Potential for ENERGY CONSERVATION in the United States: 1974-1978

A Report of the National Petroleum Council

RESIDENTIAL/COMMERCIAL

POTENTIAL FOR ENERGY CONSERVATION
IN THE
UNITED STATES: 1974-1978
RESIDENTIAL/COMMERCIAL

A Report of the
Residential/Commercial Task Group
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Prepared for the
Committee on Energy Conservation of the
National Petroleum Council
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With the assistance of the
Coordinating Subcommittee
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PREFACE

The Residential/Commercial Task Group was organized under the National Petroleum Council's Committee on Energy Conservation in November 1973. In response to the charge of the Coordinating Subcommittee based upon the study request letter from the Secretary of the Interior (see Appendix A), the Residential/Commercial Task Group (see Appendix B, Committee Rosters) has prepared an appraisal of the short-term, 1974-1978, energy conservation measures applicable to the residential/commercial sector. The work of the Task Group was divided between two Subcommittees, Residential and Commercial, and their findings are presented as separate sections of this report after a brief summary of the overall study. This report represents the detailed work which served as the basis for Chapter Three, Residential/Commercial, of the National Petroleum Council's report *PotentiaZ for Energy Conservation in the United States:* 1974-1978 published on September 10, 1974.

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SUMMARY

RESIDENTIAL/COMMERCIAL

In 1972 about 16.7 quadrillion British Thermal Units (BTU's) or almost 23 percent of the Nation's total energy usage was consumed in the residential/commercial sector in the form of oil, gas, coal and purchased electricity. Including allocated electrical utility losses, the residential/commercial sector's total 1972 consumption was 24.1 quadrillion BTU's. This report examines energy conservation measures that offer significant potential for reduction in actual or projected energy consumption levels in residential and commercial markets during the period 1974-1978.

Por purposes of this study, the residential and commercial sectors were separated and examined individually. The residential sector is defined as consisting of single family dwellings, housing units for two families and mobile homes. The commercial sector is defined as consisting of all multi-family housing for three or more families as well as public and other commercial buildings.

Over the 1974-1978 period, the following energy conservation measures are judged to offer the greatest potential savings in the residential/commercial sectors, respectively, by order of rank:

Residential

- Set thermostat back to 68°P during heating season
- Ceiling insulation
- Set water heater back to l20^{0}P
- Weatherstripping and caulking
- Purnace tune-up
- Storm doors and windows.

These six conservation actions alone could achieve energy savings of 1.6 quadrillion BTU's per year or 13.2 percent of total residential demand, if customer communications reach and hold a high level over the period.

Commercial

- Establish 68°P maximum occupied thermostat setting in apartments, hotels and motels (6S0P in commercial establishments--hospitals and nursing homes excepted) during heating season
- Establish Sop night thermostat reduction below day levels in apartments and lOoP reduction for commercial buildings during unoccupied hours (hospitals and nuring homes excepted)

- Weatherstripping and caulking

- Scheduled maintenance of equipment and systems

- Ceiling insulation.

Other significant savings opportunities that do not require capital investment are the following:

- Reduce lighting levels to a minimum acceptable level where possible

- Establish minimum ventilating air requirements for occupancy periods and zero ventilation during unoccupied periods

- Establish a cooling comfort level of 78°P if basic energy is necessary

- Cease cooling of building at least one hour before termination of occupancy.

The above nine conservation actions for commercial establishments alone could achieve savings of almost 1.0 quadrillion BTU's per year, or 8.3 percent of total commercial energy consumption. Many other less significant measures are evaluated in this report. Estimates of total savings are only "orders of magnitude" because the individual savings potentials are .not precisely additive.

PART ONE

RESIDENTIAL SECTOR

PART ONE: RESIDENTIAL SECTOR

INTRODUCTION

In 1972 the residential sector was comprised of 57 million dwelling units and accounted for 8.5 quadrillion BTU's or 12 percent of the Nation's total of primary energy consumption, and 12.0 quadrillion BTU's or 16 percent when allocated electric utility losses were added. Table 1 shows the historical growth in residential consumption by energy source between 1960 and 1972. These total consumption data for the historical period are shown for the major end-use functions in Table 2.

Existing structures provide the primary targets for short-term conservation measures because they consume about 98 percent of all residential energy. Within the existing residential market, the areas that offer the greatest potential for near-term energy savings are measures dealing with: (1) life-styles, (2) upgrading thermal performance and (3) heating, ventilating and air conditioning systems (HVAC).

- *Life-Style:* The potential for energy savings in the residential market by conservation measures which require no investment is extremely large. Measures which reduce internal building temperatures, water heater temperatures and maintenance, and use of hot water are estimated to have a total potential savings of nearly 19 percent of the energy consumed by the residential sector in 1972.

  Attainment of this high level of savings will be difficult and will be based almost entirely on voluntary compliance by consumers. Recent price increases will act as a strong incentive for compliance in this area, but a major consumer education program must be initiated in order to achieve even half of this potential by 1978.

- *Upgrading Thermal Performance:* The equivalent of over 6 percent of the energy consumed in the residential sector in 1972 could be saved if a 6-inch blanket of insulation were installed in the ceilings of the estimated 17.9 million single family, owner-occupied homes with accessible attics. It is assumed, however, that 10 years will be required to upgrade these homes and thus only 10 percent of the potential is assumed achievable in each of the years 1974 to 1978. Ceiling insulation is the second most productive energy conservation measure and is one which requires a low investment on the part of the homeowner. It is estimated that an individual's savings on fuel bills will be such that this insulation investment will be paid back in about 2 years.

  It is estimated that approximately 6.4 million homes in colder climates do not have storm windows and doors. The potential savings from installing storm windows and doors

TABLE 1

GROWTH IN RESIDENTIAL ENERGY CONSUMPTION BY SOURCE-1960-1972
(Trillion BTU's)

Source	Consumption			Percent of Sector		
	1960	1968	1972	1960	1968	1972
Natural Gas (Dry)	2,591	3,721	4,327	40.3%	39.7%	36.0%
Light Oil	1,492	1,659	1,550	23.2	17.7	12.9
Liquefied Gas	322	553	685	5.0	5.9	5.7
Kerosine	360	357	349	5.6	3.8	2.9
Electricity	598	1,125	1,562	9.3	12.0	13.0
Subtotal	5,363	**7,415**	**8,473**	83.4	79.1	70.5
Allocated Electrical Conversion Losses	1,067	1,959	3,543	16.6	20.9	29.5
Total	**6,430**	9,374	12,016	100.0%	100.0%	100.0%

Source: Stanford Research Institute, *Patterns of Energy Conservation in 'the United States,* January 1972. p. 38. (Adjusted to conform with NPC definition of residential and commercial stuctures)

TABLE 2

RESIDENTIAL ENERGY CONSUMPTION
IN THE UNITED STATES BY END-USE-1960-1972
(Trillion BTU's)

	Consumption			Percent of Sector		
End-Use	1960	1968	1972	1960	1968	1972
Space Heating	3,910	5,390	6,621	60.8%	57.5%	55.1%
Water Heating	932	1,397	1,802	14.5	14.9	15.0
Cooking	450	516	577	7.0	5.5	4.8
Clothes Drying	77	158	264	1.2	1.7	2.2
Refrigeration	296	562	805	4.6	6.0	6.7
Air Conditioning	109	347	649	1.7	3.7	5.4
Other	656	1,004	1,298	10.2	10.7	10.8
Total	6,430	9,374	12,016	100.0%	100.0%	100.0%

Source: Berg, Charles A., *Conservation Via Effective Use of Energy at the Point of Consumption,* April 1973, citing Stanford Research Institute data. (Adjusted to conform with NPC definition of residential and commercial structures.)

in these homes would be approximately 20 percent of the energy used for heating in these homes and would amount to about 128 trillion BTU's. As with ceiling insulation, however, it is estimated that 10 years will be required to retrofit these houses and thus savings of 13 trillion BTU's per year are assumed achievable during the 1974-1978 period. The payout period could be as little as 1 year if plastic film were used or as great as 10 years for permanent glass insulation.

For many homes, about one-third of the heating energy is used to warm cold air leaking into the home. Virtually all structures could add weatherstripping or caulking to prevent air infiltration into the unit. While some air must be allowed to enter the dwelling unit, if air changes per hour could be reduced from 2 to .75 in the Nation's 57 million housing units, 325 trillion BTU's could be saved. It is assumed that by 1978, 25 million homes could add weatherstripping and caulking, thus saving 140 trillion BTU's.

Ducts in areas not requiring heating or cooling should be insulated. No definite data on transient heat loss in operating duct systems exist. Research by insulation manufacturers or the National Bureau of Standards (NBS) is required. Duct insulation requirements are dependent on the quantity of exposure and no generalizations can be made. Duct insulation could be achieved by incorporating full Federal Housing Administration (FHA) minimum standards into state and local codes.

- *HVAC Systems:* Annual tune-up and proper maintenance of HVAC systems will allow them to operate more efficiently and thus reduce energy consumption. It has been estimated that as high as 10 percent of heating energy could be saved by this measure at a cost of approximately $30 per year to the consumer. If all consumers were to have their furnaces tuned-up annually, 662 trillion BTU's would be saved. Similarly, annual cleaning and tune-up of air conditioning systems, particularly the outdoor heat exchanger surface, could reduce energy consumption for air conditioning by 15 percent.

The potential and maximum assumed achievable levels of savings for the conservation measures outlined above are summarized in Table 3. The maximum assumed achievable conservation potential data are subjectively derived based on cost, timing, public compliance and consumer education. Consumer education is considered to be one of the most important factors in realizing the potentials for conservation in the residential sector. Also, many of the conservation measures are interdependent so that the actual savings total would be less than the sum of the potentials; for example, the addition of full insulation would reduce the potential savings from lower thermostat settings.

The percent of the total conservation potential which could be achieved during the 1974 to 1978 period under varying degrees of consumer education is shown in Table 4. The numbers have been developed using an adapted learning curve at three levels of communication over the 5-year period. Generally, the low communication level assumes that interest in energy conservation expressed during the winter of 1973-1974 wanes during the projection period and its level approximates half that experienced last winter. The medium level of communication assumes an effort equal to that of the 1973-1974 winter, the high communication level represents an

TABLE 3

EXISTING RESIDENTIAL CONSTRUCTION
SHORT-TERM ENERGY CONSERVATION POTENTIALS- 1978
(Trillion BTU's)

Rank	Life-Style	Savings: Total Potential Percent*	Savings: Total Potential Trillion BTU'S	Savings: Maximum Assumed Achievable
1	Set Thermostat Back to 68°F (day)	15	993	745
3	Set Water Heater Back to 120°F	22.5	405	203
7	Set Air Conditioner Thermostat Up to 78°F	15	97	49
8	Set 8-Hour Thermostat Back to 60°F (night)	7	463	46
9	Reduce Bathing Water Consumption One-Third	14	252	25
10	Turn Off Pilots in Gas Furnacet	30	56	17
	Total		2,266	1,085
	Insulation, Storm Doors and Windows, Caulking			
2	Ceiling Insulation	11	733	367
4	Weatherstripping and Caulking	5	325	140
6	Storm Doors and Windows	2	128	64
	Total		1,186	571
	Heating/Cooling			
5	Furnace Tune-up	10	662	66
11	Air Conditioner Tune-up	15	97	13
	Total		759	79
	Grand Total	35.0‡	4,211	1,735

• Percentages applied to 1972 utilization data in Table 2.
t Assumes homeowners will be educated on relighting furnaces.
‡ Total potential savings may not be additive as measures included therein are interdependent and/or mutually exclusive.

effort twice that of the 1973-1974 base period. For example, as seen on Table 3, setting back the thermostat to 68°F has a total savings potential of 993 trillion BTU's. Assuming a high communication level as displayed on Table 4, 57 percent of this amount can be saved by 1975 and 75 percent,or 745 trillion BTU's, can be saved by 1978. However, if a low level of communication were used, only 29 and 37 percent could be saved by 1975 and 1978, respectively. Thus, consumer education would have a large impact on reducing energy usage in the residential market. However, to be successful, the education programs of government and industry must be constant, coordinated and creative.

Experience indicates that the homeowner's two strongest motives for conserving energy are to save money and to reduce prospects of future shortages. The key monetary message to the consumer should be the length of the payout period and actual dollar savings resulting from the installation of energy saving devices. To assist the consumer and to shorten the payout period for conservation

TABLE 4

ACHIEVABLE CONSERVATION POTENTIALS-
EXISTING RESIDENTIAL CONSTRUCTION
(Percent Per Year of Total Potential)

Living Habits/Life-Style	Communication Level	1974	1975	1976	1977	1978
Set Thermostat Back to 68°F	low	19	29	34	36	37
	med	30	45	53	57	60
	high	38	57	67	72	75*
Set Water Heater Back to 120°F	low	12	18	21	23	25
	med	18	27	32	35	37
	high	25	38	44	47	50*
Set Air Conditioner Thermostat up to 78°F	low	12	18	21	23	25
	med	18	27	32	35	37
	high	25	38	44	47	50*
Set Additional,8-Hour Thermostat Back to 60°F (night)	low	2	3	4	5	6
	med	3	5	6	7	8
	high	5	7	8	9	10*
Turn Off Pilots in Gas Furnaces	low	7	11	13	14	15
	med	11	17	20	22	23
	high	15	23	27	29	30*
Reduce Bathing Water Consumption One-Third	low	2	3	4	5	6
	med	3	5-	6	7	8
	high	5	7	8	9	10*
Insulation, Storm Doors, Caulking						
Weatherstripping, Caulking	low	4	8	12	16	24
	med	7	14	21	28	35
	high	9	18	27	36	43*
Ceiling Insulation	low	5	10	15	20	25
	med	8	16	24	32	40
	high	10	20	30	40	50*
Storm Doors and Windows	low	5	10	15	20	25
	med	8	16	24	32	40
	high	10	20	30	40	50*
Heating/Cooling						
Furnace Tune-up	low	2	3	4	5	6
	med	3	5	6	7	8
	high	5	7	8	9	10*
Air Conditioner Tune-up	low	3	4	5	6	7
	med	5	7	8	9	10
	high	6	9	11	12	13*

*Maximum assumed achievable.

equipment, financial incentives such as low interest loans and tax credits should be considered. These and other factors which emphasize the positive aspects of conservation are important to the development of a national ethic regarding conservation.

The energy consumption of a new residential unit is directly related to the building codes and regulations followed by developers and builders. However, the effectiveness of building codes designed to encourage energy conservation in new construction is dependent on the quality control exercised in the construction of the unit, especially in the installation of insulation, windows and doors, and HVAC systems. The heat losses of typical single family dwellings can be reduced by 40 percent if architects and builders will design the structures to meet not only regional climatic criteria but also to take advantage of solar loads, wind direction, ground elevation and vegetation. Additional factors which should be given consideration include: building mUlti-family dwellings; reducing the ratio of exterior wall area to floor area; reducing the window area of the dwelling from the current average of about 15 percent to 10 percent; designing out-buildings such as garages and sheds so that they help to reduce the overall energy requirements of the housing unit; and taking advantage of new technology which is available to produce HVAC systems with greatly improved efficiencies.

While original design and construction quality control are extremely important, the operating or living habits of the occupant will greatly affect the total energy requirements of a dwelling unit. After occupancy, a new unit becomes an "existing" structure, and the life-style conservation measures discussed earlier should be employed.

The means for effecting these savings are all within current building technologies. However, in some cases revisions in building and engineering codes would be needed. It is estimated that the incremental first costs of the measures to the new home buyer would be around $1,000. The annual savings in both heating and cooling costs would be about $150, an amount sufficient to pay back the original investment over a 10-year period assuming an 8 percent annual discount rate. Using a 6 percent discount rate the pay-back period falls in the 8-9 year range.

In conclusion, energy conservation can be achieved in two ways: (1) reduction of energy use and (2) utilization of efficient energy systems. In the residential sector only the first has been given consideration for the short term. However, where a choice of fuels is available, substantial energy savings can be achieved when both efficient equipment utilization in the home and efficient energy systems from the natural resource to the home are developed and applied.

EXISTING RESIDENTIAL MARKET

The potential conservation savings in the existing residential market are much greater than in new construction during the next

5-year period. There were over 54 million housing units in 1970 and almost 57 million units in 1972. Subtracting demolitions and condemnations, this segment will have an approximate net average growth of 1.2 million units per year for the next 5 years. This includes single family, two family and mobile home units. To see the relative importance of existing and new construction relative to residential energy consumption, one need only look at the fact that of the nearly 57 million single _residential units in use in 1972, only 1.1 million single family structures were built in that year. Thus, a 4-5 percent savings of energy in the existing market could supply all energy requirements of new construction for 1 year. Exhibit I provides more detail on the size and scope of the residential energy market.

In 1972, the residential sector consumed about 12.0 quadrillion BTU's which accounted for 16.4 percent of all U.S. energy demands. This includes the portion of electric utility losses that are associated with residential power consumption. The breakdown of energy demand by sector and by fuel'appear in Exhibit II. Major appliances such as space heaters, water heaters, refrigerators, air conditioners, cooking appliances and clothes dryers, consumed 89.2 percent of all residential energy as shown in Table 2. Analyzing the conservation of energy in the existing residential market, these appliances are the variables that must be considered. The appliance data that were used in the conservation calculations are shown, by source, in Exhibits III, IV and V.

In all cases, the total BTU savings are computed on 1972 base period data. The total annual savings stated for each assessment are the volumes that could be attained at the end of the short-term period, i.e., in 1978. Por example, setting back thermostats has a total potential saving in 1978 of 993 trillion BTU's, Table 4 shows what percent of this total could be saved in each of the 5 years for three different levels of communication, while Table 3 shows the estimated maximum assumed achievable in 1978.

CONSERVATION MEASURES

<u>Living Habits/Life-Styles</u>

- *Set Back Thermostat:* A reduction of 6° to 68°P on a 24-hour basis will average about a 15 percent heating energy saving. Annual potential saving is 993 trillion BTU's. Assumed achievable saving is 745 trillion BTU's annually.

  --An additional 8° nighttime reduction to 60°P for 8 hours will average an additional 7 percent heating savings. Annual potential saving is 463 trillion BTU's. Assumed achievable saving is 46 trillion BTU's annually.

  --An 8° nighttime reduction to 66°P would average a 9 percent heating saving. Annual potential saving is 596 trillion BTU's. Assumed achievable saving is 477 trillion BTU's annually. (This proposed action would be an alter-nate to the 24-hour reduction plus a nighttime reduction to 60°P. This alternate.action would result in a 314 trillion BTU reduction in the achievable saving, com-pared to the saving .described in the previous paragraphs.)

- *Set Up Thermostat (Central Cooling):* A thermostat setting raised to 78°P from 72°P on a 24-hour basis would save an average of 15 percent cooling energy. Annual potential saving is 97 trillion BTU's. Assumed achievable saving is 49 trillion BTU's.

- *Set Back Water Heater:* A reduction in water temperature from 140-150°P to 120°P would provide savings in two dis-tinct ways:

  --It would cause a 6 to 12 percent reduction in water heating energy losses in standby tanks and pipes. Annual potential saving is 108 to 216 trillion BTU's annually. Assumed achievable saving is 81 trillion BTU's annually.

  --It would cause a 12 to 15 percent reduction in useful energy consumption, assuming 30 percent used for laundry and other household uses. Annual potential saving is 216 to 270 trillion BTU's. Assumed achievable saving is 122 trillion BTU's annually.

- *Reduce Bathing Water Consumption One-Third:* Reduction by one-third of hot water used for bathing would result in energy savings of 14 percent in daily water heating. Annual potential saving is 252 trillion BTU's. Assumed achievable saving is 25 trillion BTU's annually.

- *Turn Off Standing Pilot in Gas Furnaces During Non-Heating Months:* An estimated 56 trillion BTU's could be saved if all residential gas heating customers followed this plan for the 3 non-heating months during the year. Assumed achievable saving is 17 trillion BTU's. Supporting data appear in Table 15, Exhibit IV.

  The enormous task of turning on the nearly 30 million gas space heating units somewhat limits the use of this proposal. Consumer education would be the key factor as no one entity, be it a utility, governmental body, or business could per-form this large task by itself.

Insulation, Weatherstripping and Caulking

- *Ceiling Insulation:* Existing housing could be improved by adding R-19 insulation (a 6-inch blanket of insulation) to attics where possible. Energy savings (for heating and cooling) could approach 733 trillion BTU's per year, assuming the upgrading of only 17.9 million units. All of these homes are single family, owner-occupied, with accessible attics. It may also be possible to motivate landlords of 3.2 million units to upgrade the insulation levels of rental housing to R-19. Best estimates indicate that the total upgrading process could take as long as 10 years. Thus, the assumed achievable saving is 73 trillion BTU's per year assuming 10 percent upgrading per year. The normal payout period would be approximately 2 years.

- *Storm Doors and Windows:* Installation of storm doors and windows in homes without double glazing will save, on the average, about 20 percent of the heating energy. Annual potential savings is 128 trillion BTU's, assuming the upgrading of 6.4 million homes. Assumed achievable savings would equal 13 trillion BTU's per year, and, although the payout period is dependent on the volume of fuel used, an estimated average would be 10 years for permanent units and less than 1 year for plastic film.

- *Weatherstripping and Caulking:* Weatherstripping and caulking should be checked periodically. Also, faulty construction practices which allow air infiltration into the unit should be corrected. For many homes, about one-third of the heating energy is used to warm air that leaks into the home. Virtually all structures could add or maintain weatherstripping and caulking at minimum cost. Total potential energy savings are estimated at 325 trillion BTU's, but 140 trillion BTU's savings could be attained if 25 million units could reduce air changes per hour from 2 to .75.

- *Duct Insulation:* Ducts in areas not requiring heating or cooling should be insulated. No definite data on transient heat loss in operating duct systems exist. Research by insulation manufacturers or the National Bureau of Standards is required. Duct insulation requirements are dependent on the quantity of exposure; therefore, no generalizations are possible. Duct insulation could be achieved by incorporating full FHA minimum standards into state and local codes.

- *Insulation of Hot Water Pipes:* Insulation would cost approximately $.40 per linear foot. The major limiting factor in this recommendation is the lack of numerical data needed to project actual cost savings per unit to the user. An industry study presently in process should answer this question.

Heating, Ventilatin and Air Conditionin (HVAC) Equipment, Operation an Maintenance

- *Heating Systems:* Annual tune-ups of furnaces by properly trained appliance dealers or heating contractors should be encouraged. It has been estimated that as much as 10 percent of heating energy could be saved by this means at a cost of approximately $30 per year to the consumer. Annual potential energy saving is 662 trillion BTU's. Assumed achievable saving is 66 trillion BTU's annually.

