TEXAS ENERGY MANAGEMENT

TEXAS ENERGY CONSERVATION PROGRAM

CHURCHES

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GOVERNOR

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REDUCING ENERGY USE IN RELIGIOUS FACILITIES

A WORKSHOP

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It is hoped that the information provided through this workshop will be useful as you explore your many options and opportunities for encouraging energy conservation.

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INTRODUCTION

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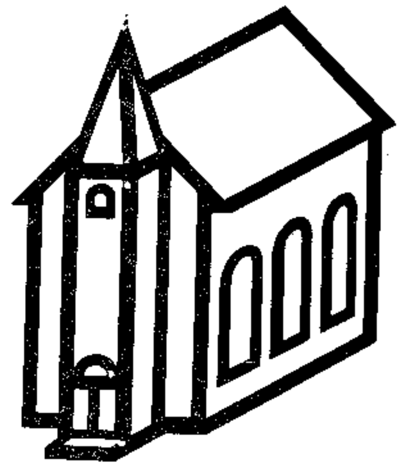
Like many other groups that own, operate and maintain facilities, religious groups are finding it more and more difficult to cope with rising energy costs. Churches are spending more for energy as well as other items such as maintenance, staff salaries, insurance, and etc. At the same time, many congregations are finding that their revenue base is not increasing at a rate necessary to off-set the increases in many budget items.

It is fairly safe to say that buildings being designed now, and those to be designed in the future will utilize many of the new techniques and systems which can lead to maximized energy efficiency. But the present building inventory is being replaced at the rate of only 2-3% per year. As a result, the majority of existing buildings for many years to come will be those which were originally not designed with energy conservation in mind.

Research reveals that existing buildings consume far more energy than necessary to accomplish the objective for which they were designed. Religious buildings are probably no exception. Energy conservation can, however, make a difference. Through energy conservation actions religious groups should be able to realize significant energy and dollar savings which allows church revenue to be used for more meaningful and worthwhile causes.

Energy conservation is a fitting activity for religious groups because in addition to saving money, conservation efforts can set a strong example, demonstrating congregations are wise, prudent and efficient users of the scarce, non-renewable energy resources.



The purpose of this workbook is to provide you with ideas, strategies and techniques involved in energy conservation that can be implemented at little or no cost with existing staff and produce immediate results.

Development of this workbook benefited greatly from case studies of churches located in Texas. The studies examine how energy is used in these buildings and the potential for conservation in the building.

As illustrations of the kind of measures that should be considered by religious groups, this workbook provides some of the specific recommendations that were made for the buildings analyzed plus some additional general recommendations. The specific recommendations pertain to the specific building studied and should not be regarded or generally applicable to all buildings. Specific recommendations for your buildings would depend on its particular physical characteristics, operational needs, and other special factors. These recommendations are generated through an energy audit of your building.

For the purpose of this workbook, energy management is emphasized because energy management considers each religious building or complex of religious buildings as a unique entity. In order to comprehend how to conserve energy via the energy management method, one must understand how energy is used, the interrelationships of the building's systems, subsystems and components. After this understanding is gained, the administrative staffs are able to determine where, when and how modifications should be made to reduce consumption. Implementation of conservation measures and of the overall energy management program becomes the responsibility of administration to ensure the realization of energy conservation goals.

While there are many specific energy management options available the overriding concept behind them all is to improve energy efficiency of the building's systems, subsystems and components. If this concept is used, it will likely produce three desirable outcomes:

(1) eliminates energy waste

(2) significantly expands areas of investigation

(3) promotes conservation without adversely affecting the religious functions and services and without loss of comfort.

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ENERGY MANAGEMENT

ENERGY MANAGEMENT

No matter how complex a religious building may be, it is possible to document the exact manner in which each element or group of systems and subsystems uses or affects consumption of energy and, as a result, to determine what modifications can be made to reduce the amount of energy consumed through an effective energy management program.

If each element of each system functioned as efficiently as possible, the minimum amount of energy required to get the job done would be expanded. While this absolute minimum is an ideal seldom achieved, nevertheless, it stands as the ultimate goal of any energy management program.

The level of technical expertise needed to accomplish these goals depends primarily on the complexity of the places of worship involved. In many cases outside assistance will be required. In other cases church personnel or members of the congregation will have the know-how needed. In either case, the individual to whom the responsibility is given should be able to explain how the various systems and their components consume energy, the options which can be used to reduce consumption and the impact that each option would have.

All religious buildings, like office buildings, supermarkets, shopping centers, etc. have three basic systems that affect energy use. They are:

(1) energized systems,
(2) nonenergized systems, and
(3) human systems.

Energized Systems are those which consume energy directly. Typical energized systems include those used to provide heating, ventilation, cooling, humidification, dehumidification, lighting, hot water heating, food cooking, dishwashing, as well as pieces of equipment such as typewriters, adding machines and copiers, etc.

Nonenergized Systems are those which do not consume energy directly but which affect the amount of energy which an energized system must expend to get its job done. Typical nonenergized systems include walls, windows, floors, roof, ceiling, doors, etc., as well as weather, landscaping, siting and similar factors.

Human Systems are those persons who somehow have an impact on when and in what quantity energy is consumed. These persons include the synagogue administrative personnel and members of the congregations.

Reduction of energy consumption in religious buildings can be achieved through the use of three methods:

The first method involves using the place of worship less or modifying present use patterns. This is referred to as an end use restriction and is a valid approach provided the place of worship is not used less than it is needed.

The second method considers habits or behavior of the occupants of the place of worship. This relates primarily to human systems and habits such as turning out lights when not needed, closing exterior doors and windows when air conditioning is on, etc.

The third method ensures that all systems in the building which affect energy consumption are operating as efficiently as possible. This requires consideration of applicable end use restrictions and occupant behavior covered in the first two methods, as well as close-up analysis of other factors which affect energy consumption. The most obvious other factor is the HVAC system. But other systems also are affected.

Obviously, the third method is the one which is most desirable. It exposes all the different ways in which energy consumption is affected and so creates numerous options -- some more effective than others which can be implemented to reduce energy consumption. This not only means more potential energy savings, but also the ability to pick and choose among those options available to reduce consumption in a manner most compatible with time and available budget. That is what energy management is all about. To illustrate the point, let us now consider how an individual or a group of individuals responsible for evolving energy conservation options for a religious building should apply their task to a church's heating and cooling system.

One of the first things they might do is to consider the amount of energy that can be saved by changing thermostat settings.

The next step would probably involve identifying ways to improve the efficiency of the system itself. Initial investigation would center on system components to ensure that they are not wasting energy, or through leaks in ductwork or piping. Inspection also would be made to ensure system components' conformity with original design. Sometimes, even in the newest buildings, systems are installed incorrectly. Controls may be missing, other may have been improperly set. Insulation on ductwork and piping may never have been installed. Operating routines also must be reviewed to evaluate this efficiency. The same applies to maintenance practices.

The third step recognizes that the amount of heating or cooling required depends not only on the thermostat setting but also on the conditions which have to be overcome. For example, if the prevailing or ambient temperature in a space is 68°F, and 75°F is desired, the heating system has to raise the temperature seven degrees. If the ambient temperture is 65°F, a ten-degree increase is involved, so more energy is consumed. Accordingly, if we reduce the impact of those factors which increase heat loss during the heating season and increases the heat gain in the cooling season, the heating/cooling system will have that much less work to do and so will consume less energy. In other words, modifying systems and subsystems which do not relate directly to the heating/cooling system can nevertheless have an impact upon it.

The factors which influence heat loss and heat gain, and a few of the many steps which can be taken to reduce their impact, are as follows: [1]

Infiltration: Infiltration refers to the passage of outside air into a building through apertures such as cracks around windows and door jambs, doors and windows left open, outside air dampers which do not close tightly, etc. In winter, infiltration causes heat loss. The cool, outside air which enters the building must be heated to meet desired conditions. During summer, infiltration causes heat gain. The warm outside air which enters the building must be cooled to meet desired conditions. In many cases additional energy must be expended to humidify, dehumidify, or filter the outside air.

Energized, nonenergized and human systems all affect infiltration. If a building's air handling system maintains a positive air pressure in the building so that interior air pressure slightly exceeds exterior pressure, the infiltration is virtually eliminated. Nonenergized systems are involved because the condition of the building's exterior envelope, doors, windows, etc., determines the number, size and location of infiltration access points. Human systems are involved because people are responsible for leaving windows and doors open, as well as for observing, reporting and correcting deficiencies which cause excessive infiltration.

Transmission: Transmission refers to the amount of heat transmitted into or from a building through the various components of the building envelope, primarily exterior walls, windows, doors, skylights, roof, and floor. The amount of heat loss or heat gain caused by transmission depends on the difference between indoor and outdoor temperatures in accord with the basic principle of heat flow. This principle states that heat always is conducted from an area of higher temperature to an area of lower temperature. Accordingly, during winter, heat flows from the interior, through the building envelope, to the exterior, causing heat loss. During summer the process reverses and heat is transmitted from outside to inside. The rate of transmission depends on the composition of the various materials utilized in construction of the building envelope. This rate can be affected by, among other things, additional insulation or storm windows, especially on those portions of the building most affected.

Ventilation: Ventilation is the term used to describe the function of the mechanical ventilation system which draws in fresh outside air. Ventilation impacts on a heating and cooling system in the same way that infiltration does, but in much greater quantities. The rate of ventilation is referred to in terms of cubic feet per minute, or CFM. The greater the CFM, the more heating or cooling is required to offset the heat loss of heat gain caused by the unconditioned air that is brought into the building. In many instances, the single most dramatic energy conservation measure -- and one achieved with virtually no expense -- involves reduction of the ventilation rate which, in many noncritical areas, may now be set far above actual requirements.

Lighting: Lighting contributes to a building's heat gain in direct proportion to the wattage of lamps involved. Heat gain is generally beneficial in winter months because it provides heat which otherwise would have to be provided by mechanical systems. In summer months, of course, the mechanical cooling system must compensate for the heat gain from light sources. There are many techniques available to modify lighting systems while keeping them consistent with the need for proper illumination. Several of the techniques involve human systems; that is, the way people use -- or do not use -- lighting for maximum efficiency.

Solar Heat: Solar heat, like the heat of light, contributes to heat gain throughout the year. The specific effect of solar heat depends on the geographical area involved, the intensity and direction of the rays, the materials which comprise the building envelope, color and texture of walls, extent and type of solar controls, and other factors. Numerous nonenergized systems -- such as blinds and drapes -- can be utilized to make maximum use of solar effect. In many cases the effectiveness of human systems (e.g., closing the drapes at the correct time) will determine how well the nonenergized systems work.

