on boilers of all sizes and furnaces in the domestic size range, many of the recommendations apply to the other types of oil powered appliances and equipment used in commercial and industrial applications.

Some of the types of equipment available include direct fired roof top heating and air conditioning units, indirect oil fired roof top units, overhead suspended heaters, horizontal suspended furnaces, specialized infrared heaters, air curtain door systems, and various types of direct fired domestic hot water heaters for commercial and large residential applications.

The selective use of infrared heating devices offers many opportunities for energy conservation. Rather than attempting to maintain the total volume of a building at a comfortable temperature, these devices often enable the designer to restrict heating to spot locations where working comfort is provided with a minimum of heat waste through open doors or ventilation openings and without heating more than a small percentage of the total building volume.

It is worthwhile to note that the Oil Industry is sponsoring many research and development projects related to the efficiency of oil appliances and apparatus. A list of these projects together with the name of the organization assigned project responsibility is presented in Table II C-2.

Table II C-2

Industry Sponsored Research and Development Projects

Related to Oil Appliance and Apparatus

Efficiency - Project Responsibility

Home Climate Control

1. Combined Oil Pump Air Compressor - Compump Systems, Inc.
2. Oil Powered Total Comfort System - American Air Filter Co.
3. Oil Powered Appliances System Study - Thermo Electron Corp.
4. Low-Emmission Oil Burner - OOHA-Carlin Co.
5. Una-Spray High Efficiency Burner - Una, Inc.
6. Vaporizing Rod Burner - Rockwell International
7. Compact High Efficiency Burner - Sonic Development Corp.

Home Appliances

1. Integrated Furnace Design - Rockwell International
2. Oil Powered HTM Total Comfort System - Raytheon Co.

Commercial and Industrial Uses

1. Infrared Spot Heater - Inray Co.

Operating Practices

Field investigation of emissions from space heating - recommended operating procedure - Battelle Columbus Laboratories

2. Appliance Design

As in the case of gas heating appliances, industry standards have been established for oil fired furnaces and boilers. The American National Standards Institute (ANSI) has adopted standards[3] for oil fired furnaces that require a minimum efficiency of 75 percent, the same minimum efficiency as specified for gas fired furnaces. Underwriters' Laboratories (UL) which lists oil fired furnaces for safety will also certify the efficiency requirements if requested to do so by a manufacturer. Standards for oil fired boilers have been established by the Institute of Boiler and Radiator Manufacturers (IBR - now part of the Hydronic Institute). Meeting the performance requirements specified in these standards requires a minimum "thermal efficiency" of approximately 75 percent. The thermal efficiency or appliance efficiency is established with the appliance operating at steady state conditions. The thermal losses are determined and subtracted from 100 percent, thus giving the thermal efficiency rating. This is the only way in which one appliance can be compared to a similar appliance of a different manufacturer. Certification testing of oil fired boilers is performed by the manufacturer. Units which meet the performance standards are so identified on their nameplates. Although the thermal efficiency

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3 ANSI Standard Z91.1-1972

of a boiler is not listed directly, the gross input and the gross output as well as the IBR ratings are listed and hence the efficiency can readily be determined.

The variation in thermal efficiency of oil fired equipment is about five percent. The maximum thermal efficiency attainable with oil fired heating appliances is limited to somewhat higher than 80 percent because of essentially the same factors that limited gas heating appliance efficiency. These factors are:

a. Excess air is required to ensure complete combustion.

b. Substantially reducing flue gas temperatures to obtain increased efficiency would result in condensation of the water vapor in the products of combustion and hence corrosion of the heating appliance. Reducing flue gas temperatures could also result in loss of adequate draft for safely venting the combustion products.

The above factors are discussed in greater detail in Section II B-3a of the Gas Sub-Committee report.

Experience has shown that a slightly higher initial efficiency is not necessarily the best selection criterion. Devices which show a higher initial efficiency may require more maintenance or be more sensitive to adjustment and may actually result in poor performance on a seasonal basis. Developing guidelines or procedures to reflect the true installed performance of equipment requires study and warrants Government or industry sponsored research, since precise criteria for appropriate test procedures do not now exist.

Standards and test procedures for the rating of domestic hot water heaters are required. It would be useful if standards and test procedures were adopted that were common to all fuels. In this manner, comparisons could be facilitated that would aid in appliance and system selection.

Oil fired appliances and apparatus, such as furnaces or boilers, should be required to carry an approval or listing by one or more of the nationally recognized agencies such as UL, ANSI, or IBR. Standards or procedures of these agencies should incorporate a minimum thermal efficiency for listing that must be verified by an independent testing laboratory.

Although the opportunity for improvement of the thermal efficiency of oil fired equipment is quite small, it is believed that proper certification and listing of efficiencies would inspire some improvement on the part of manufacturers, and facilitate a wiser choice of equipment by the consumer.

One must note the difference between the utilization and thermal efficiencies of an appliance. When a heating unit is installed in a system, it is not operated much of the time and standby losses occur. These standby losses result in a lower utilization efficiency, the efficiency at which the fuel is utilized.

The range in utilization efficiencies obtained with oil fired heating equipment is from 35 percent to about 75 percent. The actual efficiency obtained in use will depend on the appliance design, the size, the percent of rated load at which it is operated, and the fuel used, as well as the care taken in operation and maintenance. Although there may be some opportunity for improvement in the thermal efficiency of oil heating appliances, by far the greatest opportunity for energy savings is in the area of utilization efficiency improvement.

3. Fuel Oil Selection

A factor in utilization efficiency that is unique to fuel oil is the range in fuel capabilities of the equipment. At present, five different grades of fuel oil (Numbers 2, 4, 5L, 5H, and 6) are in use. High numbered fuel oil grades indicate higher viscosities and increased difficulty in handling and atomization for good combustion, unless the oil has a low sulfur content. Use of equipment with a higher numbered grade oil than it was designed to burn results in poor combustion, some loss of heating value through incomplete combustion, and additional losses due to carbon on the heat exchanger surfaces. At present, New York City has instituted strict rules to ensure that both existing and new installations will be capable of burning the grade of fuel which is actually being used. There are no theoretical reasons why residual oil cannot be used for heating of one and two family dwellings. In practice, however, the first cost of equipment and the necessity for careful supervision and maintenance when burning the residual oil means that it is not practical for small boilers. The New York City regulations are an effort to prevent building owners from misusing heating equipment. The simplest means of avoiding misuse of heating equipment would be to require all boilers to fire Number 2 fuel oil. This might result in increased efficiency and in reduced air pollution as well. However, this would work an economic hardship on larger installations that are capable of using residual oil efficiently and cleanly. A regulation to that effect would reduce the total amount of fuel oil available and, therefore, would be contrary to energy conservation goals. The Ad Hoc Committee recommends that a technical committee be brought together including professional engineers, skilled maintenance personnel and manufacturing personnel to establish exact consumption rates for each installation. In the past, the fuel oil industry has recommended that Number 4 fuel oil be used in boilers with a firing rate of 12 or more gallons per hour, and Number 6 fuel oil in boilers with a firing rate of 25 or more gallons per hour.

Selecting the most suitable grade of fuel oil, based on equipment size, is important with respect to both efficiency and air quality. Ranges specified in New York City regulations may serve as a starting point: a minimum ten gallons per hour for the use of Number 4 fuel oil; and a minimum of twenty gallons per hour for the use of Number 6 fuel oil. It should be noted that these regulations also include detailed mechanical statistics so as to make these minimums appropriate.

The American Society of Heating, Refrigeration and Air Conditioning Engineers has prepared the following guide[5] for selection of fuel oil grade as a function of firing rate.

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5. American Society of Heating, Refrigeration and Air Conditioning Engineers Guide and Data Book (1969)

Guide for Fuel Oil Grade vs. Firing Rate

Firing Rate (Gallons Per Hour)	Fuel Oil Grade
Up to 30	No. 2
15 to 40	No. 2, No. 4
35 to 60	No. 5
50 to 60	No. 5H, No. 6
Over 100	No. 6

It is recommended that a technical committee be formed to review existing recommendations and evaluate the optimum ranges, taking into account not only practical considerations of maintenance and operation, but also the present considerations of fuel shortages, requirements for low sulfur content fuels and the changing fuel price structure. Based on the recommendations of this technical committee, standards or regulations should be adopted which establish minimum firing rates for the various grades of fuel oil.

4. Boiler Size Selection

An important factor affecting the utilization efficiency of a boiler is its capacity in relation to the heating load. A mismatch between output rating and actual load results in very short cycles, or a low firing rate with burners capable of modulation. The frequent start up periods which are associated with short cycling constitute inefficient operation of the equipment and tend to cause air pollution. Typical practice on the part of designers results in gross oversizing, which in some cases may actually be over 300 percent of the necessary capacity. Some of the factors which lead to this situation are listed below.

Building heat loss calculations, basic to equipment sizing, are ordinarily performed by methods which overestimate the loss.

Until recently, heat loss calculations provided a gross value and did not allow for heat gains which would yield a net value.

Heat loss calculations frequently fail to separate peak conduction losses from peak ventilation losses, and if these two heat losses are not simultaneous, an overestimate of peak heat losses results.

Outside design temperature used for heat loss calculations is unnecessarily low.

Boiler manufacturers have been traditionally conservative in their output ratings.

Contracting and heating industry association rating systems incorporate safety factors that further de-rate equipment.

Some rating systems have incorporated "pipe tax," i.e., 15-25 percent de-rating to allow for distribution system loss.

Boilers are not made in every exact size and designers frequently take the next larger size than that called for by the calculation.

Since some of these factors compound one another, the cumulative effect can result in drastic oversizing, such that it is almost impossible to match part loads with boiler operating characteristics.

The wasteful effects of oversizing of equipment <u>can not</u> be emphasized too much. Even the use of modular boiler installations, which operate efficiently down to ten percent of rated capacity, can be negated if the installation is sufficiently oversized. For example, if four modular boilers are installed and an individual module will maintain a high utilization efficiency down to 40 percent of its capacity, it appears that efficiency can be maintained down to ten percent of the total building load. If, however, the installation is oversized to 400 percent of capacity, then a high utilization efficiency can only be maintained down to 40 percent of rated load. Further discussion of this subject is presented in Section 6, Modular Boilers.

Optimum boiler sizing is obtained by complete and thorough analysis of actual system requirements, and is an important part of system design. Recommendations for proper boiler selection follow.

Recommendations for Determining Boiler Sizes

The first step in heating system design is a determination of the comfort criteria necessary. This includes: a design indoor and outdoor temperature in winter and summer; design humidity in summer and winter; design temperatures in areas of special application, such as computer rooms; the controls necessary to maintain this design temperature.

After the above determination is made, the next step is to determine the net heating and cooling load for the building. The calculation of heat loss of the residence or building is specified in the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals in the chapter entitled "Heating Load." The chapter contains a fully detailed example of a heat loss calculation for a residence. Other procedures for calculating heat losses are contained in:

a) Manual "J", Load Calculation for Residential Winter and Summer Air Conditioning, published by the National Environmental Systems Contractors Association (1967)

b) "Heat Loss Calculations" published by the Hydronics Institute (Guide H-21, Fourth Edition, November 1969)

The determination of net heating and cooling load should include an analysis of heat gains in the structure, the time at which these heat gains occur, the use of heat reclaiming devices, ventilation requirements, and the type and complexity of the control sequencing program which will maintain the structure at the desired comfort levels.

When the previous steps have been determined, the following criteria should be used to size the boiler:

1. (a) The output capacity of small residential size oil fired furnaces and boilers should not be less than the calculated heating load nor more than 15 percent greater than the calculated heating load.

   (b) Larger boilers should be sized so that the gross output does not exceed approximately 125 percent of the net heating load.

2. When the net heating load is greater than 1,000,000 Btu per hour, consideration should be given to a multiple heating plant approach, designed so that the gross output of the individual heating plants involved will closely match the load profile of the structure at both high and low load conditions.

3. Installations with two or more boilers should have the boilers sized so that at minimum load, operation with just the smallest boiler will be at a minimum of 40 percent of its rated capacity.

In addition, the heating distribution system should have similar design criteria, so that it will neither overheat nor inadequately heat a particular section of the structure in order to maintain a comfortable level of internal temperature in another portion of the structure. In cases where this is difficult to achieve, consideration should be given to operating an isolated heating and cooling system for those portions of the structure or portions of the load which have unusual requirements, including hot water loads. Examples of these are: computer rooms, dining rooms, kitchens, and conference rooms.

5. Operation and Maintenance

As previously stated, the Oil Sub-Committee believes that the opportunity for energy conservation through better maintenance and operation is significant. The concentration of effort for existing structures and those erected in the near future should take the following factors into consideration:

> Small domestic units offer less opportunity for conservation. High manufacturing standards for one and two family equipment already exist.
>
> Interviews and contacts with building operators, design engineers, service and maintenance personnel and installation contractors confirmed that medium sized (with heating requirements of 1,000,000 to 10,000,000 Btuh) commercial and residential structures offer the maximum opportunities for energy conservation through maintenance, repair or replacement of combustion equipment, and improved system operation.
>
> Heating plants for very large structures are usually the best maintained and operated, although there are significant exceptions. The control system in large buildings may result in wasteful overheating, and is discussed in the Report of the Ad Hoc Committee for Energy Efficiency in Large Buildings.

To accomplish energy conservation program goals in the area of operation and maintenance, the Sub-Committee recommends the following intermediate and long range measures: [These proposed measures are based on the points that fuel efficiency begins with efficient combustion, and that good combustion can be achieved by regular inspection and maintenance. Those units which cannot meet test standards should be repaired or replaced.] The key step is the initiation of a regular inspection program for each size and type of equipment.