- *Install Clock Thermostat to Aid or Assist .Thermostat Turn Down:* See discussion under "Living Habits/Life-Styles."

- *Air Conditioner Tune-Up:* Annual cleaning and tune-up of air conditioning systems by qualified maintenance personnel should be encouraged. Of particular importance is cleaning of the outdoor heat exchanger surface. The coils contained in most outdoor air conditioning units can be cleaned by the homeowner, using a water hose and/or brush after disconnecting the power. Professional air conditioning maintenance will cost the average consumer approximately $75 per year with potential savings of 15 percent, or 97 trillion BTU's annually. Do-it-yourself maintenance could accomplish at least half of this potential (48.5 trillion BTU's annually). Homeowners should also clean or replace air filters and have them checked regularly. Assumed achievable saving is 13 trillion BTU's annually.

Appliance/Lighting Conservation

Suggestions listed below do not include a quantitative evaluation of energy savings but, if followed, should have a significant cumulative effect.

- Close off unused rooms and shut off registers or radiators.
- Eliminate hot water leaks.
- Install a low water consumption (2.5 gallons per minute maximum) shower head. Studies show that bathing requires about 40 percent of the hot water used in the typical household.
- Drain a gallon of hot water out of the bottom of the water heater monthly.
- Keep all appliances clean and free of obstructions.
- Keep radiators and baseboard heaters clean and provide for an unobstructed flow of air.
- Paint radiators with a flat paint or darker color. (Aluminum paint reduces efficiency.)
- Replace incandescent lights with fluorescent lighting wherever possible.
- Reduce lighting levels wherever possible.
- Turn off lights in unused rooms.
- Eliminate decorative lighting.
- Use manual defrost refrigerators wherever possible.

- Reduce usage of self-cleaning oven feature.

- Accumulate full loads for dishwasher, clothes washer and dryer.

- Par heating, draw drapes at night, open during sunny days. Reverse the process for cooling.

- Clean or replace air filter in furnace as recommended by manufacturer. Check at least once per month.

NEW HOUSING MARKET

In 1972, new construction contributed about 1.8 million new units to the existing residential market and is expected to average about 1.8 million units per year over the next 5 years. The total annual gross consumption of energy added in 1972 is estimated at 379 trillion BTU's.

Proposals for energy conservation measures in the residential sector that are considered to be achievable in the 1974-1978 period are described in the following section. Energy consumption in this residential segment is significantly affected by codes and regulations applying to the construction of homes. In addition to proper specifications, the effectiveness of conservation measures are dependent in large part on quality control exercised during the installation of insulation, windows and doors, heating and cooling systems.

Conservation Measures

In the conservation measures cited below, all data are based on an "average" or standard one-story, single family, detached home, having 1,600 square feet and design temperature difference of 70°P. Also, the standard home is located in the mid to upper range of thermal conditions in the country or at 6,000 degree days.* It has not been uncommon to have heat losses under these conditions range from 75 thousand to 100 thousand BTU hours per year. It is estimated that future heat losses, under the above conditions, will average between 30 to 50 thousand BTU hours. All calculations that follow were developed by Ralph Johnson, Vice President, National Association of Home Builders.t

* See Glossary.

t Johnson, Ralph, "Designing and Building Energy Conserving Homes." Paraphrased from speech delivered to National Association of Homebuilders Meeting, Houston, Texas, January 21, 1974.

- *Design and Construction Criteria:* The structure should be designed to meet not only regional (climatic) criteria, but should also be so oriented on the lot as to take advantage of solar loads, wind direction, ground elevation and vegetation. Additional cost to the consumer would be minor. Such design criteria can be encouraged through contacts with trade and professional associations and educational institutions. Builders must be induced to consider energy savings in designing and building for optimization of the structure as it relates to its total environment.

- *House Type:* Multi-family buildings should be constructed for lower heat loss and heat gain. Individual dwellings in condominium buildings, townhouses, semi-detached dwellings and apartments all have less heat loss per square foot of floor area than single family, detached dwellings.

- *House Shape:* Reducing the ratio of exterior wall area to floor area will reduce energy cbnsumption. Theoretically, a two-story, square house has the least heat loss, but with R-ll (3-1/2 inches of blanket insulation) and R-19 insulation (6 inches of blanket insulation) use in the walls and ceilings, respectively, a one-story horne, relatively deep front to back, has essentially the same heat loss as a two-story horne.

  A one-story horne, 32 feet deep by 50 feet long, uses 675 BTU hours less than a horne having the same area whose dimensions are 24 by 66-1/2 feet (assuming R-ll wall insulation). Reducing the wall height in this one-story horne from 8 feet to 7-1/2 feet, even with full thick wall insulation, will conserve another 400 BTU hours.

  Avoiding the use of L, T and H shaped dwellings conserves energy. A 24- by 50-foot house with a 20- by 20-foot L has the same area as the 32- by 50-foot house but has about 1,000 BTU hours greater heat loss.

- *Reducing Window Area:* The window area of the typical dwelling is probably equal to about 15 percent of the floor area. This can be reduced under most codes to 10 percent. In a 1,600 square foot horne, for example, this would mean a reduction of 6,300 BTU hours if single glass is used or 3,300 BTU hours with double glass or storm sash.

  When reducing window area, it is preferable to do so by raising the sill height. This method has two advantages. First, it retains the upper portion of the window, which provides better natural illumination. Second, it helps to reduce heat gain in the summer because the upper portion of the window is more easily shaded by overhang. Using a light color finish for walls, ceilings and floors will also enhance the level of natural light.

- *Increasing Window Glazing:* If only the minimum glass area of 10 percent is used, switching from single glass to either double glazing or storm sash will save 6,200 BTU hours. Using double glass and storm sash (i.e., triple glazing) will save another 2,500 BTU hours.

Thermal break type metal windows reduce heat loss. Authorities disagree on the amount of heat conducted through the metal sash compared to the wood sash, but in any event, the thermal break does reduce heat loss and condensation.

- *Reducing Window Air Infiltration:* The quality of windows greatly influences the amount of air infiltration, which is a major heat loss factor. A poorly fitting window not weatherstripped, will allow 5-1/2 times as much air infiltration as an average fit window that is weatherstripped. In terms of energy consumption, the difference is very large (20,400 BTU hours for the average home, even with the minimum 10 percent glass area). On the other hand, the thermal effect of air infiltration between a poorly fitted, weatherstripped window and an average fit, weatherstripped window is much less but still quite significant--a savings on the order of 4,500 BTU hours.

  Storm sashes not only reduce heat loss but they also reduce air infiltration--a savings of 3,700 BTU hours. Thus, in an average home, the addition of storm sashes would save 9,900 BTU hours, about two-thirds due directly to reduced heat loss and the other one-third due to reduced wind infiltration. In the standard home, three-fourths of an air change per hour for infiltration would provide a healthy environment for occupants.

- *Reducing Heat Gain Through Windows:* The area, location and shading of windows and the use of double glazing or storm sash are important to energy conservation in the use of air conditioning.

  --If we assume that the standard house has 200 square feet of window area (12-1/2 percent of total area) which is equally distributed on all four sides of the dwelling, the heat gain, in the mid-section of the country, is reduced 2,000 BTU hours with double glazing or storm windows instead of single glazing. (This assumes a 95°P daily temperature with a range of 15°-25°. Thus,.the daily low temperature could range from 70°P to SOop.)

  --If the area of glass on the east and west walls is reduced to 10 percent of the total for each exposure, and 40 percent is used in the north wall and 40 percent in the south wall, another 2,100 BTU hours can he saved, over and above the savings from the use of double glazing or storm sashes.

  --Shading southern exposure glass with an overhang is an important method of reducing heat gain in the summer without impairing heat gain in the winter. In summer in the 35° latitude region (North Carolina, Oklahoma, Nevada), a 32-inch overhang will completely shade floor to ceiling glass having a southern exposure and reduce heat gain 50 percent. This action would save 1,200 BTU hours. In homes where large east or west glass area is essential to the design, and shading is not feasible, reflective coating, double-paned glass can cut heat gain by as much as 75 percent.

- *Storm Doors:* Assuming that the standard house has two regular size exterior doors, the addition of storm doors saves 600 BTU hours because of the increased insulating value of the storm doors.

- *Reducing Air Infiltration from Doors:* A well-fitted door allows as much air infiltration as a poorly fitted, double-hung wood window. For wood doors this is doubled due to warpage. Storm doors cut air infiltration in half, saving 1,400 BTU hours due to infiltration reduction and a potential total of about 2,000 BTU hours.

- *Reducing Heat Loss Through the Framing:* The use of 24-inch, on-center wall framing and the adoption of some of the lumber framing techniques set forth in the *Manual of Lumber and Plywood Saving Techniques* can reduce heat loss by about 700 BTU hours.* This is because heat loss through the wood section is greater than through the full insulated cavity (assuming that 1/2-inch insulation board is used for sheathing).

- *Isolation:* Garages and carports can help reduce the energy load. If there is a choice, in cold climates, attached garages should be put on the north, northeast, or northwest exposures. In hot climates, put the attached garages or carports on the east or west walls of the dwelling to shade east or west glass, thereby reducing heat gain.

  It is thermally advantageous to have the ridge of the house about parallel to the east/west axis. If appropriate, use proportionately more glass on the south wall and shade it with 'the right amount of overhang to reduce heat gain. Occasionally, it is possibly to locate the dwelling or windows to take advantage of the shadow cast by existing trees to reduce solar heat gain in the summer. Locating the air conditioning unit where it will be shaded, particularly in the afternoon, by the house, trees, garage or carport will increase unit efficiency and reduce energy use.

- *Crawl Space:* Using closeable vents (closed in winter) and a vapor barrier ground cover if the crawl space is unheated will reduce heat loss even if the floors are insulated. A preferable and more economic design is a heated crawl space

* National Association of Home Builders, *Manual of Lumber and Plywood Saving Techniques*, June 1971.

(plenum) with a vapor barrier on the ground and insulation on the perimeter walls rather than in the floor. In the standard home, this reduces the area and cost of required insulation by two-thirds; the cost of ductwork can be reduced; and the resulting higher mean radiant temperature will increase the comfort of the occupants. Furthermore, the heat loss will be reduced at least 2,800 BTU hours, using R-ll insulation in both cases and taking into account· the different design temperatures.

- *Basement Walls:* If we assume the standard house has a full basement and that the average basement wall exposure above grade is 2 feet, the heat loss through the typical 8-inch block wall would be 11,600 BTU hours. Adding furring strips and R-3 or masonry wall insulation, covered with either gypsumboard or 3/8-inch plywood, reduces the heat loss by 6,400 BTU hours. If 2- by 2-inch furring strips are used, and R-7 insulation (2 inches of blanket insulation) is compressed to *1-1/2* inches in thickness, another 1,300 BTU hours can be saved.

- *Slab-On Grade:* If the standard house has a slab-on grade, the use of 1- by 2-inch wide-edge insulation will save 4,000 BTU hours, compared to using no-edge insulation. The use of 2-inch by 24-inch wide-edge insulation will save an additional 2,900 BTU hours. If a perimeter heat duct system under the slab is used, the savings from using edge insulation are greater.

- *Wall Insulation:* R-7 insulation in the walls, rather than none, will save 8,800 BTU hours. R-ll insulation instead of R-7 will save another 1,800 BTU hours. (In usual calculations, these numbers would be 17 percent higher because the above savings take into account the difference in heat loss through the wood studs and through the insulation.)

  If *3/4-inch* foam polystyrene board is substituted for the lIZ-inch insulation board, the heat loss would be reduced an additional 1,200 BTU hours.

- *Ceiling Insulation:* Heat loss through the ceiling would be reduced by 4,400 BTU hours annually by using R-ll ihstead of R-7 insulation in the ceiling. Using R-19 saves an additional 3,600 BTU hours. Using R-22 saves an additional 700 BTU hours.

- *Attic Ventilation:* Even with ceilihg insulation and a vapor barrier in the ceiling, good practice requires 1 square foot of attic ventilation area for each 300 square feet of ceiling. Forced mechanical ventilation of the attic space can significantly reduce air temperatures during the summer and thereby decrease air conditioning loads. Sufficient data are not available to pinpoint the required amount of ventilation or the contribution that would make to reducing the heating load. In general, however, 10 to

60 air changes per hour, depending on the humidity, will have a significant temperature reducing effect.

In the standard home using a 4 in 12 pitch roof, 10 air changes per hour would require a fan having a capacity of 350 cubic feet per minute, and 60 air changes per hour would require a 2,100 cubic feet per minute fan. The higher number of air changes per hour is necessary in climates having high humidity.

It is estimated that, with R-19 insulation in the ceiling and an exhaust fan system thermostatically controlled to maintain a temperature no higher than 100°F, the yearly reduction in heat gain would be about 1,500 BTU hours where the design temperature is 95°F with a daily temperature range of 15°-25°.

- *Roof Shingle Color:* Even with a well insulated ceiling, the color of the roof does make a difference insofar as heat gain is concerned. In the standard home, a light colored roof surface compared to a dark colored roof surface lowers the design energy requirement for cooling by 600 BTU hours.

- *Duct Insulation:* Ducts should not be run through non-conditioned space. If this is not possible, they should be insulated. In the standard home, 2-inch flexible or 1-inch rigid insulation on the ducts in non-conditioned spaces will reduce heat loss by about 3,400 BTU hours, or about 30 percent, compared to the use of 1-inch flexible insulation. For cooling, the 2-inch flexible or 1-inch rigid insulation will save 1,500 BTU hours compared to the 1-inch flexible insulation, assuming that the ducts are in the attic space.

The preceding recommendations and their potential savings calculations are based on a specific system design. Ideally, thermal performance levels should be improved by changing the design rather than by modifying specific system elements.

Standards and Codes

New construction should be upgraded to required Federal Housing Administration thermal performance levels outlined in FHA MPS-1, 4900.1 or MPS-1, 4910.1.* These requirements list minimum performance criteria for walls, ceilings, floors and windows of single and multi-family structures. In most cases this is a requirement of: .05 "u" value for ceilings; .08 "u" value, for walls; and. .10 "u" value for floors and storm windows.† The term "u"

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* Federal Housing Administration, *Federal Minimum Property Standards for One and Two Family Dwellings*, revised July 1974; and *Federal Minimum Property Standards for Multi-Family Dwellings*, 1973 edition.

† See Glossary.

value is defined as BTU's per hour per square foot per 1° , or as the reciprocal of resistance. These factors apply where degree days exceed 4,500.

Energy savings over current practice would be about 14 trillion BTU's per year at a housing start level of 1.6 million units. Cost to the consumer is estimated to be less than $100 per unit. Modes of motivation to achieve such standards are:

- Effect changes in state building codes.
- Add requirements to National Codes.
- Request National Association of Home Builders and other related associations to stress conservation concepts to its members, including quality control.
- Require minimum thermal performance criteria, established by regulatory commissions as in the case of the New York State Public Service Commission's recent action establishing minimal insulation standards.

In consideration of mobile home thermal performance, the American National Standards Institute (ANSI) Standard A 119.1 (1974) should be the guide specification for the construction of all mobile homes in the United States. This standard requires insulation levels of R-l6 for ceilings, R-8 for walls and R-lOfor floors.

Heating, Ventilating, Air Conditioning Systems (HVAC)

Proper sizing and installation of heating and cooling systems should be encouraged. There appears to be considerable agreement within the industry that, by and large,gas and oil heating equipment is oversized at the time of original installation. Similarly, air conditioning equipment is often oversized to insure that more than enough capacity is available for the one peak day each summer. This often leads to energy waste in a number of ways: (1) the equipment is used more intermittently as opposed to "steady state" operation where utilization efficiency is higher; (2) energy conserving living habits (keeping doors closed, etc.) are not encouraged from a comfort standpoint since recovery is so fast.

The most comman explanation for this practice of oversizing is the lack of proper training for installers in how to perform complex heat loss/heat gain calculations. Even those with proper training find "rule of thumb" methods more convenient, with the installer preferring to err on the high side. This also provides more allowance for error in the installation of ductwork, vents, and other elements of the heating and cooling system.

It has also been suggested that the pricing system for new equipment doesn't really encourage careful determination of the ideal size furnace unit. The price differential between capacities is so slight that relatively small first cost savings can be achieved by installing somewhat smaller units. Over two-thirds of these installations go into new homes built for resale in which the ultimate owner has no influence over the choice of heating and cooling units. Some manufactvrers have made vigorous efforts toward dealer training on this matter. However, the large number of dealers and installers coupled with the limited incentives for correcting the problem make progress very difficult.

Heat pumps should be considered if electricity is the source of energy for heating and cooling. Heat *pumps* use about one-third to two-thirds less energy than electric resistance heating. While the electric resistance heater is 100 percent efficient in dwellings, conversion of primary fossil fuels to electricity plus line losses result in overall fuel efficiencies of approximately 29 percent.

More efficient furnaces and air conditioners should be installed. Some are now available that are over 10 percent more efficient than conventional units.

Zone control provides independent temperature control for each area to be heated or cooled that cannot be properly provided for by the normal action of a single thermostat. With the addition of a thermostat and a component to direct the flow of water (for hot water systems) and/or a damper to direct the flow of air (warm air systems or air conditioning systems), a unit, for a moderate cost, can be zoned for independent distribution.

There are a number of advantages of zone heating and air conditioning. Fuel savings will be achieved because only the occupied area is heated or cooled. Temperatures in unoccupied areas can be adjusted when higher or lower temperatures are required, and thus a quicker response in temperature change is normally achieved. Finally, comfort in sleeping and living areas, can be individually controlled for desired temperatures.

Automatic ignition systems for gas heating equipment should be installed. The American Gas Association (AGA) estimates that 11.6 percent of residential gas consumption in 1972 was consumed by gas pilots. This equates to approximately 502 trillion BTU's. Of this amount, 75 percent was determined to produce useful energy. Presumably, 25 percent, or 125 trillion BTU's, of pilot consumption did not produce useful work. In fact, the usefulness of the constant pilot is highly dependent on the climate of the area in which the appliance is located. In warmer climates, where a positive heat balance exists for most of the year, the pilot provides little useful heat and usually produces an added burden on air conditioning equipment.

One way to reduce pilot consumption is by installing automatic ignition systems which consume energy only while being used to actually ignite the appliance burners. Presently, such units are only in widespread use on gas dryers. Practically all gas dryers produced today have such systems. It is generally concluded that little energy could be saved by including such devices on gas water heaters. This is due to the fact that pilot heat helps in heating the water and maintaining tank temperatures.

Automatic ignition has been most widely discussed in connection with cooking. In regard to cooking, American Gas Association tests concluded that pilots consume 30 percent to 32 percent of total range consumption. However, the range is not a major gas consumer, using only 5 percent taB percent of total residential gas (see Table 11, Exhibit IV). Research and development is continuing regarding automatic ignition for furnaces, and such systems should be available in 1 to 3 years for most models. One industry spokesman commented that they are technologically feasible today, but economic incentive has been lacking for their development.

Furnaces should be installed so that it will be relatively simple for the homeowner to change filters. Clock thermostats should be installed on heating units (see discussion under "Living Habits/Life-Styles").

Automatic damper control devices save fuel by preventing the escape of conditioned air through the stack during the time that the burner is not firing; therefore, they are only useful where the heating unit is located in a heated area. The AGA estimates a 3-4 percent fuel saving for these devices under optimum conditions. Furnaces with factory-installed automatic damper controls have already been certified for safety by AGA. There are, however, strong reservations about field-installed units in existing systems.

<u>Appliances</u>

- *Water Heaters:* The manufacture of more efficient water heaters, including better insulation, would be desirable. No quantitative data is available at present on energy savings to be gained from this measure; however, it is estimated that the cost to the consumer would be minimal.

- *Refrigerators:* Promote the use of the conventional over/under refrigerator-freezer as these units use less energy than a side-by-side refrigerator-freezer. Promote manual defrost refrigerators. The frost-free refrigerators use up to 50 percent more energy than the manual defrost type. This requires about 200 BTU hours of additional energy.

- *Exhaust Pans:* Minimize the use of exhaust fans, especially in cold climates. Research has shown that they can be the source of very large amounts of infiltration air. When they are necessary, use a model with a positive shutter closure.

- *Lighting:* In the typical dwelling, lighting is the fourth largest energy user, consuming about 2 to 3 percent of the total. During the winter, heat from lighting is useful. In the summer, however, it is estimated that lighting adds about 500 to 1,000 BTU hours to the air conditioning load in a typical size dwelling. Not much can be done about this in terms of installed capacity, although the use of less general purpose lighting and more specific purpose lighting will tend to cut back the total energy used for lighting. Fluorescent lamps should be used when possible, since they produce nearly four times as much light per watt as does the typical general purpose light bulb. Do not use recessed or "bullet" lamps that penetrate into non-conditioned space like an attic. All heat from such lamps is lost. Also, they can be a large source of air infiltration.

EXHIBIT I

SIZE AND SCOPE OF RESIDENTIAL MARKET

RESIDENTIAL SECTOR

TABLE 5

RESIDENTIAL YEAR-ROUND HOUSING UNITS--TOTAL U.S., 1970

Type of Structure	All		Owner-Occupied		Renter-Occupied		Vacant	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
One Family	46,790,551	86.0	35,509,334	92.1	8,530,590	69.6	570,818	64.0
Two Family	5,443,910	10.0	1,706,430	4.4	3,401,876	27.6	325,604	36.0
Mobile Home	2,072,887	4.0	1,751,682	4.5	321,205	2.6		
Total	54,307,348	100.0	38,967,446	100.0	12,253,671	100.0	896,422	100.0

Source: U.S. Bureau of the Census, *1970 Detailed Housing Characteristics Final Report HC (l)-B1 United States Summary*, Washington, D.C., July 1972, Table 22.

Exhibit II

TABLE 6

PRIVATELY OWNED HOUSING UNITS
COMPLETED--1968-1973*
(Thousands of Units)

Year	Total	Units Per Structure: One Unit Number	One Unit Percent	Two Units Number	Two Units Percent
1968	903	859	95	44	5
1969	852	808	95	44	5
1970	845	802	95	43	5
1971	1,065	1,014	95	51	5
1972	1,197	1,143	95	54	5
1973	1,224	1,166	95	58	5

* Net of demolitions and condemnations. Excludes Mobile Homes.

Source: U.S. Bureau of the Census, Construction Reports Series C22, *Housing Completions*, U.S. Department of Commerce, Washington, D.C., 1974, p.2.