Equipment: Virtually all energized devices including business machines, food service equipment, television sets, etc., contribute to heat gain. In some cases this heat, or portions of it, can be recovered from one part of a building where heat is not needed and be ducted to another part of a building which requires heat.

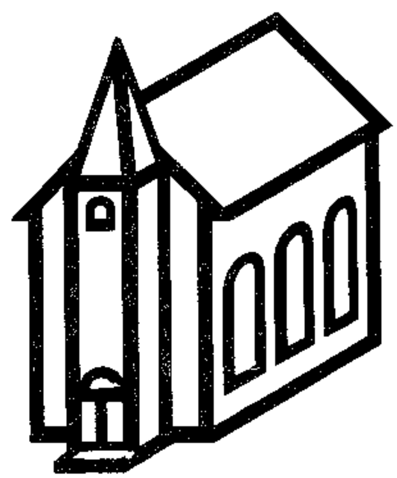
Occupants: People contribute to heat gain whenever the room temperature falls below their body temperature. People also affect the moisture content of air through perspiration and exhalation. The way in which different types of spaces are utilized will determine the extent of heat gain involved.

In almost all cases, those factors which contribute negatively to heat loss and heat gain can be modified to a greater or lesser extent. Modification can reduce the load placed on heating and cooling equipment and so the energy required for the equipment's operation.

Modifying heat gain/heat loss factors is not the only method available for reducing the amount of heating and cooling energy required. Adjustment and modification of the heating and cooling equipment itself can achieve substantial economies. It has been shown, for example, that heating and cooling systems of even the most modern buildings often have extensive inefficiencies, usually due to faulty installation, maintenance or operation. Correction of these inefficiencies -- which will not require any significant expense -- can result in substantial energy savings. Other modifications also can be made. Time clocks can be added to achieve automatic night and weekend setback for certain pieces of equipment and, in some cases total shutdown, as for HVAC (heating, ventilation and airconditioning) systems serving areas such as cafeterias which go unused for extended periods. Controls can be added to regulate ventilation equipment more efficiently. New devices can be installed to transfer heat or cooling from exhaust air to incoming air. In all cases, however, all modifications must be made in light of the various building systems involved and their effect upon each other. For example, while the amount of lighting in a given area can be reduced, the extent or reduction depends on the tasks being performed in the spaces involved, the type of persons performing the work, the ability to move desks and other furnishings to take advantage of available light in a more effective manner, the color and texture of walls, and so on. Similarly, more effective maintenance cannot be achieved unless elements of the human systems are in tune. Maintenance personnel are not likely to establish new, effective maintenance procedures unless they have direction from management. Nor are new operating procedures likely to have continuing effect unless those in charge of building operation are continually willing to do the work, and management is willing and able to continually monitor the effectiveness of the work. Human systems also can have an impact on user requirements, not so much in terms of modifying the way in which systems are used to meet requirements. In other words, users can be encouraged to turn off lgihts when a room is unoccupied; to close all exterior doors securely; to close windows when heating or cooling systems are in operation, etc.

Whenever human systems are involved, management (another human system) usually must be involved as well, generally to create incentives, monitor progress, and provide additional incentives, training or other forms of remedial action if necessary. If improved maintenance is required, management must explain why improved maintenance is required; provide guidelines which indicate how it is to be provided; perform monitoring procedures to ensure that improved maintenance is being performed, and so on.

In essence, successful application of energy management, and through it achievement of substantial energy and energy cost savings, first requires intimate knowledge of the make-up of each of your church's three fundamental systems and how they interrelate to affect energy consumption.



DEVELOPING ENERGY CONSUMPTION DATA [2]

Developing data on historical and ongoing patterns of energy use in your church is an essential element of energy management. In most cases the task is relatively easy and can be performed by clerical personnel. The records required -- mostly utility bills -- either will be on file at the place of worship or at the utility or fuel company from which energy is purchased.

At the very least, energy consumption data are required for the year prior to that in which a TEM program is to be launched. (Use of a calendar year is suggested because it makes subsequent record-keeping far easier.) The purpose of this information should be clear. It enables comparison of energy consumption data before TEM and after TEM and so indicates what impact application of TEM options has had.

Compilation of consumption data for more than just the first year prior to TEM also may be worthwhile for several reasons. Most importantly, and as discussed in more detail below, it enables one to identify how energy consumption varies with changing weather conditions. As such, it provides a means to analyze energy data more meaningfully. As an example, if January 1976 is substantially colder than January 1977, a comparison of energy consumption data for the two months would not be meaningful unless the impact of the different climatic conditions is first accounted for. Historical data also are useful in determining how consumption patterns have changed over the years. If a new piece of major equipment was added and it resulted in a significant increase in energy consumption it could be possible to estimate how much energy consumption the device is responsible for. Records could be reviewed to see if changes in key operating or maintenance personnel resulted in consumption changes.

Development of ongoing energy consumption data is a relatively simple undertaking because it involves no more than logging data as they are received from utilities and fuel suppliers. The simplicity of the task should not be allowed to obscure its importance, however. These data in most cases will comprise the sole method by which the impact of TEM procedures can be evaluated. In turn, this evaluation is used to determine -- among other things -- how well modifications were made, whether or not additional action in a specific area is necessary, and what plans for the next year or for longer periods should include. Consumption statistics also may be useful for the following purposes:

Effort Direction: When more than one building, similar in design and actual use is involved, comparison of data may indicate that one is far more energy inefficient than the other, thus serving to indicate where initial efforts should be concentrated.

Estimating: Consumption data enable development of more accurate estimates of how much money should be budgeted for energy use the coming year. They also support accurate estimation of how projected energy cost escalation is likely to impact upon budgets. These estimates and projections, in turn, can be used as supportive materials to document presentations regarding rate increases.

Operational Overview: Regular compilation and review of consumption data can lead to prompt identification of problems which otherwise may have gone undetected. For example, a sudden surge in electrical demand could indicate improper start-up sequencing of several major pieces of equipment, an easily corrected problem providing it is known. It also could indicate a billing error by the utility which, if left unattended, could result in completely needless expense.

Comparisons with Similar Facilities: When several synagogues collect similar data through use of similar forms, comparisons can be made to indicate the relative effectiveness of various actions. It should be noted that the many variables involved make it misleading to compare EUIs to evaluate the efficiency of your place of worship systems.

Logging Energy Consumption Data and Developing the EUI

A form such as the one shown in Figure IV-1 can be used to log energy consumption data. In addition to other uses for the data previously discussed, they also are used to develop an Energy Utilization Index, or EUI. The EUI is a reference which reduces all forms of energy used (electricity, oil, gas, etc.) to one common base (British Thermal Units, or BTU's) and divides that total by the total number of gross conditioned square feet in the building involved. The EUI is most useful as a ready reference which quickly shows changes in overall energy consumption from month to month, year to year, one month of one year to the same month in the following year, etc. It also facilitates comparisons between similar buildings enabling you to determine quickly which buildings are most energy efficient. When several similar churches in the same area calculate their energy consumption on the basis of EUIs, similar comparisons are possible. Recognize that such comparisons must be made with extreme care. Because of different utilization patterns, design, and other factors, a building which is as energy efficient as it possibly can be could feasibly have an EUI higher than a building whose efficiency has not been optimized.

The following is a discussion of each of the items referenced in the Total Energy Management Energy Consumption Record, Figure IV-1.

Building: Identify the building for which the form is being prepared. If only one building is involved, completion of this element is not essential. If separate EUIs are being developed for each of two or more buildings in a complex, building identification is essential.

Gross Conditioned Square Feet: The amount of gross conditioned square feet in the building involved should be entered here. Gross conditioned (heated and/or cooled) square feet (g.c.ft.) can be determined easily by measuring the outside wall-to-wall distance of each floor, including the basement and/or garage (if they are heated and/or cooled). Make deductions for any significant spaces which are not conditioned. These generally include mechanical equipment rooms, elevator rooms, and certain types of storage areas, among others. Do not make deductions if these or similar rooms and spaces are heated and/or cooled.

Year: The year for which the form is being prepared.

Month: Regardless of the billing date used by the electric, steam or gas suppliers, energy units consumed should be extracted from the bill for that month in which the greatest number of days occurred. If the billings period is March 2-April 2 enter the usage under the month of March. It is recognized that this technique can cause some inconsistencies. For example, the electric utility may use the March 2-April 2 method while the gas utility may use March 10-April 10. It is feasible -- through extra work -- to develop all data for a calendar month alone. If you are willing to perform this work (which can be identified by the various fuel suppliers and utilities involved, data extracted will be somewhat more exact.

Heating Degree Days and Cooling Degree Days: Past studies indicate that daily requirements for space heat and fuel/energy consumption vary directly with the difference between 65F and the outdoor, mean daily temperature. The outdoor mean daily temperature is the average of the maximum and minimum outdoor temperature during the 24 hours of a given day. For example, if the maximum temperature during the day is 55F and the minimum is 35F, the mean would be 45F. The heating degree days involved would be 20 (65F-45F). If there are 30 days in the month, and each has 20 degree days, total degree days for the month would be 60 (20 x 30). Cooling degree days are determined in the same manner, although it is readily admitted that many other factors -- such as humidity, solar conditions and wind -- play a significant role during the cooling season. Until such time as an accurate index is established, however, cooling degree days will have to suffice. The purpose of this information is to provide a basis for comparison. As already noted, it would be unfair to compare the EUI of January 1976 to the EUI of January 1977 if January 1977 was twice as cold as Jauary 1976. Information on the number of degree days in your area for each month usually can be obtained from your local electric or gas utility, oil distributor, or the U.S. Weather Bureau's local climatological reports. These reports are issued monthly and are available for a nominal amount from the National Climatic Center, Federal Building, Asheville, North Carolina 28801. Normally, heating degree day entries will be made for the months of October through May. Cooling degree days usually include the months of June through September.

Electricity-Kilowatt Hours (kWh): Under this column, enter the kilowatt hours shown on the elecric utility bill for the month involved.

Electricity - MBtu: As noted above, the Btu, or British Thermal Unit, is a measure of energy into which all other energy measures (kilowatt hours, gallons of oil, etc.) can be converted. MBtu indicates thousands of Btu's. The amount of MBtu's represented by the amount of kWh shown is determined easily by multiplying the kWh amount by the conversion factor shown on the bottom of the form. The product is in MBtu's and should be entered in this column.

Electricity-Kilowatt Hours Per Degree Day (kWh/Deg. Days): If electricity is used for heating, note the product of dividing kWh for the heating month by the number of heating days involved. If electricity is used for cooling, divide the kWh for the cooling month by the number of cooling degree days. In either case, as efficiency increases, the product decreases.