(a) For oil powered units up to one million Btu per hour, annual inspection is considered adequate to provide a significant average improvement. Shorter intervals between tests are recommended for larger units.

(b) Specific recommendations should be developed for various grades of fuel, ranges of firing rates and types of combustion equipment.

(c) A joint committee of design engineers, equipment manufacturers, and technical service personnel from the petroleum industry should be established to develop the necessary guidelines for (a) and (b) above.

(d) The essential step in testing is to analyze carbon dioxide (CO_2) and stack temperature (maintaining Ringelmann smoke number at legally acceptable levels). A minimum goal should be established, such as 8 to 9 percent CO_2 at 500 to 600°F with higher minimums for various types of equipment as recommended by the technical committee mentioned in paragraph (c).

(e) The implementation steps can be both immediate and longer range. As an initial step, it is recommended that the State issue executive orders for regular testing, adjustment and reporting of results of combustion efficiency covering all State installations, both to get the program started and to set an example for private industry. Further, that the State, through the Office for Local Government, require counties and municipalities to test combustion equipment.

(f) Test records should be made in such form that a clear and simple tag may be attached to the equipment as evidence of the testing and the results thereof, with an additional copy going to the agency having jurisdiction, such as the Building Department, Air Resources Department, or other agency selected.

(g) Test records should also include the estimate of the fuel cost savings accomplished by keeping the equipment in proper adjustment. It is further recommended that the State establish a system of annual energy use records for major institutions and installations covering: fuel consumption, purchased energy, labor and materials, and showing the building areas or volumes served. Such records would provide an index of performance and pinpoint those installations in need of revised operating procedures or major equipment overhaul and modernization.[4]

(h) As a long range measure, it is recommended that the State Building Code, New York City Building Code, and the

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4. The General State Authority (GSA) in Pennsylvania has an effective form for collecting and publishing such data from major State institutions and installations. This procedure provides additional benefits such as showing comparative performance, indicating whether maintenance or upgrading is required and providing data for estimating future building costs.

operating manuals of State, county, and municipal agencies be amended to require regular testing and adjustment procedures for heating and air conditioning equipment.

Proper operation and maintenance of new and existing equipment can result in a fuel savings of up to 15 percent.

6. Modular Boilers

The use of multiple boilers rather than one or two large boilers is increasing in new installations. However, the modular boiler concept is not a cure for all building heating systems.

The important point is to separate the objective attained by the multiple boiler concept from the specific way that it is accomplished. The objective is to permit close matching of heating load with the range of output within which the boiler will operate efficiently. Provided that this objective is met, the means are not particularly important.

Modulation of firing rate has sometimes been claimed as a complete solution to the load matching problem, while other references suggest that it is ineffective. Properly applied, the use of high-low firing, or modulating firing rate, is a useful device and past problems may often be traced to the fact that the controls previously in use fail to maintain the optimum air fuel ratio at all firing rates. Lack of control linearity was particularly a problem with combination gas and oil burners, but recent advances in control design make possible good performance even with this type of burner.

Quite aside from efficiency considerations, there are specific design advantages to the modular boiler concept in certain situations. A series of small modules may be better suited to a long narrow space, and may fit low head room or roof top situations better than a single large boiler. In the smaller size ranges, the use of modules may reduce unit size so that less costly, easier to maintain and more automatic boilers of essentially domestic type may be used.

In many cases it may be shown that equally efficient results may be obtained with two or, at the most, three boilers of conventional design, particularly where they are not of the same size. In many applications, the source of a small load which produces short cycle operation, or requires a low percentage firing rate, is domestic hot water. Placing the hot water load on a heater designed for that purpose, or on a small boiler used exclusively for that purpose, will permit a much better match between efficient firing rates and load. In other instances, such as the offices in a Church which are used daily, and the main body of the Church which is only used once or twice a week, the best design solution for efficiency is to separate the heating system by use into two parts, and to serve them separately. This may provide both capital and operating savings as compared to using either a large conventional boiler or a modular boiler to serve the whole structure.

In general, a significant sacrifice in efficiency is made when operating a boiler at a small percentage of rated load. As shown in Exhibit II C-1, boiler efficiency falls below 70 percent at less than 40 percent of rated load. At very low percentages of rated load, the efficiency of a boiler can be extremely poor.

This characteristic efficiency curve is essentially the same for all boilers. The capacity at which the efficiency drastically falls off, however, will vary from one boiler design to another. Exhibit II C-2 shows the performance characteristic of a boiler that maintains a high efficiency above 30 percent of rated load. Although the performance below 30 percent load is not shown, it would be typified by the performance characteristics of Exhibit II C-1.

Operating a boiler at low loads is not an efficient process, mainly because of the long burner "off" times in the burner on/off cycle. As can be seen in Figure II C-3, when operating a boiler from a cold start, typically as much as 15 minutes are required before reaching desired levels of efficiency. In actuality, because of the thermal inertia of a boiler, it will not completely cool down during a burner off cycle. The lower the percentage of rated load on the burner, the longer will be the "off" times and the shorter the "on" times. The short "on" times result in most of the operation occuring at the low efficiency portion of the performance curve. A typical curve of Boiler Efficiency vs. Percent Operating Time is shown in Exhibit II C-4.

As has been demonstrated, gross oversizing can defeat the best efforts of boiler design. Thus, the basis of good load matching must be accurate analysis of the load itself. This is a sophisticated problem, and when properly done it should involve analysis of the load profile on an hourly basis with full consideration for heat gains. Average values should not be used.

Boiler Operating Rate VS Efficiency

(Commercial Size Range)

Exhibit III C - 1

EMORY UNIVERSITY		GEORGIA TECH	
Load (%)	Efficiency (%)	Load (%)	Efficiency (%)
85.5	81.29	87.1	78.67
92.0	76.95	88.0	72.45
90.4	76.95	92.8	79.92
100.0	81.95	100.0	78.06
50.6	76.36	38.2	70.92
45.0	74.12	22.1	57.22
40.7	74.12	6.6	34.60
41.6	73.58	6.8	35.96
43.5	73.58	6.8	40.28
40.4	75.22	9.4	41.61
47.8	72.00	36.2	72.45
69.6	74.67	70.5	76.29

SOURCE: Report by Professor W. A. Hinton, Department of Mechanical Engineering, Georgia Institute of Technology, based on measured steam generated and metered fuel consumption over one-year period.

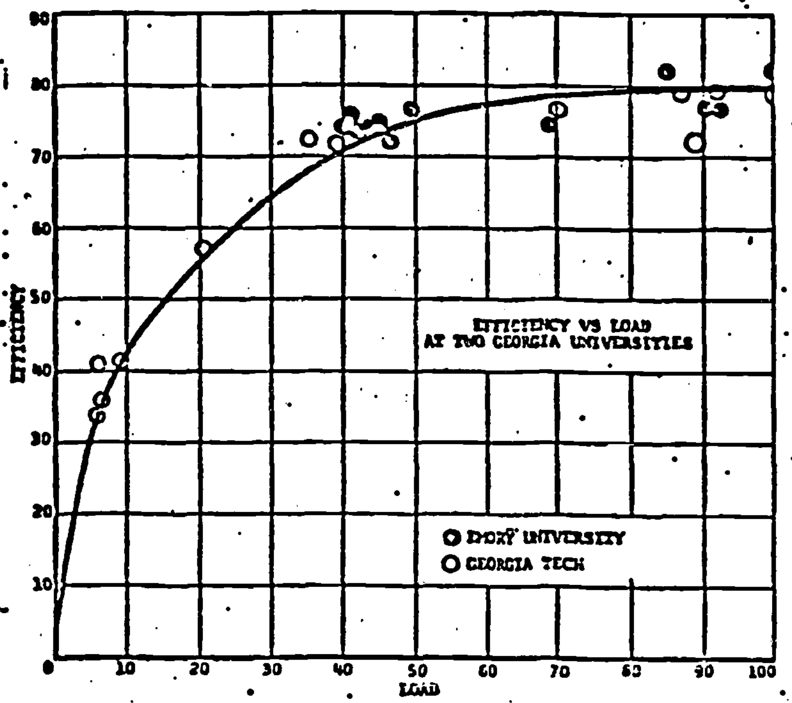
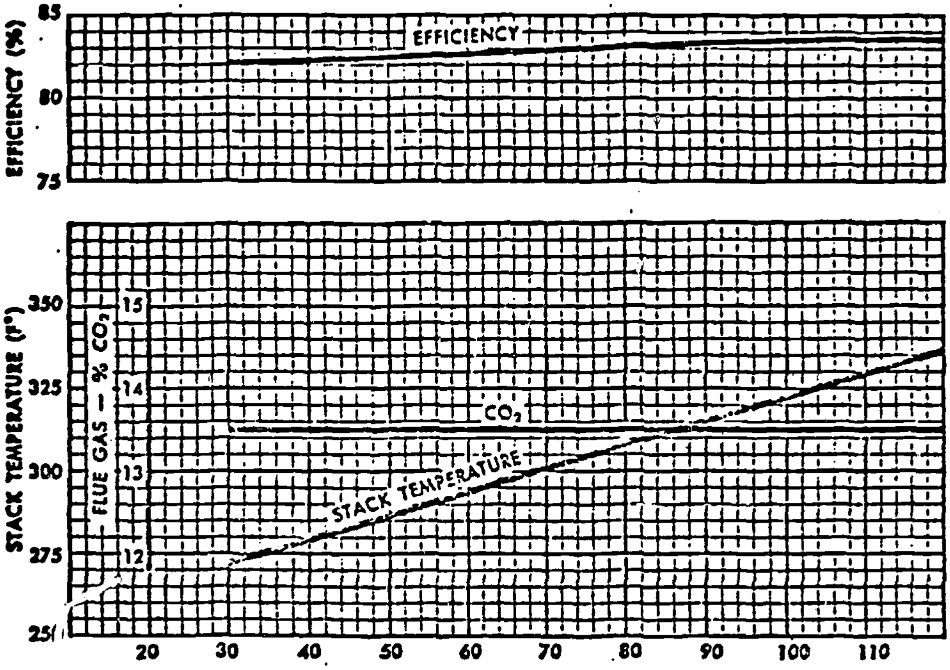


Exhibit II C-2



Percent of Unit Rating
Typical Performance Curve of a Low Pressure Boiler
Fired with No. 6 Oil

Exhibit III C - 3

BOILER EFFICIENCY CURVES

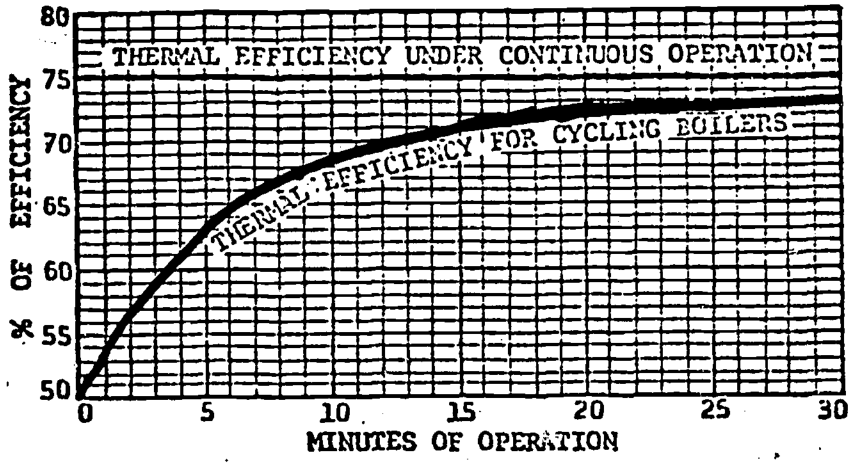
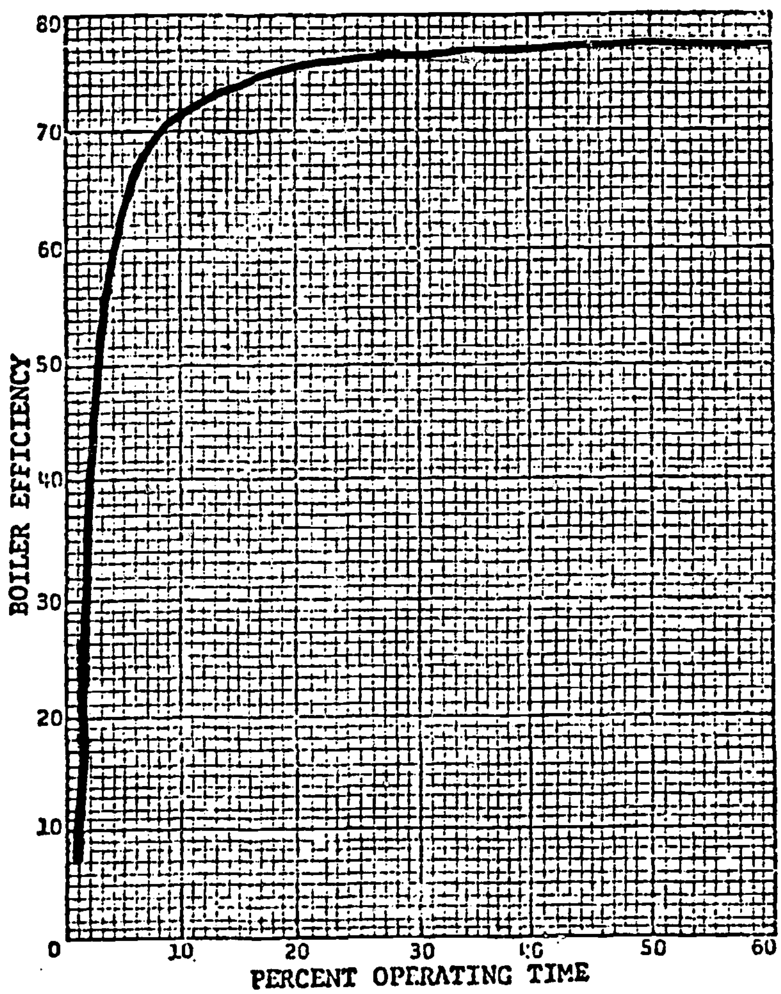


Exhibit III C - 4

BOILER EFFICIENCY VS. OPERATING TIME



III. Redirection of Energy Consumption

A. The Difficulty of Redirection

The concept of energy conservation is diametrically opposed to the present high and wasteful energy consumption practices which have become a part of the American life style. The United States, with six percent of the world's population, is responsible for 33 percent of the world's energy consumption.