Exhibit II

EXHIBIT II

ENERGY DEMANDS BY SECTOR AND FUEL

RESIDENTIAL SECTOR

TABLE 7

ENERGY USE BY SECTOR

Sector of Consumption	Energy Use: Quadrillion BTU's	Energy Use: Percent of Total
Commercial	12.051*	16.5
Residential*	12.016	16.4
Transportation	17.000	23.2
Industrial	28.380	38.8
Feedstock (Non-energy)	3.700	5.1
Total	73.147	100.0

* Computation of Residential Energy Demand:

1972 Residential Consumption (Quadrillion BTU's)		Electric Conversion Allocated to Residential Sector (Quadrillion BTU's)		Actual Residential Market (Percent)--Remainder Allocated to Commercial	Total Residential Energy Demand (Quadrillion BTU's)
10.5	+	(33.8% x 13.0) = 4.39	x	80.7%	12.016

Source: National Bureau of Standards, *Technical Options for Energy Conservation in Buildings*, June 1973. (Adjusted to conform with NPC definition of residential and commercial structures.)

TABLE 8

PROJECTED DEMAND FOR ENERGY INPUTS TO THE
HOUSING AND COMMERCIAL SECTORS BY ENERGY SOURCE
(Trillions of BTU's)

	1975		1980		1985	
Energy Source*	Amount	Percent	Amount	Percent	Amount	Percent
Coal	262	1.6	242	1.3	81	0.4
Petroleum	5,609	34.5	6,230	32.4	7,102	31.7
Natural Gas	6,988	42.9	7,650	39.7	8,118	36.3
Synthetic Gas	--	--	258	1.3	759	3.4
Purchased Electricity	3,422	21.0	4,874	25.3	6,295	28.2
Total Sector Energy Input	16,281	100.0	19,254	100.0	22,355	100.0

* Does not include non-energy uses.

Source: Dupree, Walter G., Jr. and West, James A., *United States Energy Through the Year 2000*, U.S. Department of the Interior, December 1972, p.24. (Adjusted to conform with NPC definitions of residential and commercial structures.)

Exhibit II

EXHIBIT III

RESIDENTIAL APPLIANCES IN USE

RESIDENTIAL SECTOR

TABLE 9

NUMBER OF HOME APPLIANCES IN USE--TOTAL U.S., 1970

Appliance	Number of Homes With at Least One Unit	Percent Saturation
Ranges/Stoves	54,144,426	99.7
Water Heaters	52,243.669	96.2
Television Sets	51.863,517	95.5
Clothes Washers	°38,612,524	71.1
Central Furnaces	34.965,317	64.2
Clothes Dryers	22,646,164	41.7
Home Food Freezers	15,314,672	28.2
Room Air Conditioners	14,500,062	26.7
Dishwashers	10,264,089	18.9
Central Air Conditioners	6,245,345	11.5
Vented Room Heaters	6,191,038	11.4
Unvented Room Heaters	3,041,211	5.6
Built-in Electric Heating	2,769,675	5.1
Occupied Housing Units		54,307,348

Source: U.S. Bureau of the Census, *1970 DetaiZed Housing Characteristics FinaZ Report HC (1)-B1 United States Summary*, Washington, D.C., July 1972, pp. 254, 288. (Adjusted to conform with NPC definition of residential and commercial structures.)

Exhibit III

TABLE 10

MAJOR HOME APPLIANCE SATURATION, BY FUEL--TOTAL U.S., 1970

Fuel Type	Space Heating		Water Heater		Range/Stove		Clothes Dryer		Air Conditioner	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Natural Gas	29,977,658	55.2	29,923,349	55.1	26,773,523	49.3	6,734,111	12.4	271,537	0.5
Electricity	4,181,665	7.7	13,794,066	25.4	22,048,783	40.6	15,912,053	29.3	5,973,808	11.0
Fuel Oil	14,119,910	26.0	5,322,120	9.8	271,537	0.5				
Coal or Coke	1,574,912	2.9	325,845	0.6	108,615	0.2				
Wood	705,996	1.3	54,307	0.1	325,844	0.6				
Bottled Gas/ Liquefied Petroleum Gas	3,258,441	6.0	2,715,368	5.0	4,561,817	8.4				
Other Fuel	217,229	0.4	108,614	0.2	54,307	0.1				
None	271,537	0.5	2,063,679	3.8	162,922	0.3	31,661,184	58.3	48,062,003	88.5
Total	54,307,348	100.0	54,307,348	100.0	54,307,348	100.0	54,307,348	100.0	54,307,348	100.0

Source: U.S. Bureau of the Census, *1970 DetaiZed Housing Characteristics FinaZ Report He(l) - B1 United States Summary,* Washington, D.C., July 1972; AGA Information Data Sheet, March 19, 1974. (Adjusted to conform with NPC definition of residential and commercial structures.)

EXHIBIT IV

APPLIANCE ENERGY CONSUMPTION

RESIDENTIAL SECTOR

TABLE 11

RESIDENTIAL CONSUMPTION OF NATURAL GAS BY MAJOR END-USE IN 1970 (PRIMARY INPUT)

Sources: U.S. Bureau of the Census, *1970 Detailed Housing Characteristics Final Report HC(l) - B1 United States Summary*, p. 254; AGA Research and Engineering Division, *Energy Utilization Efficiencies of Major Home Appliances*, July 1973, p. 5; AGA Information Data Sheet, March 19, 1974. (Adjusted to conform with NPC definition of residential and commercial structures.)

Exhibit V

TABLE 12

RESIDENTIAL CONSUMPTION OF OIL BY MAJOR END-USE IN 1970 (PRIMARY INPUT)

End-Use	(1) U.S. Average Dwelling Unit Consumption (Million BTU's/Yr.)	(2) Dwelling Units in Use (1970)	(lx2) End-Use Consumption (Million BTU's/Yr.)	(lx2 ÷ .88) Primary Energy Consumption (Million BTU's/Yr.)
Space Heating	154.8	14,119,910	2,185,762,068	2,483,820,532
Water Heating	41.0	5,322,120	218,206,920	247,962,409
Total			2,403,968,988	2,731,782,941

Source: U.S. Bureau of the Census, *1970 Detailed Housing Characteristics Final Report HC(l) - B1 United States Summary*, p. 254. The average annual consumption of fuel oil represents data from 28 heating oil consuming states. These states in the Pacific Northwest, Upper Mid-West, New England and Atlantic Coast consume 98 percent of oil used for space and water heating purposes.

TABLE 13

RESIDENTIAL CONSUMPTION OF ELECTRICITY BY MAJOR END-USE IN 1970 (PRIMARY INPUT)

End-Use	(1) U.S. Average Dwelling Unit Consumption (Million BTU's/Yr.)	(2) Dwelling Units in Use (1970)	(1x2) End-Use Consumption (Million BTU's/Yr.)	(1x2 ÷ .30) Primary Energy Consumption (Million BTU's/Yr.)
Space Heating	99.0	4,181,665	413,984,835	1,379,949,450
Water Heating	23.3	13,794,066	321,401,738	1,071,339,126
Cooking	5.9	22,048,783	130,087,820	433,626,065
Clothes Drying	6.9	15,912,053	109,793,166	365,977,219
Air Conditioner	15.8	5,973,808	94,386,166	314,620,554
Total			1,069,653,725	3,565,512,414

Sources: U.S. Bureau of the Census, *1970 Detailed Housing Characteristics Final Report HC(l) - B1 United States Summary;* AGA Research and Engineering Division, *Energy Utilization Efficiencies of Major Home Appliances*, July 1973, p. 5; "Conservation of Energy" a National Fuel and Energy Policy Study: Proposed by Committee on Interior and Insular Affairs, U.S. Senate, Senate Resolution #45. (Adjusted to conform with NPC definitions of residential and commercial structures.)

Exhibit IV

TABLE 14

ANNUAL ELECTRICITY CONSUMPTION BY HOME APPLIANCES AND LIGHTING

Appliance	Consumption (Kilowatt Hours)	Consumption (BTU's)
Electric Blanket	150	511,800
Can Opener	0.3	1,024
Clock	17	58,004
Coffee Maker	100	341,200
Dishwasher (With Heater)	350	1,194,200
Fan (Attic)	270	921,240
Fan (Furnace)	480	1,637,760
Fluorescent Light (3-Fixture)	260	887,120
Food Freezer (16 Cu. Ft.)	1,200	4,094,400
Food Mixer	10	34,120
Food Waste Disposer	30	102,360
Frying Pan	240	818,880
Hair Dryer	15	51,180
Hot Plate (2-Burner)	100	341,200
Iron (Hand)	150	511,800
Light Bulbs	1,870	6,380,440
Radio (Solid State)	20	68,240
Radio Phonograph (Solid State)	40	136,480
Refrigerator (Frost-Free) (12 Cu. Ft.)	750	2,559,000
Sewing Machine	10	34,120
Shaver	0.6	2,047
Television (Black/White)	400	1,364,800
Television (Color)	540	1,842,480
Toaster	40	136,480
Vacuum Cleaner	45	153,540
Washer (Automatic)	100	341,200
Total	7,188	24,525,456

Source: Citizens' Advisory Committee on Environmental Quality, *Citizen Action Guide* to *Energy Conservation*, September 1973, p. 32.

TABLE 15

ESTIMATED NON-PRODUCTIVE ENERGY CONSUMED BY STANDING GAS PILOTS

Appliance	Annual Pilot Consumption* (Million BTU's)	Percent of Pilot Consumption Not Contributing To Heat Load†	Non-Productive Energy Consumed By Gas Pilot (Million BTU's)
Water Heater	210,003,480	30.4	63,841,057
Range	139,459,200	30.4	42,395,596
Heating	224,944,750	30.4	68,383,204
Clothes Dryer	10,884,300	100.0	10,884,300
Total			185,504,157

* Cuccinelli, Kenneth, "Gas Pilots... A Useful Ignition Device With Fringe Benefits," *AGA Monthly*, September 1973, p. 21.

† Developed from Census data and U.S. Statistical Abstract, 1972.

EXHIBIT V

REGIONAL ANALYSIS

RESIDENTIAL SECTOR

TABLE 16

REGIONAL ANALYSIS OF HOUSING CHARACTERISTICS

Housing Characteristics	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	Total
Owner-Occupied Homes	2,221,732	6,694,727	8,353,042	3,569,467	5,991,876	2,578,596	3,885,729	1,648,443	4,941,568	39,885,180
(Less Mobile Homes)	(46,217)	(132,272)	(249,534)	(128,883)	(366,450)	(125,109)	(137,762)	1132,985)	(225,661)	(1,544,873)
Owner-Occupied Homes	2,175,515	6,562,455	8,103,508	3,440,584	5,625,426	2,453,487	3,747,967	1,515,458	4,715,907	38,340,307
Number Normal Degree Days	6,676	5,769	6,273	6,676	2,665	2,532	2,815	5,298	3,713	4,729
Attics (Sq. Ft.)	982	1,013	957	1,019	1,228	1,290	1,323	1,132	1,157	1,122
Percent Accessible Attics	77	75	71	77	81	83	82	79	79	77
Number Accessible Attics	1,675,147	4,921,841	5,753,491	2,649,250	4,556,595	2,036,394	3,036,394	1,197,212	3,725,567	20,588,830
Little or No Insulation (Percent)	26	24	26	22	18	17	16	20	21	22
Number Uninsu1ated Attics	435,538	1,181,242	1,495,908	582,835	820,187	346,187	491,733	239,442	782,369	6,375,441
2 Inches But Less Than 3 Inches Insulation (Percent)	34	32	32	31	24	22	22	28	27	28
Number Insulated Attics	569,550	1,574,989	1,841,117	821,268	1,093,583	448,007	676,133	335,219	1,005,903	8,365,769

Note: Information derived from 18-cities study, National Association of Home Builders and 1970 Census data. There are also 23.6 million units that are renter-occupied; of these, 8.6 million are single family units. None of these are considered in this study since there is no current motivation to upgrade.

PART TWO

COMMERCIAL SECTOR

PART TWO: COMMERCIAL SECTOR

INTRODUCTION

In 1972, the commercial sector (including multi-family residential units housing three or more families) consumed 8.2 quadrillion British Thermal Units (BTU's), or about 11 percent, of the Nation's total primary energy and 12.1 quadrillion BTU's, or 17 percent, when allocated electric utility losses are included. Computations of energy consumption in the commercial sector for 1972 are included as Exhibit VI.

As with the residential sector, various measures for potential energy conservation have been analyzed. Since the commercial sector is comprised of a number of varying building types, separate analyses were prepared for the following categories: (1) colleges, (2) hotels and motels, (3) offices, (4) hospitals, (5) supermarkets, (6) schools, (7) stores and (8) apartments. Together, these eight building types account for 90 percent of the total energy consumed in the commercial market. Each of the eight building types was analyzed for potential savings based on four major end-use applications: (1) space heating, (2) air conditioning, (3) water heating and (4) lighting.

In order to quantify the savings potentials by end-use and building type, it was necessary to develop a model of an average building for each type and to hypothetically locate it in an average geographical area. Energy demand for all end-uses was developed by building type. Methods of energy conservation were then applied to the model buildings, and resultant savings were computed. An analytical presentation of the comparison of the values of various energy conservation approaches in each building type category, indicating the degree of diffiCUlty of implementation, is included in Exhibit VII. Exhibit VIII contains the matrices for the various energy conservation approaches upon which Table 30, Exhibit VII, is based.

Table 17 shows the energy conservation measures which were considered and ranks them by the magnitude of the estimated BTU savings attainable through their implementation. These BTU savings potentials are aggregated from the savings potentials of the eight building type categories studied, but the percentages are calculated on the total consumption of the commercial sector. It is logical to assume that the results of applying energy conservation measures to the building types represented by the remaining 10 percent of the commercial market would be somewhat comparable to those estimated for the 90 percent of the market evaluated. Thus, if the entire market were analyzed, savings on the order of approximately 10 percent greater than those displayed in Table 17 could be anticipated.

Categories designated I-IV were assigned to the conservation measures in order to rank them by degree of consumer acceptance. Category I measures are those which would require no consumer investment and are similar to those described in "Living Habits/Life-

TABLE 17

ENERGY CONSERVATION MEASURES BY RANK, CATEGORY AND YIELD-COMMERCIAL SECTOR

Rank by Potential Yield	Category	Conservation Measure	Total Potential: Total (OBTU)	Total Potential: Percent of 1972 Commercial Sector	Assumed Achievable: Total (OBTU)	Assumed Achievable: Percent of 1972 Commercial Sector
"		Establish a 68°F. maximum occupied temperature level in apartments and hotel/motels and 65°F. in commercial estab· lishments; hospitals and nursing homes excepted.	1.084	9.0	.358	3.0
2.		Establish a 5°F. night setback below day levels in apartments and 10°F. for commercial buildings during unoccupied hours; hospitals and nursing homes excepted.	.688	5.7	.227	1.9
3.	II	Caulk and weatherstrip around all windows and between building walls and window frames.	.591	4.9	.089	.7
4.	II	Scheduled maintena",;e on equipment and systems.	.587	4.9	.088	.7
5.	III	Insulate ceiling, above or below roofs, using insulation having an equivalent "R"factor of 19.	.542	4.5	.011	.0
6.	III	Insulate sidewalls using insulation having an equivalent "R" factor of 1"	.513	4.3	.010	.0
7.	III	Install storm sash, or high efficiency glass.	.493	4.1	.010	.0
8.	I	Reduce lighting levels to a minimum acceptable level where possible.	.292	2.4	.096	.7
9.	II	Establish minimum ventilating air requirements for occupancy periods and zero ventilation during unoccupied periods where possible.	.159	1.3	.024	.2
10.	II	Use restricted flow shower heads. (2.5 gallons per minute maximum)	.097	.8	.015	.1
11.•		Establish a cooling comfort level of 78°F. if basic energy is **necessary.**	.096	.8	.032	.2
12.		Cease cooling of building at least one hour before termination of occupancy.	.086	.7	.028	.2
13.	II	Use automatic shutoff faucets in lavatories.	.064	.5	.010	.0
14.	II	Reduce water distribution pressure to a maximum of 25 p.s.!.	.063	.5	.009	.0
15.	I	Reduce temperature of general purpose hot water by 20°F. (120°F. minimum) except where dishwashers require otherwise.	.059	.5	.019	.1

-Reheat systems should be considered as separate cases.

Styles" in Part One. Category II measures would require some small investment by the consumer such as that required for scheduled equipment and systems maintenance or caulking and weatherstripping. Category III measures would require more substantial investments. Category IV comprises those measures which would be associated with new construction and/or major renovation of existing buildings. All approaches in Category IV are assumed to be future methods that will be implemented as part of building codes by regulatory bodies. Since they are not feasible in the short term, they will be considered in the Phase 11--1979-1985 report of the Committee.

In the majority of cases, the dollar savings from instituting conservation measures would compensate the owner for the investment in a reasonable time. A definition of "reasonable," of course, is dependent upon the consumer's financial status and, in extreme instances, some type of incentive beyond savings benefits would be required to induce the consumer to act.

In Table 17 the total potential of these various conservation measures is shown. However, it is not realistic to assume that all of the approaches will be applied by 100 percent of the commercial market. Thus, assumptions have been made in order to calculate the *achievable* portion of this potential.

Based on recent experience of energy supplying utilities, it has been assumed that Category I measures would be implemented in about one-third of the commercial market. It is assumed that Category II measures would be employed by only half of the consumers reacting to the Category I measures or about 15 percent of the commercial consumers. Generally, however, the cost of energy in the commercial market is a cost of doing business and would be passed on in the form of higher prices, rents, etc. Category III measures, on the other hand, will require investments of such a substantial nature that, based on 1973 energy cost levels, a pay-back period of over 10 years would be required. For purposes of this analysis, a 2-percent implementation factor is assigned to the measures in Category III. In Table 17 the 33, 15 and 2 percent implementation factors are applied to the Category I, II and III potentials, respectively.

Tables 18 and 19 display the total potential savings of the various categories by building type and end-use, respectively. These data represent a recompilation of the *total potential* column in Table 17 and demonstrate that measures affecting heating and air conditioning in stores, schools and apartments offer the highest potential for reducing energy consumption in the commercial market. Category I approaches account for 42 percent of the savings potential represented in the combined effects of all category conservation measures. However, it must be assumed that some portion of the savings potential of Category I measures has already been implemented, during the winter of 1973/1974.

IMPLEMENTATION OF ENERGY CONSERVATION MEASURES

All Category II and III conservation measures require owner investment. Some measures such as adjustment of equipment and routine maintenance are highly labor intensive and could be performed in whole or in part by the building owner. Generally, performance of these adjustment and maintenance functions yields a sufficient return to support the cost of implementation and produce a profit, since it represents a relatively low cash outlay. Other measures, especially those in Category III (structure alterations, insulation, storm windows and doors, etc.), require sizable investments, and cash pay-back through reduced energy costs would not be rapid enough to justify the investment.

A number of incentives sponsored by energy suppliers, government and manufacturers, as well as consumers, have been analyzed. In the case of incentive programs initiated by utilities or energy suppliers, it is assumed that provisions for compensation together with exemption from legal responsibility will be provided. Governmental agencies could increase the incentive for implementation of

TABLE 18

ANNUAL POTENTIAL SAVINGS BY BUILDING TYPE-COMMERCIAL SECTOR

Building Type	Category I (No Investment)				Category II (Low Investment)				Category III (High Investment)			
			Percent of 1972				Percent of 1972				Percent of 1972	
	Savings (QBTU)	Ranking by Yield	Commercial Sector	U.S. Total	Savings (QBTU)	Ranking by Yield	Commercial Sector	U.S. Total	Savings (QBTU)	Ranking by Yield	Commercial Sector	U.S. Total
Colleges	.192	6	1.6	.3	.127	6	1.0	.2	.068	7	.6	.1
Hotel/ Motel	.155	7	1.3	.2	.127	5	1.0	.2	.054	8	A	.1
Offices	.220	4	1.8	.3	.146	4	1.2	.2	.188	4	1.6	.3
Hospitals	0	8	0	0	.084	7	.7	.1	.088	6	.7	.1
Super- markets	.210	5	1.7	.3	.049	8	A	.1	.107	5	.9	.1
Schools	.510	2	4.2	.7	.243	3	2.0	.3	.294	2	204	A
Stores	.537	1	4.5	.7	.246	2	204	.3	.262	3	304	.6
Apartments	0481	3	4.0	.6	.512	1	4.3	.7	0404	1	304	.5
Total	2.305		19.1	3.1	1.534		12.7	2.0	1.465		12.2	2.0

TABLE 19

ANNUAL POTENTIAL SAVINGS BY END-USE-COMMERCIAL SECTOR

End-Use	Category I (No Investment!		Category II (Low Investment!		Category III (High Investment!	
	Savings (QBTU)	Ranking by Yield	Savings (QBTU)	Ranking by Yield	Savings (QBTU)	Ranking by Yield
Heating	1.772	1	1.157	1	1.284	1
Air Conditioning	.245	2	.146	3	.181	2
Water Heating	.059	4	.231	2	0	3
Lighting	.229	3	0	4	0	4
Total Savings	2.305		1.534		1.465	
Percent of 1972 Commercial Sector	19.1		12.7		12.2	
Percent of 1972 U.S. Total	3.1		2.0		2.0	

conservation measures in the commercial market, primarily through modifications in taxing and lending procedures. These would include: investment tax credits for conservation related equipment; low interest loans through the Small Business Administration (SBA), the Federal Housing Administration (FHA), the Department of Housing and Urban Development (HUD), etc.; or guaranteeing or subsidizing loans from private sector lending institutions. In addition, governmental actions should be taken to revise local building and operating codes to encourage energy conservation in buildings.

The role of industry and equipment manufacturers in sponsoring and implementing energy conservation incentives is a major one. Within the industry, conservation programs could be implemented by forming teams of consultants, building management representatives and building code agency representatives to inspect existing and planned buildings, and recommend major areas of building improvements to reduce the energy use.

Since all approaches relative to structural modifications also involve the manufacture of a product, new manufacturing facilities must be constructed or present ones expanded. Industry is already planning increased production capabilities at formidable capital investment. This will be necessary if the existing market is to be served without constricting the new construction market, and if the increased demand for energy saving materials, such as insulation, is to be met.

If inroads are to be made in energy reduction within the next 5 years, a substantial amount of capital is necessary. This investment may not be economically feasible on a 5- to 10-year payout basis, so some incentive may be necessary to promote a more rapid industry involvement. The problem is complex and lies outside the scope of this report. However, it should be investigated since this is a vital factor to the success of energy conservation.

An evaluation of trade-offs of total energy requirements *versus* net energy savings gain should also be made. Insulation manufacturers claim that to produce sufficient material to save 14 BTU's per year requires the expenditure of 1 BTU. This is an excellent trade-off; however, other methods of reducing energy such as storm sashes may not represent as favorable a ratio. An in-depth evaluation is necessary in order to assess the effect these factors will have on retrofitting existing commercial buildings.