Electricity-KW Demand-Actual and Billed: Electricity charges for larger facilities usually are broken into two major components -- the amount of electricity used (kWh) and the rate of electricity used (kW) over a preselected short period of time, usually 15 to 30 minutes. The greatest level of demand is registered during peak periods, when several major pieces of equipement are operated simultaneously. Charges for the amount of electricity used (in kWh's) are based on the cost of generation of electricity. Demand charges reflect the fixed investment which a utility has in the distribution, transmission and generating equipment which must be available to meet your church's peak demand. In many cases, the actual and billed demands will be different. Actual demand is a record of what your demand really was during the month. Billed demand is the actual demand adjusted by the various rate provisions and is the demand used for the computation of charges. In Philadelphia, for example, demand rates for certain schedules are billed in accordance with this provision: "during the eight months of October through May, the billing demand will not be less than 40% of the maximum demand specified in the contract, nor less than 75% of the highest billing demand in the preceding months of June through September." The way in which the rates are structured will enable you to establish during which months an effort should be made to reduce demand and demand charges. For example, in Philadelphia highest demand usually is recorded in July or August. If demand during both these months can be reduced, then billed demand charges for heating months (which cannot be less than "75% of the highest billing demand") will be lowered. Be certain to enter actual and billed demand in the correct columns.

Electricity-Cost-Total: Enter the total cost of electricity for the month involved.

Electricity-Cost-Per Unit (Per Ut.): Obtain per unit cost by dividing total cost by kWh. This will enable you to compare costs of different months or of different buildings.

Fuel-Oil-Quantity Gallons: Enter the amount of fuel oil actually consumed during the month. Note that this is not necessarily the amount of oil purchased. By knowing how much was on hand at the beginning of the month, how much was added, and how much was left at the end of the month, you will be able to determine consumption.

Fuel-Oil-MBTU: Enter the MBTU equivalent for the type oil involved using the appropriate conversion factor provided.

Fuel-Oil-Cost-Total: Multiply the per gallon cost shown on the bill by the amount of oil used during the month.

Fuel-Oil-Cost-Per Unit (Per Ut.): Enter the per unit cost shown on the bill.

Fuel-Gas-Quantity-Thousand Cubic Feet (Mcf)): Enter the amount of gas consumed for the period in terms of thousands of cubic feet. Adjust figures indicated on the bill as necessary.

Fuel-Gas-MBTU: Multiply the figure in the space immediately to the left by the conversion factor provided and enter the product in this space.

Fuel-Gas-Cost-Total: Enter the total cost for the period.

Fuel-Gas-Cost-Per Unit (Per Ut.): Divide the total amount charged for the period by the amount of Mcf involved to obtain cost per Mcf. Note that you could alter this and similar sections to obtain cost per hundred cubic feet or per cubic foot. Such adjustments are completely acceptable, provided they are made on a uniform basis.

Other Fuels: Enter in the appropriate columns the quantity (Quant.) of other fuels (such as coal or propane) used, the amount of MBTU's involved (MBTU), the total cost (Cost-Total) and per unit (Per Ut.).

Fuel-Fuel/Degree Day: Note that the total quantity of fuel used to heat during a heating month should be divided by the total number of heating degree days in the month. During a cooling month, the quantity of fuel used for cooling should be divided by the number of cooling degree days in the month. If more than one fuel is used to heat and/or cool, a separate column may be required.

Purchased Steam-M (lbs.): Enter total steam consumption (in terms of thousands (M) of pounds) as shown on the bill.

Purchased Steam-MBTU: Apply the appropriate conversion factor to the amounts of Mlbs. of steam consumed in the period to determine the amount of MBTU's involved. Insert the product in this column for the appropriate month.

Purchased Steam M(lbs.)-Degree Days: If steam is used for heating and/or cooling, divide quantity of steam by appropriate heating or cooling degree days, as for kWh.

Purchased Steam-Lbs./Hour Demand-Actual: Enter actual demand as shown on the bill.

Purchased Steam-Lbs./Hour Demand-Actual: Enter actual demand as shown on the bill.

Purchased Steam-Lbs./Hour Demand-Billed: Enter billed demand as shown on the utility bill. The difference between actual and billed demand is essentially similar to the difference involved for electricity.

Purchased Steam-Cost-Total: Enter total cost as shown on the bill for the appropriate period involved.

Purchased Steam-Cost-Per Unit: Divide total cost by quantity (M(lbs.) and enter.

Total MBTU: Total BTU's for the period is determined easily by adding together MBTU's for the various other energy forms.

EUI: EUI is derived by dividing the total MBtu's for the month or year by gross conditioned square feet of the building involved. Note that measures other than a "standard" EUI can be used.

Figure IV-1: Total Energy Management Energy Consumption Record

Year ________
Building ____________________
Gross conditioned area ________ ft.^{2}

Month	Heating Deg. Days	Cooling Deg. Days	Electricity							Fuel				
										Oil				
			KWH	MBTU	KWH/ Deg. Days	KW Demand		Cost		Quant. (Gal.)	MBTU	Cost		Quant. (MCF)
						Actual	Billed	Total	Per Unit			Total	Per Unit	
Jan.														
Feb.														
March														
April														
May														
June														
July														
Aug.														
Sept.														
Oct.														
Nov.														
Dec.														
Total Per Year														

CONVERSION FACTORS:

Electricty (____KWH × *3.413* = ____MBTUs)

Gas (____ MCF × 1030 = ____MBTUs)

Oil (____ Gallons × #2-138 / #6-146 = ____MBTUs)

Steam (____Mlbs. × 1000 = ____MBTUs)

Coal (____ Short tons × 26000 = ____MBTUs)

Gas			Other Fuels				Fuel/ Deg. Days	Purchased Steam							Total MBTU
	Cost		Quant.		Cost			M (lbs.)	MBTU	M lbs./ Deg. Days	lbs/hr Demand		Cost		
MBTU	Total	Per Unit		MBTU	Total	Per Unit					Actual	Billed	Total	Per Unit	

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It should be noted that some congregations have found it useful to plot energy consumption and related data in graph form, as shown in Figure IV-2. This technique provides a quick method to note developing trends and interrelationships as well as means for judging the effectiveness of a conservation program.

Establishing An Initial Energy Conservation Estimate

It may be appropriate to make an initial presentation to governing board and discuss the amount of money which TEM could save in its first year of implementation. Since 10% to 15% energy savings often are achieved, the dollar figure discussed could be based on that 10% to 15% range. Note that a 10% energy savings does not necessarily translate into a 10% energy dollar savings. The amount of money actually involved depends on which types of energy are conserved most and the rate for the energy at the time. For example, one thousand gallons of oil in 1976 may have cost $320. In 1977 the equivalent amount may be worth $420.

In making the presentation it should be stressed that the numbers provided are strictly "ballpark estimates." There is no way of obtaining an accurate fix on the true extent of savings potential until a comprehensive building survey is made and options to be implemented are identified. Once a realistic savings estimate can be made, however, it becomes the goal for the first year of TEM or, more likely, the first full calendar year of TEM. In fact, sometimes frustrating time lags may occur between the time a proposed plan of action is developed and approval and funding are received. This is to be expected when a major new program is launched. As such, while a goal can be set once the survey is completed, it should be a modest one which recognizes some of the problems and delays which are likely to occur.

As the program progresses and plans for the following year are developed well ahead of time, it will be far easier to identify realistic reduction goals based on plans and experience. Eventually, of course, the ultimate goal is to achieve and maintain the maximum level of efficiency which cost effectiveness permits.

Climatic Adjustment

As mentioned, it is difficult to compare energy consumption from one year to the next without considering varying climatological factors -- temperature, wind, humidity, precipitation, cloud cover, etc. -- which affect a building's hating, ventilating and cooling system. What is needed, obviously, is some means whereby climatological factors can be indexed and then integrated with consumption data so energy consumption in the base year can be compared to a subsequent year on the basis of identical climatological conditions. At this writing numerous private and public organizations are involved in research aimed at developing such a climatological adjustment factor. Until such time as the factor is developed, however, you will be forced to rely on one of two methods which should result in a reasonable basis for comparison.

The first method is to contact the local gas or electric utility. In most cases they have material on climatic factors readily available and utilize the degree day method -- adjusted for local conditions -- to determine their own future requirements. Chances are members of a utility's energy management staff can review data concerning your building, and give you a reasonably accurate appraisal of how your EUI data can be adjusted for the impact of weather.

The second method, which can be used in conjunction with the first, requires collection of historical energy consumption data on your place of worship for the past five years. You probably will be able to rely on your own records or those which the utility may have. Obtain data on heating and cooling degree days for your area for the same period from the National Climatic Center, Federal Building, Asheville, North Carolina 28801. Analyze the relationship between changes in heating and cooling degree days (and other weather factors) and resultant changes in energy consumption (assuming that the HVAC system, load and operating and maintenance practices have remained relatively unchanged over the period under review). The more detailed your review, the more factors which can be considered and the more accurate your adjustment can be.

CONDUCTING THE FACILITY SURVEY

Proper performance of a facility survey is absolutely fundamental to successful development and implementation of a TEM program.

The purpose of a facility survey is to identify those factors which affect energy consumption in the synagogue. This would involve, as examples, identifying types of energized systems involved, the condition they are in, the ways in which they are operated and maintained, etc.; actual monitoring of the way in which a system or space is used, as well as surveying windows to observe daylighting characteristics, and inspecting painted surfaces to determine if cleanliness and/or coloration is in keeping with the requirements of good illumination.

Obviously, the survey must be performed in a painstaking manner. This is completely as it should be when one considers that the survey in many cases may be used as the basis for one, two, three or more years' worth of TEM activity.

Those directing and performing the survey must know what to look for and understand what they are looking at. The level of expertise required usually is in proportion to the complexity of the systems involved. One of the keys to making the survey is lack of bias. One of the problems which feasibly could develop when in-house personnel are involved is a tendency -- conscious or subconscious -- to downplay certain deficiencies which could reflect poorly on certain individuals.

Recognize that there are many consulting engineers experienced in the field of energy conservation in religious facilities. A qualified consultant could be utilized to conduct the complete survey, prepare the report, and participate in subsequent actions, or his role could be to conduct only the survey and prepare a report, or simply to review findings and make recommendations to in-house staff.

It is to be anticipated that, in some cases, the decision to retain outside assistance in whole or in part will be based on the cost involved. Cost estimates can be obtained directly from consulting engineers, from those in similar positions who have used consultants' services for similar undertakings, or from utility representatives. In any event, the cost involved should be recognized as an investment because the recommendations contained in the survey report generally will result in substantial savings.