Economic forces in New York State have increased energy requirements among all sectors of the State's population. This energy demand is further stimulated by the commercial sector developing products which appeal to consumer pride and status.

Social forces, too, tend to push energy consumption upward. The change from a rural to an urban society, and then to a suburban-oriented culture, results in the use of more automobiles, more appliances and increased levels of energy consumption for space conditioning.

The consumption of energy in the United States has been found to parallel the trend in the Gross National Product, and energy consumption on a per capita basis has been a reasonable indicator of our standard of living. However, conserving energy need not imply a reduction in our standard of living, but rather the elimination of waste. It is in this context that the promotion of energy conservation is being pursued.

The first step in redirecting the energy consumption habits of the consumer is to recognize and define the problem, and to articulate it in terms which are most comprehensible and credible to the consumer. To speak of energy efficiency ratios, or heat transfer coefficients and constants is meaningless to most people. The many esoteric dialogues among experts have convinced only the experts that there is a problem, but the consumer remains only vaguely aware that some problem exists. Efforts by the media to entreat the consumer to conserve energy are often met with cynicism. Therefore, this Ad Hoc Committee must direct its efforts not only to ways of conserving energy, but also to convincing the consumer that conserving energy is necessary.

Manufacturers have produced larger and more consumptive appliances and advertised them through the media. Society has responded by purchasing large numbers of these appliances. It was only when increasing rates and massive power deficiencies became headlined, that all eyes turned toward the individual consumer as the precipitating cause and the near-term solution to the energy crisis. Thus, it is only when business and government, as the inherent causative agents, take the initiative toward reaching the consumer that the first step will be made toward resolving the comprehensive-credibility crisis and the energy dilemma itself.

The joint task force of government and industry must begin by defining the energy crisis in terms of people (as opposed to the impersonal quantity population). Opinion surveyors indicate that the individual consumer believes hydro-electric dams and nuclear power plants can produce an infinite quantity of electricity. After countless years of being told of the efficiency and availability of electricity, and the effectiveness and inexpensiveness of gas, it is small wonder that the consumer cannot begin to understand the problem, not to mention its scope.

Any educational campaign must demonstrate the relationship between the individual consumer and the supply of energy in the environment. It has become apparent that fossil fuels are no longer available in limitless reserves to industry and the consumer.

The challenge, therefore, is to gain the support of the public in conserving our energy resources. This involves overcoming a lifetime of indoctrination in a society of consumptive affluence, and redirecting the consumer towards a wise and prudent use of our resources within the existing social order. A discussion of the means available to accomplish this immense task, and recommendations for actions which are considered appropriate at this time, are presented in the sections that follow.

III. B. Review of Present Programs

Education has been listed as an effective approach to reducing the waste of fuel in the residential market. By education, we means the dissemination of information on the fuel shortage, the necessity of conserving energy, and specific actions to accomplish this. The energy conservation messages included here are based on the energy conservation suggestions which have been reviewed during the work of this *Ad Hoc* Committee.

In September 1972, when this *Ad Hoc* Committee conducted its first meeting, the consensus of opinion of the Committee members was that education would be a relatively inefficient means of achieving the Committee's conservation goals. The public, including some members of the Committee, were unaware of the impending "Energy Crisis" and the necessity to do something about it. Now, after intensive study for several months, it is recognized that, like any other means to reduce energy waste, even if only by a small percentage, education is essential if the energy needs of the people of New York State are to be met during the next several years.

All of the major utility companies in New York State, many professional organizations, and many governmental agencies, have been engaged in educational activities to inform the public of the impending energy crisis, of the need for conserving energy, and of the actions they can take to accomplish this.

At least one utility, Consolidated Edison, has cited gratifying results of its educational Save-A-Watt program. This program is discussed later in this section.

Methods Used in Energy Education

In order to insure that the public is informed of the need for energy conservation and provided with ideas that will help save energy, the utilities of New York State have used many means of communication, including the following:

1. Individual company newspapers and magazines.
2. Local newspapers and magazines.
   - News Items
   - Advertisements
3. Company newsletters.
4. Radio
   - News Items
   - Advertisements
5. Television
   - News Items
   - Advertisements
6. Posters and pictures.
7. Badges
8. Games - Similar to Parcheesi
9. Pamphlets, booklets, brochures and folders.
10. Bill Stuffers - small folders enclosed with customer's bill.
11. Additional information printed directly on customer's bill.

12. Meetings, symposiums and seminars with:

- Public
- Municiple Organizations
- School Organizations
- Church Organizations
- Service Organizations
- Environmental Organizations
- Library Organizations
- Contractor Organizations
- Architectural Organizations
- Facility Engineering Organizations
- Engineering Organizations
- Plant Engineering Organizations
- Owner Organizations
- Utility Marketing Organizations

13. Discussions between customers and:

- Utility Public Relations Departments
- Utility Marketing Departments
- Utility Sales Departments
- Utility Economics Departments
- Utility Home Service Departments
- Utility Residential Departments
- Utility Commercial Departments
- Utility Industrial Departments
- Utility Customer Relations Departments

14. Language of minority groups either in print or speech in many of the above items.

Topics Used in Education

The information that is presented to further educate the society comes from many sources, including the public relations departments of the various New York State utility companies, trade associations such as the Association of Home Appliance Manufacturers, the Electric Energy Association, and the American Gas Association, and government agencies such as National Bureau of Standards, the United States Department of

Commerce, Office of Consumer Affairs, and the United States Printing Office. Each of these sources has written about the areas with which it is most concerned and has described specific items that can be used to reduce energy consumption. The best articles attempt to place a quantitative value to energy savings and to also place a value of dollars saved by the actions. However, unless the conditions that exist are very well defined, it is very difficult to assign energy or dollar savings. The general topics that have been discussed in various energy conservation programs are listed below:

1. Buildings Design
2. Heating Systems
3. Central Air Conditioning
4. Lighting
5. Water Heating
6. Refrigerators and Freezers
7. Room Air Conditioners
8. Cooking Ranges
9. Clothes Dryers
10. Dishwashers
11. Washing Machines
12. Miscellaneous Appliances

Detailed energy conservation suggestions promoted by the programs in each of the above areas are presented in Appendix A of this report.

Consolidated Edison's Save-A-Watt Program

In 1971 Consolidated Edison initiated a program called "Save-A-Watt" directed toward the reduction of summer peak demand and the conservation of electrical energy. The Save-A-Watt program was the direct outgrowth of Consolidated Edison's problems of power supply during the summer of 1970. The combination of extremely hot days that year, coupled with unfortunate equipment failures, caused the reduction of voltage on 15 days, necessitated appeals to customers to reduce loads on twelve occasions, and resulted in load shedding on September 22. The Save-A-Watt program was used in 1971 and 1972, and is being implemented again in 1973.

Description of the Program

The Save-A-Watt program is a two-part energy conservation program directed to:

1. Large customers with demands in excess of 100 kW
2. Residential and small commercial and industrial customers.

Consolidated Edison Company has approximately three million residential, small commercial and industrial customers in its franchise area. The system demand approached 8,000 megawatts in 1972. The Save-A-Watt program was implemented to inform customers how to conserve energy and to appeal for their cooperation in reducing loads that would occur at peak times.

The program included bill enclosures, television and radio announcements, newspaper ads, and other methods of communication.

As part of the Save-A-Watt program, Consolidated Edison endeavored to educate the consumer and publicize the benefits of selecting energy efficient air conditioners. As is shown in Exhibit III B-1, an ad used by Consolidated Edison actually rated air conditioner performance in terms of Energy Efficiency Ratio (EER), and attempted to induce the consumer to buy the more energy efficient appliance. The appeal stressed that saving energy saved money for the customer.

The Consolidated Edison system contains, by the Company's definition, 5,600 large customers. These customers contribute approximately 40 percent of the summer peak demand. The Company, by the use of individual communications, seeks their cooperation by requesting the following actions:

1. Reduce lighting on a summer long basis to minimum levels consistent with continued efficient operation.

2. Reduce air conditioning requirements on a summer long basis by raising control temperature setting so as to maintain no more than a 15 degree differential between indoor and outdoor temperature on hot days.

3. During emergencies remove additional equipment from service.

Results of the Program

At the time of the summer peak, the incremental load relief could have been as much as 400 megawatts. This occurred on July 19, 1972, a day of intense publicity about distribution problems in Brooklyn and Queens. However, on a sustained basis, the result obtained from large customers was about 200 megawatts. In addition, there was probably another 75 megawatts of reduction due to economic conditions, particularly vacant office space.

By projecting the trends of electrical usage among the customers, and making allowances for variations in weather conditions, Consolidated Edison estimated savings of approximately 105 million kWh in 1971 and 285 million kWh in 1972. These savings are related to summertime usage during the months of June, July, August, and September, and do not take into account any residual carryover into other months which might have resulted from changes which were induced in the living and operating modes of these customers.

Average usage of individually metered residential customers which had grown at an eight percent annual rate from 1967 through mid 1971 has increased at an annual rate of only a little more than one percent since that time.

A sample of 40 apartment houses in which energy for tenants is included in the rent showed a growth rate approaching 4.4 percent in 1969, 1970, and 1971. These buildings use a total of approximately 50 million kilowatt hours a year. The usage in 1972 actually declined 1.2 percent compared with 1971 indicating some effects of the "Save-A-Watt" program.

During the summer of 1971 there was no occasion when Consolidated Edison had to appeal to the public to make an emergency load reduction. In 1972 there were three times when appeals were made to the public.

For the foreseeable future, Consolidated Edison plans a continuation of energy conservation programs in its territory. It appears Consolidated Edison will need summer time peak load saving because of its inability to bring new capacity on line as fast as it is projected to be needed.

Room Air Conditioner Energy Conservation Program Sponsored by the Appliance Industry

In 1972 the appliance manufacturing industry sponsored, through its national trade association, The Association of Home Appliance Manufacturers (AHAM), an electrical energy conservation program for the New York City area. The program urged the consumer to "Be Watt Wise" in the selection and use of room air conditioners by selecting units of the proper cooling capacity, buying units with high efficiency, and properly using and maintaining their room air conditioners. AHAM has established for its participants the following industry advertising practices for New York City as part of the "Be Watt Wise" program:

> "Whenever the price of a room air conditioner is included in an ad, these additional factors should be included. (See sample label in Exhibit III B-2).

Brand and Model Number

AHAM-Certified Cooling Capacity in Btu's Per Hour

AHAM-Certified Watts

Btu/hr Per Watt "Energy Efficiency Ratio" (EER)

The Energy Efficiency Ratio (EER) should be included whenever the AHAM-Certified Btu/hr rating is given."

As is indicated, the above information is based on AHAM's Room Air Conditioner Certification Program. This program required that nameplate cooling and heating capacity rating and electrical input data (watts and amps) of a room air conditioner be accurately stated and independently verified in accordance with the appropriate AHAM Standard (RAC-1). Certification covered all models manufactured or marketed and offered for sale in the United States by a participant of AHAM. Over 1800 models by approximately 62 manufacturers were certified under the program. Certification covered both window and through-the-wall units and cooling only and cooling and heating types.

The AHAM Room Air Conditioner Energy Conservation Program was considered reasonably successful for its initial season and it is hoped that continuation of the program will result in greater awareness of energy efficiency by consumers in their purchase of room air conditioners. This in turn is expected to result in the design and manufacture of more efficient units to meet the consumer demand.

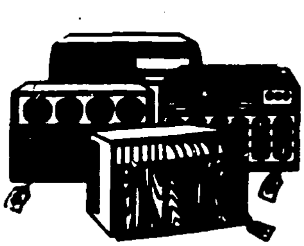
Conclusion

The companies and agencies that are active in education programs find it difficult to estimate exact energy savings, and even more difficult to estimate savings in dollars to utility customers. The savings depends upon many things, among which the most important and most difficult to assess is the efficiency at which an individual presently uses energy. Other contributing factors to potential savings at the point of utilization are: the cost of electricity, oil or gas; and the acceptable level of compromise between comfort, economy, and a desire to help reduce the effect of the pending energy crisis. The best estimate of potential savings of the presently wasted energy in New York State is between 10 and 50 percent.

$\frac{\text{BTU}}{\text{watts}} = ?$

10 or over - very good
8 or 9--- good
6 or 7---- pass
under 6-- flunk

Make sure any air conditioner you buy can pass this save-a-watt test.



The higher your air conditioner scores, the better—for the environment, for reliable power supply and for your electric bills.

Any air conditioner takes a lot of power to run. But some take more than others.

So divide before you decide.

Divide the watts (amount of electricity consumed) of any air conditioner into its BTU (cooling power). That will give you an efficiency number usually between 5 and 12. The *higher* the number the better.

Chances are there'll be a stick-on tag on each model at the store you visit, telling you the efficiency number. If not, any salesman should be able to tell you the watt and BTU figures. Or just look for them on the metal plate required on every air conditioner. Usually it's under the filter cover.

Suppose you require 10,000 BTU's of cooling power, and the model you're considering consumes 1000 watts. Divide watts (1000) into BTU (10,000) and you get 10—a very good score. Another 10,000 BTU model might consume 2000 watts. Divide and you get 5—an air conditioner to be avoided.