EXHIBIT VI

COMPUTATIONS OF 1972 ENERGY CONSUMPTION

COMMERCIAL SECTOR

Table 12 (PEC, page 23) is updated for 1974; however, increases over 1972 were insignificant in the areas under discussion. Therefore, 1974 data was used for 1972.

Another area in the PEC report which warranted discussion was the allocation" of fuels (oil, gas, coal) and electricity. Where the use of fuels or electricity was insignificant in an end-use category, such as space heating, the energy representing the preponderant source was assigned to that end-use and the alternate source designated as "nil." For example, there are applications where electricity is used for space heating; however, the vast majority of the commercial sector would utilize energy from the fuels category. Under this condition electrical energy used in space heating was marked nil. This situation was balanced in other areas where the use of fuel type energy was negated and electricity assigned to the total end-use. The Electric Energy Association (EEA) estimates that between 1.5 percent and 2.0 percent of all commercial establishments are electrically heated. This information was not available in 1972 when the PEC report was published.

Another area of ambiguity in the PEC report involved the energy allocation for water heating in the commercial sector. Table 41 (PEC,page 71) indicates that 36 percent (.232 quadrillion BTU's) of the energy used in water heating in the commercial sector was supplied by electricity. A footnote at the bottom of Table 41 (PEC, page 71) states that 20 percent of the total was assigned to electricity. Table 3 (PEC, page 16) breaks down the energy for fuels and electricity in the various end-uses. Under water heating, the amount of electricity in the commercial sector is marked njl. If the .232 quadrillion BTU's figure (Table 41, PEC, page 7l)for electric energy is correct, the percentage of the national total in the commercial sector under water heating (Table 3, PEC, page 16) for electrical energy should be 0.3 percent. Following the same procedure and using the figures in Table 41 (PEC, page 71) for fuels (indicated as natural gas), the figure in Table 3 (PEC, page 16) should be 0.7 percent instead of 0.6 percent for the total of water heating energy. Because of these inconsistencies and the inability to obtain figures which will correlate, the data in Table 29 of this task group report was used as it appears for subsequent evaluations.

These slight inconsistencies are discussed to provide the reader with some insight into the complexities of obtaining exact data for any report which deals with the subject of national energy utilization. However, the variation from the actual, assuming the latter could be determined, does not affect the overall projections. This is due to the fact that energy savings in the various categories involve total BTU's which includes all energy end-use sources.

Table 21 summarizes ene.rgy consumption in the commercial sector. The matrix indicates the total annual fuel and electricity used in each building type comprising the commercial sector and for each end-use within that building type. The energy is expressed in quadrillion BTU's. The percent savings produced by the recommended approaches in Exhibit VIII are multiplied by the appropriate

TABLE 21

FUEL AND ELECTRICITY CONSUMED BY BUILDING CATEGORY AND END-USE--1972
(Quadrillion BTU's)

	%/Building Category		Space Heating		Air Conditioning		Water Heating		Light		Other		Total		Totals
	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F + E
STORES	20	31.2	.996	0	.082	.454	.108	0	0	.455	.011	.095	1.197	1.004	2.201
SCHOOLS	22.5	15.5	1.139	0	.021	.116	.174	0	0	.335	.014	.047	1.348	.498	1.846
SUPERMARKETS	9.2	13.7	.495	0	0	.073	.050	0	0	.149	.005	.210	.550	.432	.982
HOSPITALS	10.5	8.2	.460	0	.035	.109	.127	0	0	.051	.008	.100	.630	.260	.890
OFFICES	8.5	11.5	.433	0	.030	.149	.041	0	0	.149	.005	.070	.509	.368	.877
HOTELS	7.6	6.8	.359	0	.025	.082	.066	0	0	.105	.005	.031	.455	.218	.673
COLLEGE	7.2	4.5	.345	0	.020	.058	.062	0	0	.072	.003	.014	.430	.144	.574
OTHER	14.5	8.6	.708	0	.010	.049	.142	0	0	.146	.005	.079	.865	.274	1.139
TOTAL			4.935	0	.223	1.090	.770	0	0	1.462	.056	.646	5.984	3.198	9.182
APARTMENTS			1.550	.099	0	.105	.283	.146	0	.141	.104	.441	1.937	.932	2.869
TOTAL			6.485	.099	.223	1.195	1.053	.146	0	1.603	.160	1.087	7.921	4.130	12.051

Note: F = Fuel
E = Electricity

Exhibit V

energy totals in Table 21 to produce the estimated annual energy savings. An example would be the installation of storm sashes on all buildings which currently do not have them.

Table 21 figures reflect the energy losses related to the generation of electricity. The *apartment* category represents 19.3 percent of the residehtial market, and consumption was developed by applying this figure to the residential data. The energy consumption listed for *cooking, clothes drying,* and *refrigeration* in Table **11,** (Exhibit IV, Part One) was added to the *other* category for reporting apartment end-uses. The same procedure was followed in the commercial sector for the consumptions listed under cooking and refrigeration. As noted elsewhere, the feedstock consumption was removed from the commercial sector totals. In the building type category the *other* category pertains to miscellaneous building types, such as bowling alleys, restaurants, refrigeration plants, radio and television stations, etc. They were collected and are unidentified due to the small incremental energy use they represent as individual types. Energy conservation measures implemented by these consumers will not, therefore, generally yield commensurate reductions in total energy use.

The percent of fuels and electricity per building category and the total BTU's relative to the end-use applications in Table 21 are firm numbers supported by referenced data. The distribution of this energy in the various building type categories appears under the *percent building* category. The dispersement is based on a recent national survey by private enterprise as part of a marketing analysis program. Since this data is proprietary, it cannot be included in the bibliography; however, permission was granted to use the figures. This is the only data relative to the distribution of energy in the commercial sector that was available. The experience and knowledge of study participants was added to this reference material, and distribution of fuels and electricity energy within the end-use and building type categories was generated.

As an example, in Table 21 under the *school* category, it is established that 22.5 percent of the fuel and **15.5** percent of the electric of the total energy in each end-use category *(space heating, air conditioning,* etc.) is the total used in each end-use for schools. In using these factors, it became apparent that the ratios between heating and air conditioning, and heating and water heating are not consistent with experience. This discrepancy exists because previously there has been no need to break down energy uses to as fine an increment as demanded by the objective of this study--topredict energy savings by applying recommended procedures for reducing energy consumption to individual end-uses in specific building types. Therefore, in order to establish realistic ratios of energy uses in schools, empirical data was used where available and the remaining energy was distributed based on interpolation. This was accomplished in each building type category.

In reality, shifting of energy quantities did not occur as extensively as one might imagine. The energy in *lighting* and *other* was fixed and, therefore, not changed. The major adjustments (this does not refer to the base quantities) were made between space heating, air conditioning, and water heating involving fuel and electricity. Since electricity was not represented in space heating and water heating, it was only affected in the air conditioning end-use category. It is important to note that the rearrangement did not alter the totals of Table 21. Applying these procedures resulted in more objectivity, both in analyzing the input and in making the final predictions.

TABLE 22

DETERMINATION OF TOTAL ENERGY USE IN COMMERCIAL CATEGORY BASED ON 1972 NATIONAL CONSUMPTION

Parameters

1. Commercial to include all dwellings with 3 or more families.

$$\frac{\text{Total Residential Structures* 3 + Families}}{\text{Total Residential Structures (All)}} = \frac{12{,}224{,}075}{63{,}445{,}192} \times 100 \quad 19.3\%$$

(19.3% of Total Residential Classified as Commercial)

2. Total National Consumption (1972) 73.1 x QBTU†

Total Energy In Commercial Sector By End-Use

	QBTU		
	Total	Fuel	Electric
Space Heating‡	6.584.	6.485	.099
Air Conditioning	1.418	.223	1.195
Water Heating	1.199	1.053	.146
Lighting	1.603	0	1.603
Other	1.247	.108	1.139
Total	12.051	7.869	4.182

* U.S. Bureau of Census, *1970 Detailed Housing Characteristics Final Report HC(l) - B1 United States Summary.*

† See Table 24.

‡ See Table 23. Feedstock deducted from commercial sector electric losses in generation included in totals.

TABLE 23

ESTABLISH FUEL AND ELECTRIC
FOR END-USES IN RESIDENTIAL AND COMMERCIAL SECTORS

Residential*

	% F	% E	Total %	% Total / 100 F	% Total / 100 E
Space Heating	10.2	.7	10.9	.94	.06
Air Conditioning	0	.3	.3	0	1.0
Water Heating	1.9	1.0	2.9	.66	.34
Lighting	0	All		0	1.0
Other	.8	3.4	4.2	.19	.81

Commercial *

	% F	% E	Total %	% Total / 100 F	% Total / 100 E
Space Heating	7.0	0	7.0	1.0	0
Air Conditioning	.3	1.5	1.8	.17	.83
Water Heating	.6	0	.6	1.0	0
Lighting	0	All		0	1.0
Other	.1	1.1	1.2	.08	.92

	Residential ‡			QBTU F	QBTU E †	Commercial ‡			QBTU F	QBTU E †
Space Heating	1.649	x	.94	1.550	.099	4.935	x	1.0	4.935	0
Air Conditioning	.105	x	0	0	.105	1.313	x	.17	.223	1.090
Water Heating	.429	x	.66	.283	.146	.770	x	1.0	.770	0
Lighting	.141	x	0	0	.141	1.462	x	0	0	1.462
Other	.545	x	.19	.104	.441	.702	x	.08	.56	.646
				1.937	.932				5.984	3.198

				QBTU F				QBTU E
Space heating	1.550	+	4.935	6.485	.099	+	0	.099
Air Conditioning	0	+	.223	.223	.105	+	1.090	1.195
Water Heating	.283	+	.770	1.053	.146	+	0	.146
Lighting	0		0	0	.141	+	1.462	1.603
Other	.104	+	.056	.160	.441	+	.646	1.087
QBTU Totals -				7.921(F)				4.130(E)

6

Note: F = Fuel
E = Electricity

* See Table 29.
† Derived by subtracting fuel from total.
‡ See Table 24.

TABLE 24

ESTABLISH 1972 TOTAL END-USE
FOR COMMERCIAL SECTOR
(Quadrillion BTU's)

	Residential						Commercial				
	*		†		‡	1972	*		†		1972
Space Heating	6.675	x	1.28	x	.193	1.649	4.182	x	1.18	=	4.935
Air Conditioning	.427	x	"	x	"	.105	1.133	x	"	=	1.313
Water Reating	1.736	x	"	x	"	.429	.653	x	"		.770
Other	2.778	x	"	x	"	.686	1.834	x	"		2.164
						2.869					9.182

(1972) Total Energy Commercial Sector 12.051 ‖

Establish "Lighting" Portion of "Other"

Residential .01 x 73.1 x .193 - .141 x
Commercial .02 x 73.1 1.462 x

Residential - Lighting = .141 Other .686 - .141 .545 (Other 79% Total)

Commercial - Lighting = 1.462 Other 2.164 - 1.462 .702 (Other 32% Total)

Total Commercial Energy by End-Use For 1972

Space Heating	1.649	+	4.935	6.584
Air Conditioning	.105	+	1.313	1.418
Water Heating	.429	+	.770	1.199
Lighting	.141	+	1.462	1.603
Other	.545	+	.702	1.247
				12.051

* See Table 26--1968 Totals.
† See Table 27--Factor for increased energy consumption, 1972 over 1968.
‡ Percent of residential assigned to commercial.
§ See Table 28--It is assumed that although Table 28 represents 1974 figures, the 1972 percentages for lighting would not have been significantly less than 1974; therefore, 1 percent of the 1972 total energy use (73.1 QBTU) was used for residential and 2 percent for commercial.
‖ Slightly higher than base figure of 11.984 QBTU due to rounding in Table 27.

TABLE 25

U.S. ENERGY DEMAND PROJECTIONS
BASE CASE, PRE-CONSERVATION*
(Quadrillion BTU's)

	1972	1977	1980	1985
Residential	10.5	12.4	13.3	14.7
Heating	7.0	7.9	8.4	9.1
Other	3.5	4.5	4.9	5.6
Commercial	6.2	7.2	8.1	9.6
Industrial	22.7	23.4	24.9	27.8
Transportation	17.0	21.0	22.9	26.3
Passenger Cars	9.44	11.68	12.60	14.23
Trucks and Buses	3.96	5.00	5.50	6.39
Aircraft	2.04	2.69	3.08	3.76
Other	1.56	'1.64	1.72	1.92
Non-Energy	3.7	5.7	6.5	8.2
Electricity Conversiont	13.0	18.2	21.7	27.8
Total Energy Consumption	73.1	87.9	97.4	114.4

Notes: (1) 1972 energy demand is based on available Bureau of Mines and American Gas Association data.

(2) Energy demand projections for 1980 and 1985 are NPC U.S. Energy Outlook Intermediate Cases reduced by the high energy cost and low population factors.

(3) 1977 energy demand estimated from adjusted 1975 (Initial Appraisal) and Indicated 1980.

* Based on Table 1, page 20, of the National Petroleum Council's report, *Energy Conservation in the United States Short-Term Potential 19?4-1978--An Interim Report of the National Petroleum Council,* March 29, 1974.

t This category includes only energy losses in generation, transmission and distribution. *Electricity Consumption* is included in the appropriate sector above, as shown in the following memorandum, converted at 3,412 BTU's per kilowatt hour.

	(Allocation of Electricity Conv.	(13.0)	1972	% Total	1977	1980	1985
Residential	13.0 x .338	4.39	1.84	=33.8%	2.69	3.24	4.21
Commercial	13.0 x .224	2.91	1.22	=22.4%	1.78	2.23	2.92
Industrial	13.0 x .437	5.68	2.38	=43.7%	3.16	3.83	5.25
Total Electricity Use			5.44		7.63	9.30	12.38
Total Electricity Losses as %Utility Inputs			70.5%		70.5%	70.0%	69.2%

TABLE 26

ENERGY CONSUMPTION IN THE UNITED STATES BY END-USE
1960-1968
(QBTU and Percent per Year)

Sector and End-Use	Consumption 1960	Consumption 1968	Annual Rate of Growth	Percent of National Total 1960	Percent of National Total 1968
Residential					
Space heating	4.848	6.675	4.1%	11.3%	11.0%
Water heating	1.159	1.736	5.2	2.7	2.9
Cooking	.556	.637	1.7	1.3	1.1
Clothes drying	.093	.208	10.6	0.2	0.3
Refrigeration	.369	.692	8.2	0.9	1.1
Air conditioning	.134	.427	15.6	0.3	0.7
Other	.809	1.241	5.5	1.9	2.1
Total	7.968	11.616	4.8	18.6	19.2
Commercial					
Space heating	3.111	4.182	3.8	7.2	6.9
Water heating	.544	.653	2.3	1.3	1.1
Cooking	.098	.139	4.5	0.2	0.2
Refrigeration	.534	.670	2.9	1.2	1.1
Air conditioning	.576	1.113	8.6	1.3	1.8
Feedstock	.734	.984	3.7	1.7	1.6
Other	.145	1.025	28.0	0.3	1.7
Total	5.742	8.766	5.4	13.2	14.4
Industrial					
Process steam	7.646	10.132	3.6	17.8	16.7
Electric drive	3.170	4.794	5.3	7.4	7.9
Electrolytic processes	.486	.705	4.8	1.1	1.2
Direct heat	5.550	6.929	2.8	12.9	11.5
Feedstock	1.370	2.202	6.1	3.2	3.6
Other	.118	.198	6.7	0.3	0.3
Total	18.340	24.960	3.9	42.7	41.2
Transportation					
Fuel	10.873	15.038	4.1	25.2	24.9
Raw materials	.141	.146	0.4	0.3	0.3
Total	11.014	15.184	4.1	25.5	25.2
National total	43.064	60.526	4.3	100.0%	100.0%

Note: Electric utility consumption has been allocated to each end-use.

Source: Stanford Research Institute, using Bureau of Mines and other sources.

TABLE 27

ESTABLISH ENERGY CONSUMPTION INCREASE 1968 TO 1972
IN COMMERCIAL AND RESIDENTIAL SECTORS-FEEDSTOCK DEDUCTED
(Quadrillion BTU's)

	1968*		Total 1968	1972t		Total 1972
RESIDENTIAL	11.6		11.6	10.5	+ 4.39§	14.89
COMMERCIAL	8.7	- (1.0)‡	7.7	6.2	+ 2.91§	9.11
INDUSTRIAL	25.0	- (2.2)*	22.8	22.7	+ 5.68§	28.38
TRANSPORTATION	15.2		15.2	17.0		17.0
NET (Less Feedstock)	60.5		58.3			69.38

INCREASE CONSUMPTION 1972 OVER 1968:

Residential	14.89 / 11.6	128.3%	1.28 (Factor)
Commercial	9.11 / 7.7	118.3%	1.18 (Factor)
All Sectors	69.4 / 58.3	119%	
Residential	14.9 / 73.1	.203 Or 20.3% of National Total	
Commercial	9.1 / 73.1	.124 Or 12.4% of National Total	

* See Table 26.
t See Table 25.
‡ Feedstock.
§ Electric Conversion Energy re-allocated to Residential, Commercial, and Industrial, Table 25.

TABLE 28

ESTIMATED USE OF ELECTRICAL ENERGY FOR LIGHTING*

	Lighting KWH % of total KWH use in each field>'(	By Field KWH % of total Lighting KWH*	Lighting KWH % of total elec. generation*	Lighting % of total ·energy consumptionf
Residential	16.0%	20.0%	4.0%	1.0%
Commercial				
Store	22.0%	20.0%	4.0%	1.0%
Offices, Schools	22.0%	20.0%	4.0%	1.0%
Industrial	11.5%	20.0%	4.0%	1.0%
Street & Highway	100.0%	4.0%	.8%	.2%
Commercial Outdoor	100.0%	8.0%	1.6%	.4%
All Other	42.0%	8.0%	1.6%	.4%
Lighting KWH as a % of total KWH Generated	20.0%	100.0%	20.0%	5.0%

Note: Above compilation by E. A. Campbell, ERA, based on information provided by C. M. Crysler on September 26, 1972 and updated by phone on February 11, 1974.

* C. M. Crysler, General Electric Co., Ne1a Park, Cleveland, Ohio on February 11, 1974, based on lamp industry's sales to various market segments.

t Based on estimate that 25 percent of total consumption of energy resources go into generation of electricity.

TABLE 29

ENERGY CONSUMED, BY SECTOR AND END-USE
AS A PERCENTAGE OF NATIONAL TOTAL*
1960 AND 1968

	1960			1968		
	Direct	Purchased Electricity Energy	Total	Direct	Purchased Electricity Energy	Total
Residential						
Space heating	11.1%	0.2%	11.3%	10.2%	0.7%	10.9%
Water heating	1.7	1.0	2.7	1.9	1.0	2.9
Cooking	0.8	0.5	1.3	0.7	0.4	1.1
Clothes drying	0.1	0.1	0.2	0.1	0.2	0.3
Refrigeration	nil	1.7	1.7	nil	1.6	1.6
Air conditioning	nil	0.2	0.2	nil	0.3	0.3
Other	nil	1.1	1.1	nil	2.1	2.1
Total	13.7%	4.8%	18.5%	12.9%	6.3%	19.2%
Commercial						
Space heating	7.6	nil	7.6	7.0	nil	7.0
Water heating	0.5	nil	0.5	0.6	nil	0.6
Cooking	0.1	0.1	0.2	0.1	0.3	0.4
Air conditioning	0.1	1.5	1.6	0.3	1.5	1.8
Feedstock	1.7		1.7	1.6		1.6
Other	nil	1.7	1.7	nil	3.1	3.1
Total	10.0%	3.3%	13.3%	9.6%	4.9%	14.5%
Industrial†						
Process steam	25.1			20.7		
Electricity generation	0.8			0.7		
Direct heat	5.1			7.0		
Feedstock	3.5			3.6		
Total	34.5%	8.4%	42.9%	32.0%	9.2%	41.2%
Transportation	25.1	0.2	25.3	25.0	0.1	25.1
Total	83.3%	16.7%	100.0%	79.5%	20.5%	100.0%

Sources: Bureau of Mines, Stanford Research Institute.
* Including heat wasted in production of electricity.
† Purchased electricity not allocated separately.

EXHIBIT VII

ENERGY CONSERVATION APPROACHES

BY BUILDING TYPE AND

DIFFICULTY OF IMPLEMENTATION

COMMERCIAL SECTOR

TABLE 30

Total QBTU each Building Category x % Saved = Total QBTU Saved

CATEGORY	APPROACH †	END-USE *SPACE HEATING SAVING	COLLEGE Total	%	Total Saved	HOTEL - MOTEL Total	%	Total Saved	OFFICE Total	%	Total Saved	HOSPITAL Total	%	Total Saved	TOTALS
I	4.	Perm. Temp. setback	.345	21.3	.062	.359	31.3	.095	.433	19.3	.071	.460	NA		
	5.	Night Temp. setback	"	20.9	.061	"	13.8	.043	"	22.9	.084	"	NA		
					.123			.138			.155				.416 I
II,III	10.	Reduce ventilation	"	7.9	.023	"	7.1	.021	"	10.3	.038	"	NA	△	
	6	Scheduled Maintenance	"	10.0	.029	"	10.0	.031	"	10.0	.037	"	10.0	.039	
	1.	Caulk & Weatherstrip	"	14.4	.043	"	10.8	.033	"	10.6	.039	"	9.3	.037	
		SAVINGS TOTAL			.095			.085			.114			.076	.370 II,III
		* I 1.772 x QBTU													
		* II, III 1.191 x QBTU													

CATEGORY	APPROACH †	END-USE	SUPERMARKETS Total	%	Total Saved	SCHOOLS Total	%	Total Saved	STORES Total	%	Total Saved	APARTMENTS Total	%	Total Saved	TOTALS
I	4.	Perm. Temp. setback	.495	23.0	.097	1.139	15.8	.153	.996	25.1	.213	1.649	28.0	.393	
	5.	Night Temp. setback	"	15.4	.065	"	26.0	.252	"	15.7	.133	"	2.6	.050	
					.162			.405			.346			.443	1.356 I
II,III	10.	Reduce ventilation	"	NA		"	4.5	.043	"	3.1	.026	"	NA		
	6.	Scheduled Maintenance	"	10.0	.042	"	10.0	.097	"	10.0	.085	"	0.0	.140	
	1.	Caulk & Weatherstrip	"	‡		"	4.5	.043	"	5.4	.046	"	8.9	.265	
					.042			.183			.157			.405	.787 II, III

Note: BTU's in *total saved* column were obtained by applying the mid-range of factors appearing in Table 31.

△ signifies generally good maintenance (an estimated 25 percent not good).