If you are considering utilizing the services of a consultant, and if the synagogue was constructed within the past ten years, be certain to contact the firm which was responsible for the mechanical and electrical design elements of the building to determine if it also has energy conservation capabilities. Also consider firms which have performed well for other institutional and references obtainable through telephone conversations. Additional references may be obtained from electric and gas utilities, as well as from the various organizations listed in Appendix A of this handbook, or local chapters of those organizations.

Do not select a consulting engineer on the basis of references alone. It is considered good practice to ask as many as three or more firms to provide information on relevant projects which they have had in the past two or three years, special capabilities which may be brought to bear, personnel who would be assigned to your project, current client listings, and related information. Based on these submissions, rank the firms in order of priority, the firm which seems most competent being listed first. Representatives of all firms should meet with TEM management to review the nature of the project, inspect the facility on a firsthand basis, and discuss ways by which they would approach the assignment. Based on impressions received from this procedure, firms should be reranked as necessary and cost negotiations should be opened with the one considered most acceptable.

In most cases the rates charged by consulting engineering firms are roughly equivalent. Total costs for the project usually vary because of the extent of work which will be involved in the specific approach developed by a specific firm. By keeping discussion of cost separate from evaluation of other factors, qualifications of the firm are considered separately. Without such separation, selection could be based on cost when, in fact, quality factors comprise the key criteria.

Whoever conducts the survey first must obtain a copy of the architectural, mechanical and electrical design drawings and specifications to familiarize himself with the buildings configuration and design, and electrical and mechanical systems and equipment layout, operation and control. If such drawings are not available, it may not be necessary to develop single-line diagrams of existing mechanical and electrical systems. The surveyor also should be given access to any written operating and maintenance procedures manuals supplied by equipment manufacturers or original building design professionals. He also should be familiar with utility rate schedules as well as materials which relate to any planned building modernization programs and their applications. Much of this information can be recorded in a form such as shown in Appendix B.

Once the surveyor has familiarized himself with the various building systems and equipment data, the next step is to conduct the walk-through survey. The basic tools required for this task are writing implements and paper, although a tape recorder may prove to be a valuable substitute, especially for interviews with selected personnel. A camera could be valuable to illustrate certain critical areas. Instruments required generally include lightmeters, psychometers, ammeters, etc.

The items which require investigation and analysis are discussed in the following chapter. Just a quick glance indicates that some of the most critical areas include: airtightness of the building and how infiltration can be reduced; transmission characteristics and how they can be modified; ventilation system operation and controls and how they can be improved; departmental procedures and how they may be contributing to excessive energy consumption; heating and cooling equipment, maintenance and controls and methods of improving their efficiency; lighting and lighting levels and how they can be modified, and so on. If in-house personnel are not making the survey, it will be necessary for the surveyor to interview them to determine how they go about performing their jobs and what ideas they have for energy conservation measures. In this regard, it is worthwhile to emphasize that every effort should be made to ensure that in-house operating, maintenance and other personnel see the survey for what it is and not as a challenge to their own ability or credibility. In most cases the cooperation of in-house personnel is essential for proper conduct of the survey.

The survey should result in a thorough report which details deficiencies of energized, nonenergized and human systems which have led to excessive energy consumption. The report also should contain a list of alternative actions which can be undertaken to correct deficiencies in light of building interrelationships. It also may be practical to include the expected cost of such modifications when costs are involved. In addition, the report should indicate the type of equipment and controls which could be added to the various systems, and those new procedures, such as following a prepared lighting schedule, which can be developed to reduce energy consumption. Cost factors appropriate for your institution also should be identified. These typically include payback period and/or rate of return for each modification. In some cases not all factors can be identified precisely. When they can be, however, computations must be made utilizing accounting methods approved or recommended by the church's comptroller.

Whenever a change involves a significant capital outlay or the possibility that a portion of a building must be closed for a period of time, or an action of similar imact, it is suggested that no action be taken until thorough feasibility study is conducted. Such studies provide the full, in-depth information required to base a decision on all relevant facts. While the retrofitting opportunities which are subject to feasibility studies may be mentioned in a report, the feasibility study itself usually is far more detailed, and prepared subsequent to review of the initial study, in full light of other alternatives which exist.

Building Automation Systems

A building automation system can provide constant surveillance of all building systems to enable the most efficient and effective use of energy and manpower possible. While an automated control system obviously can be used to monitor and control central system elements, it also serves to connect virtually all other energized systems of a building or complex of buildings into one central location.

Building automation, or central control systems are most applicable for larger more complex buildings or groups of buildings. They vary from the relatively simple types designed to perform a few functions to the progressively more complex types performing more and more complicated function.

Typical functions performed by building automation systems include:

-- monitor all fire alarm and security devices;

-- monitor operating conditions of all systems and reschedule set points to optimize energy use;

-- monitor all systems for off-normal conditions;

-- limit electrical demand by predicting trends of loads and shedding nonessential services according to programmed priorities;

-- monitor continuously selected portions of any systems and store information in bulk memory for later retrieval and use in updating software;

-- optimize maintenance tasks to effect maximum equipment life for minimum manpower labor and costs;

-- optimize operation of all systems to obtain the maximum effect for the minimum expenditure of energy, and;

-- provide inventory control of spare parts, materials, and tools used for maintenance.

Judicious use of these functions enables staff to operate all systems from the central console and have minute-by-minute control of operations. Any physical plant critical alarm will be reported automatically at the console. The operator will then be able to scan the system in alarm, analyze the fault and dispatch the correct maintenance man to effect repairs. Maintenance alarm summaries will be available on demand and will be printed out once each day. These maintenance alarms will allow work scheduling and maximum use of maintenance personnel.

Although systems usually are very costly, they generally are so cost-effective that they generate rapid paybacks. Sources of cost benefit include:

-- energy cost/savings generated by energized systems optimization;

-- energy cost savings generated by demand control;

-- labor cost savings due to reduced manpower requirements (operating, maintenance and security personnel) and reduced manpower educational requirements (central plant operators);

-- increased useful life of energized systems and their components due to more efficient operation and improved maintenance;

-- reduced insurance costs due to improved security and fire protection systems; and

-- added value to the building.

System Types and Components: Building automation systems can be specified on a component or package basis. Using components enables specification of different manufacturers', products and often results in a design which is highly responsive to the needs of a given installation, providing that all components are completely compatible with one another. A component system sometimes may be less costly than a packaged system, but different types of warranties, service requirements, etc. -- when they exist -- may cause some problems.

Packaged systems are available from the major control manufacturers. These systems all have common features and can accomplish a similar range of tasks. Each manufacturer uses coding and computer languages which are unique to the system, however, and cannot be decoded by any other system. Once a basic system has been selected and installed, however, all subsequent additions must be obtained from the original manufacturer. For this reason it is important to investigate thoroughly the expansion potential of a system in relation to future predicted requirements.

The typical systems -- be it component-based or packaged -- is composed of four major parts.

Interface panels: Located at strategic points throughout the building, usually in equipment rooms. These panels form the focal point of all signals to and from a particular area.

Transmission System: Between the central console and all interface panels.

Central Control Console and Associated Hardware: Located in a control room (usually close to boiler room and chief engineer's office).

Software: Program generated by the manufacturer of another source in conjunction with the prospective user. Software input via magnetic tapes, paper tapes, or cards, contains the basic operating instruction for the computer and is stored in the form of "bits" of information either in core or bulk memory.

DEVELOPING AND IMPLEMENTING THE BASIC PLAN

Once the survey is complete, analyze findings to determine what they mean in terms of corrective actions that should be taken. Once that is done, analyze each corrective action of TEM option from several different points of view to establish priorities, that is, which option should be implemented first, which second, and so on. This type of ranking leads to development of a tentative plan and schedule for TEM activity which should be reviewed by the TEM committee of department heads and others. Committee review and approval turns the tentative plan into an actual, basic plan which provides guidance for future TEM work.

Survey Analysis

If a consultant was retained to perform the initial survey, he also should be instructed to perform an analysis to identify actions which can be taken to effect energy conservation, providing details on those which are most feasible and general information about those which probably will not be undertaken for a while, such as addition of heat recovery equipment.

If the analysis is to be performed in-house, consider these guidelines:

(1) Determine where energy inefficiencies and wastage now exist. This does not imply modifications to the system, but rather those actions which should be taken to bring elements of the system up to the efficiency at which they should function. This in itself can save a considerable amount of energy.

(2) If a given piece of equipment is operating poorly, determine why. Is it because it: needs adjustment, repair or replacement? is not being maintained well? is being operated improperly? etc. The cause, of course, leads directly to the cure. If poor maintenance seems to be the problem, it could mean that a revised maintenance schedule may be required or that more instruction must be given. Many of the guidelines provided in this manual will provide direction on this subject. At all times, however, consider how any change -- even bringing the system up to full operating efficiency -- will affect other elements of the same or other systems.

(3) Determine where systems can be modified in accordance with guidelines provided to achieve greater energy efficiency. In so doing, consider how the modifications should be made and what the effect will be on other systems related to it directly or indirectly.

(4) Determine the problems which may occur due to implementation of actions, especially those which impact on delivery of health care and related services. The more you can think along these lines and recognize beforehand the stumbling blocks which probably will present themselves later on, the better your chances of avoiding the stumbling blocks completely. Considera-

tion of codes and other regulations is of critical importance. Some of these include:

-- Building Code

-- Electrical Code

-- Mechanical Code (Heating, Cooling, Ventilation, etc.)

-- Plumbing Code

-- Fire Prevention Code

-- Elevator Code

-- Health Codes

-- Occupational Safety and Health Administration Regulations

-- Public Utility Regulations (Electricity, Steam, Gas, Water, Sewer, Telephone)

-- Air and Water Pollution Regulations

While representatives of each of the agencies involved can be contacted, it may be far easier to utilize a consultant who is familiar with most of these concerns.

Categorizing Options

Once the initial survey review is complete and the various options are identified, analyze each option in terms of energy and energy dollar impact, cost of implementation, and funding factors, as follows:

Energy and Energy Dollar Impact

The most obvious set of criteria which can be applied relate to energy and energy dollar impact. Those options which will yield the most substantial savings must receive close scrutiny. In some cases, such as weatherstripping doors and windows, it will be difficult to determine exactly how much energy is involved. Nonetheless, a reasonable estimate should be made.