Air conditioners consume more than 40 percent of the electricity Con Edison customers use during peak summer hours. And about 250,000 people will buy air conditioners in our territory this year. If all are the highest scoring models instead of the lowest, Con Edison would need about 100,000 kilowatts less at peak times.

So buy an air conditioner that can pass the save-a-watt test!

You'll help protect the environment, even though when it comes to air pollution, power plants are far from the worst offenders.

You'll lessen the risk of serious power shortages.

And you'll save money on your electric bills.

Con Edison conserve energy

Exhibit III B-1

Exhibit III B-2

BRAND ______________________

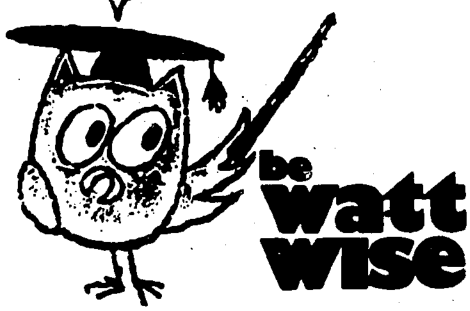
PRICE

MODEL ______________

WATTS ______________

BTU/HR ______________

EER ______________



III. C. Recommended Action Plan

1. Establishment of an Organization to Direct and Coordinate the Task of Redirecting Energy Consumption

Only a well planned systematic approach to education can achieve some degree of success in altering the life long accumulated habits of the citizenry. If a successful educational system is not developed and initiated immediately, more serious measures to conserve energy may result.

The Committee suggests the establishment of a central organization to perform the following duties:

Coordinate activities of State agencies and private industry that are performing energy related functions;

Advise and make recommendations to State agencies, corporations and authorities that have regulatory powers affecting the consumption of energy;

Undertake activities to encourage business and industry to maintain high standards and public responsibility in all affairs involving the consumption of energy;

Conduct studies and analyze matters affecting the consumption of energy;

Recommend to the Governor new laws and amendments to laws affecting the consumption of energy;

Collect and disseminate to local community organizations and the general public data regarding energy conservation activities by these organizations;

Assist all local governments in the development of energy conservation activities;

Encourage the development of educational programs for children and adults.

The organization should function with an overall concern for the use and conservation of energy in all fields - buildings and transportation, as well as appliances and apparatus. Energy consumption is complex and involves multiple disciplines; therefore, the organization should work with existing establishments that have the knowledge and the regulatory powers to effect change in their area of expertise. It is important that individual efforts of existing organizations be directed and coordinated by the central organization, so that the program to conserve energy is not fragmented, duplicated or conflicting. In addition, the Attorney General's Office should coordinate enforcement power with the organization.

Considering the existing structures in New York State government, the Committee suggests the following alternatives to establishing a body responsible for creating an awareness of the energy problem in the general public and promulgating the conservation of energy:

a) That a special division be established within the existing structure of the New York State Consumer Protection Board or the Department of Environmental Conservation, thus eliminating the creation of a new bureaucracy. It is also relevant to note that both agencies are developing credibility with the present day general public that has a tendency to mistrust government. One reason for recommending a new division within the Consumer Protection Board, is the presence of the Chairman of the Public Service Commission on the board, since it is important that the division cooperate and coordinate its work with that of the Public Service Commission.

b) That a new office be established in the existing Public Service Commission to carry out the coordination of energy use and conservation. It is noteworthy to mention that the regulatory powers of the Public Service Commission and the educational and advisory powers described herein might best be served when located in two separate but related structures. However, the establishment of a new office in the Public Service Commission could be more effective since the Public Service Commission interfaces with energy producer organizations.

c) That a new Board of Energy Conservation be established and structured as a matrix organization. A diagram of a possible organizational format is presented in Exhibit III C-1.

2. Organizational Activities to Promote Energy Conservation

The central organization assigned the task of directing and coordinating energy use should concern itself with the following functional areas:

a. Search, Retrieval and Analysis of Material

b. Media

c. Formal Education Programs

d. Grassroots Programs

e. Industry/Labor Programs

f. Governmental Programs

a. Search, Retrieval and Analysis of Material

1. Search and retrieval of material from numerous private and public research institutes.

2. Initiation of research projects by means of contracts to outside consultants or private foundations.

3. Analysis of research findings with a view toward determining prospective legislation and establishing educational programming for whatever purpose the Board of Energy Conservation deems necessary in the public interest.

b. Media

1. Educational and Network Television

   a. Spots

   b. Television Films

      - animated
      - documentaries

   c. Specials

2. Radio

   a. Spot Announcements

   b. Community Participation Programs

   c. Public Service Interview Programs

   d. Network Editorials

   e. Specials

3. Visual

   a. Film

      - animated
      - documentary
      - video tape
      - film and tape cassettes

   b. Photography

      - still photography (prints)
      - slides

   c. Exhibits

      - travelling exhibits
      - permanent installations
        (museums, schools, public buildings, libraries)

4. Printed Graphic Material

   - newspapers
     articles
     editorials

   - supplements
     educational
     industrial
     technical

   - newsletters
   - brochures
   - magazines
   - posters
     public transportation
     public buildings
     schools

5. Teacher Kits

c. <u>Formal Education Programs</u>

1. Teachers

   a. Incorporation of energy studies in basic teacher preparatory courses in college and graduate schools.

   b. Mandatory studies in energy use as a requirement to maintain teaching certification for those teachers who have not received prior training.

   c. Section a and b should apply equally to teachers of technical vocational courses because maintenance and operation of equipment is vital to energy use.

   d. Symposia for teachers conducted periodically to augment their basic education in energy use.

2. Students

   a. Incorporation of energy studies as a mandatory requirement in primary and secondary levels.

   b. Availability of information in energy use as a regular part of an educational program in environmental conservation in college and post-graduate curricula.

   c. The student enrolled in a vocational training program should be required to study energy use as it relates to his particular vocational speciality.

d. <u>Grassroots Programs</u>

1. Although the Energy Conservation Board is designed to create and initiate programs in energy use, it should be recognized that a related goal is to encourage the local community, in cooperation with the Board, to implement indigenous programs.

2. The following is a list of some community organizations and activities which would be instrumental in the implementation of the programs designed by the Energy Conservation Board.

   a. Civic Groups

   b. Environmental Groups

   c. Consumer Groups

   d. Church Organizations

   e. Political Clubs

   f. Continuing Education Programs

   g. Private Social Groups

e. Industry and Labor Programs

1. The Energy Board would work with private industry and labor organizations to assist and coordinate development and implementation of programs that promote conservation of energy. For example:

   a. The Board could request manufacturer's associations to develop selective appliance labeling systems intelligible to the general public, and subsequent promotional materials for retailers stocking those appliances.

   b. The Board could request private manufacturers and associations to utilize funds from advertising budgets to make documentary films or spot commercials which the Board would have run as public service items on network television.

   c. The Board could assist private industry to develop energy conservation campaigns for employees.

d. The Board could encourage building owners to develop refresher courses for building operation and maintenance personnel, utilizing cost benefit analysis to indicate possible dollar savings in terms of yearly energy utilization.

e. The Board could work with labor organizations to develop statistics on the number of jobs affected by plant shut downs or relocations due to energy shortages, thereby encouraging individual workers to conserve energy.

f. Governmental Programs

1. The Energy Board would work in conjunction with all levels of government (local, state and federal) to assist in the development and implementation of programs designed for the efficient utilization of energy. For example:

   a. The Board could request the Codes Council to consider changes and/or additions to the building code to allow for efficient energy utilization in the design, construction and operation of large buildings.

   b. The Board could request that all public building organizations develop a contractual clause that requires architects to develop an energy utilization study during the schematic phase of building design.

   c. The Board could request State agencies to procure only equipment systems that have a high energy efficiency ratio.

   d. The Board could encourage the Civil Service Commission to include knowledge of energy efficiency as related to the operation and maintenance of building mechanical systems on all civil service tests for relevant jobs. Retraining courses for those already employed could also be developed.

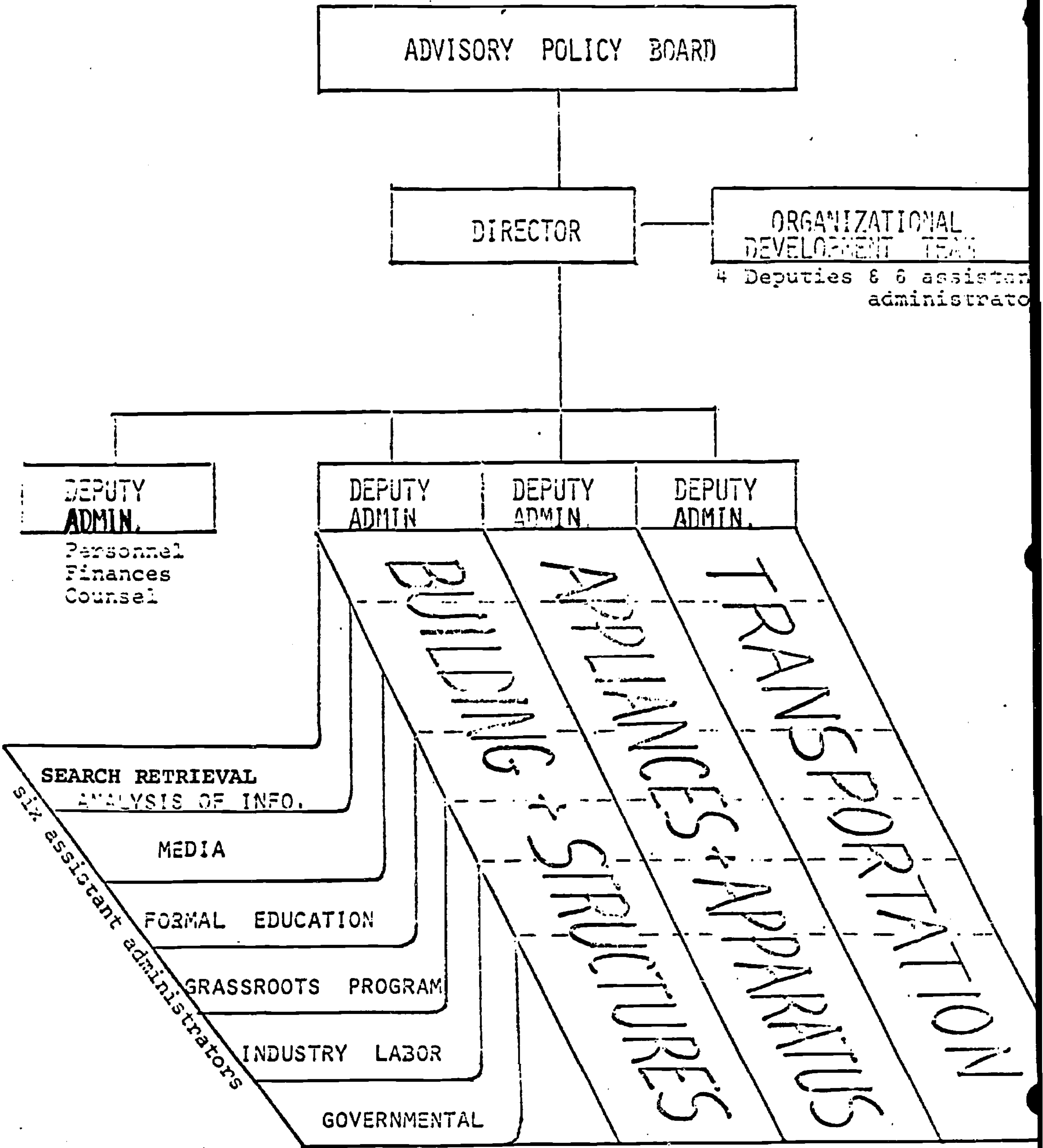
e. Large cities, such as New York City, Buffalo, and Rochester could be encouraged to develop their own training requirements and refresher courses for civil employees.

f. The Board could request changes in the tax structure to allow for tax incentives for builders utilizing less energy.

g. The Board could also develop and recommend an escalated sales tax that increases in proportion to decreases in energy efficiency ratios in equipment and/or cars.

Proposed Format for

Board of Energy Conservation



III. D. Consideration of Specific Policies that Could Induce Improved Energy Utilization

1. Evaluation of the Merits of Labeling Specific Appliances and Apparatus with Respect to Energy Efficiency and Energy Cost

The *Ad Hoc* Committee has examined appliance labeling as an approach for reducing annual energy consumption and peak load requirements in New York State. Answers were sought to the following questions:

a) Which appliances, if any, should be considered for a labeling program?

b) Could a labeling program result in the promotion of increased appliance efficiency?

c) Is a labeling program the most effective way to accomplish the desired result?

The findings of the *Ad Hoc* Committee with respect to the above questions, and the recommendations of the Committee in regard to the labeling of the energy efficiency or energy cost of specific appliances, are presented in this section.

Types of Labeling Programs

There are two basic approaches to product labeling, distinguished basically by the method of regulation:

1. *Voluntary* - A voluntary program of product labeling would depend upon non-regulated market mechanisms. The assumption is that publicity about energy shortages, and consumer education

programs about appliance operating costs, will create consumer demand in the marketplace for information about the energy consumption characteristics of appliances. Manufacturers and sellers of appliances will respond to this consumer demand by voluntarily providing this information. The information may, or may not, be certified through an industry certification program which would assure that all brands' product claims are based on the same operating assumptions. Otherwise, the product claims will be self-certified and subject to the surveillance of the Federal Trade Commission. This type of program is similar to the program conducted by the manufacturers of room air conditioners through the Association of Home Appliance Manufacturers (AHAM) in New York City during the summer of 1972. This program was discussed in Paragraph III.B. of this report.