* See Exhibit VIII.

† Listed on Table 33.

‡ Insignificant.

TABLE 30 (Cont'd.)

Total QBTU each Building Category x % Saved   Total QBTU Saved

CATEGORY	APPROACH †	END-USE *AIR CONDITIONING SAV.	COLLEGE Total	COLLEGE %	COLLEGE Total Saved	HOTEL - MOTEL Total.	HOTEL - MOTEL %	HOTEL - MOTEL Total Saved	OFFICE Total	OFFICE %	OFFICE Total Saved	HOSPITAL Total	HOSPITAL %	HOSPITAL Total Saved	TOTALS
	1.	Reset temp. to 78°F.	.078	10.0	.005	.107	18.0	.013	.179	9.4	.012/	.144	NA		
	2.	Shut down 1 hr. prior close	"	9.0	.042	"	NA		"	8.3	.01D	"	NA		
	4.	Reduce lighting	"	7.5	.004	"	NA		"	9.5	.012	"	NA		
					.051			.013			.034				.098 I
II, III	7.	Reduce ventilation	"	‡		"	4.8	.004	"	3.2	.00	"	NA		
	3.	Scheduled Maintenance	"	10.0	.005	"	10.0	.008	"	10.0	.01	"	10.0	Δ .003	
	12.	Caulk & Weatherstrip	"	6.1	.003	"	5.6	.006	"	1.6	.00	"	3.2	.005	
		SAVINGS TOTAL			.008			.018			.020			.008	.054 II, III

* I .247 x QBTU
* II,III .146 x QBTU

CATEGORY	APPROACH †	END-USE	SUPERMARKETS Total	SUPERMARKETS %	SUPERMARKETS Total Saved	SCHOOLS Total	SCHOOLS %	SCHOOLS Total Saved	STORES Total	STORES %	STORES Total Saved	APARTMENTS Total	APARTMENTS %	APARTMENTS Total Saved	TOTALS
	1.	Reset temp. to 78°F.	.073	.15.0	.009	.137	10.0	.008	.536	10.0	.038	.105	18.0	.O11	
	2.	Shut down 1 hr. prior close	"	7.0	.004	"	9.0	.007	"	6.1	.023	"	NA		
	4.	Reduce lighting	"	3.6	.002	"	10.0	.008	"	9.8	.037	"	NA		
					.015			.023			.098			.011	.147 I
II, III	7.	Reduce ventilation	"	NA		"	NA.		"	NA		"	NA		
	3.	Scheduled Maintenance	"	10.0	.006	"	10.0	.008	"	10.0	.038	"	10.	.006	
	12.	Caulk & Weatherstrip	"	1.4	.001	"	1.2	.002	"	2.9	.016	"	13.9	.015	
					.007			.010			.054			.021	.092 II, III

Note: BTU's in *total saved* column were obtained by applying the mid-range of factors appearing in Table 31.

Δ signifies generally good maintenance (an estimated 25 percent not good).

* See Exhibit VIII,
† Listed on Table 35.
‡ Insignificant.

TABLE 30 (Cont'd.)

CATEGORY	APPROACH †	END-USE	Total QBTU each Building Category x % Saved — Total QBTU Saved													
			COLLEGE			HOTEL - MOTEL			OFFICE			HOSPITAL			
		* WATER HEATING SAVINGS	Total	%	Total Saved	Total.	%	Total Saved	Total	%	Total Saved	Total	%	Total Saved	TOTALS
I	1-	Reduce Temp. 20°F	.062	7.5	.004	.066	7.5	.004	.041	7.5	.003	.127	N.A.		.011 I
II,III	2.	Use 2.5 GPM Shower Heads	"	22.6	.012	"	26.3	.014	"	N.A.		"	N.A.		
	3.	Reduce Water Pressure	"	7.5	.004	"	7.5	.004	"	N.A.		"	N.A.		
	5.	Use Auto. Shut Off Faucets	"	15.0	.008	"	10.0	.006	"	33.0	.012	"	N.A.		
					.024			.024			.012				.060 II, III

SAVINGS TOTAL

* I .059 x QBTU
* II, III .231 x QBTU

CATEGORY	APPROACH †	END-USE	SUPERMARKETS			SCHOOLS			STORES			APARTMENTS			
			Total	%	Total Saved	Total	%	Total Saved	Total	%	Total Saved	Total	%	Total Saved	TOTALS
I	1.	Reduce Temp. 20°F	.050	7.5	.003	.174	7.5	.011	.108	7.5	.007	.429	7.5	.027	.048 I
II, III	2.	Use 2.5 GPM Shower Heads	"	N.A.		"	11.3	.017	"	N.A.		"	15.0	.054	
	3.	Reduce Water Pressure	"	‡		"	7.5	.011	"	12.5	.012	"	8.8	.032	
	5.	Use Auto. Shut Off Faucets	"	N.A.		"	15.0	.022	"	25.0	.02	"	N.A.		
								.050			.035			.086	.171 II, III

Note: BTU's in *total saved* column were obtained by applying the mid-range of factors appearing in Table 31.

* See Exhibit VIII.

† Listed on Table 37.

‡ Insignificant.

TABLE 30 (Cont'd.)

Total QBTU each Building Category x % Saved — Total QBTU Saved

CATEGORY	APPROACH†	END-USE	COLLEGE Total	COLLEGE %	COLLEGE Total Saved	HOTEL - MOTEL Total	HOTEL - MOTEL %	HOTEL - MOTEL Total Saved	OFFICE Total	OFFICE %	OFFICE Total Saved	HOSPITAL Total	HOSPITAL %	HOSPITAL Total Saved	TOTALS
		*LIGHTING SAVINGS													
1	1.	Reduce Levels 25% Average	.072	25.0	.014	.105	N.A.		.149	25.0	.028	.051	N.A.		.042

CATEGORY	APPROACH†	END-USE	SUPERMARKETS Total	SUPERMARKETS %	SUPERMARKETS Total Saved	SCHOOLS Total	SCHOOLS %	SCHOOLS Total Saved	STORES Total	STORES %	STORES Total Saved	APARTMENTS Total	APARTMENTS %	APARTMENTS Total Saved	TOTALS
I	1.	Reduce Levels 25% Average	.149	25.0	.030	.335	25.0	.071	.455	25.0	.086	.141	N.A.		.187

SAVINGS TOTAL

* I = .229 x QBTU
* II, III = No Estimation

Note: BTU's in *total saved* column were obtained by applying the mid-range of factors appearing in Table 31.

* See Exhibit VIII.

† Listed on Table 39.

Exhibit VII

TABLE 31

Multipliers in a range to reflect portion of buildings in each building type category which can be affected by approaches in each energy application.

(Temperature Reduction and Night Setback Not Included)

Type	Ranges			
	Air Conditioning	Lighting	Heating	Water Heating
Apartment	.50 - .70	NA	.80 - .90	.80 - .90
Store	.60 - .80	.65 - .85	.80 - .90	.80 - .90
School	.50 - .70	.75 - .95	.80 - .90	.80 - .90
Supermarket	.70 - .90	.70 - .90	.80 - .90	.80 - .90
Hospital	.70 - .90	NA	.80 - .90	.80 - .90
Office	.60 - .80	.65 - .85	.80 - .90	.80 - .90
Hotel	.60 - .80	NA	.80 - .90	.80 - .90
College	.50 - .70	.70 - .90	.80 - .90	.80 - .90

The above table is based on the following data and assumptions:

1. The 1972 *Office BuiZding Experience Exchange Report* published by Building Owners and Managers Association (BOMA) International indicates that buildings, under the supervision of BOMA members, on a national basis breaks down as follows:

   a. Under 25 years in age: 54% - Group I

   b. Over 25 years in age: 46% Group II

With the above in mind, it was further assumed that buildings occupied up to 20 years can be classified as more modern insofar as structure and mechanical system technology is concerned. As a result, suggested approaches to energy conservation, in some instances, will have a different value when applied to Group I and Group II. Since the maximum age of new buildings was reduced to 20 years, it is not unrealistic to assume that the average split between old and new structures is 50 percent of the total commercial market for each group. The acceptance of the assumption that even though the effect is slightly different between old and new buildings, the overall effect will balance out, is supported by the following factors:

1. The "model" buildings from which the energy demands and, subsequently, energy savings were computed, were assumed to be average construction or analogous to a building about 20 to 2S years old. Savings, therefore, are conservative since the majority of the buildings over 2S years of age would use 1Oto 20 percent more energy for heating. This would tend to balance out the minor portion of newer buildings which might have annual energy uses slightly less than that represented by the model building. The result, however, is conservative since the increased loss in older buildings is in excess of the reduction represented by newer buildings.

2. On the assumption that only 40 percent of the Group II buildings are air conditioned, the savings would be reduced in this area. In addition, the cooling demands indicated by the model building are generally higher than that experienced in older buildings where "spot" cooling is the general approach using window units. These facts influenced the reduction in the percent of the total buildings which could be affected by energy reduction for air conditioning approaches as compared with space heating. The above factors under air conditioning reflect this situation.

3. Water heating was assumed to be parallel with heating--that is, a majority of the buildings use some hot water. This percentage is probably slightly higher than heating since there are some buildings in southern climates that do not require heat but do utilize hot water. The difference, of course, is reflected in the total annual BTU's used in each of these categories and is, therefore, self-regulating.

4. Lighting levels are definiteiy higher in Group I buildings, however, power consumption in Group II buildings are generally higher for the lighting involved since incandescent fixtures are more prevalent in Group II buildings and fluorescent in Group I buildings. The factors under the lighting section in the table reflect this situation.

TABLE 32

DERIVATION OF CATEGORY III
INVESTMENT APPROACHES*

	QBTU's Saved Annually					
	Roof Insulation		Sidewall Insulation		Double Glass	
	HEAT	COOL	HEAT	COOL	HEAT	COOL
COLLEGES	.015	.004	.014	*	.031	.004
HOTEL/MOTEL	.005	.002	.016	.005	.022	.004
OFFICES	.018	.004	.063	.005	.078	.020
HOSPITALS	.022	.005	.028	.001	.028	.004
SUPERMARKETS	.064	.009	.025	*	.009	*
SCHOOLS	.145	.012	.074	.002	.059	.002
STORES	.094	.058	.050	.018	.030	.012
APARTMENTS	.081	.004	.158	.002'	.155	.004
TOTALS	.444	.098	.428	.033	.412	.050

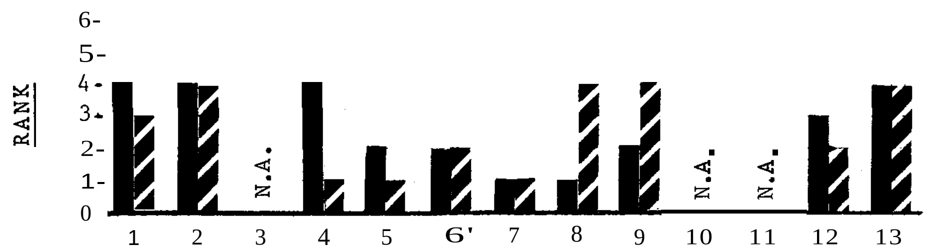
*Savings in QBTU derived from model bldgs. Heat/Cool demands, Tables 45-52.
tlnsignificant.

Figure 1.

Comparison of Energy Reduction Approaches

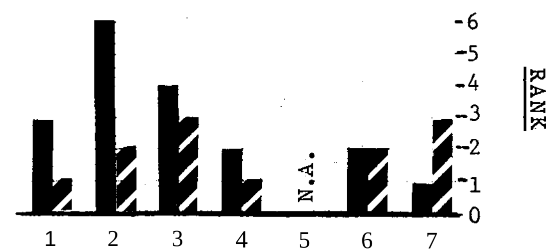
Application APARTMENTS

SPACE HEATING



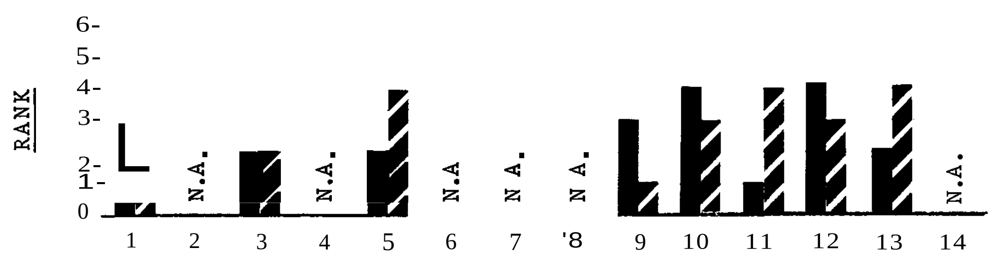
APPROACHES

WATER HEATING



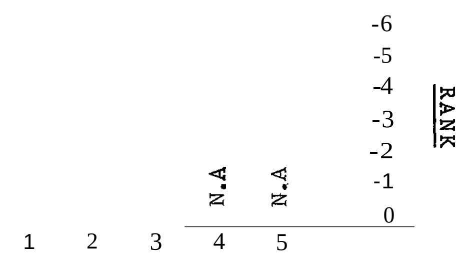
APPROACHES

AIR CONDITIONING



APPROACHES

LIGHTING



APPROACHES

Fuel Effectiveness

Difficulty

Figure 2.

Comparison of Energy Reduction Approaches

Application STORES

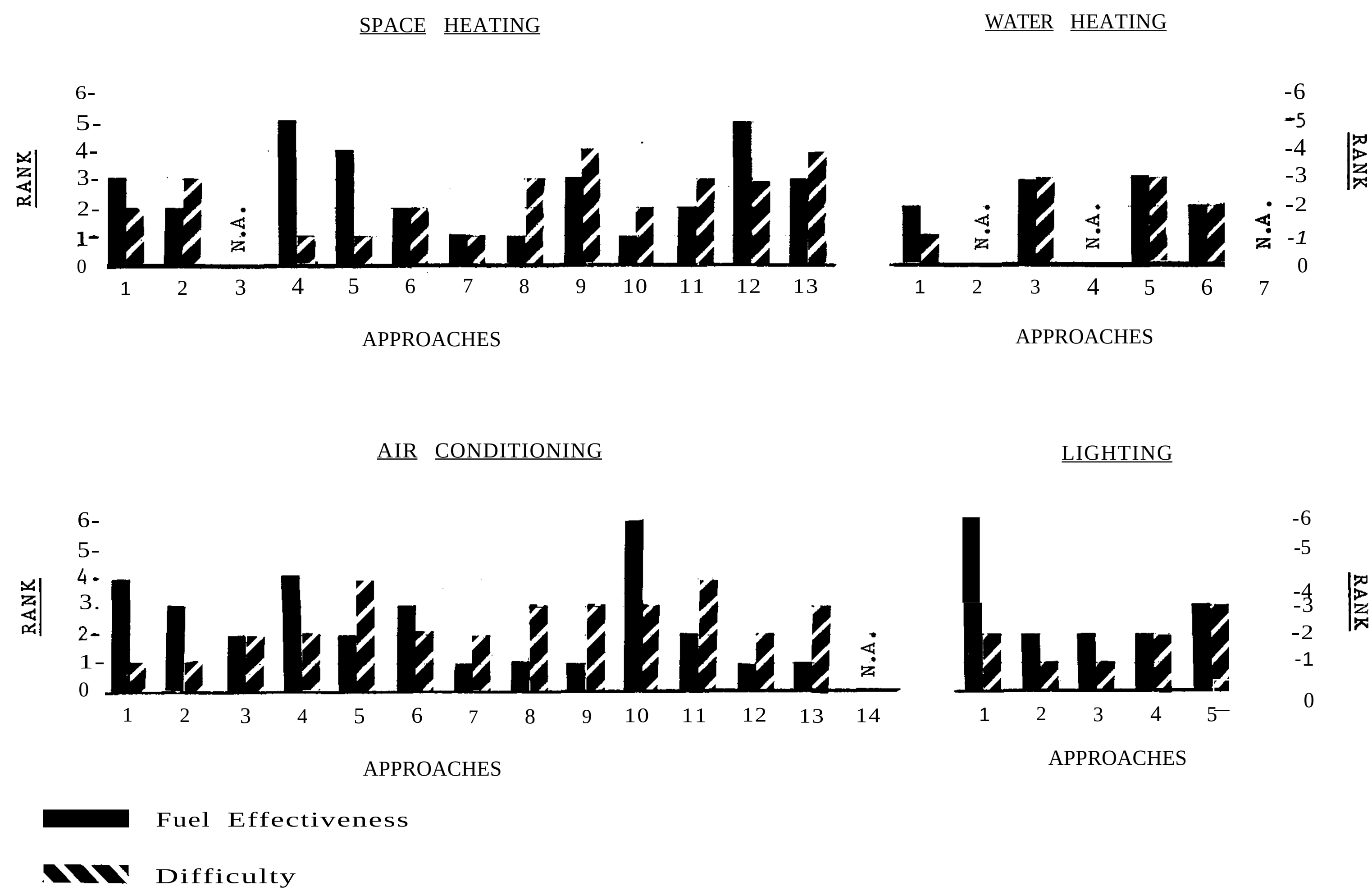


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Exhibit VII

Figure 3.

Comparison of Energy Reduction Approaches

Application SCHOOLS

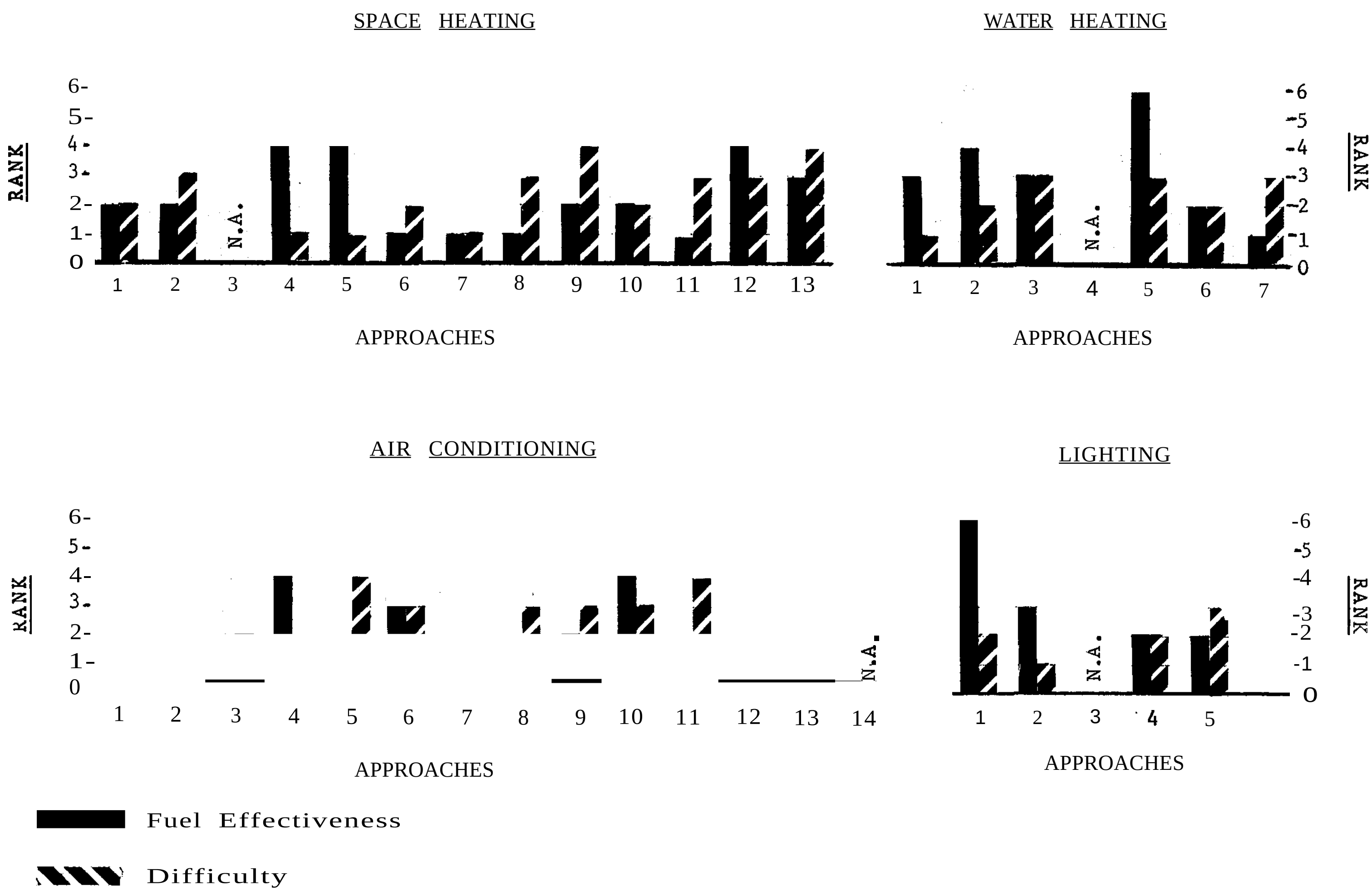

Exhibit VII

Figure 4.
Comparison of Energy Reduction Approaches

Application SUPERMARKETS

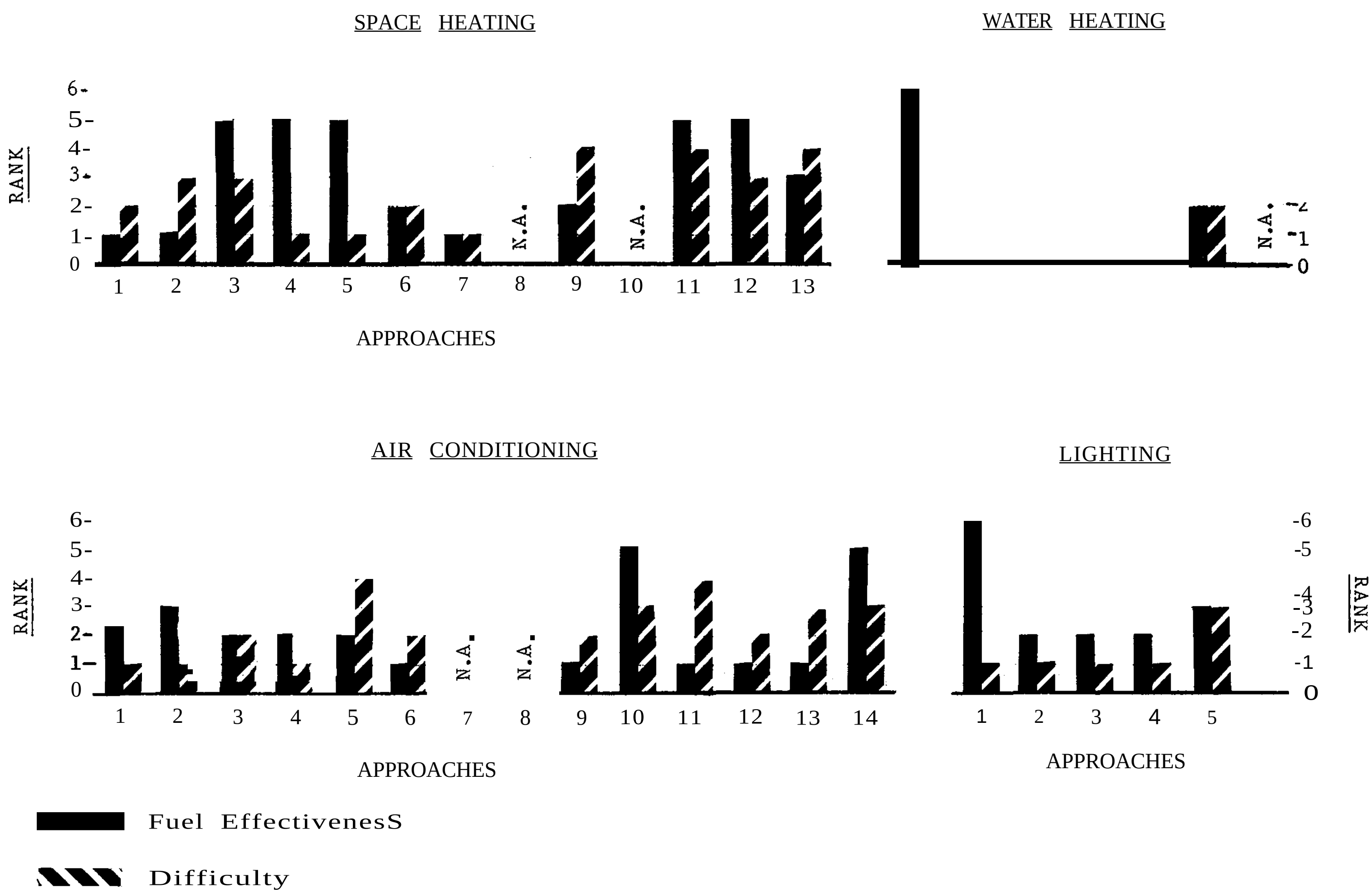

Exhibit VII

Exhibit VII

Figure 5.