MONITORING YOUR PROGRAM AND KEEPING IT EFFECTIVE

Monitoring a TEM program properly is critically important. In essence, by maintaining accurate records, TEM program management is able to document what has been done, the effectiveness of various actions, cost and cost savings involved, etc. Among other things, this kind of information is essential to maintain a high level of human interest in the program. If people are asked to help achieve a goal, they want to know how effective their assitance has been. Monitoring also is essential to determine the effectiveness of given individuals, where aditional changes are required, and to project the impact of prospective actions based on past experience. Despite the importance of monitoring, it generally can be performed with very little difficulty, in many cases being incorporated into regular daily, weekly, or monthly routine.

Monitoring your program involves two distinct types of effort.

The first type effort consists of monitoring changes implemented in terms of the quality of implementation. If a contractor is hired to perform certain work, for example, his work should be inspected before signing off on it to ensure that it has been done in a satisfactory manner. If maintenance schedules are revised, you should check with maintenance personnel to ensure they can handle the revised schedule. Check on equipment being maintained to ensure that maintenance is being performed well. In essence, this is doing nothing more than following procedures of good management -- making sure that those responsible for carrying out specific functions carry them out in the most effective manner.

All changes implemented should be noted on a form such as shown in Figure X-1. Duplicate copies of operating and maintenance manuals and schedules and related information also should be kept on file should replacement become necessary. The same holds for cost and inspection records.

The second type of effort concerns monitoring the effectiveness of the program itself in terms of energy consumption. This can be done easiest through use of the form discussed in Chapter IV. This form will provide information on the entire system and on certain subsystems if the subsystem involved is the only subsystem which utilizes a certain form of energy. For example, if coal is used only for heating purposes, amount of energy utilized for heating can be determined exactly by referring to coal consumption records. In most cases, however, subsystem information cannot be extracted easily nor is there any great need that subsystem information be determined precisely. If, however, you do feel that it is imperative to determine exactly how much energy specific subsystems consume, such information can be obtained either through check metering or conduct of an empirical survey.

Check metering involves actual metering of power being supplied by the various electrical feeders to the subsystems thereby establishing how much energy each subsystem utilizes. In more contemporary buildings, where individual subsystems are supplied power independently, such metering is a relatively simple undertaking. For older buildings, however, which typically have several systems operating from one feeder, the task is far more difficult, if not practically impossible. Even when contemporary buildings are involved, however, the cost of check metering -- although as mentioned a relatively simple task -- can be very high.

The alternative to check metering is an empirical survey wherein a professional is retained to survey the building and its various subsystems to establish data on all connected loads, their usage and load factors, and to determine subsystem energy consumption. The larger the building involved, the more difficult and expensive the task becomes. Nonetheless, such work has and is being done.

In certain cases -- when a building is heated and cooled by electricity -- energy utilized by heating and cooling subsystems is obtained easily by installing and monitoring separate, totalized and general load meters.

The monitoring process, and the information which results from it, should be utilized to keep your TEM program as effective as possible by making improvements where data suggest improvement can be made; by undertaking alternatives which have not as yet been attemped; by revising goals where revision seems warranted, etc. In addition, it is suggested that the program be made as permanent a part of the management function as possible. This effort would include holding periodic meetings with building and management personnel to keep them abreast of accomplishments, set-backs, and future planning, as well as to request information and ideas which would benefit the program. Occupants should be treated in a similar manner to help ensure their involvement with the program and their continued willingness to make those efforts required to achieve conservation of energy.

3

ENERGY MEASUREMENT

FACTORS WHICH EFFECT UTILITY RATES

1. Basic Rate
2. Surcharge
3. Fuel Adjustment
4. Sales Tax
5. Demand
6. Demand Ratchet
7. Efficiency of Consumption
8. Off Peak Load
9. Reactive Demand
10. Reactive Demand

1. Basic Rate for Electric Energy (KWH)

A. Determined by State Public Service Commission.

B. Measured by watt-hour meter

2. Surcharge

A. Temporary adjustment allowed by Public Service Commission for interim relief of utility while pending decision on new Basic Rate.

3. Fuel Adjustment

A. Changes each month.

B. To reflect costs of fuel used to generate power.

C. Utility estimates fuel adjustment in advance and includes adjustment for error in past month's estimate. (Fuel $ cost vs. Fuel adjust. $ recovered)

4. Sales Tax

A. State Sales & Use Tax plus county sales taxes where applicable.

B. Identical to Sales tax on general purchases – shoes, shirts & sealing wax.

5. Demand

A. Requires separate meter, usually incorporated in watt-hour meter.

B. Is the speed at which KWH go through the meter over a short period of time.

C. Pulses

1. Time intervals generated inside Demand meters.

2. Used for purposes of determining the speed at which KWH go through the meter.
3. 15 minute, 30 minute, 60 minute

D. Example:

Assume 3 new meters reading zero watt hours and zero KW Demand. 15, 30 and 60 minute pulses. Connect to 100 KW load

1. At end of 15 minutes: all 3 watt hour meters will indicate 25 KWH

   15 min. meter registers 100 KW Demand

   20 min. meter registers 50 KW Demand

   60 min. meter registers 25 KW Demand

2. At end of 30 minutes: all 3 watt hour meters will indicate 50 KWH

   15 min. meter registers 100 KW Demand

   30 min. meter registers 100 KW Demand

   60 min. meter registers 50 KW Demand

3. At end of 60 minutes: All read 100 KWH 7 100 KW

E. Demand is calculated separately as a demand charge by the utility and is added to the bill for energy (KWH) consumed.

F. In effect, the charge for demand is a penalty for using surges of power over a short period of time.

6. Demand Ratchet

A. Demand meters are reset to Zero each month by the meter reader.

B. Registered Demand on the meter will reflect the peak KW Demand for whatever time interval or pulse used by the utility.

C. Some utilities calculate the demand charge based on whatever Demand is registered on the meter each month.

D. Other utilities calculate the demand charge based on the highest Demand registered for a period of 12 months.

E. Thus, each new demand peak sets a new, higher peak and any subsequent reduction in demand is virtually ignored for 12 months.

This creates an artificial, "Billing Demand" which can ratchet upward every 15, 30 or 60 minutes but can ratchet downward only after 12 months.

F. This would not have a great effect on power costs if Demand charges were only a few center per KW.

7. Efficiency of Consumption

A. Energy per peak demand or KWH per KW Demand

B. The more efficiently that energy is used, the less expensive the demand.

C. Conversely, the less efficiently energy is used, the greater the penalty.

D. This is the determining factor which decides which rate is applied to your measured consumption and demand billing.

8. Off peak load

A. There are many peaks and valleys in utility energy loads.

1. Seasonal
2. Weekly
3. Daily
4. Weekends & holidays

B. Utilities are constantly encouraging customers to shave the peaks and fill the valleys.

C. Electric energy cannot be inventoried and rationed, but must be, by law, generated at the instant it is required.

D. This creates a legal committment by the utility to have reserve generating capacity to meet the highest peak demand on its lines during the instant of greatest load.

E. Inasmuch as this peak lasts only for an instant during the year it leaves generating capacity which is unused and incapable of amortizing the utility's investment until the next peak instant which may not occur until perhaps a year later.

F. It is this unused generating capacity which must be paid for by demand charges since it might never amortize itself out of energy sales.

b. Customer has no proof of error in Demand reading

c. Erroneous Demand reading can set a peak which may last all year

d. Multiplier of the meter naturally multiplies the error

e. Protection of the Customer

    1. Ask for meter reading verification by Supervisory personnel

    2. Learn the day of each meter reading cycle

    3. Read the meter before the meter reader reset the demand meter.

    4. A suspicioned error in demand may be appealed and an adjustment made.

        a. This must be based on credibility.

        b. Credibility is earned over a long period of time from a good knowledge of specific meter data

        c. Credibility may be earned in a new installation from monthly photographs of the meter.

    5. Power interruption over an extended period can set a false Demand peak

        a. Power interruptions should be recorded and placed in a data file to support a possible claim for adjustment of a false peak

        b. Peaks set while testing equipment in new construction.

            1. If possible, run test of equipment on contractors temporary power

            2. If not possible to use contractors power, then arrange with utility to make adjustment of any demand peak made while testing.

            3. Make these arrangements <u>before</u> the test.

Extracted From: State of Wisconsin, Energy Conservation Manual, Wisconsin Restaurants

READING UTILITY METERS

To assist in checking the quantity of electricity, gas, or water used during the billing period, or other time periods as may be desirable, the following information on utility meters should be studied.

The meter faces illustrated are types in common use; however, your particular meter faces may vary somewhat. The illustrations should give enough information to familiarize you with general meter types and the method of reading meters.

ELECTRIC METERS

Electric meterings are of two major types:

Kilowatthour meter - general demand customers where the rate schedule is based only on kilowatthours.

Kilowatthour meters plus kilowatthour demand meter - for larger energy consumers. The rate is based on kilowatthours consumed plus maximum short-term energy demand. The demand charges, based on the demand meter reading, cover the cost to the utility to maintain sufficient energy-generating capacity to properly supply the large, short-term energy demand required of the customer. This demand is the maximum KW demand in any 15 or 30 minute interval during the billing period.

Reading Kilowatthour Meters

Meter dials are read from left to right noting the number the pointer is on or has passed. Note: Each pointer rotates in the opposite direction to its adjoining pointer. Therefore, start at 0 and rotate in the same direction the pointer rotates (0-1-2-3-4, etc.).

To determine energy consumed, subtract the initial reading from the final reading for any time period. Record times, reading, and energy consumed.

The meter face may have "multiply all readings by ___" inscribed on it. To determine the correct reading, multiply this multiplier as noted on the face, with the actual meter reading.

Reading Kilowatthour meter with kilowatt demand meter -

The kilowatthour meter reads as described in the kilowatthour meter section.

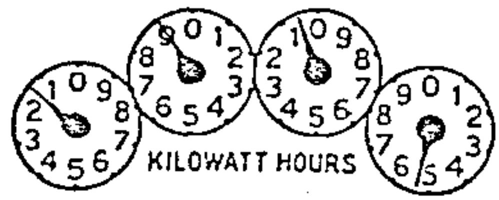
The kilowatthour demand meter may be separate from or be a component of the kilowatthour meter. Due to the many variations in demand meters and methods of reading each, you should consult with your utility company for instructions in reading your specific demand meter.

The meters shown herein are of (1) large single sweep dial face, and (2) the multiple dial face, similar to the kilowatthour meter dial faces.