2. Mandatory Compliance - This type of program is based on legislation which requires the labeling of specified information about the energy consumption characteristics of products. An appropriate regulatory agency would have to be designated, penalties for non-compliance established, and the parties responsible for complying with the regulations established. The legislation would have to provide for establishing sound, basic ground rules for the basis for the product information to be provided, thereby assuring that all information is provided on the same basis. Such legislation would, of course, have to be approved by the appropriate legislative body.

A program of this type, Int. No. 974, has been proposed for room air conditioners by the Council of the City of New York, and is included herein as Exhibit IIID-1. The Committee has been informed that this legislation has undergone minor modifications and was passed by the City Council on May 17, 1973. The bill (1098-A) was awaiting the signature of the Mayor at the time of publication of this report.

It is believed that a labeling program could best be applied to appliances and apparatus:

(a) Having a large total annual energy consumption;

(b) Having a wide range of energy efficiencies between the various models presently available to the consumer;

(c) Which lend themselves to having their energy utilization efficiency or cost of energy consumption readily defined;

(d) Which will provide an economic incentive to the consumer to buy the more energy efficient units.

The purpose of an Efficiency Labeling Program is to make a significant contribution in terms of reducing annual energy consumption and/or peak load requirements.

Based on the above guidelines, a labeling program could be instituted on a statewide basis for the following two types of appliances:

1. Room Air Conditioners
2. Refrigerators, Refrigerator-Freezers and Food Freezers

It should be noted that temperature affected loads constitute approximately 40 percent of the peak electrical load in the downstate area Both of the appliances considered for application of a labeling program are major contributors to the peak electrical load and, hence, a reduction of their energy demand would be of particular importance in the downstate Consolidated Edison territory.

The consideration for the application of labeling programs for these two types of appliances is based on the following information:

Room Air Conditioners

Application of a statewide labeling program for room air conditioners would be the simplest to enact. Essentially, all room air conditioners have been tested and certified with respect to the parameters influencing energy efficiency and energy consumption. AHAM has already conducted a consumer and dealer education program for room air conditioners which included distribution of labels as discussed in Paragraph III.B., so that the process of educating the consumer about energy efficiency has already begun.

There are presently 2,301,000 room air conditioning units in New York State with an annual energy consumption of 1,365,000,000 kWh. In 1970 only 28.6 percent of the households in New York State had one or more room air conditioners. There were 358,000 new air conditioners purchased in New York State in 1971 with a potential electrical load of approximately 430 megawatts. The average room air conditioner has an energy efficiency ratio of between 6.0 and 6.5 Btuh/watt, whereas the efficiencies of commercially available machines may vary from less than five to more than twelve Btuh/watt.

Refrigerators, Refrigerator-Freezers, and Food Freezers

The refrigerator is the greatest user of electric power among the major appliances. Essentially, all occupied households contain a refrigerator. There are additionally 960,000 separate food freezers in New York State. The combined total annual energy consumption of all appliances in this group is approximately 7,120,000,000 kWh or about five times the annual energy consumption of room air conditioners. The estimated service life of refrigerators and freezers is approximately 15 to 16 years. There were approximately 368,221 refrigerators and 48,067 food freezers sold in New York State in 1971 with a potential annual energy consumption of 490,000,000 kWh.

AHAM is now working on an energy consumption designation for refrigerator-freezers, called the "energy factor" which takes into consideration the various configurations of refrigerator and freezer sections. As in the case of energy efficiency ratios for air conditioners, the energy factor for refrigerator-freezers will enable efficiency comparisons between units. Because of similarities with the air conditioner, it is believed that testing will reveal a wide range of efficiencies among models presently available to the consumer. Because of the large quantity of electrical energy involved, improvement of the energy utilization efficiency of this equipment is a potentially fruitful area.

Whether a labeling program could result in the promotion of increased appliance efficiency is the subject of considerable controversy. In Paragraph III. B. of this report, the AHAM Room Air Conditioner Energy Conservation Program was discussed. This program employed labeling in conjunction with consumer education to promote the sale of the more efficient units, and is the only known program of its type. The program was considered reasonably successful for its initial season. However, the program has not really been given sufficient time to be tested fairly; therefore, conclusions about its effectiveness are premature.

There are many people who feel that labeling an appliance with an energy efficiency ratio or similar factor is not effective because such factors are not understood by the consumer. It is argued that in order to persuade the consumer to purchase energy efficient appliances, the consumer must be shown that it is financially advantageous for him to do so. From a first cost standpoint, the more energy efficient appliances are more expensive. Therefore, for a more efficient unit to offer a financial advantage to the consumer, its operating cost must be sufficiently lower to make its total owning and operating cost less over its life span. A knowledge of the operating cost of the appliance, rather than just a performance indicator, is required in order to make a total cost comparison.

Many factors require consideration in the evaluation of the merits of a labeling program and its possibility of success in promoting the manufacture and sale of more efficient appliances.

Defining the cost of operation of an appliance in a manner that is factual, easily understood and has applicability to all the consumers of the State does not appear to be feasible. The following difficulties in this approach are encountered:

(a) Utility rates vary within the State and from consumer to consumer depending on energy usage.

(b) Operating times for the appliances in question (air conditioners and refrigerator-freezers) would vary from household to household depending on climatic location and habits of the inhabitants.

(c) Labeling of annual cost of operation will cause consumer confusion since it is unlikely to describe any individual situation. Labeling of cents per hour rather than annual operating cost would minimize the variables and still provide the consumer with a straight-forward method of computing annual operating costs. This could be done on the basis of locally provided information on operating time averages for a region for room air conditioners, and on run times (which could be provided by the manufacturer) for various model types of refrigerator-freezers. It is noted that labeling of appliances with the operating cost in cents per hour is not any more useful than providing a performance factor such as EER, since a computation of annual operating cost to the consumer could be made just as easily on the basis of EER.

$$AOC = \frac{CRH}{1000\ (EER)}$$

Where:

AOC	=	Annual Operating Cost in Dollars
C	=	Capacity in Btuh
EER	=	Energy Efficiency Ratio in Btuh/watt
R	=	Cost of electricity in $/kWh
H	=	Operating time in hours

The problem with this approach is that it is too complicated for most consumers and they will probably not take the trouble to make the cost comparison.

A vigorous consumer education program would be required in conjunction with a labeling program so as to make the consumer aware of the program and its significance to him. The success of the program would be based on the following two assumptions:

1. Buying the more efficient appliance will be cheaper in the long run.

2. Educating the consumer on the cost benefits of energy conservation will be reflected in his purchases.

The above two assumptions to a great extent identify the potential weaknesses in a labeling program for the purpose of promoting the sale of the more energy efficient appliances.

The first assumption is undoubtedly true for many cases, especially when an efficient appliance is compared with a very inefficient one. As the efficiencies of appliances are increased, the cost associated with each increment of performance becomes higher. At some point the cost of improving appliance efficiency can not be made up during the life of the appliance by reduced energy costs. The point at which the less efficient unit is cheaper depends on a combination of factors associated with the design and manufacture of the unit and will vary with manufacturer. The reality must be faced that life cycle cost comparisons do not always favor the most energy efficient equipment.

The second assumption is known to have many exceptions and the assumption itself may actually be the exception rather than the rule. Many appliances are bought by landlords who don't pay for the energy used. Their only concern is first cost. Other consumers just don't plan that far in the future and prefer only to concern themselves with the initial price. Still others might ignore both price and performance and base appliance selection on appearance or special features.

The conclusion that is drawn from the above discussion is that only limited success can be expected in promoting increased appliance efficiency by means of a labeling program.

The following recommendations with respect to appliance labeling are made based on the findings and judgement of the Ad Hoc Committee.

1. Labeling of appliances and apparatus with respect to performance is desirable from the standpoint of promoting increased appliance efficiency and should be encouraged throughout the State. This is particularly the case with respect to air conditioners and refrigerator-freezers. The appliance industry should be encouraged to define a performance factor for refrigerator-freezers and publish comparative appliance data as has been done by air conditioners. It is recommended that industry's cooperation be solicited on a voluntary basis.

2. Performance, rather than cost, should be stressed since cost data is more complicated and might easily mislead the consumer.

3. Legislation for a mandatory appliance performance labeling law should not be pursued at this time, and any statewide legislation proposed should take the form of mandatory performance standards. Recommendations with respect to mandatory performance standards for specific appliances are presented in Paragraph 2 of this Section.

THE COUNCIL

The City of New York

Int. No. 974 September 28, 1972

Introduced by Mr. Scholnick (by request of the Mayor)—read and referred to the Committee on Buildings.

A LOCAL LAW

To amend the administrative code of the city of New York, in relation to information required to be provided about room air conditioners offered for sale in New York city.

Be it enacted by the Council as follows:

Section 1. Tittle B of chapter sixty-four of the administrative code of the city of New York is hereby amended by adding thereto a new article, to be article two, to read as follows:

Article 2

INFORMATION WITH RESPECT TO ROOM AIR CONDITIONERS

§ B64-10.0 ***Legislative findings.***—*The council hereby finds that the demand for electricity in the city of New York has been steadily growing; that the supply of electricity has on frequent occasions been inadequate fully to meet the demand therefor; that the distribution system of the public utility company serving most of the city has frequently been disrupted by heavy loads; that major brownouts and blackouts in various sections of the city have frequently resulted from such conditions, particularly in the summer; that there is no present basis for concluding that such conditions will not continue for the foreseeable future; that fifty per cent of the annual summer growth in demand for electricity in the city is due to air conditioning, that forty per cent of the peak summer demand for electricity in the city is attributable to air conditioning; that room air conditioners use a significant part of the electricity used for air conditioning in the*

Exhibit III D-1

city; that the amount of electricity used by room air conditioners of comparable cooling capacity varies widely; that most sellers of room air conditioners do not presently advertise, display or otherwise provide prospective purchasers information as to the amount or cost of electricity required to operate the various models of room air conditioners; that such information, if provided, would lead consumers to purchase more efficient models; that the growth in demand for electricity in the city, particularly in summer months, would thereby be slowed and there would be an amelioration of some of the conditions which lead to brownouts and blackouts.

The council also finds that an adequate supply of electricity is vital to the health, safety and welfare of all persons in the city.

Accordingly, the council further finds that, in order to conserve electricity, there is a need to provide prospective purchasers of room air conditioners with information with respect to the efficiency and cost of operation of such units.

§ B64-11.0 ***Definitions.***—*(a) "Room air conditioner" shall be defined as any electrical appliance which has a compressor, a condenser, an evaporator and a fan to cool and dehumidify the surrounding air and which is capable in ordinary usage of being mounted in a window or through a wall.*

(b) "Cooling capacity rating" shall be defined as the quantity of heat in British thermal units which a room air conditioner is capable of removing in one hour.

(c) "Wattage rating" shall be defined as the number of watts of electricity necessary to obtain the cooling capacity rating of a room air conditioner.

(d) "Person" shall be defined as any individual, firm, company, partnership, corporation, association or other organization.

§ B64-12.0 ***Display of information.***—*Any person selling, offering for sale or displaying for sale any room air conditioner shall set forth by a stamp, tab, label or sign at the point of display the model number, cooling capacity rating, wattage rating and estimated yearly cost of electricity necessary to operate such room air conditioner.*

§ B64-13.0 ***Furnishing information.***—*Upon request, any person selling or offering for*

Exhibit III D-1
(Continued)

sale any room air conditioner shall furnish to any person who inquires about such room air conditioner information as to the model number, cooling capacity rating, wattage rating and estimated yearly cost of electricity necessary to operate such room air conditioner.

§ B64-14.0 ***Advertising.****—Any person who advertises a room air conditioner for sale in the city of New York shall include in any advertisement therefor the model number, cooling capacity rating, wattage rating and estimated yearly cost of electricity necessary to operate such room air conditioner.*

§ B64-15.0 ***Regulations.****—(a) The commissioner of consumer affairs shall adopt regulations setting forth procedures for determining the cooling capacity rating, wattage rating and estimated yearly cost of electricity necessary to operate room air conditioners.*

(b) In determining procedures for estimating the yearly cost of electricity necessary to operate room air conditioners, the commissioner may use such published electric rate or rates, hours of operation, and average thereof as he deems reasonable.

(c) The commissioner may adopt such other reasonable rules and regulations as he deems necessary to effectuate the purposes of this article.

§ B64-16.0 ***Penalties.****—Any person or agent or employee thereof who shall violate any provision of this article or of the regulations promulgated pursuant thereto shall be subject to a civil penalty of not less than twenty-five dollars nor more than two hundred fifty dollars for each day in which a violation occurs.*

§ B64-17.0 ***Separability.****—If any provisions of this article shall be held invalid in whole or in part or inapplicable to any person or situation, all other provisions thereof shall nevertheless remain fully effective and the application of any such provisions to other persons not similarly situated or other situations shall not be effected thereby.*

§ 2. This local law shall take effect ninety days after it shall have become a law.

Exhibit III D-1
(Continued)

2. Development of Minimum Standards for Energy Efficiency of Appliances and Apparatus

As has been discussed in Paragraph III B, voluntary measures have been used for the promotion of energy conservation. However, such voluntary programs have thus far achieved limited success. Voluntary programs require the education and cooperation of the consumer. The difficulty with these programs is the lack of comprehension and credibility on the part of the general public, and the public's reluctance to change life-long beliefs and habits. An intense program in consumer education has been recommended by this Ad Hoc Committee and if carried out will enhance the long term results of voluntary programs of energy conservation.