Comparison of Energy Reduction Approaches

Application HOSPITALS

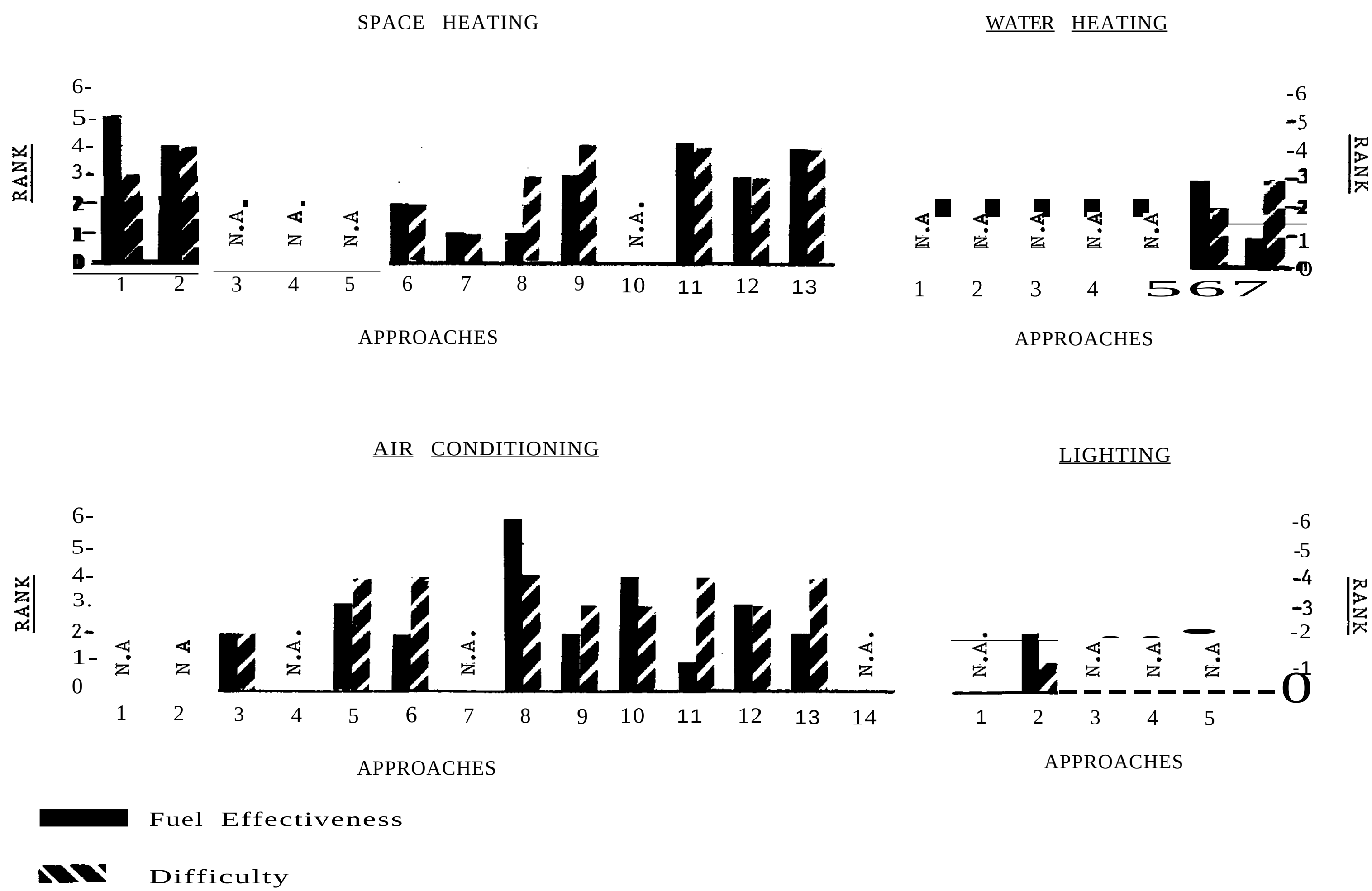

Figure 6.
Comparison of Energy Reduction Approaches

Application OFFICES

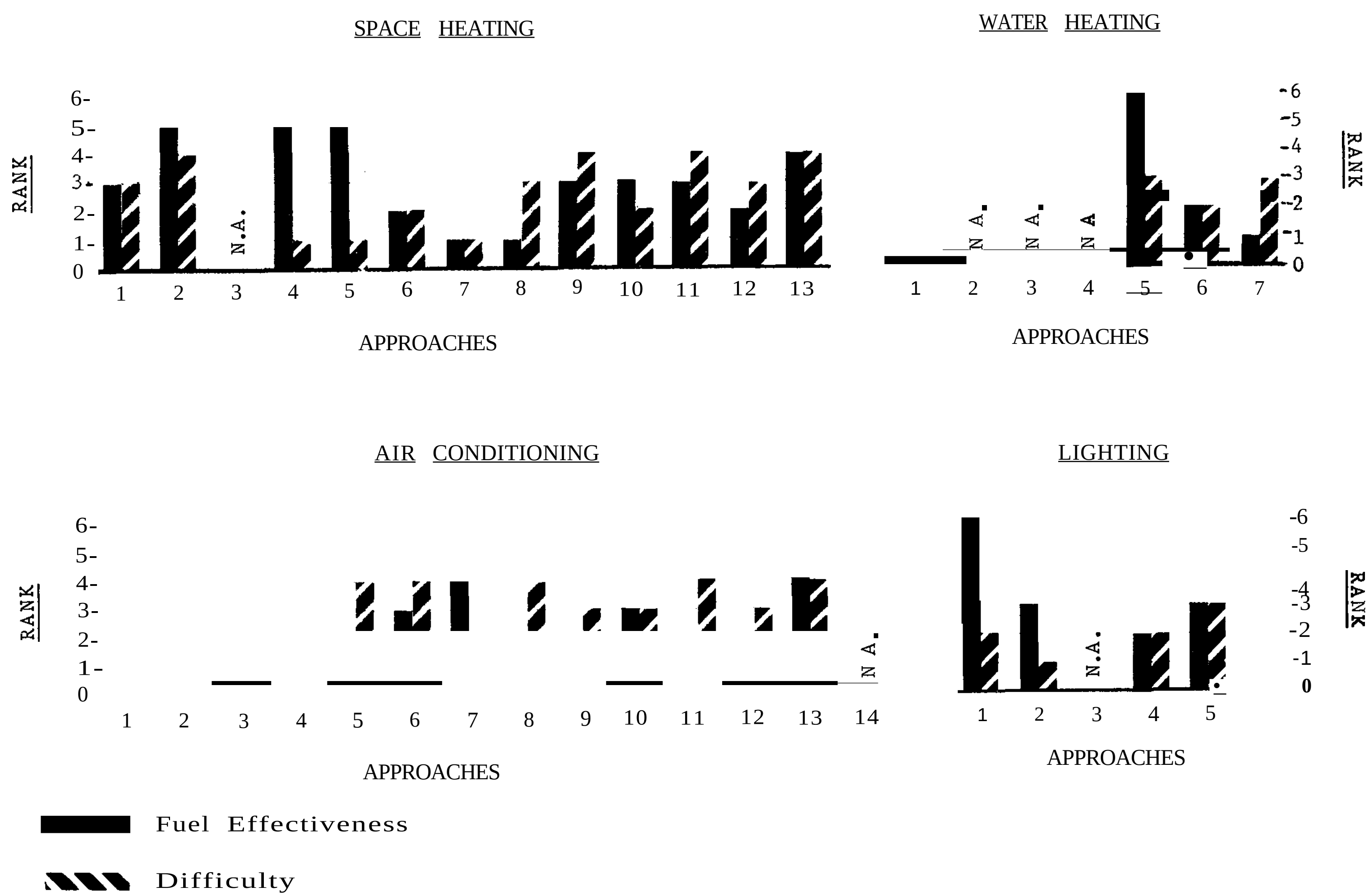

Exhibit V-I

FIgure 7.

Comparison of Energy Reduction Approaches

Application HOTELS-MOTELS

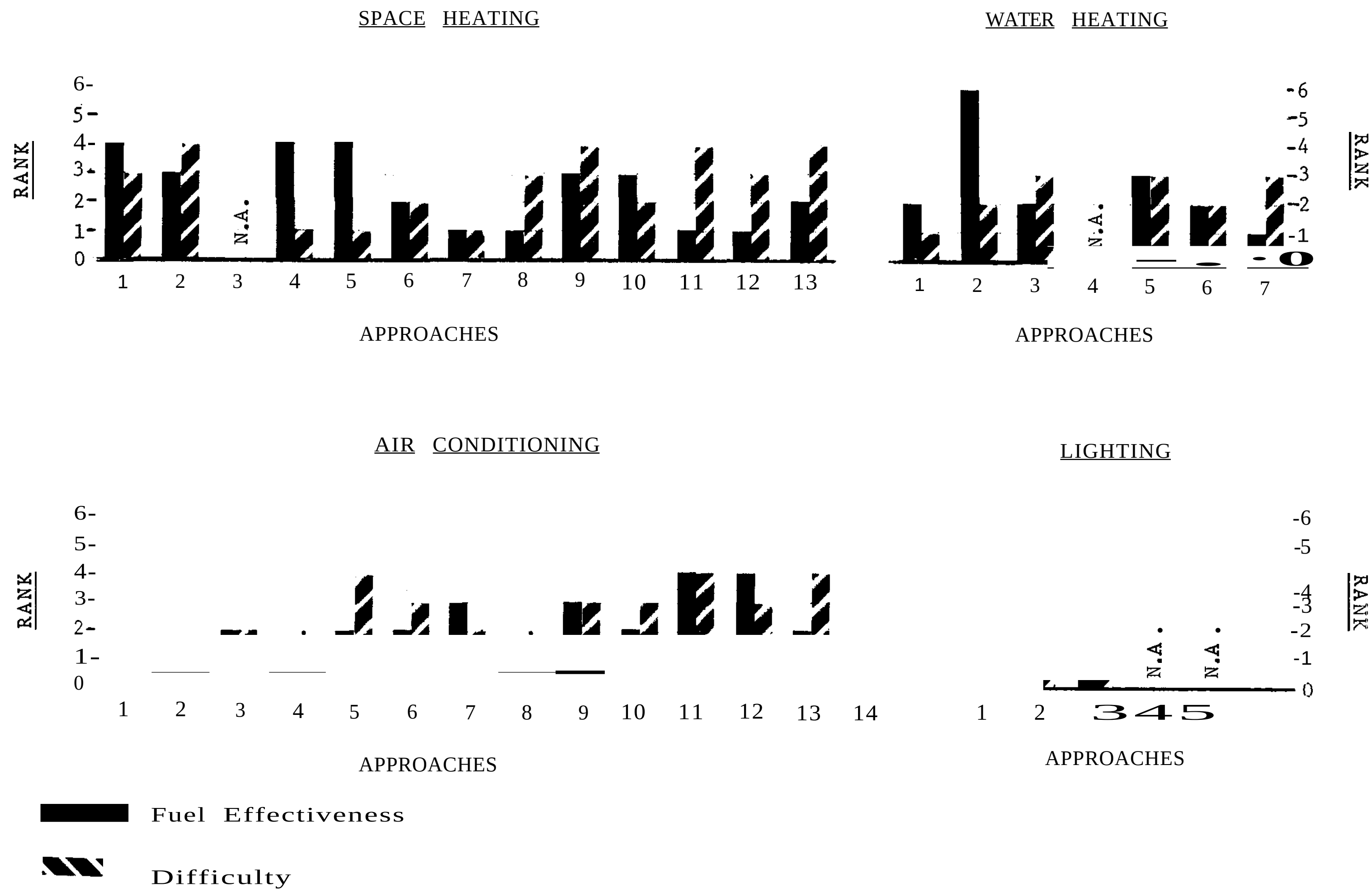

Exhibit VII

Figure 8.
Comparison of Energy Reduction Approaches

Application COLLEGES

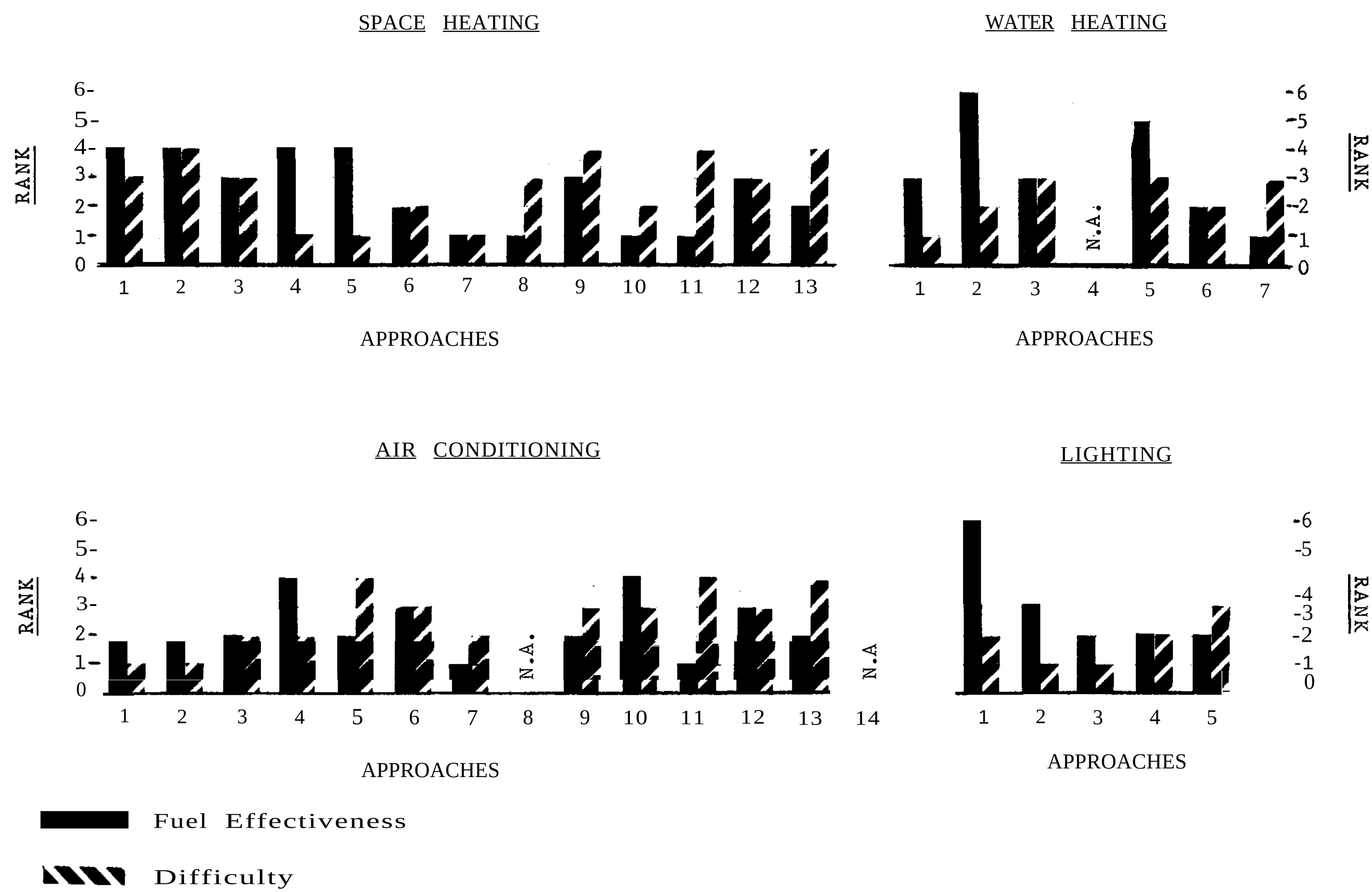

Exhibit VII

EXHIBIT VIII

MATRICES FOR ENERGY CONSERVATION APPROACHES

COMMERCIAL SECTOR

Exhibit Vln

TABLE 33

ENERGY CONSERVATION APPROACHES
BY CATEGORY--TERMS

Category	Approach	Space Heating
II, III	1.	Weatherstrip and caulk around all windows and between building walls and window frames.
II, III	2.	Double glass or high efficiency glass.
II, III	3.	Install revolving doors and/or vestibules.
I	4.	Establish 68°F maximum occupied temperature level in apartments and 65°F in commercial establishments except hospitals.
I	5.	Establish night setback temperature of 10° below day levels in commercial buildings (hospitals excepted), and 5° setback for apartments.
II, III	6.	Schedule maintenance of equipment and system.
I	7.	Shut off heating appliance pilots during non-heating months.
II, III	8.	Insulate piping and ducts where heat loss/gain will occur.
IV	9.	Replace inefficient equipment and systems.
I, II, III	10.	Establish minimum ventilating air requirements for occupancy periods and zero ventilation during unoccupied periods where possible.
II, III, IV	11.	Install energy recovery equipment where applicable.
II, III, IV	12.	Insulate ceilings under roof areas using insulation having an equivalent "R" factor of 19.
II, III, IV	13.	Insulate sidewalls using insulation having an equivalent "R" factor of 11.

Exhibit VIII

TABLE 33 (Cont'd.)
Matrix Terms

Matrix:		Low					High
E	Relative energy reduction	I	2	3	4	5	6
D	Relative difficulty of implementation	I	2	3	4	5	6
V =	Overall value or desirability of consideration	-5		0			+5

Category: Relative to *time* of implementation (I and 11-- I to 5 years; 111--5 years plus).

I--Immediate, consumer compensation automatic and economically feasible.

II/III--1nterim, requires consumer incentive and/or investment analysis.

IV--Future, relates to design parameters of new construction influenced by economic benefits or legislation, system renovation and building rehabilitation.

Approach: Method of effecting energy reduction.

TABLE 34

ENERGY REDUCTION APPROACHES

APPLICATION: SPACE HEATING

ENERGY REDUCTION APPROACHES	APPROACHES CATEGORY		OTHER	COLLEGES	HOTELS-MOTELS	OFFICE BUILDINGS	HOSPITALS	SUPERMARKETS	SCHOOLS	STORES	APARTMENTS
1	II, III	E	+	+6	+4	+3	+5	+1	+2	+3	+5
		D	-	-3	-3	-3	-3	-2	-2	-2	-3
		V	=	+3	+1	0	+2	-1	-0-	+1	+2
2	II, III	E	+	+4	+3	+5	+4	+1	+2	+2	+4
		D	-	-4	-4	-4	-4	-3	-3	-3	-4
		V	=	0	-1	+1	0	-2	-1	-1	0
3	II, III	E	+	+3	+	R	+	+5	+	+	+
		D	-	-3	-		-	-3	-	-	-
		V	=	0	N.A.	N.A.	N.A.	+2	N.A.	N.A.	N.A.
4	I	E	+	+6	+6	+6	+	+6	+5	+6	+6
		D	-	-1	-1	-1	-	-1	-1	-1	-1
		V	=	+5	+5	+5	N.A.	+5	+4	+5	+5
5	I	E	+	+6	+5	+6	+	+5	+6	+4	+2
		D	-	-1	-1	-1	-	-1	-1	-1	-1
		V	=	+5	+4	+5	N.A.	+4	+5	+3	+1
6	II, III	E	+	+2	+2	+2	+2	+2	+1	+2	+2
		D	-	-2	-2	-2	-2	-2	-2	-2	-2
		V	=	0	0	0	0	0	-1	0	0

Exhibit VIII

TABLE 34 (Cont'd.)