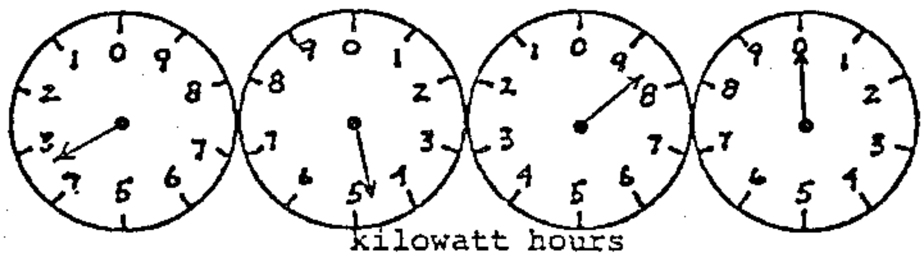
The sweep dial face meter records the maximum demand during the billing period. The pointers will indicate directly and hold the maximum KW demand during any period of the billing month. This indicated demand must be multiplied by the indicated dial face multipliers, if there is one, to obtain the correct KW demand for the period. The pointers must be reset to '0' by the meter reader. It, therefore, indicates maximum demand for the billing period only.

The multiple demand dials are read in the same fashion as the kilowatthour meter dials. The vertical line between dials indicates where the decimal point will appear in the reading. If there is no vertical line, the period comes after the reading from the last dial face. This reading must be multiplied by the indicated dial face multiplier, if there is one, to obtain the correct KW demand. The demand meter dials must be reset to '0' by the meter reader. This also indicates maximum demand for the billing period only.

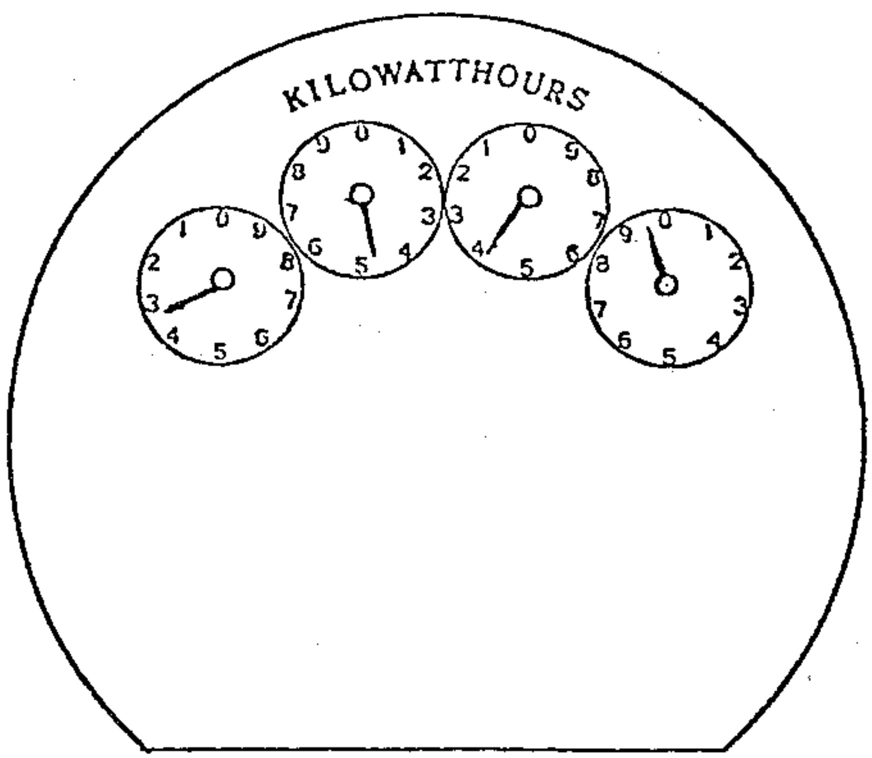
KILOWATTHOUR METERS



Reading = 1905 KWH

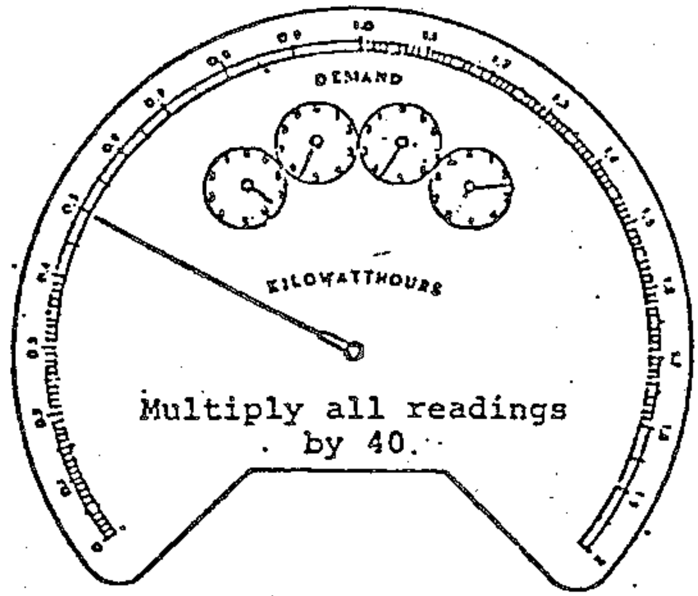


Reading = 3480 KWH

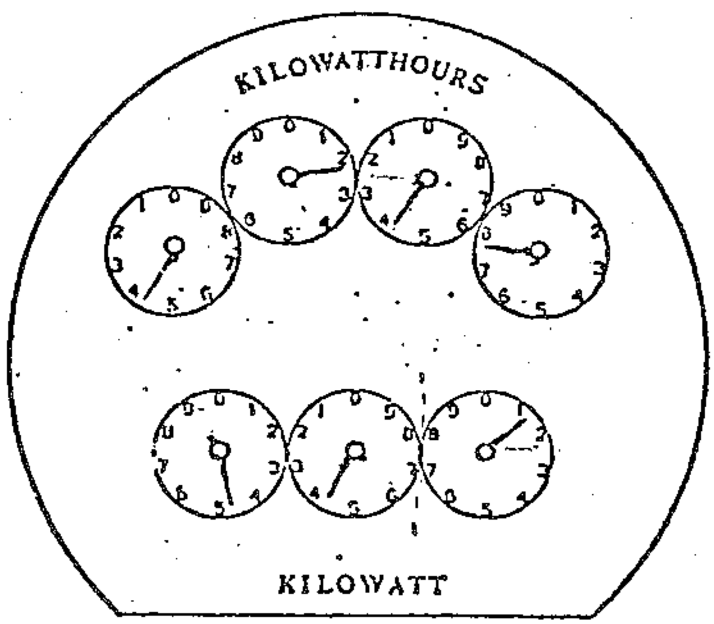


Reading = 3449 KWH

Kilowatthour Meters with Kilowatthour Demand Recorders

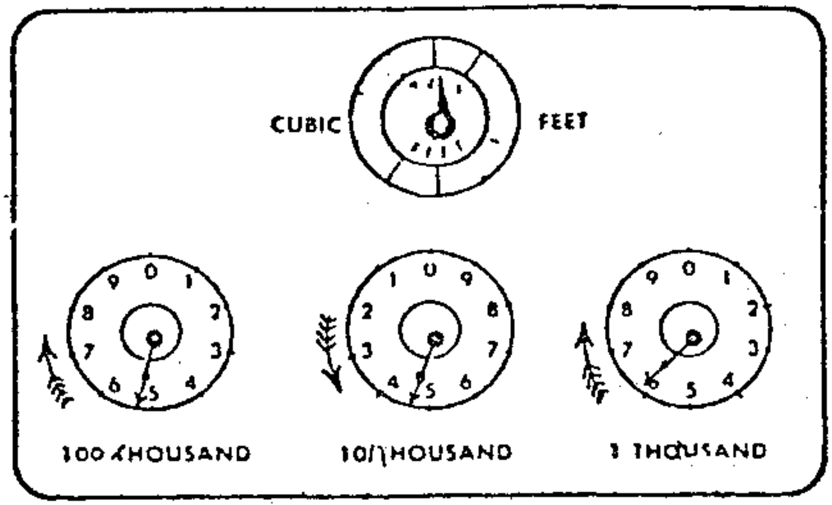


Reading 6542 KWH
.5 x 40 = 20 KW demand

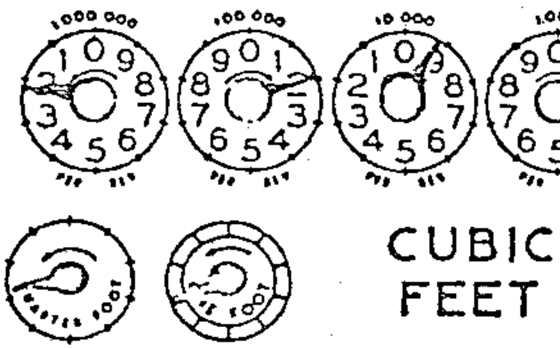


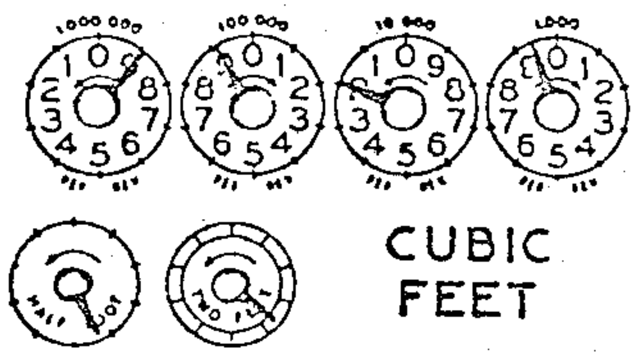
Reading 4247 KWHR
44.1 KW demand

Gas Meters



Reading = 546,000 ft 3





Reading 2,193,000 $ft.^3$

Reading 8,929,000 $ft.^3$

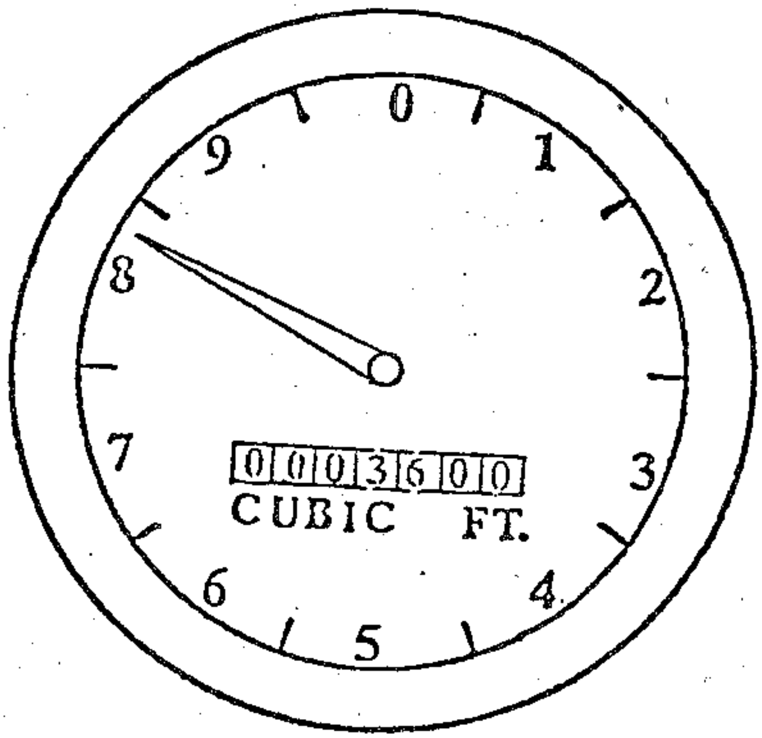
The above indicates different arrangements of gas meter faces. Others exist, however, are similar.