In addition to the need for conserving energy, there is the more immediate problem of being able to meet the peak electric power demands. This problem is particularly critical in the downstate area where residential air conditioning contributes approximately 40 percent of the summer peak demand. Because of the seriousness of this problem and the need for significant short term results, this Ad Hoc Committee recommends that minimum performance standards be imposed on all room air conditioners offered for sale in New York State. A recommendation to this effect has been made by Mr. Joseph D. Lewin[1]

1. Also a member of the Ad Hoc Committee

representing the New York State Society of Professional Engineers in his prepared testimony before the City Council Committee on Buildings on Proposed Local Law Int. No. 974 pertaining to Room Air Conditioners. He recommended that performance standards for room air conditioners be promulgated that would impose incremental minimum performance requirements over a five-year period.

The minimum standards of performance for room air conditioners proposed by Mr. Lewin are studied in great detail by the Ad Hoc Committee. A special meeting of the Ad Hoc Committee was arranged with technical representatives of the air conditioning industry for the purpose of discussing minimum performance standards for room air conditioners. The meeting covered the following topics:

Product Changes for Increasing the Energy Efficiency Ratio of Air Conditioners

Technical Limitations

Marketing Implications

Based on information obtained from the technical representatives of the air conditioning industry, the Ad Hoc Committee proposes that the minimum performance standards presented in Table III D-1 be imposed on all room air conditioners offered for sale in New York State.

The minimum standards of performance for room air conditioners proposed in Table III D-1 are considered by the

Ad Hoc Committee to be reasonable and well within the capability of present technology. In addition, available data indicates that the proposed performance standards are justifiable in terms of minimum total owning and operating costs for room air conditioners.

A tabulation of room air conditioner energy efficiency ratio (EER) range as a function of rated cooling capacity has been made based on the data compiled in the AHAM - Room Air Conditioner Directory No. 2 - 1973. This data is presented in Table III D-2.

A review of the 115 volt air conditioner EER data of Table III D-2 indicates that there are presently some units in each of the three capacity ranges that already meet the last increment of the proposed minimum standards.

For the case of the 230 V air conditioners, it is obvious that many of the 1973 models will not meet the proposed minimum standards for 1975 and very few would meet the proposed minimum standards for 1979. From the above observation, it might be concluded that it is much more difficult to produce an efficient air conditioner that operates at 230V than 115V. This, however, is not really the reason for the difference in performance at the two different voltages. At the lower voltage manufacturers have been striving to get the maximum capacity out of an air conditioner without exceeding the electrical current limits for a normal household circuit. This required the development of high efficiency units. Because of the lower current drawn at the higher voltage, emphasis has not been placed in the past on high efficiency 230V air conditioners. Higher efficiency 230V air conditioners are within the capability of present technology and should be manufactured.

Recommendations

It is the recommendation of the Ad Hoc Committee that legislation be promulgated with respect to the proposed minimum performance standards for room air conditioners presented in Table III D-1.

Table III D-1

Proposed Air Conditioner Performance Standards

Size Btuh		Performance in Btuh/Watt (EER)* 1975	1976	1977	1978	1979
Up to 5,999		6.0	6.5	7.0	7.5	8.0
6,000 to 9,999	115V	7.0	7.5	8.0	8.5	9.0
10,000 and Higher		7.0	7.5	8.5	9.0	9.5
Up to 17,999		6.5	7.0	8.0	9.0	9.5
18,000 to 23,999	230V	6.5	7.0	8.0	8.5	9.0
24,000 and Higher		6.5	7.0	7.5	8.0	8.5

* The test conditions are 80°F room air temperature at 50% relative humidity and 95°F outside air temperature at 39% relative humidity per ASHRAE Publication No. 16-69.

Room Air Conditioner Energy Efficiency Ratio (EER)
As a Function of Rated Cooling Capacity
(AHAM-RAC Directory No. 2 - 1973)

115 Volts

Capacity	EER Range		Capacity	EER Range	
4,000	4.7	7.0	8,250	6.2	6.2
4,800	8.3	8.3	8,300	7.0	7.0
5,000	4.9	6.8	8,500	6.2	9.8
5,200	6.5	6.5	8,700	6.3	6.6
5,500	6.3	8.8	8,800	6.4	6.4
5,600	6.5	6.5	9,000	6.2	10.4
5,700	6.6	6.6	9,200	10.1	10.1
5,800	7.0	7.0	9,400	6.8	6.8
6,000	4.9	8.8	9,500	6.8	6.9
6,200	5.7	5.7	9,700	7.0	7.0
6,300	7.2	7.3	10,000	7.2	11.6
6,500	5.7	7.9	10,300	11.9	11.9
6,700	7.7	7.7	10,500	7.6	7.6
7,000	8.8	8.8	11,000	7.9	8.1
7,200	6.0	6.0	11,200	8.1	8.1
7,400	5.8	5.8	11,500	6.5	8.5
7,500	5.4	8.7	12,000	8.6	8.7
7,600	8.6	8.6	13,000	9.5	9.5
7,800	6.1	6.1	13,500	9.7	9.7
8,000	5.7	9.8	14,000	10.1	10.1
8,200	7.0	7.0	14,500	10.5	10.5

230 Volts

Capacity	EER Range		Capacity	EER Range	
5,000	6.4	6.4	16,500	8.9	8.9
6,000	5.3	5.3	17,000	7.0	7.0
7,500	6.6	6.6	17,300	6.5	6.5
8,000	6.6	7.2	17,600	7.3	7.3
8,500	5.6	5.7	17,700	6.3	6.3
8,700	6.2	7.1	18,000	6.0	9.0
9,000	4.7	6.9	18,500	6.4	9.7
9,500	5.0	6.0	18,800	7.6	7.6
9,700	5.3	5.3	19,000	5.4	8.1
10,000	5.2	7.2	19,500	9.5	9.5
10,200	5.3	5.3	20,000	5.7	7.1
10,400	6.7	7.9	20,500	6.7	7.1
10,500	5.3	5.5	21,000	5.9	7.[illegible]
10,600	6.8	6.8	21,500	6.1	7.1
10,800	6.7	6.7	22,000	6.1	7.9
11,000	5.2	6.8	23,000	6.2	7.1
11,100	6.9	6.9	23,200	7.8	7.8
11,400	5.1	5.1	23,500	5.9	7.5
11,500	5.2	6.5	24,000	6.3	7.5
11,700	6.0	6.6	25,000	6.4	6.4
11,800	6.0	6.0	26,000	6.1	7.7
12,000	5.2	6.9	26,400	9.2	9.2
12,100	6.2	6.2	26,500	6.6	7.5
12,300	6.0	6.0	27,000	6.9	7.9
12,500	5.5	7.1	27,500	6.7	6.7
12,800	6.7	6.7	28,000	6.5	7.3
13,000	5.0	8.5	28,400	6.3	6.3
13,200	8.2	8.2	29,000	6.7	6.7
13,300	6.3	8.7	30,000	5.9	7.5
13,500	5.0	5.1	32,000	6.4	6.8
13,800	4.8	4.8	33,000	6.5	6.5
14,000	5.0	7.0	33,300	6.9	6.9
14,500	5.2	6.9	33,500	6.2	6.2
14,700	6.1	6.6	33,700	6.2	6.2
15,000	5.1	6.6	34,000	6.4	7.0
15,500	6.6	8.7	36,000	7.0	7.0

3. Increased Emphasis on Energy Efficiency in Government Purchases of Appliances and Apparatus

This committee has recognized that Federal, State, local governments and quasi-governmental agencies can play an important role in promoting the use of energy efficient appliances and apparatus by setting an example in their actions. Government officials can not in good conscience request private industry and the general public to purchase energy efficient appliances and apparatus unless government agencies are conforming to the same policy. Furthermore, government agencies in total are purchasers of a significant quantity of appliances and apparatus and by seeking energy efficient equipment in their purchases, government can actually create a demand for high efficiency equipment. This in turn will provide the financial incentive to industry to design and develop equipment which is more energy efficient.

The purchase of appliances and apparatus by Federal, State and local government agencies generally is made in accordance with appropriate specifications. The General Services Administration (GSA) of the Federal government is responsible for specifications for equipment purchased for use by that agency as well as many other Federal agencies. Its specifications, however, presently do not give sufficient consideration to energy efficiency. For example, Federal specifications for the procurement of room size air conditioners (Exhibit III D-2) are so unrestrictive that almost all room size air conditioners now on the market meet the federal specifications. We understand that these specifications are now in the process of being reviewed by GSA so that increased emphasis can be placed on energy conservation parameters.

Similar to the GSA, the New York State Office of General Services (OGS) is responsible for the specifications for equipment purchased for use by State agencies.[2] The Standard and Purchase Group of OGS handles about 16,000 purchase requests each year and issues a large number of "term" contracts (contracts in effect for an extended period) for materials, supplies and equipment of which over 100 are open to political subdivisions. The value of the contracts negotiated by OGS amounts to roughly $250,000,000 each year.

The OGS Specification[3] for room air conditioners contains energy efficiency requirements that are significantly more restrictive than those in the corresponding GSA specification, however, it does not limit the purchase of air conditioners to the most efficient units. In effect only the grossly inefficient units are eliminated by the present requirements. Various other OGS appliance specifications also have requirements which limit maximum energy consumption.

There is no distinction made or preference given to higher efficiencies required by specification. This would require

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2. State Agencies can purchase directly items amounting to less than $500.

3. See Exhibit III D-3

a cost-benefit analysis to be performed taking into consideration both owning and operating cost over the life of the item. However the operating cost of an air conditioner is not only dependent on its efficiency but also:

> The cooling degree days and hours of operation which are dependent upon the climatic zone in which it is used.
>
> The cost of electricity which varies depending on the supplier of electricity and the rate block for purchased power at the location where the air conditioner will be used.

Because of the above variations, a given air conditioner may not prove to be the most economical for all applications within the State. Therefore, a single cost-benefit, analysis can not be used to determine the air conditioner of lowest total cost for all potential purchasers under a term contract.

The alternatives open to effect a greater savings of money and energy are:

> Perform a cost-benefit analysis for each climatic zone and award different term contracts for different zones as required.
>
> Review the maximum energy consumption limits in the purchase specification to insure that units which would be basically uneconomical over the average New York State conditions of usage and energy cost are eliminated.

Recommendations

This committee recommends that all New York governmental agencies at both the State and local levels, including Authorities and other quasi-govermental units shall be required to take the lead in placing increased emphasis on energy efficiency in the purchase of appliances and apparatus. In order to meet this end, it is recommended that the Governor issue a proclamation requesting all public purchasing officials to review their specifications and purchasing practices for appliances and apparatus which consume a significant quantity of energy. Energy efficiency requirements for this equipment should be added or, if existing, re-evaluated, taking into consideration the present importance of conserving energy in New York State.

Exhibit III D-2

Federal Specifications for the Procurement of Air Conditioners

00-A-00372B (GSA FSS) September 3, 1969
Interim Federal Specification
Air Conditioners, Electric Motor Driven
Self Contained (For Shore Use)

Para. 3.5.1 Performance Factor. The air conditioning units shall have the following minimum performance factors in cooling units per watt based on net total room cooling effect and total watt input to the unit.

Size	Capacity Btuh	Btuh/Watt
1	8,000 - 10,499	5.0
2	10,500 - 13,999	5.2
3	14,000 - 17,999	5.4
4	18,000 - 22,999	5.6
5	23,000	6.0

*   *   *

00-A373 August 5, 1966
Air Conditioners, Self Contained Space Types;
Water, Air, or Evaporative Cooled

Para. 3.10.3 Performance Factor. The units shall have the following minimum performance factor based on the total cooling effect expressed in Btu/hr divided by the total watt input.

Type		Capacity Btuh	Performance Factor
Type I	(air cooled)	21,000 - 90,000	7
Type II	(water cooled)	36,000 - 400,000	9

*   *   *

Exhibit III D-2
(Continued)

00-A-374 May 11, 1967
Air Conditioners with Remote Condensing Units
or Remote Air-Cooled Condenser Units

Para. 3.10.3 Performance Factor. With a cooling capacity as specified in 3.10.1, the air conditioner shall have a minimum performance factor as shown in Table I, based on the ratio of total cooling effect expressed in Btu/hr and the total watts input.

Table I Performance Factors

	Type	Capacity Btuh	Performance Factor
I	Evaporative Blower Unit Remote Air-Cooled Condensing Unit Evaporative Blower Unit	20,000 - 120,000	7.0
II	Remote Water Cooled Condensing Unit Evaporative Blower, Compressor Unit	35,000 - 180,000	9.0
III	Remote Evaporatively Cooled Condenser Unit	31,000 - 240,000	7.0

DETAILED SPECIFICATIONS

PART II

SPECIFIC REQUIREMENTS

Item	Minimum Cooling Capacity BTU/HR	Minimum Delivered air (at Hi-speed	Dehumidification PTS/HR (Min.)	Max. Watts	Max. Amps.	Minimum BTU/ Watt	** Volts	Freq.	Fan Speeds Minimum	Min. Net Wt. In Lbs.	Minimum Dimensions
1.	5,000	170	1.3	860	7.5	5.8	115	60	2	60	18-1/2"W x 12-1/4"H
2.	6,500	240	1.3	890	7.5	7.5	115	60	2	95	22-3/4"W x 14-1/2"H
3.	8,500	240	2.0	1350	12.0	6.0	115	60	2	95	22-3/4"W x 14-1/2"H
4.	10,000	250	2.5	1380	12.0	7.1	115	60	2	105	22-3/4"W x 14-1/2"H
5.	10,000	275	3.0	1980	9.8	5.7	230/208	60	2	110	22-3/4"W x 15"H
6.	13,000	350	3.6	2400	12.0	6.2	230/208	60	2	135	24"W x 15"H
7.	15,000	400	4.4	2800	14.0	6.2	230/208	60	2	140	24"W x 15"H
8.	18,500	450	5.8	3300	15.0	5.9	230/208	60	2	160	24"W x 16"H
9.	22,500	500	7.0	3850	19.0	5.9	230/208	60	2	180	25"W x 16"H
10*	6,000	185	1.5	875	7.5	6.8	115	60	2	75	14-3/4" wide - max.
11*	7,500	200	2.0	1400	12.0	5.7	115	60	2	79	14-3/4" wide - max.