ENERGY REDUCTION APPROACHES: APPROACHES	CATEGORY		OTHER	COLLEGES	HOTELS-MOTELS	OFFICE BUILDINGS	HOSPITALS	SUPERMARKETS	SCHOOLS	STORES	APARTMENTS
7	I	E + / D - / V =		+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0	+1 / -1 / 0
8	II, III	E + / D - / V =		+1 / -3 / -2	+1 / -3 / -2	+1 / -3 / -2	+1 / -3 / -2	+ / - / N.A.	+1 / -3 / -2	+1 / -3 / -2	+1 / -4 / -3
9	IV	E + / D - / V =		+3 / -4 / -1	+3 / -4 / -1	+3 / -4 / -1	+3 / -4 / -1	+2 / -4 / -2	+2 / -4 / -2	+3 / -4 / -1	+2 / -4 / -2
10	I, II, III	E + / D - / V =		+1 / -2 / -1	+3 / -2 / +1	+3 / -2 / +1	R / N.A.	+ / - / N.A.	+2 / -2 / 0	+1 / -2 / -1	+ / - / N.A.
11	II, III, IV	E + / D - / V =		+1 / -4 / -3	+1 / -4 / -3	+3 / -4 / -1	+6 / -4 / +2	+5 / -4 / +1	+1 / -3 / -2	+2 / -3 / -1	+ / - / N.A.
12	II, III, IV	E + / D - / V =		+3 / -3 / 0	+1 / -3 / -2	+2 / -3 / -1	+3 / -3 / 0	+5 / -3 / +2	+5 / -3 / +2	+5 / -3 / +2	+3 / -2 / +1
13	II, III, IV	E + / D - / V =		+2 / -4 / -2	+2 / -4 / -2	+4 / -4 / 0	+4 / -4 / 0	+3 / -4 / -1	+3 / -4 / -1	+3 / -4 / -1	+4 / -4 / 0

Exhibit VIII

TABLE 35

ENERGY CONSERVATION APPROACHES
BY CATEGORY--TERMS

Category	Approach	Air Conditioning
I	1.	Eliminate use of basic energy to establish a cooling comfort level below 78°F. D.D.
I	2.	Cease cooling of building at least one hour before termination of occupancy.
II, III	3.	Schedule maintenance and adjustment of equipment and systems especially economizer component.
I, II, III	4.	Minimize heat gain from lighting.
IV	5.	Replace inefficient equipment and systems.
II, III, IV	6.	Install economizer system and controls.
I, II, III	7.	Establish mimimum ventilating air requirements of occupancy periods and zero ventilation during unoccupied periods where possible.
II, III, IV	8.	Install energy recovery equipment where applicable.
II, III, IV	9.	Utilize solar screening devices.
II, III, IV	10.	Insulate ceilings under roof areas using insulation having an equivalent "R" factor of 19.
II, III, IV	11.	Insulate sidewalls using insulation having an equivalent "R" factor of 11.
II, III	12.	Weatherstrip and caulk around all windows and between building walls and window frames.
II, III	13.	Double glass or high efficiency glass.
II, III	14.	Vestibules.

Matrix Terms

Matrix:		Low ←			1	→		High
E	Relative energy reduction	1	2	3		4	5	6
D =	Relative difficulty of implementation	1	2	3		4	5	6
V	Overall value or desirability of consideration	-5 ←			a	→		+5

TABLE 35 (Cont'd.)

ENERGY CONSERVATION APPROACHES
BY CATEGORY--TERMS

Category:	Relative to *time* of implementation (I and 11--1 to 5 years; 111--5 years plus).
1--	Immediate, consumer compensation automatic and economically feasible.
11/111--	Interim, requires consumer incentive and/or investment analysis.
IV--	Future, relates to design parameters of new construction influenced by economic benefits or legislation, system renovation and building rehabilitation.
Approach:	Method of effecting energy reduction.

TABLE 36 (Cont1d)

ENERGY REDUCTION APPROACHES											
APPROACHES	CATEGORY		OTHER	COLLEGES	HOTELS-MOTELS	OFFICE BUILDINGS	HOSPITALS	SUPERMARKETS	SCHOOLS	STORES	APARTMENTS
7	I, II, III	E	+	+1	+3	+4	+	+	+1	+1	+
		D	-	-2	-2	-2	-	-	-2	-2	-
		V	=	-1	+1	+2	N.A.	N.A.	-1	-1	N.A.
a	II, III, IV	E	+	+	+	+1	+6	+	+1	+1	+
		D	-	-	-	-4	-4	-	-3	-3	-
		V	=	N.A.	N.A.	-3	+2	N.A.	-2	-2	N.A.
9	II, III, IV	E	+	+2	+3	+2	+2	+1	+2	+1	+3
		D	-	-3	-3	-3	-3	-2	-3	-3	-1
		V	=	-1	0	-1	-1	-1	-1	-2	+2
10	II, III, IV	E	+	+4	+2	+3	+4	+6	+6	+6	+4
		D	-	-3	-3	-3	-3	-3	-3	-3	-3
		V	=	+1	-1	0	+1	+3	+3	+3	+1
11	II, III, IV	E	+	+1	+4	+1	+1	+1	+1	+2	+1
		D	-	-4	-4	-4	-4	-4	-4	-4	-4
		V	=	-3	0	-3	-3	-3	-3	-2	-3
12	II, III	E	+	+3	+4	+1	+3	+1	+1	+1	+5
		D	-	-3	-3	-3	-3	-2	-2	-2	-3
		V	=	0	+1	-2	0	-1	-1	-1	+2
13	II, III	E	+	+2	+2	+6	+2	+1	+1	+1	+2
		D	-	-4	-4	-4	-4	-3	-3	-3	-4
		V	=	-2	-2	+2	-2	-2	-2	-2	-2
14	II, III	E	+	+	+	+	+	+5	+	+	+
		D	-	-	-	-	-	-3	-	-	-
		V	=	N.A.	N.A.	N.A.	N.A.	+2	N.A.	N.A.	N.A.

Exhibit VIII

TABLE 37

ENERGY CONSERVATION APPROACHES
BY CATEGORY--TERMS

Category	Approach	Water Heating
I	1.	Reduce temperature of general purpose hot water by 20^0. (120^0F. minimum) except where dishwashers require otherwise.
II, III, IV	2.	Use restricted flow shower heads. (2.5 GPM maximum)
II, III, IV	3.	Reduce water distribution pressure to a maximum of 40 p.s.i.
I	4.	Use clothes and dishwashers at full load capacity.
II, III, IV	5.	Use automatic shut off faucets in lavatories.
II, III	6.	Schedule maintenance on system and equipment, most especially to reduce water leakage.
II, III, IV	7.	Assure adequate and proper insulation on tanks used for storage of hot water.

Matrix Terms

Matrix:		Low ←			1 →		High
E	Relative energy reduction	1	2	3	4	5	6
D	Relative difficulty of implementation	1	2	3	4	5	6
V	Overall value or desirability of consideration	-5 ←			0		→ +5

Category: Relative to *time* of implementation (I and 11--1 to 5 years; 111-- 5 years plus).

1-- Immediate, consumer compensation automatic and economically feasible.

11/111-- Interim, requires consumer incentive and/or investment analysis.

IV-- Future, relates to design parameters of new construction influenced by economic benefits or legislation, system renovation and building rehabilitation.

Approach: Method of effecting energy reduction.

TABLE 38

ENERGY REDUCTION APPROACHES

APPLICATION: WATER HEATING

ENERGY REDUCTION APPROACHES: APPROACHES	CATEGORY		OTHER	COLLEGES	HOTELS-MOTELS	OFFICE BUILDINGS	HOSPITALS	SUPERMARKETS	SCHOOLS	STORES	APARTMENTS
1	I	E	+	+3	+2	+2	+	+6	+3	+2	+3
		D	-	-1	-1	-1	-	-1	-1	-1	-1
		V	=	+2	+1	+1	N.A.	+5	+2	+1	+2
2	II,III,IV	E	+	+6	+6	+	+	+	+4	+	+6
		D	-	-2	-2	-	-	-	-2	-	-2
		V	=	+4	+4	N.A.	N.A.	N.A.	+2	N.A.	+4
3	II,III,IV	E	+	+3	+2	R	+	+	+3	+3	+4
		D	-	-3	-3		-	-	-3	-3	-3
		V	=	0	-1	N.A.	N.A.	N.A.	0	0	+1
4	I	E	+	+	+	+	+	+	+	+	+2
		D	-	-	-	-	-	-	-	-	-1
		V	=	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	+1
5	II,III,IV	E	+	+5	+3	+6	+	+	+6	+6	+
		D	-	-3	-3	-3	-	-	-3	-3	-
		V	=	+2	0	+3	N.A.	N.A.	+3	+3	N.A.
6	II, III	E	+	+2	+2	+2	+3	+2	+2	+2	+2
		D	-	-2	-2	-2	-2	-2	-2	-2	-2
		V	=	0	0	0	+1	0	0	0	0
7	II, III, IV	E	+	+1	+1	+1	+1	+	+1	+	+1
		D	-	-3	-3	-3	-3	-	-3	-	-3
		V	=	-2	-2	-2	-2	N.A.	-2	N.A.	-2

Exhibit VII

TABLE 39

ENERGY CONSERVATION APPROACHES BY CATEGORY--TERMS

LIGHTING

Category	Approach	
I	1.	Reduce lighting levels to a minimum acceptable level. This should range between 0 percent and 65 percent (average 25 percent) where a reduction is possible.
I	2.	Turn off lights in unoccupied areas.
I	3.	Eliminate decorative lighting.
II, III, IV	4.	Maintain minimum levels of outside and inside lighting for security, safety and identification of business.
II, III, IV	5.	Use more efficient light sources (i.e., replace incandescent with fluorescent) •

Matrix Terms

Matrix:		Low ←			1			→ High
E	Relative energy reduction	1	2	3		4	5	6
D	Relative difficulty of implementation	1	2	3		4	5	6
V	Overall value or desirability of consideration	-5 ←			0			→ +5

Category: Relative to *time* of implementation (I and 11--1 to 5 years; 111--5 years plus).

1-- Immediate, consumer compensation automatic and economically feasible.

11/111-- Interim, requires consumer incentive and/or investment analysis.

IV-- Future, relates to design parameters of new construction influenced by economic benefits or legislation, system renovation and building rehabilitation.

Approach: Method of effecting energy reduction.

TABLE 40

ENERGY REDUCTION APPROACHES

APPLICATION: LIGHTING

ENERGY REDUCTION APPROACHES: APPROACHES	CATEGORY		OTHER	COLLEGES	HOTELS-MOTELS	OFFICE BUILDINGS	HOSPITALS	SUPERMARKETS	SCHOOLS	STORES	APARTMENTS
1	I	E	+	+6	+	+6	+	+6	+6	+6	R
		D	-	-2	-	-2	-	-1	-2	-2	
		V =		+4	N.A.	+4	N.A.	+5	+4	+4	N.A.
2	I	E	+	+3	+2	+3	+2	+2	+3	+2	+3
		D	-	-1	-1	-1	-1	-1	-1	-1	-1
		V =		+2	+1	+2	+1	+1	+2	+1	+2
3	I	E	+	+2	+1	R	+	+2	+	+2	+3
		D	-	-1	-1		-	-1	-	-1	-1
		V =		+1	O	N.A.	N.A.	+1	N.A.	+1	+2
4	II, III, IV	E	+	+2	+	+2	+	+2	+2	+2	+
		D	-	-2	-	-2	-	-1	-2	-2	-
		V =		O	N.A.	O	N.A.	+1	0	0	N.A.
5	II, III, IV	E	+	+2	+	+3	+	+3	+2	+3	+
		D	-	-3	-	-3	-	-3	-3	-3	-
		V =		-1	N.A.	O	N.A.	O	-1	O	N.A.

Exhibit VIII

EXHIBIT IX

MODEL BUILDING PARAMETERS

COMMERCIAL SECTOR

EXHIBIT IX

HEAT LOSS COMPUTATIONS

It was assumed that currently most internal space temperatures were carried at 75°P in the majority of building types and that there was a 10° setback for night and weekend operation in commercial buildings. Apartments and hospitals were considered maintaining a 75°P internal temperature without night setback. On this basis, the current annual BTU consumption was established (line 1, "Model Building Energy Summary" [MBES] sheets, Exhibit X). Suggested approaches to energy reduction were then applied to these base line figures. All savings in annual BTU's were related to this *current annuaZ figure* to compute percent annual savings.

Having established current annual operating conditions it was next assumed that if an owner or occupant reduced internal temperature by 10° in a commercial building and 7° in an apartment, he would be somewhat reluctant to follow his original procedure of night setback; therefore, no savings for setback is reflected in the figure on lines 2 and 3 of the MBES sheets (Exhibit X). The saving with a night reduction savings is reflected on lines 4 and 5.

The construction savings are predicated on the building under conditions of an internal temperature reduction (lines 2 and 3). These changes on construction or system alterations are compared to the *current* annual heating requirements (line 1) to compute percent annual savings.

The normal daily and weekend setback times (where applicable) assumed for each building type is noted in the heading of each MBES sheet (Exhibit X). This data was used in conjunction with the hourly heat loss figure to establish the annual figure on line 1.

In all instances the philosophy applied was one of conservatism in respect to annual savings represented by the various energy reduction approaches. Where a judgment factor was involved, the course yielding the lower savings was selected.

Lighting reduction was not added to the space heating requirements. There is no doubt that some increase in heating will be required by reduced lighting. This is most especially true in systems designed to provide some or all of the space heating demands with lighting. These systems, however, are in the minority and variations in the thermal value of lighting due to differences in fixtures, building structure, and heating, ventilating and air conditioning systems make it impossible to compute the effect on heating demands with any degree of accuracy. Heating, unlike cooling,involves the majority of buildings on a national basis, thereby, increasing the average age of the buildings under consideration.

Note: Energy reduction approaches for heating are listed on Table 33, Exhibit VIII.

COOLING COMPUTATIONS

Cooling loads were computed using American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) recommended approaches with some judgment factors applied. Where these instances occurred the decision always favored that position which would provide a more conservative savings estimate. As in heating, the *current* annual cooling load at 75°F internal temperature (I.T.) was used as the base. This figure appears on line 6 of the "Model Building Energy Summary" (MBES) sheets (Exhibit X). A reduction to a new base is established on line 7 reflecting the suggested increase in the internal space temperature to 78°F. The reduction was obtained by multiplying the ratio of the equivalent full load hours (EFLH) at 78°F over the EFLH at 75°F by the annual cooling requirements appearing on line 6. Annual savings on lines 8 and 9 and under Construction and System alterations are based on the "set up" temperature requirements, 78°F I.T. appearing on line 7. The annual savings were obtained by dividing the savings in million BTU's (MMBTU) by the annual requirements in MMBTU's on line 6. A reduction in lighting was converted to BTU's (3,413 BTU's x KW saved) and multiplied by the EFLH at 78°F I.T. on line 7 to obtain the reduction in annual cooling requirements. Unlike heating, the effect of lighting on cooling load demand can be established with a reasonable degree of accuracy. This is true for two basic reasons: (1) the average age of the buildings which have air conditioning is generally lower than the national average of all buildings; (2) buildings constructed since 1965 tend to have higher lighting levels than those prior to 1965 and in addition are more likely to be air conditioned. These two factors place air conditioned buildings on a more comparable basis than those which are heated only. See Tables 41 and 42 which follow.

Note: Energy reduction approaches for air conditioning are listed on Table 35, Exhibit VIII.

Exhibit IX

TABLE 41

MODEL BUILDINGS--HEATING/COOLING PARAMETERS

Base Construction Described in Table 42

Design Conditions Based on St. Louis, Missouri Weather Data

Le.	Ambient Conditions	Space Conditions
	Heating - +lO°FDB	70°FDB Space Temp.
	Cooling - 95°FDB and 78°FWB	75°FDB
	Degree Days = 4,SOO	EFLH = 1,000

Current Conditions are assumed at:

Heating 7S0F Space Temp. in all categories

Cooling - 75°FDB and 63°FWB

Night and Weekend Temp. Setback as and where indicated.

Under above conditions:	Internal Temp. (I.T.)	Ambient Temp.	Degree Days
	7S0F	+lO°F	S,700
	68°F	+lO°F	4,100
	6SoF	+lO°F	3,SOO
	63°F	+lO°F	3,100
	SSoF	+lOoF	1,900

Heating Calculations

1. Annual savings from reduction in space (I.T.) temperatures based on assumed conditions noted in Exhibit X.

2. Annual savings, where applicable, for night setback were established by reducing I.T. SO in apartments and 10° in remaining building types.

3. Insulation - Sidewalls figured at 3-S/8", (R-ll)
   Roof figured at 6", (R-19)

Air Conditioning Calculations

1. Annual savings from increase in space (I.T.) temperatures based on an increase from 7SoF to 78°F, where applicable.

Exhibit IX

TABLE 42

HEATING/COOLING PARAMETERS--MODEL BUILDING CONSTRUCTION CRITERIA

All data referenced in ASHRAE Fundamentals Guide 1972.*

Sidewalls

1.	4" brick veneer, 8" block with lathe and plaster	"u" = .24
2.	4" brick veneer, 8" block painted inside	- "u" .33
3.	8" block wall	"u" •39
4.	8" block wall with lathe and plaster	"u" •26
5.	Wood frame lathe and plaster	"u" .24

Windows

Single glass	"u" 1.13
Double glass	"u" = .61

Roof

Flat metal deck with 3/8" gypsum board and 1" rigid roof insulation (no plaster)	- "u" = .20
Same above, wood deck with 1/2" rigid insulation (with plaster)	- "u" = .20

Insulation

3-5/8" in walls, R-U	"u" = •07
6" in ceilings, R-19	- "u" = •05

Crackage

Infiltration resulting from crackage around window frames and between its wall and window frames is a judgment factor to some extent. Average values were used to estimate this effect. Factors used appear below.

* American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., *Handbook of Fundamentals*, Chapters 21 and 22, 1972.

Heating

Window frames: (.2" W.C. pressure differential)

	Without Caulking	With Caulking
Infiltration around and through frame	122 CFH	44 CFH
Frame - wall leakage	26 CFH	5 CFH
Total	148 CFH	49 CFH

Air Conditioning

Window frames: (.15" W.C. pressure differential)

	Without Caulking	With Caulking
Infiltration around and through frame	100 CFH	36 CFH
Frame - wall leakage	21 CFH	4 CFH
Total	121 CFH	40 CFH

Supermarkets - Frame to wall leakage *only:* (.2" W.C. pressure differential) differential)

	Without Caulking	With Caulking
Cooling and heating	26 CFH	5 CFH

Reference Chapter 19 ASHRAE Fundamentals 1972

	Page Number
• Infiltration	
--Through Windows	337
--Through Walls	339
--Through Doors	341
--Through Vestibules	341
• Wind Velocity *versus* Inches of Water	333
• Temperature Difference *versus* Inches of Water	334
• Vestibules and Revolving Doors	341
• Solar Gain	390 (Table 4) 402 (Table 15)

August 21, 4:00 **p.m.,** 7.5 MPH, *1/8"* Extra Strength Single Glass 40° North Latitude.

	Base BTU/Ft.^{2}		Shade Factor		Venetian Blind-Med.		Transmission 1.17 x 20° T.D.	*BTU/Ft.*^{2}	
N	23	x	1.0	x	.64	+	23	37.7	N
W	216	x	1.0	x	.64	+	23	161.2	W
E	22	x	1.0	x	.64	+	23	37.1	E
S	40	x	1.0	x	.64	+	23	48.6	S

Venetian blinds save 36 percent of Total Solar Load, therefore, if blinds are not used: $\frac{\text{Total Solar Load} \times .36 \times 100}{\text{Total Heat Gain}}$ = Percent Annual Cooling Savings.

WATER HEATING COMPUTATIONS

Shower Heads

The average shower head consumption is approximately 4 gallons per minute (GPM) with a line pressure of 40 pounds per square inch. This is a conservative figure since the flow range of shower heads is between 4 and 8 GPM. The installation of 2-1/2 GPM shower heads would reduce the flow by 37-1/2 percent. In a building that uses 40 percent of its total hot water for showers, the savings would amount to 37-1/2 percent of 40 percent, or 15 percent.

Water Pressure

The reduction of water line pressure to 40 pounds per square inch from an average pressure of 80 pounds per square inch for instance, would reduce the water flow by approximately 25 percent. In our conservative approach to determining energy savings, we did not assign any value to pressure reduction; however, there, in fact would be some savings although probably not in the magnitude of 25 percent--more likely, the savings may be in the area of 5 percent. This approach, although it would not represent a comparable yield in energy savings, would be a less expensive method of reducing water flow in fixtures where water pressures exceed 40 pounds per square inch.

Thermostat Setting

A reduction in storage tanks temperature by 20°p would reduce standby losses from the tank regardless of the energy source. The reduced temperature would increase the flow of hot water for all body use applications. In most instances, storage capacity is sufficiently adequate to permit this reduction. Standby losses in automatic water heaters amount to approximately 25 percent of the total energy used for hot water consumption. The storage temperature reduction of 20° (average temperature l50°P) would decrease the standby loss by 30 percent. This would reduce energy consumption by 30 percent of 25 percent or 7-1/2 percent of the total water heating energy requirements.

Clothes Washers

The average number of loads in a household could be reduced based on the realistic assumption that washer capacity is only 75

Note: Energy reduction approaches and utilization for water heating computations are listed on Tables 43 and 44.

percent utilized. "Full load" washing would result in 3 loads for every 4 loads now being washed. This, of course, would achieve a savings of 25 percent in both hot and cold water. Since there is a wide variation in clothes washing schedules, no actual savings has been computed. However, it deserves to be placed on the list of recommended methods of reducing energy.

Spring Return Faucets

Based on a flow of 1 minute duration in water basins, a spring return shut off device with a 15 second time duration could reduce the volume of hot water used. If we further assume that 15 seconds is not long enough and the user activates the faucet a second time, a 50 percent savings would still be realized.

There is generally an excessive use of hot water in basins, most especially where single spouts are utilized and water is pre-mixed. Offices, schools and industrial plants are prime candidates for the application of automatic shut off or restricted flow faucets in washbasins. In computing savings, the more conservative estimate of 50 percent reduction in hot water use in wash basins has been applied.

TABLE 43

WATER HEATING

PERCENT SAVINGS FOR APPROACHES LISTED

CATEGORY	APPROACH		OFFICES % Saved	SCHOOLS %	COLLEGES %	SUPERMARKETS %	STORES %	APARTMENTS %	HOTELS AND MOTELS %	HOSPITALS
I	1	Reduce Temperature 20^0 F	7.5	7.5	7.5	7.5	7.5	7.5	7.5	N.A.
II,III	2	Use 2.5 GPM Shower Heads	N.A.	11.3	22.6	N.A.	N.A.	15.0	26.3	N.A.
II, III	3	Reduce Pressure to 40 psi.	N.A.	7.5	7.5	N.A.	12.5	8.8	7.5	N.A.
I	4	Clothes and Dishwasher	N.A.	N.A.	N.A.	N.A.	N.A.	5.0	N.A.	N.A.
H, III	5	Automatic Shut Off Faucet	33.0	15.0	15.0	N.A.	25.0	N.A.	10.0	N.A.
II, III	6	Maintenance	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
II,III	7	Insulate Tanks	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Note: Energy reduction approaches for water heating are listed on Table 37, Exhibit VIII.