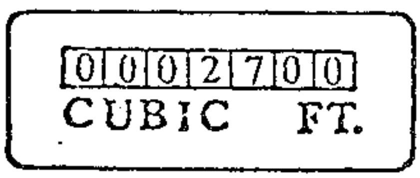
The low capacity, 1/4, 1/2, and 2 cubic feet dials are used to test the meter, as well as check gas consumption in the building under controlled gas usage.

The high capacity recording dials indicate the amount of gas consumption required to turn the pointer one revolution, i.e.: 1000 cubic feet, 10000 cubic feet, etc.

To determine gas consumed between billings, determine the reading at the start of the billing period (say 2,193,000 ft^3) and the reading at the end of the billing period (say 8,929,000 ft^3) and calculate the difference: 8,929,000 ft^3 - 2,193,000 ft^3 = 6,756,000 ft^3 or 67,560 CCF or 6,756 MCF of gas consumed.

Water Meters



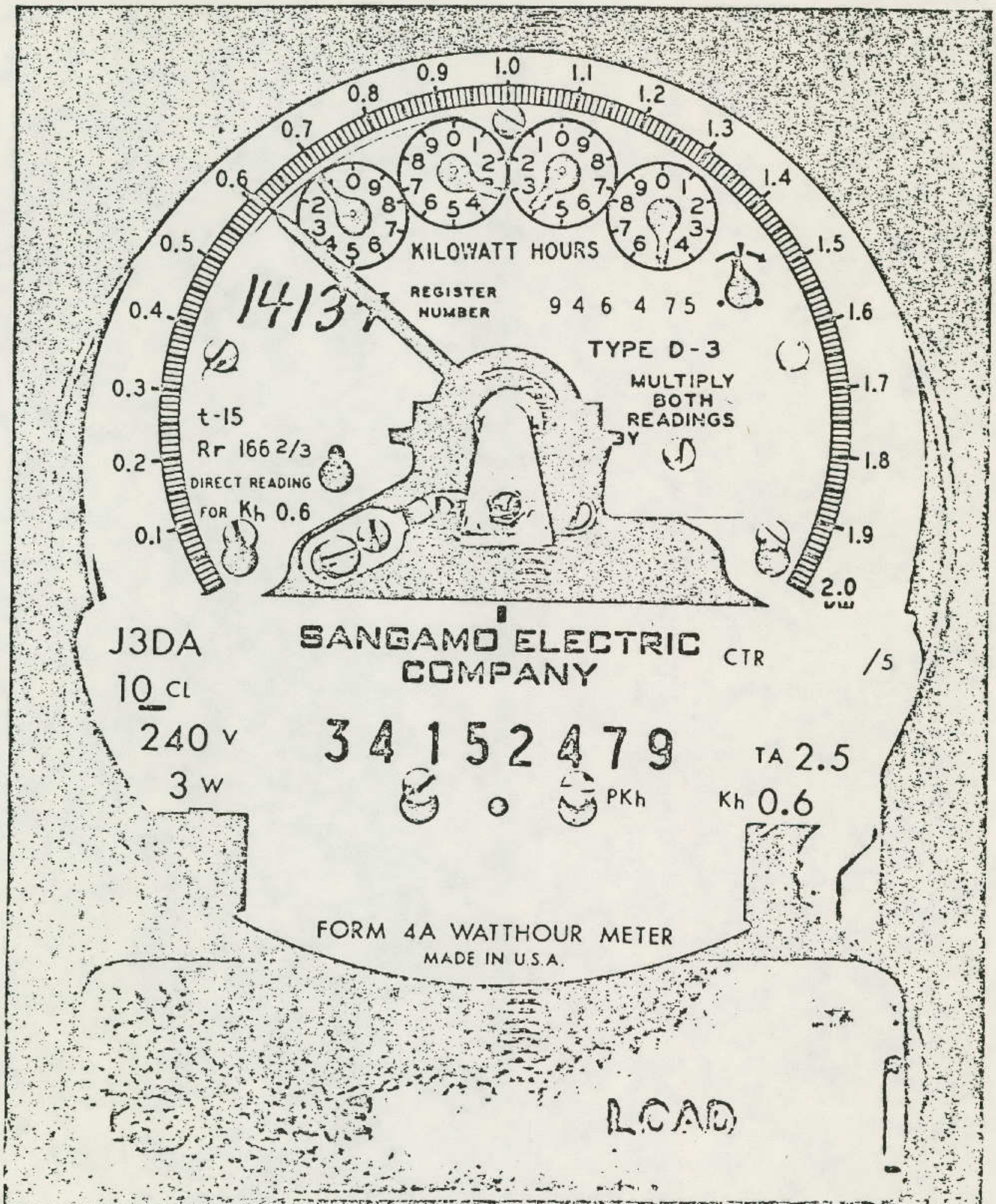


Water meter quantities are read directly as recorded on the meters as shown above. Meters may read in cubic feet, as shown, or in gallons. The type of measure will be shown on the meter face.

When using a circular dial with pointer, do not regard the pointer reading. This dial indicates only the instantaneous flow rate, in cubic feet per minute or gallons per minute.

To determine water consumed between billings, assuming the prior reading to be 2700 cubic feet and the present reading to be 3600 cubic feet, as recorded above, the consumption during the billing period would then be 3600-2700 = 900 cubic feet. 900 ft^3 x 7.48 gal/ft^3 = 6732 gals.

ELECTRIC METER



TEXAS ELECTRIC SERVICE COMPANY	TARIFF FOR ELECTRIC SERVICE	SECTION NO. III	SHEET NO. 10
		EFFECTIVE DATE October 26, 1978	
SP0311		REVISION Second	PAGE 1 OF 2
SECTION TITLE Rate Schedules	TARIFF NAME Rate G General Service	APPLICABLE Entire System except Ordinance Towns	

APPLICATION

To any customer for electric service provided at one point of delivery and measured through one meter.

Not applicable to shared or resale service in any event, nor to temporary, standby, or supplementary service except in conjunction with applicable rider.

TYPE OF SERVICE

Single or three phase, 60 hertz, and at any one of company's standard service voltages required by customer. Where service of the type required by customer is not already available at the location to be served, or where a nonstandard type of service is required, additional charges and contract arrangements, in accordance with company's service regulations, may be required prior to its being furnished. If customer takes service at primary voltage, company may at its option meter service on the secondary side of customer's transformers and adjust for transformer losses in accordance with company's service regulations.

NET MONTHLY BILL

Rate: $9.00 customer charge
$2.65 per kw of demand in excess of 10 kw, and

3.36¢ per kwh first 2500 kwh
2.20¢ per kwh next 3500 kwh*
0.32¢ per kwh all additional kwh

*Add 120 kwh per kw of demand in excess of 10 kw

Primary Service Credit: $2.00 plus 15¢ per kw of demand in excess of 10 kw when service is provided at the most available primary distribution voltage.

Minimum: $9.00 plus $1.00 for each kw of the highest kw recorded at the premises during the 15-minute period of maximum use in the 12 months ending with the current month, which is in excess of 10 kw.

Fuel Cost: Plus fuel cost in accordance with Rider F.

Payment: Bills are due when rendered and are past due if not paid within 15 days thereafter. Bills are increased 3% if not paid within 40 days after being rendered.

DEMAND

The kw recorded during the 15-minute period of maximum use during the month, but not less than 80% of the amount by which the highest kw, recorded at the premises during the billing months of June, July, August, September, or October in the 12 months ending with the current month, exceeds 30 kw.

AGREEMENT

An agreement for electric service with a term of not less than one year is required for customers having maximum electrical loads of 150 kw or more and may be required by company for smaller loads.

NOTICE

This established rate is subject to any change authorized by law, applicable charges in Rate M (Miscellaneous Service Charges), and to the provisions of company's service regulations.

CITY PUBLIC SERVICE BOARD

OF SAN ANTONIO

GENERAL SERVICE

ELECTRIC RATE

PL

APPLICATION

This rate is applicable to alternating current service, for which no specific rate is provided, to any customer whose entire requirements on the premises are supplied at one point of delivery through one meter.

This rate is not applicable (a) when another source of electric energy is used by the Customer or (b) when another source of energy (other than electric) is used for the same purpose or an equivalent purpose as the electric energy furnished directly by City Public Service, except that such other source of energy as mentioned in (a) and (b) may be used during temporary failure of the City Public Service electric service.

This rate is not applicable to emergency, standby, or shared service. It also is not applicable to resale service except that submetering will be permitted under this rate only for the purposes of allocating the monthly bill among the tenants served through a master meter in accordance with City Public Service Rules And Regulations Applying To Electric Service.

MONTHLY BILL

Rate

$2.25	Service Availability Charge
5.0¢	per KWH for the first 1200 KWH*
4.1¢	per KWH for the next 3400 KWH
3.0¢	per KWH for all additional KWH

*120 KWH are added for each KW of Billing Demand over 5 KW.

A rebate of 0.26¢ per KWH will be applied to the first 300 KWH of monthly consumption in each bill in compliance with City of San Antonio Ordinances No. 44748 and No. 45575.

Minimum Bill

$2.25 plus $1.40 per KW of Billing Demand over 5 KW. A higher Minimum Bill may be specified in Customer's Application And Agreement For Electric Service. The Minimum Bill is not subject to reduction by credits allowed under the adjustments below.

Adjustments

Plus or minus an amount equal to the average cost of fuel above or below $0.01860 per KWH sold.

The average cost of fuel per KWH sold will be the below calculated total cost of fuel divided by the estimated KWH sold during the billing month immediately preceding the current billing month.