NOTE: Minimum BTU capacities and maximum wattage and current capacities of dual voltage units are established at the lower voltage.

*Casement Type

**Agency will indicate on purchase order whether units shall be for service on 230 V or 208 V. Units shall be wired or connected for operation on the voltage specified on the purchase order. Transformers to adapt 230 V units to 208 V service are not acceptable.

4. <u>Application of Energy Efficiency Standards in Specifications for the Procurement of Appliances and Apparatus by Design and Construction Agencies</u>

The design and construction process usually requires the preparation of several documents prior to the letting of construction contracts. Two of these documents, drawings and specifications, are generally completed during the design phase and serve as instructions to the contractor.

In December of 1971, Governor Rockefeller issued a Directive requesting all State agencies, corporations and authorities to utilize a uniform specification system, the Construction Specifications Institute's (CSI) format, on all state financed structures. The format, similar to a table of contents, allocates Division No. 11, to the specifying of equipment that is to be bid and installed by the contractor. Equipment such as dishwashers, stoves, refrigerators, laundry washers and dryers, are often specified by the architect and/or client in Division 11. Subsequently, the contractor awarded the bid supplies the equipment according to the prescribed specifications. Presently, equipment defined in Division 11, does not contain energy efficiency ratio criteria or contains the lowest common criteron.

State agencies, corporations and authorities could be directed to adopt energy efficiency standards for equipment which is included in the specifications and required as part of construction contracts.

Once standards are developed, agencies, corporations and authorities, utilizing the services of outside architects and consultants, as well as inhouse staffs, could impose these energy efficiency standards in all specifications.

The State would thus encourage equipment manufacturers to develop equipment with high energy efficiency ratios, in order to compete as building industry suppliers.

It is a critical element of this proposal to point out that no individual design/construction agency has the resources to develop energy standards for equipment specified in Division 11. Furthermore, it would be undesirable to initiate a situation whereby agencies were not only duplicating work but developing conflicting standards.

It is therefore strongly recommended that the task of developing energy efficiency standards for specifications be immediately assigned to one organization. Once standards are established, all agencies, corporations and authorities can be directed to include the standards in equipment specifications.

5. Minimum Standards for Thermal Insulation

Although the main thrust of this report is to concentrate on ways to improve the energy utilization efficiency of appliances and apparatus, a discussion of thermal insulation requirements is appropriate since building insulation is usually the most important factor contributing to the total energy consumption of space conditioning appliances and apparatus.

In the discussion of electric heat it was noted that the efficiency was essentially 100 percent at the point of use. For gas and oil heat the combustion efficiency was approximately 70 percent at the point of use. Practical limitations to increasing the efficiency of gas and oil heating appliances were covered in the applicable Sub-Committee reports. The potential for conserving energy through the improvement of the efficiency of space heating devices was significant but in general limited to at most 10 percent. With this in mind, opportunities to save as much as 50 percent of the energy used in space heating a home should not go overlooked.

The amount of thermal insulation installed in a new home heated with gas or oil is generally about 50 percent of that which would be prescribed based on a total annual cost comparison. Builders tend to minimize the initial cost of insulation at the expense of the non-suspecting home purchaser.

Since the 1950's the electric industry has used the "All Weather Comfort Standard" for electrically heated homes. This standard prescribes insulation requirements which are approximately equal to those prescribed for use with all fuels in the April 1971 Interim Revision 51A of the Federal Housing Administration (FHA) Minimum Property Standard No. 300. The FHA Standard, however, applies only to federally-assisted housing, which is only about six percent of the total for new construction in New York State.

The Ad Hoc Committee on Appliances and Apparatus Efficiency recognizes both the potential and the need for saving energy in residential and commercial space conditioning and makes the following recommendations regarding thermal insulation.

Recommendations

The State Building Code Council or a similar new council shall:

1. Develop from existing information residential and commercial insulation requirements for mandatory statewide minimum standards for new construction.

2. Impose immediately on new residential and commercial buildings mandatory statewide interim standards, which should not be lower than those prescribed by the United States Department of Housing and Urban Development for federally-assisted housing.

3. Conduct an investigation to determine the feasibility of promoting the upgrading of insulation in refurbished homes.

6. Consideration of Other Policies that Could Induce Improved Energy Utilization

In addition to the approaches already discussed in this Section, there are many other policies that could be adopted to promote better utilization of energy. For completeness, a brief discussion of other policies is presented in the following paragraphs.

a) Policies designed to provide a financial incentive for development and use of energy conserving appliances and devices. Policies to be considered in this category are:

1. Tax Relief
2. Low Interest Loans

In some instances there appears to be a need to provide additional incentive to induce people to purchase energy efficient equipment even though the total owning and operating cost of this equipment may be comparable or actually lower over the long term. In many cases, the consumer is not very interested in the long term, with his primary concern being initial cost. This might be true whether the consumer was an individual, purchasing for his own needs or a purchasing agent buying equipment for multi-family dwellings or a commercial building. In these cases offering an income tax exemption to an individual or short term real estate tax relief to a builder using energy efficient equipment might provide sufficient incentive to tip the scales toward the purchase of efficient equipment. Low interest loans could also be made available to induce buyers to purchase energy efficient equipment. Tax relief and low interest loans could also be made available to manufacturers of energy efficient equipment.

b) Policies designed to change the user cost of energy. Policies to be considered in this category are:

1. Sales or Use Tax
2. Changes in the Utility Rate Schedule

A study by the Office of Economic Research[4] of the New York State Department of Public Service indicated that small increases in the prevailing price of electricity can be expected to have only a negligible effect on residential demand over the short run (3-5 years). The same conclusion is undoubtedly true for oil and natural gas. This is true because of the inflexibility of equipment with respect to the form of energy input used and the amount used per hour of operation as well as the high cost of scrapping or converting existing equipment. In the long run, this inflexibility is somewhat reduced because economic growth and depreciation of old equipment makes additions and alterations of energy using equipment far less costly. Additional encouragement is provided by the passage of time in the form of new designs or types of equipment. This new equipment is more likely to have design parameters which have been influenced by higher energy costs.

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4. "The Inverted Rate Structure - An Appraisal Part I - Residential Usage", New York State Department of Public Service, Office of Economic Research Report No. IX, February 17, 1972

In the short term, however, an energy price increase of two or three times the present rate may dampen the rate of growth, but it is not expected to decrease the present demand.

Over the long term a significant increase in the cost of energy would inevitably result in the installation of increased building insulation and a reduction of energy requirements for space conditioning new homes and buildings.

From the standpoint of equitably distributing the true cost of electricity, the need for flattening the electric rate structure or eliminating the quantity discount for electricity is already becoming apparent especially in the Consolidated Edison territory. The present rate structure is based on the premise that the big costs to the utilities were building power plants, transmission lines and getting the generators going - and after that it was cheaper to produce more power.

Consolidated Edison now needs more power plants and transmission lines because of the greater demand per customer - but not because the number of customers has increased. Presently, those responsible for the systems growth and the city's energy crisis are paying the cheapest rates per unit of energy.

To further aggravate this problem, the cost of producing more power is not necessarily lower. During peak periods Consolidated Edison is now forced to buy electricity from other companies and use more of its least efficient and hence most expensive power plants. The cost of new power plants also keeps rising because of such entities as inflation and environmental regulations. These cost trends could result in higher rates for larger users. From the standpoint of energy conservation, this trend could be beneficial since it might discourage inefficient uses of large amounts of energy based primarily on a discounted price.

c) Policies designed to change the purchase cost of energy consuming equipment. Policies to be considered in this category are:

1. Sales Tax on Appliances and Apparatus
2. Estimated Annual Energy Use Tax
3. Elimination of Promotional Rebates or Activities

The imposition of an additional sales tax on appliances and apparatus would tend to discourage purchase of the item rather than promote energy efficiency unless the amount of tax was in some way graduated downward or eliminated with increased energy efficiency. With this provision, approaches 1 and 2 would be very similar. For most energy consuming equipment, the non-existence of efficiency standards or certified test data does not make this approach of increasing energy utilization very feasible even if it were desirable. For the consumer it just represents another tax and is not likely to inspire an enthusiastic response for energy conservation.

The New York State Public Service Commission has already taken a stand against promotional activities in the sale of gas and electricity.

Effective January 1, 1972 all gas distributors have been required to cease all promotional activities designed to acquire new gas customers or increase sales of gas to existing customers.

The Commission also requested that the electric utilities exercise restraint in respect to promotional advertising. In electric rate cases it will consider objections that expenditures for promotional advertising are excessive and inappropriate.

d) Policies designed to limit or restrict by law the use of energy. Policies to be considered in this category are:

1. Building Code Requirements.
2. Bans on either manufacture, sale, installation or use of equipment.

Building codes could be used to limit energy consumption in buildings. This could be done by the imposition of a requirement limiting the total amount of energy that could be used per year per square foot of building floor space. This approach to more efficient energy utilization would fall under the jurisdiction of the Ad Hoc Committee for Energy Efficiency in Large Buildings although its application would definitely tie in to the selection of appliances and apparatus. In order to limit overall building energy use, the architectural aspects of the building such as heat transmission coefficients (U factors) for the walls and shading coefficients for the glass would certainly be primary considerations. However equally important in the overall efficient utilization of energy are the space conditioning (heating, ventilation and air conditioning) hot water heating, and lighting systems with the basic functions being performed by some type of appliance or apparatus. However, their efficiencies with respect to building energy utilization must be considered on a system basis and this approach was not considered by the Ad Hoc Committee on Appliance and Apparatus Efficiency.

Bans on the manufacture, sale, installation or use of equipment were not given any detailed consideration by this Committee although it was noted that some policies which would fall under this category have already been invoked by the New York State Public Service Commission with respect to the sale and use of natural gas. The Public Service Commission has restricted with few exceptions, the sale of gas to new industrial and commercial customers. All advertising for new gas customers is also prohibited.

The use of natural gas for decorative torches has also been prohibited by the Commission because it represents a waste of a scarce fuel.

These measures are severe and should only be employed to guarantee an adequate gas supply for the more essential purposes.

Appendix A

Detailed Energy Conservation Suggestions

Promoted by Present Programs

1. Buildings

Install wall and ceiling insulation.

Install storm windows.

Caulk and weatherstrip windows and doors.

Install storm doors.

Use curtains, blinds, shades, draperies, and awnings to reduce heat loss in winter and heat gains in summer through windows and doors.

Use exhaust fans to cool house with outdoor air at night and when outdoor weather permits during summer.

Vent heat producing equipment in summer.

Adjust outside air intake dampers.

Operate kitchen vent for cooking.

Check for and remove obstructions to air flow at registers or obstructions at radiators.

Close fireplace damper when not in use.

Open storm windows and doors on mild summer days instead of operating air conditioners.

Check for adequate attic ventilation.

Close kitchen and laundry room doors during heat producing activities during summer and open them during winter.

Let the sun shine in the windows in winter.

Check for excessive air leaks and ventilation.

2. Space Heating

Select the proper size of equipment

Select equipment with the highest system and annual efficiency.

Check suitability of the type of system for the particular application, consider gas infrared direct fired, heat pumps or other types of systems.

Have an expert calculate the heating load and select the equipment size.

Have an expert design the heating system.

Have an expert install the heating system.

Insulate piping and ductwork in non-conditioned areas.

Study instructions to learn to operate the system at maximum efficiency.

Adjust outside air intake dampers.

Check thermostat location, operation and setting.

Check outdoor thermostat location, operation and setting.

Check main boiler adjustment.

Check for excessive air leakage and ventilation.

Change or clean air filters in warm air system.

Flush boiler in wet system.

Check for and repair all steam, water, and air leaks.

Clean heat transfer surfaces and keep them in good repair.

Check operating efficiency; have an expert do this.

Turn off heating system when not in use for extended periods.

Reduce thermostat setting to coolest temperatures at which individual comfort is maintained.

Maintain a constant thermostat setting.

Check lubrication of moving parts.

Check condition of fan belts.

3. Central Air Conditioning

Select proper size equipment.

Select equipment with highest system and annual efficiency.

Check suitability of the type system for the particular application, consider air or water cooled condensers, and gas or electric powered.

Have an expert calculate the cooling load and select the equipment size.

Have an expert install the air conditioning system.

Have an expert design the air conditioning system.

Insulate chilled water piping and ductwork in unconditioned areas.

Study instructions to learn to operate system at maximum efficiency.

Adjust outside air intake dampers.

Check thermostat location, operation, and setting.

Check outdoor thermostat location, operation, and setting.

Check main burner adjustments, if gas.

Check for excessive air leakage and ventilation.

Change or clean air filters.

Clean heat transfer surfaces and keep them in good repair.

Check for and repair all water and air leaks.

Check operating efficiency; have an expert do this.

Increase thermostat setting to warmest temperature at which individual comfort is maintained.

Maintain a constant thermostat setting.

Turn off air conditioner when not in use for extended periods.

Check lubrication of moving parts.

Check condition of fan belts.

4. Lighting

Select the type of lighting that gives the maximum lighting efficiency. Fluorescent lamps produce about two and one-half times as much light as incandescent lamps.

Select the minimum size lamps that will provide adequate light.

Install the lighting to avoid glare. Provide high intensity light only where it is required.

Use light colored interior paint and decorations whenever possible.

Use natural light from windows when possible.

Turn off lights when light is not essential. This not only saves the energy that produces unnecessary light, but also reduces the energy consumed by air conditioning equipment.