TABLE 44

HOT WATER UTILIZATION DATA

% Usages of Hot Water Output

	APARTMENTS	STORES	SCHOOLS	SUPERMARKETS	HOSPITALS	OFFICES	HOTEL MOTEL	COLLEGES
SHOWER	40	0	40	0	N.A.	0	70	60
CLOTHES WASHER	25	0	0	0	"	0	0	0
DISHWASHER	15	0	0	0	"	0	0	0
BASINS	15	50	40	0	"	66	20	30
CLEANING	5	50	20	100	"	34	10	10
TOTALS	100	100	100	100	N.A.	100	100	100

Note: The percentages in the above table are in some instances the result of judgment factors applied to the referenced data. Following is a discussion of the more pertinent areas of energy conservation relative to water heating.

Sources: All data obtained from Rheem Manufacturing Company and Edison Electric Institute publication, *Sizing of Service Water Heating Equipment in Commercial and Institutional Buildings*, August 1969.

LIGHTING

Lighting Levels

Lighting specified or in place often exceeds Illuminating Engineering Society/American National Standards Institute (IES/ANSI) Recommended Levels. For example, a "general office" situation where 150 cubic feet are recommended might be lighted to 200 cubic feet, 33 percent higher than the recommended minimum. While the relationship between watts input to the lamps and lumen output is not strictly arithmetic, it might be stated as a simplification in this instance that a saving of 33 percent of input wattage (and heat) might be effected by reducing the lighting level to the recommended minimum. (Important savings are also available from using more efficient sources.) One electrical manufacturer, for example, has recently introduced an 8-foot slimline lamp wHich operates at 20 percent lower wattage consumption chan the standard lamp, reducing the power consumption about 70 watts in a 4-lamp fixture. They also state that the 20 percent reduction in wattage reduces the lighting level only 18 percent. Relamping a 2,000-lamp installation with the new lamps, the company goes on to say, would result in a savings of 630,000 KWH over the l8,000-hour average life of the lamps. It should be noted that a reduction in lamp operating temperature can reduce energy consumption up to 25 percent.

Turn Off Lights in Unused Areas

When fluorescent lights are to be unused for 15 minutes or longer, it is cheaper to turn them off (incandescent lamps are always cheaper to turn off). If, for example, an office with two 4-lamp, 4-foot fixtures (320 watts) were unoccupied during a I-hour lunch period every day during the year (presuming 250 working days), turning the lights off would result in 80 KWH saved per year.

Eliminate Decorative Lighting

Typically, decorative lighting is incandescent, with its relatively high wattage input and heat output. A large percentage of decorative incandescent lighting fixtures utilize ISO-watt PAR lamps. If one assumes a typical area with ten such lamps in operation 10 hours per day, 250 days per year, consumption (which might be eliminated) amounts to 3,750 KWH per year.

Maintain Minumum Levels, etc.

This section refers to nightime hours when business is not in operation. Some businesses, particularly retail establishments, have in the past maintained full lighting after closing up to 10 to 12 o'clock at night. Reduction of lighting to minimums for safety, security, and identification of business, while difficult to quantify, could conceivably save as much as 70 percent of energy consumption.

Exhibit IX

Use More Efficient Light Sources

To dramatize the KWH savings which might be effected in this area, we list below quantities of 4 different light sources which would produce approximately the same amount of light (lumen output), and assume usage of 2,SOO kilowatt hours per year:

		Annual KWH Consumption
10	2S0-watt Lucalox	6,2S0
82	40-watt Fluorescent	8,200
32	175-watt Deluxe Mercury	14,000
113	ISO-watt PAR-38 (incandescent)	42,37S

EXHIBIT X

MODEL BUILDING ENERGY SUMMARIES

COMMERCIAL SECTOR

Exhibit X

TABLE 45

MODEL BUILDING ENERGY SUMMARY

APARTMENT

Bldg.. Length	100	Type Windows	Daubl e Sash		Other:
Bldg Width	60	Window Size	W= 36" H= 52"		Suites, Beds,
Height Per Floor	9	Glass Area	2800	FT^2	Students, Etc.
No. Floors	4	Lights	.625	W/FT2	35 Suites

Setback Conditions Currently No Setback

Heat Loss 722.7 MBH @ 65^0 T.D. Heat Gain 555.2 MBH @ 20^0 T.D.

ANNUAL ENERGY PROJECTIONS

Line	INTERNAL TEMP. RESET		HEATING			COOLING		
	-Heating-		MMBTU's Reqd.	MMBTU's Saved	% Saved	MMBTU's Reqd.	MMBTU's Saved	% Saved
1	75°1.T.-5700 D.D.		1520					
2	68° 1.T.-4100 D.D.	(Apt.)	1093	427.0	28.0			
3	65° 1.T.-3500 D.D.	(Corum.)						
4	63° 1.T.-3100 D.D. Setback	(Apt.)	1038	55.0	3.6			
5	55°1.T.-1900 D.D. Setback	(Corum.)						
	-Cooling-							
6	75° I.T. 1000 EFLH					555.2		
7	78° 1.T. 820 EFLH					455.2	100.0	18.0
8	Shut down one hr. prior Closing*					NA		
9	Lighting Reduction					NA		
	Construction		1520			555.2		
10	Double Glass			143.3	9.4		19.4	3.5
11	Wall R-ll			145.5	9.6		11.2	2.0
12	Roof R-19			88.6	5.8		35.8	6.4
13	Caulk, Weatherstrip			287.5	18.9		77 .4	13.9
14	Ventilation			NA			NA	
15	Revolving Door or Vestibule			14.2	.9		4.8	.9
16	Lighting (25% Red.) ✓ NA			NA			NA	

100 % Annual Savings

No. hrs./day of oper.

Exhibit X

TABLE 46

MODEL BUILDING ENERGY SUMMARY

STORES

Bldg. Length	193	Type Windows	Plate & Dbl. Sash	Other:
Bldg Width	55	Window Size	W=____ H=____	Suites, Beds,
Height Per Floor	12	Glass Area	976 FT2	Students, Etc.
No. Floors	2	Lights	3 W/FT2	100

Setback Conditions Assume Temp. Currently Setback at Night 75° to 65° - 15 hrs./day - 6 Days/wk. "On."

Heat Loss 698.1 MBH @ 65° T.D. Heat Gain 398.1 MBH @ 20° T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line	-Heating-	HEATING MMBTU's Reqd.	HEATING MMBTU's Saved	HEATING % Saved	COOLING MMBTU's Reqd.	COOLING MMBTU's Saved	COOLING % Saved
1	75° I.T.-5700 D.D.	1204.8					
2	68° I.T.-4100 D.D. (Apt.)						
3	65° I.T.-3500 D.D. (Comm.)	902.2	302.6	25.1			
4	63° I.T.-3100 D.D. Setback (Apt.)						
5	55° I.T.-1900 D.D. Setback (Comm.)	712.7	189.5	15.7			
	-Cooling-						
6	75° I.T. 1000 EFLH				398.1		
7	78° I.T. 900 EFLH				358.3	39.8	10.0
8	Shut down one hr. prior Closing*					24.1	6.1
9	Lighting Reduction					38.9	9.8
	Construction	1204.8			398.1		
10	Double Glass		42.6	3.5		9.2	2.3
11	Wall R-11		71.0	5.9		13.2	3.3
12	Roof R-19		133.8	11.1		61.5	15.4
13	Caulk, Weatherstrip		65.8	5.4		11.5	2.9
14	Ventilation		37.8	3.1		5.4	1.4
15	Revolving Door or Vestibule		N.A.				
16	Lighting (25% Red.) NA					15.9 KW	25

$$* \frac{100}{\text{No. hrs./day of oper.}} \text{ \% Annual Savings}$$

Exhibit X

TABLE 47

MODEL BUILDING ENERGY SUMMARY

SCHOOLS

Bldg.. Length	300	Type Windows	Double Sash	Other:	
Bldg Width	150	Window Size	W= 44" H= 78"	Suites, Beds,	
Height Per Floor	12	Glass Area	4320 FT2	Students, Etc.	
No. Floors	2	Lights	3.0 W/FT2	1000 Students	

Setback Conditions Assume Current Setback 10°-114 hrs. / week, Remainder @ 75°F

Heat Loss 2462.4 MEH @ 65° T.D. Heat Gain 2428.7 MEH @ 20° T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line	-Heating-		HEATING MMBTU's Reqd.	HEATING MMBTU's Saved	HEATING % Saved	COOLING MMBTU's Reqd.	COOLING MMBTU's Saved	COOLING % Saved
1	75° 1.T. -5700 D.D.		3783.2					
2	68° 1.T.-4100 D.D.	(Apt.)						
3	65° 1.T.-3500 D.D.	(Comm.)	3182.2	601.0	15.8			
4	63° 1.T.-3100 D.D. Setback	(Apt.)						
5	55° 1.T.-1900 D.D. Setback	(Comm.)	2192.5	989.7	26.0			
	-Cooling-							
6	75° I.T. 1000 EFLH					2428.7		
7	78° 1.T. 900 EFLH					2185.8	242.9	10.0
8	Shut down one hr. prior Closing*						218.6	9.0
9	Lighting Reduction						230.0	10.0
	Construction		3783.2			2428.7		
10	Double Glass			196.1	5.2		42.0	1.7
11	Wall R-11			244.4	6.5		30.9	1.3
12	Roof R-19			567.1	15.0		364.5	15.0
13	Caulk, Weatherstrip			171.5	4.5		~~30.0~~	1.2
14	Ventilation Reduction, 25%			170.1	4.5		36.5	1.5
15	Revolving Door or Vestibule			NA			NA	
16	Lighting (25% Red.)	NA					67.5 KW	25.0

$$\frac{100}{\text{No. hrs./day of oper.}}$$ % Annual Savings

Exhibit X

TABLE 48

MODEL BUILDING ENERGY SUMMARY

SUPERMARKET

Bldg.. Length	200 '	Type Windows	Plate-Fixed	Other:
Bldg Width	100 '	Window Size	W= 60' H= 12 '	Suites, Beds,
Height Per Floor	16 '	Glass Area	720 FT2	Students, Etc.
No. Floors	1	Lights	4.0 W/FT2	

Setback Conditions Assume Current Setback 10°F, 84 hrs./wk. - Remainder @ 75°F

Heat Loss 974.8 MEH @ 65° T.D. Heat Gain 804.3 MEH @ 20° T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line	-Heating-	HEATING MMBTU's Reqd.	HEATING MMBTU's Saved	HEATING % Saved	COOLING MMBTU's Reqd.	COOLING MMBTU's Saved	COOLING % Saved
1	75° I.T.-5700 D.D.	1640					
	68° I.T.-4100 D.D. (Apt.)						
3	65° I.T.-3500 D.D. (Comm.)	1260	380.0	23.0			
4	63° I.T.-3100 D.D. Setback (Apt.)						
5	55° I.T.-1900 D.D. Setback (Comm.)	1008	252.0	15.4			
	-Cooling-						
6	75° I.T. 1000 EFLH				804.3		
7	78° I.T. 850 EFLH				683.7	120.6	15.0
8	Shut down one hr. prior Closing*					56.7	7.0
9	Lighting Reduction					28.9	3.6
	Construction	1640			804.3		
10	Double Glass		31.5	1.9		5.0	.6
11	Wall R-11		83.3	5.0		8.2	1.0
12	Roof R-19		252.0	15.3		130.0	16.2
13	Caulk, Weatherstrip		34.0	2.0		11.6	1.4
14	Ventilation		N.A.			NA	
15	Revolving Door or Vestibule		237.0	14.5		100.1	12.(
16	Lighting (25% Red.) NA					10 KW	25.0

100 % Annual Savings
No. hrs./day of oper.

Exhibit X

TABLE 49

MODEL BUILDING ENERGY SUMMARY

HOSPITAL

Bldg. Length	315	Type Windows	Double Sash	Other:
Bldg Width	104	Window Size W= 5' H= 6'		Suites, Beds,
Height Per Floor	10	Glass Area 25%-.-	FT^2	Students, Etc.
No. Floors	5	Lights	2.2 W/FT2	225 Beds

Setback Conditions None

Heat Loss 5732.3 MBH @ 65^0 T.D. Heat Gain 1525.4 MBR @ 20^0 T.D.
60,000 sq. ft. only

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line		HEATING MMBTU's Reqd.	HEATING MMBTU's Saved	HEATING % Saved	COOLING MMBTU's Reqd.	COOLING MMBTU's Saved	COOLING % Saved
	-Heating-						
1	75° I.T.-5700 D.D.	12037.8					
2	68° I.T.-4100 D.D. (Apt.)						
3	65° I.T.-3500 D.D. (Corom.)	NA					
4	63° I.T.-3100 D.D. Setback (Apt.)						
5	55° I.T.-1900 D.D. Setback (Corom.)	NA					
	-Cooling-						
6	75° I.T. 1000 EFLH				1525.4		
7	78° I.T. EFLH				NA		
8	Shut down one hr. prior C10sing*				NA		
9	Lighting Reduction				NA		
	Construction	12037.8			1525.4		
10	Double Glass		726.8	6.0		38.9	2.6
11	Wall R-ll		728.7	6.1		13.4	.9
12	Roof R-19		669.9	5.6		62.1	4.1
13	Caulk, Weatherstrip		1119.8	9.3		49.1	3.2
14	Ventilation		NA			NA	
15	Cooling or Heating Reclaim.		3325.	27.6		216.0	14.2
16	Lighting (25% Red.) ✓ NA						

100 — No. hrs./day of oper.

% Annual Savings

Exhibit X

TABLE 50

MODEL BUILDING ENERGY SUMMARY

OFFICE BUILDING

Bldg. Length	198'				Other:
Bldg. Width	no'	Type Windows	Double Hung		Suites, Beds,
Height Per Floor	12'	Window Size	W=44" H= 84"		Students, Etc.
Height First Floor	15'	Glass Area	19,252 FT^2		
No. Floors	10	Lights	3.0 W/FT2		1000 Occupants

Setback Conditions Current setback at night & weekends = 9 hrs./day-5 days/wk.
"on" 4 hrs. Sat.

Heat Loss 4733.7 MBH@650T.D. Heat Gain 5597.5 MBH@200T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line	-Heating-	HEATING MMBTU's Reqd.	HEATING MMBTU's Saved	HEATING % Saved	COOLING MMBTU's Reqd.	COOLING MMBTU's Saved	COOLING % Saved
1	75^0 1.T.-5700 D.D.	7578.6					
2	68^0 I.T.-4100 D.D. (Apt.)						
3	65^0 1.T.-3500 D.D. (Comm.)	6117.4	1461.2	19.3			
4	63^0 1.T.-3100 D.D. Setback (Apt.)						
5	55^0 I.T.-1900 D.D. Setback (Comm.)	4383.5	1733.9	22.9			
	-Cooling-						
6	75^o I.T. 1000 EFLH				5597.5		
7	78^0 1.T. 950 EFLH				5072.4	525.1	9.4
8	Shut down one hr. prior Closing*					466.8	8.3
9	Lighting Reduction					529.6	9.5
	Construction	7578.6			5597.5		
10	Double Glass		1374.5	18.1		627.8	11.2
11	Wall R-ll		1102.7	14.6		173.9	3.1
12	Roof R-19		361.8	4.8		183.1	3.3
13	Caulk, Weatherstrip		803.9	10.6		88.7	1.6
14	Ventilation-Reduction 33%		778.6	10.3		179.6	3.2
15	Revolving Door or Vestibule		N.A.			N.A.	
16	Lighting (25% Red.) NA					163.35 KW	25

$\frac{100}{\text{No. hrs./day of oper.}}$ % Annual Savings

Exhibit X

TABLE 51

MODEL BUILDING ENERGY SUMMARY

HOTELS-MOTELS

B1dg..Length	156	Type Windows	Db1. Sash	Other:
Bldg Width	144	WindowSizeW= 3' H= 5'		Suites, Beds,
Height Per Floor	10	Glass Area	19,728 FT^2	Students, Etc.
No. Floors	8	Lights Rooms	N.A. W/FT^2	300 Rooms
		1st and 2nd	= W/FT^2	

Setback Conditions Rooms 68° and 63° - 1st and 2nd floor 65° and 55°
No current setback nights

Heat Loss 7591.7 MBH @ 65° T.D. Heat Gain 4294.5 MBH @20° T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET

Line		Heating MMBTU's Reqd.	Heating MMBTU's Saved	Heating % Saved	Cooling MMBTU's Reqd.	Cooling MMBTU's Saved	Cooling % Saved
	-Heating-						
1	75°1.T.-5700 D.D. Rooms 10647.6 1st & 2nd F1 5294.9	15942.5					
2	68° 1.T.-4100 D.D. (Apt.)	7675.7	2971.9	18.6			
3	65° I.T. -3500 D.D. (Comin.)	3258.4	2036.5	127			
4	63° 1.T.-3100 D.D. Setback (Apt.)	6421.4	1254.3	7.8			
5	55°1.T.-1900 D.D. Setback (Corrun.)	2260.4	998.0	6.3			
	-Cooling-						
6	75° I.T. 1000 EFLH				4294.'		
7	78° 1.T. 820 EFLH				3521.	773.0	18.0
8	Shut down one hr. prior Closing*					N.A.	
9	Lighting Reduction					N.A.	
	Construction	15942.5			4294.5		
10	Double Glass		991.1	6.2		168.3	3.9
11	Wall R-ll		701.8	4.4		216.8	5.0
12	Roof R-19		280.6	1.8		140.0	3.3
13	Caulk, Weatherstrip		1716.9	10.8		239.2	5.6
14	Ventilation		1136.6	7.1		204.8	4.8
15	Revolving Door or Vestibule		N.A.				
16	Lighting (25% Red.) ✓ NA						

100 / No. hrs./day of oper. % Annual Savings

Exhibit X

TABLE 52

MODEL BUILDING ENERGY SUMMARY

COLLEGES

Bldg. Length 288
Bldg Width 72
Height Per Floor 12
No. Floors 3

Type Windows Double Sash
Window Size W= 44" H= 72"
Glass Area 10,604 FT^2
Lights 3.0 W/FT2

Other:
Suites, Beds,
Students, Etc.
500

Setback Conditions Assume Currently Setting Back Nights-Weekends. 114 hours reduced - 70 hours normal.

Heat Loss 3,135.1 MBH @ 65^0 T.D. Heat Gain 2130.5 MBH @ 20^0 T.D.

ANNUAL ENERGY PROJECTIONS

INTERNAL TEMP. RESET Line		HEATING			COOLING		
	-Heating-	MMBTU's Reqd.	MMBTU's Saved	% Saved	MMBTU's Reqd.	MMBTU's Saved	% Saved
1	75^0 I.T.-5700 D.D.	5146.6					
2	68° I.T.-4100 D.D. (Apt.)						
3	65° I.T.-3500 D.D. (Comm.)	4052.5	1094.1	21.3			
4	63° I.T.-3100 D.D. Setback (Apt.)						
5	55^0 I.T.-1900 D.D. Setback (Comm.)	2978.0	1074.5	20.9			
	-Cooling-						
6	75° I.T. 1000 EFLH				2130.5		
7	78° I.T. 900 EFLH				1917.5	213.0	10.0
8	Shut down one hr. prior C10sing*					191.8	9.0
9	Lighting Reduction					158.7	7.5
	Construction	5146.6			2130.5		
10	Double Glass		463.2	9.0		99.3	4.7
11	Wall R-ll		218.7	4.2		18.5	.9
12	Roof R-19		261.3	5.1		168.0	7.9
13	Caulk, Weatherstrip		738.6	14.4		129.5	6.1
14	Vestibule or RevolVing Door		268.3	5.2		-	-
15	Ventilation		408.2	7.9		14.6	0.7
16	Lighting (25% Red.) NA					46.5 KW	25.0

100 % Annual Savings
No. hrs./day of oper.

Appendices

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

In Reply Refer To:
AS-EM

July 23, 1973

Dear Mr. True:

In his energy statement of June 29, the President announced additional steps being taken to conserve America's fuel supplies and their use, and called upon private industry to respond to the energy conservation directives with all the imagination and resourcefulness that has made this Nation the richest on earth.

In December 1972, the National Petroleum Council submitted to me a comprehensive summary report on "U.S. Energy Outlook," the supporting detailed task force reports being *now* received for each fuel as completed. The results of this exhaustive work done by the energy industries has been of major value to the Department and other agencies of Government, shedding considerable light on the U.S. fuel supply situation in particular.

In order to further assist us in assessing the patterns of future U.S. energy use, the National Petroleum Council is requested to conduct a study which would analyze and report on the possibilities for energy conservation in the United States and the impact of such measures on the future energy posture of the Nation.

You are requested to submit a progress report by January 1, 1974.

Sincerely yours,

Rogers C B Morton

Secretary of the Interior

Mr. H. A. True, Jr.
Chairman
National Petroleum Council
1625 K Street, N. W.
Washington, D. C. 20006

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GLOSSARY OF TERMS AND ABBREVIATIONS

APT.--Apartment

ASHRAE--American Society of Heating, Refrigerating and Air Conditioning Engineers.

basic energy--The use of electricity, gas, oil or coal to operate air conditioning equipment, for example, *versus* using outside air.

British Thermal Unit (BTU)--A unit to measure the amount of heat required to raise one pound of water one degree Fahrenheit. (Standard measurement from 59°F to 60°F.)

COMM.--Commercial Sector

degree-days (DD)--The difference between the daily mean temperature and 65°F when the temperature is below 65°F for a given day. Degree day fuel oil delivery systems are based on the principle that the consumption of fuel oil for heating is roughly proportionate to the number of degree days. The number of degree days for a given period is arrived at by adding together the number of degree days for individual days in the period.*

end-use--The final use for which the energy was consumed (i.e., heating, water heating, air conditioning, cooking).

equivalent full load hours (EFLH)--A measurement of air conditioning equal to the number of hours of an air conditioning machine running at full load.

°FDB--Degrees Fahrenheit dry-bulb temperature.

°FWB--Degrees Fahrenheit wet-bulb temperature.

GPM--Gallons per minute.

I.T.--Internal temperature.

KWH--Kilowatt hour.

MMBTU--One million BTU's (Roman numeral M for thousand--MM = 1,000 x 1,000).

N.A.--Not applicable.

night setback--Lowering the temperature of a room or space at night--"setting back the thermostat."

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* Guthrie, Virgil B., ed., *Petroleum Products Handbook*, McGraw-Hill Book Co., New York, New York, 1960, pp. 17-8, 17-9.

psi--Pounds per square inch.

R factor--A unit used to measure the resistance of heat flow through material--the reciprocal of the *"u"* factor.

scheduled maintenance--Performing maintenance on a preplanned, pre-programed basis to prevent breakdowns *versus* maintenance only when a machine breaks down.

solar gain--The amount of heat absorbed by a building due to the sun shining on it.

T.D.--Temperature difference.

"U" factor--A unit used to measure the transmittance of heat flow through material, usually expressed in BTU's per hour per square foot.

W.C.--Water column.