If you have a postlamp, or lights in your outside driveway, do not leave them on during the day. If necessary, an automatically timed switch can be added to save energy.

Check and clean lamps, lamp shades and light reflectors for maximum lighting efficiency.

5. Water Heating

Select the type of water heater that will give most efficient use of energy. Consider oil or gas fired as well as electric equipment.

Select water heater size that is adequate to supply the necessary quantity of hot water without oversizing the heater.

Insulate hot water piping.

Install a tempering tank ahead of a domestic hot water heater in normally heated locations.

Check thermostat setting and adjustment.

Check auxiliary system if heater is parallel with hot water space heating system.

Repair leaky hot water faucets.

Check and repair leaky pipes.

Check and repair heater insulation.

6. Refrigerators and Freezers

Place the refrigerator or freezer far enough from the range so that heat from the range will not affect the refrigerator.

Maintain adequate clearances from walls to refrigerator or freezer for air circulation.

Let heated foods cool for at least 30 minutes before placing in refrigerator or freezer.

Do not overcrowd your refrigerator or freezer.

Do not leave the refrigerator or freezer door open longer than necessary.

Keep the refrigerator or freezer defrosted.

Check the gaskets around the door.

7. Room Air Conditioners

Calculate cooling load of the space to be conditioned.

Select a unit with a Btuh rating adequate to supply load without oversizing unit.

Select a unit with a high energy efficiency rating.

Study instructions to learn to operate the unit at maximum efficiency.

Install air conditioner in a location where it will not be in the direct rays of the sun and preferably on a north side, and if possible shade it with an awning.

Check unit to determine that all air channels and passages are clean and not restricted and that all panels are in place so that there is no air leakage.

Use only outside air through doors and windows when it will provide adequate comfort.

Use only the fan for cooling when outside air through doors and windows alone will not provide adequate comfort and if refrigerated air is not necessary.

Use highest thermostat setting at which individual comfort is maintained.

Change or clean air filters.

Check lubrication of moving parts.

Check conditions of fan belt

Have an expert check the performance efficiency of the unit annually.

8. Cooking Ranges

Check flame adjustments.

Select utensils to fit surface units, i.e., use a six inch pan on a six inch surface unit.

Use flat bottomed, clean utensils for a better, more even transfer of heat.

Plan oven meals to accommodate more than one dish at a time or time your baking for multiple chores.

When cooking on surface units, cover utensils whenever possible.

Turn down the heat when bubbles start to form.

Do not preheat more than two or three minutes.

Turn off heater several minutes before food is done.

Never leave a kitchen range or oven on when not actually in use.

If there is a vent on the range, use it. This will keep air fresh and reduce air conditioning load.

If a single use small appliance will do the job, use it instead of the range. If the small appliance can double as a serving dish, this will also save energy for the washing water.

Do not cover grid with foil, except when making cookies.

Avoid using the fast oven cleaning feature when the air conditioner loads are heavy.

Never allow flames to lick up the sides of utensil.

Do not use the range to heat the house.

Clean range exhaust filter.

9. Clothes Dryers

Check burner adjustments.

Take advantage of different types of heat for different types of laundry. Permanent press needs only warm heat.

If possible, plan dryer loads for evenings and weekends. Do one full load instead of many small loads.

Dry at precise temperature required.

Partially dry clothes, fold and place on top of dryer during next cycle.

Overdrying any fabric increases wear and tear, yellows the fabric, and uses excess energy.

10. Dishwashers

If possible, use dishwasher just once a day - after the evening meal.

Remove excess foods before placing in washer.

When practical, use "short wash" cycle for dishwasher and fill machine before use.

Match the amount of dishwasher detergent to the hardness of the water. Too much soap will leave water spots; too little will not clean properly; the proper amount avoids rewashing.

11. Washing Machines

If possible, plan washer loads for evenings and weekends. Do one full load instead of many small loads.

Take advantage of any special features on your washer. A soak cycle may save multiple washings of stained clothes.

Suds savers allow you to re-use hot or warm wash water for several loads.

Choose the right cycle. Permanent press items require cool rinse cycles and saves hot water.

12. Miscellaneous Appliances and Apparatus Such As:

Television
Hand Iron
Frying Pan
Coffee Maker
Radio
Bed Covering
Roaster-Oven
Small Motor Driven Appliances or Tools
Small Resistance Heated Appliances and Tools

Turn off television sets when they are not being viewed. Sets having instant on features and which are provided with a switch or switches which permit the sets to be completely de-energized should always be completely turned off.

Turn off radio and hi-fi sets when you are not listening.

Turn off all appliances when not actually in use. Heating appliances and tools will increase the air conditioning load, as well as use unnecessary energy.

Save time and energy by doing a whole batch of ironing - not just one piece at a time. You will save money by having to warm the iron only once.

Save once-in-a-while jobs like vacuum cleaning or working with power tools until the weekend. You will not be using energy during utility peak load.

Whenever possible, plan to use major appliances, and minor appliances as well, before 8 a.m. and after 6 p.m.

Defective appliances usually have to work longer and use more energy. Paying to have appliances repaired costs more money, but may save energy dollars in the long run.

Whenever appliances require repairs or approach the end of their expected useful life, a study should be made to determine the life cycle economics of replacement, rather than repairs. Replacement should be made with high energy efficient equipment.

Appendix B

Energy Savings in Gas Appliances Through Proper Operation and Maintenance

There is a significant opportunity for energy savings with gas appliances through proper operation and maintenance. The most effective way to implement energy conservation in operation and maintenance is by means of an intensive educational compaign. The approach recommended for this program in energy conservation is discussed in detail in Section III of this report. Listed below are individual items that could be covered by the educational program.

Space Heating

Size boilers and furnaces realistically to more closely match heat losses.

Do not set thermostats higher than actually required for comfort. Set back temperature a few degrees during nighttime operation.

Rapair leaks in condensate and steam lines.

Repair defective radiator air valves.

Regularly change or clean air filters.

Flush boilers seasonally.

Check burner adjustment.

Properly adjust outside air intake dampers.

Check thermostat location and operation.

For heating systems which are run by operators, proper training of the operators is essential.

Improve wall, floor, and ceiling thermal insulation.

Insulate piping and ductwork in non-heated areas.

Caulk and weatherstrip windows and doors.

Install storm windows or insulating glass.

Check for excessive air leaks and ventilation.

Let sun shine in windows.

Use curtains and draperies to cut heat loss at night.

Check for obstructions to air flow at registers and connectors, or obstructions at radiators.

Close fireplace damper when not in use.

Reduce attic ventilation during the winter.

Water Heating

Flush water heater during seasonal maintenance of heating system.

Check thermostat setting and adjustment.

Insulate hot water piping.

Repair leaky hot water faucets.

Use cold water soap or detergents for clothes washing.

When practical use "short wash" cycle for dishwashers and fill machine before use.

Use shower heads that limit the flow of water to reasonable quantities.

Ranges

Adjust burners and pilots.

Use proper flame setting for cooking.

Do not preheat broiler longer than required.

Use proper cooking utensils.

Replace obsolete gas range and oven with new modern, well insulated cooking units. Look for "burner-with-a-brain" and other features which conserve energy.

Commercial Cooking and Baking

Use full oven capacity for baking and roasting.

Use slow roasting.

Preheat oven to exact temperature required.

Turn broiler flame off or to low during slack periods.

Do not overheat griddles.

Before frying, bring fat to frying temperature.

Check and adjust thermostats.

Check flame adjustments.

Replace obsolete equipment with equipment including new features such as infrared broilers and high-speed range burners.

Clothes Dryers

Set timing device for proper drying time.

Dry at precise temperatures required.

Fold and place partially dry clothes on top of gas dryer during next cycle.

Check burner adjustments on commercial gas dryers.

Replace obsolete dryer with fully automatic equipment.

Processing

Large quantities of heat are exhausted to the outside of many industrial plants and commercial buildings. This results in a negative pressure within the building, which in turn causes inefficient combustion of gas or other fuels. Make-up air heaters solve the negative pressure problem, but use additional fuel to heat the incoming air. A better solution is to install thermal recovery units which can reclaim up to 80 percent of the exhausted heat.

Monitoring equipment such as combustion controls can assure higher combustion efficiency. Sequence draft controls can also improve efficiency, particularly where very high stacks are used.

Use of direct fired instead of indirect fired ovens reduces fuel consumption.

Tailor Shops

Clothes pressing machines use steam for drying by aspirating air and exhausting the steam to the outside. The use of air vacuum systems eliminates this waste.

Process Steam and Hot Water Boilers

Adjust burner.

Check combustion efficiency.

Blow down boiler on regular basis.

Keep tubes and flue passages clean.

Clean and repair combustion chambers.

Repair boiler insulation.

Check auxiliary systems.

Insulate steam and return lines, and hot water lines.

Repair steam and hot water leaks.

Check use of steam and hot water to ensure efficient utilization.

Replace old gas units with modern efficient gas equipment.

Process Ovens, Furnaces, Melters, Etc.

Maintain proper air/gas ratio (this can reduce gas consumption up to 15 percent).

Install modern air/gas ratio control devices to eliminate manual settings.

Limit excess air.

Keep heat transfer surfaces clean and in good repair.

Check that refractory and insulation is adequate and in good condition to minimize radiation losses.

Confine flames to heating areas and check flame.

Accurately maintain required, not excessive, temperatures.

Rearrange schedule to utilize equipment for continuous periods of time.

Shut down or reduce temperatures on equipment when not in use.

Recover waste heat from process equipment for steam generation, water heating, and heating of combustion air or plant air.

Take advantage of the improved quality, improved production, and lower gas consumption afforded by modern gas processing equipment over older models.

Steam Generation

Check burner adjustment.

Flush boiler.

Check for steam leaks.

Insulate piping.

Check boiler operation.

Replace old gas boiler with modern well insulated gas boiler.

Appendix C

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Appendix D

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APPENDIX E

Abbreviations

Organizations

AASHO	American Association of State Highway Officials
A.G.A.	American Gas Association
AHAM	Association of Home Appliance Manufacturers
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
EEI	Edison Electric Institute
FHA	Federal Housing Administration
FPC	Federal Power Commission
GAMA	Gas Appliance Manufacturers' Association
GSA	General Services Administration (U.S.A.)
IBR	Institute of Boiler and Radiation Manufacturers
IES	Illuminating Engineering Society
NESCA	National Environmental Systems Contractors Association
OGS	Office of General Services (New York State)
SEE	Southeastern Electrical Exchange
UL	Underwriters' Laboratories, Inc.

Abbreviations

Equipment

A/C	Air Conditioner
ES	Extended Service (Lamp)
GS	General Service (Lamp)
HID	High Intensity Discharge (Lamp)
LP	Liquified Petroleum
RAC	Room Air Conditioner
RCU-A-C	Split System: Air Cooled Condensing Unit, Coil Alone
RCU-A-CB	Split System: Air Cooled Condensing Unit, Coil with Blower

Miscellaneous

A	Ampere
Btu	British Thermal Unit
Btuh	British Thermal Units Per Hour
CF	Cubic Feet
CFM	Cubic Feet Per Minute
CF/YR	Cubic Feet Per Year
CO_2	Carbon Dioxide
CP	Coefficient of Performance
ERF	Effective Radiant Field
EER	Energy Efficiency Ratio, Btuh/Watt

Abbreviations

Miscellaneous

F, °F	Fahrenheit, Degrees Fahrenheit
HR	Hour
Hz	Frequency, Cycles Per Second
kW	Kilowatt
kWh	Kilowatt Hour
kWh/Yr	Kilowatt Hour Per Year
PF	Performance Factor
V	Volt
W	Watt
YR	Year

APPENDIX F

Definitions

Appliance	1)	An instrument, apparatus, or device for a particular purpose or use, and not requiring technical knowledge or artisan skill in its selection, installation, or operation.
	2)	A device, operated by electricity, oil, or gas, especially for use in the home or for performance of domestic chores.
Apparatus	1)	A group or aggregate of instruments, machine tools, etc., having a particular function or intended for a specific use.
	2)	Any complex instrument or machine for a particular use.
Consumer	1)	A person who uses goods or services to satisfy his personal needs and desires, rather than to resell them or to produce other goods or services with them (ANSI By-Laws B 6.4.1.1)
Efficiency	1)	The ratio of the work done or energy developed by an appliance or apparatus to the primary fuel energy consumed, usually expressed as a percentage.
	2.	The ratio of the work done or energy developed by an appliance or apparatus to the energy supplied it, usually expressed as a percentage.

Electric Demand

The electric energy drawn from the source of supply at the receiving terminals of an installation or system arranged over a suitable and specified interval of time. The proper interval of time is dependent upon local conditions, the most common being 15, 30, or 60 minutes. Demand is usually expressed in kilowatts.

Electric Energy Consumption

The electric energy measured and registered by a watthour meter which measures and registers the integral, with respect to time, of the active power of the circuit in which it is connected. This power integral is the energy delivered to the circuit during the interval over which the integration extends, and the unit in which it is measured is usually the kilowatt hour.

Equipment

An instrument or machine having a particular function or intended for a specific use, and requiring technical knowledge or artisan skill in its selection, installation, or operation.

Household

A house, an apartment, a group of rooms, or a single room occupied or intended for occupancy as separate living quarters. Separate living quarters are those in which the occupants live and eat independently of other persons in the structure and which have either:

(a) Direct access from outside of the building or through a common hall; or

(b) Complete kitchen facilities for the exclusive use of the occupants.

Power Rating

Output:	The power produced when an appliance or apparatus is tested under industry specified conditions and tolerances.
Input:	The power required when an appliance or apparatus is tested under industry specified conditions and tolerances.

Saturation	The ratio in percent of households that contain one or more of the given appliance or apparatus to the total number of occupied households supplied with electricity in New York State.