The total cost of fuel will be an amount equal to the total estimated fuel cost in dollars at the electric generating plants for the calendar month immediately preceding the billing month plus or minus any balance (debit or credit) which has accrued in a memorandum account entitled "Fuel Adjustment Electric System". The "Fuel Adjustment Electric System" is a memorandum account which will be credited every month with the total amount of revenue produced by the application of the fuel adjustment clause, reduced by the amount corresponding to the payments to the City of San Antonio, plus the amount obtained from the product of the KWH actually sold during the same month and $0.0186. The account will be debited with the actual cost of the fuel for the same month at the electric generating plants (as computed from Account #501 "Fuel", in the books of City Public Service Electric System). This account will further be debited or credited to reflect the total cost of any electric energy which may be subsequently purchased or sold to other interconnected utilities as conditions for such purchase or sale are warranted.

Plus or minus the proportionate part of the increase or decrease in taxes, required payments to governmental entities or for governmental or municipal purposes which may be hereafter assessed, imposed, or otherwise required and which are payable out of or are based upon revenues of the electric system.

Monthly Demand

The Demand will be the KW as determined from the reading of the City Public Service demand meter for the 15 minute period of Customer's greatest Demand reading during the month. For those existing accounts utilizing KVA meters, the demand will be equal to the reading of the KVA demand meter multiplied by 0.88.

Billing Demand

For the period June through September, the Billing Demand is equal to the Monthly Demand as defined above. For the period October through May, the Billing Demand is equal to the Monthly Demand or 80% of the highest measured demand established during the previous summer period months (June through September), whichever is greater.

Prior to the establishment of a previous summer peak Demand, the Billing Demand shall be equal to the Monthly Demand as defined above.

Power Factor

When, based on a test of the Customer's power factor, the power factor is below 85% lagging, the Billing Demand may be increased by adding 1% of the Actual Demand for each 1% that the power factor is below 85%.

LATE PAYMENT CHARGE

The Monthly Bill will be charged if payment is made within the period indicated on the bill. Bills not paid within this period w be charged an additional late payment charge of 2.5 percent times the Monthly Bill excluding the adjustment for fuel costs.

TERM OF SERVICE

The term of service will be in accordance with the City Public Service Application And Agreement For Electric Service.

RULES AND REGULATIONS

Service is subject to City Public Service Rules And Regulations Applying To Electric Service which are incorporated herein by this reference.

CURTAILMENT

City Public Service shall have the right at any and all times to immediately adjust in whole or in part, the supply of electricity to Customers, in order to adjust to fuel supplies for generation of electricity or to adjust to other factors affecting delivery capability.

MISCELLANEOUS GENERAL SERVICE — MGS — 1L

AREA I — Incorporated Areas

AVAILABILITY — At all points for loads in excess of 50 Kva where facilities of adequate capacity and the required phase and suitable voltage are adjacent to the premises to be served. Loads in excess of 50 Kva will not be served under the Miscellaneous General Service rate except under this Rate Schedule MGS-1L and in accordance with a written contract for an initial term of at least one year. For loads where the service desired by the customer is not adjacent to the premises to be served additional contract arrangements may be required prior to service being furnished. Not available for temporary, breakdown, standby, supplementary or resale service.

APPLICATION — To any customer for all Electric Service supplied at one premises through one Point of Delivery and measured through one Meter.

TYPE OF SERVICE — Single or three phase, 60 cycles and at any one of the Company's standard service voltages as described in the Company's Service Standards.

NET MONTHLY BILL

Rate — $2.30 including the use of 20 kwh;
5.30¢ per kwh for the next 80 kwh;
3.57¢ per kwh for the next 700 kwh (subject to adjustment stated below);
3.20¢ per kwh for the next 2300 kwh;
1.51¢ per kwh for all additional kwh.

Adjustment Plus — The above rate is applicable to loads of 10 kva or less and when in excess thereof the kwh to be charged for at the above stated 3.57¢ step of the rate will be increased by 100 kwh per kva over 10 kva.

Minimum — If upon expiration of any 24 consecutive monthly billings, subsequent to the date service is first supplied under this rate schedule, customer's total payments are not equal to or more than $12.00 per kva for each kva in excess of 10 kva of the maximum kva supplied during such period Company may remove its facilities unless the customer agrees to pay a minimum billing equivalent to $12.00 per kva for each kva in excess of 10 kva of the maximum kva required to satisfy customer's service requirements for the next 24 consecutive monthly billings or any fraction thereof.

Adjustments — First: Plus or minus an amount for changes in fuel cost calculated in accordance with Rider FC.

Second: Plus or minus an amount for changes in cost of service in accordance with Rider COS.

DETERMINATION OF KVA — The KVA (kilovolt amperes) applicable to the Net Monthly Bill shall be as follows:

(A) For the billing months of May through October the Kva shall be the average Kva supplied during the 15 minute period of maximum use during the month then being billed, as determined from meter readings. The Kva may be determined by the use of a standard block interval integrated Kva meter or thermal ammeter calibrated to read Kva based on the Company's standard voltage supplied.

(B) For the billing months of November through April the metered Kva will be determined as outlined above and the billing Kva will be determined as follows:

(1) If the metered Kva is less than the Kva used for billing the preceding

August (hereinafter called August Kva) then the metered Kva will be the Kva used for billing.

(2) If the August Kva is less than the metered Kva then the August Kva will be used for billing except that the billing Kva will not be less than

(a) 70% of the metered Kva in the month, or

(b) the metered Kva in the month less 100 Kva

(3) The above provision (2) is not applicable to:

(a) new customers taking service subsequent to the start of the August billing month.

(b) new customers taking service prior to the August billing month whose total electrical equipment is not installed and in operation prior to the August billing month.

(c) existing customers adding and/or operating new facilities during the period subsequent to the August billing month and prior to the following billing month of May.

Under such circumstances the metered Kva will be the Kva used for billing.

PAYMENT – Net bills are due when rendered and are payable within 10 days thereafter. Bills not so paid shall be the net bill as rendered plus 10% of the first $50.00.

CONTRACT PERIOD – Not less than 1 year.

NOTICE – Electric Service hereunder is subject to the Company's Terms and Conditions for the sale of Electric Service.

HOUSTON LIGHTING & POWER COMPANY Section IV – Rate Schedules

FUEL COST ADJUSTMENT – Rider FC
Applicable in all Areas

Electric Service billed under all applicable rate schedules shall be subject to a Fuel Cost Adjustment for changes in fuel cost. Monthly billing shall be adjusted upward or downward by an amount per kwh to be calculated according to the following formula:

$$\text{Fuel Adjustment Factor (FAF)} = \left\{ \frac{\left(\frac{F - CF}{S}\right) - .7386¢}{1 - T} \right\} \cdot LF \left(\begin{matrix}\text{rounded to nearest} \\ .0001¢\end{matrix}\right)$$

DEFINITIONS

F = Fuel Costs estimated to be incurred by the Company for the current month and shall be composed of those costs as recorded in F.P.C. Accounts 501. 547 and 555 less the cost of fossil fuel recovered through interchange transactions.

S = All kilowatthours estimated to be sold and recorded in the current month by the Company, excluding interchange transactions.

T = Estimated composite tax rate for gross receipts and other revenue related taxes and gross receipts payments for the Company expressed as decimal.

CF = A Correction Factor adjustment to be applied in the current month to provide for an allowance due to variance between actual and estimated fuel adjustment revenues derived from the Fuel Adjustment Factor for the third preceding month prior to the current month. The calculation of the Correction Factor is as follows—CF = [(A) — (B)] X (1—T) where (A) is the actual fuel adjustment revenues received from the Fuel Adjustment Factor applied in the third preceding month and (B) is the fuel adjustment revenues which would have been received from application of the Fuel Adjustment Factor in the third preceding month if actual rather than estimated fuel cost and kilowatthour sales (described above) had been available to calculate the Fuel Adjustment Factor for that month.

LF = Loss factors to recognize differences in losses due to voltage levels of service. Such loss factors are as follows:

Secondary Voltage Rate Schedules	1.03
Transmission Voltage Rate Schedules	0.96

Penalty Clause

If at the end of December 31, 1976, and on an annual basis thereafter, the net sum of the Correction Factors for the previous 12 months exceeds 5% of the sum of "(B)" above for the same period, then a penalty equal in amount to 10% of such excess will be computed and this amount will be used to reduce the Fuel Adjustment Factor in the next succeeding March. This reduction will not otherwise affect such computation of the Fuel Adjustment Factor for subsequent periods.

HOUSTON LIGHTING & POWER COMPANY Section IV – Rate Schedules

COST OF SERVICE ADJUSTMENT – RIDER COS
Applicable in all Areas

Electric Service billed under all applicable rate schedules shall be subject to a Cost of Service Adjustment for changes in costs as defined below. Monthly billing for the current month shall be adjusted upward or downward by an amount per kwh to be calculated according to the following formula:

$$\frac{\frac{(C - BC) - [CF(R - BR)]}{12}}{1 - T} + CA = \text{Dollar COS Adj.}$$

$$\frac{\text{Dollar COS Adj.}}{\text{EKWH}} = \text{COS Adj./KWH (rounded to nearest .0001¢)}$$

DEFINITIONS

BC = Base cost equal to the sum of the year-end level expenses for the twelve months ended April 30, 1975, as follows:

(a)	Salaries and wages	$ 42,811,733
(b)	FICA Taxes	2,403,059
(c)	Depreciation	50,551,764
(d)	Interest	67,666,026
(e)	Preferred dividends	11,210,746
	Total base cost	$174,643,328

C = Sum of actual expense as described (for BC above) for 12 months ending with second preceding month.

BR = April 30, 1975, year-end level electric operating revenues less fuel revenue which would have been derived from associated fuel costs=$434,938,776

R = Sum of electric operating revenues exclusive of cost of service revenues less fuel revenue which would be derived from associated fuel costs adjusted to reflect the effect of new rates and new fuel adjustment clause for 12 months ending with second preceding month.

CF = $\frac{BC}{BR} = \frac{\$174,643,328}{\$434,938,776} = .40154$

T = Composite tax rate for gross receipts and other revenue related taxes and gross receipts payments for the Company expressed as a decimal for 12 months ending with second preceding month.

CA = Correction adjustment which is derived by subtracting the actual dollar cost of service adjustment revenue from the calculated dollar cost of service adjustment for the second preceding month.

EKWH = All kilowatt-hours estimated to be sold and recorded in the current month excluding interchange transactions.

Utility Bill Review

All utility bills for the past five years should be reviewed to determine their accuracy. In fact, there are companies which can do just that for you (see discussion below re: utility consultants).

In most cases a bill will include charges for:

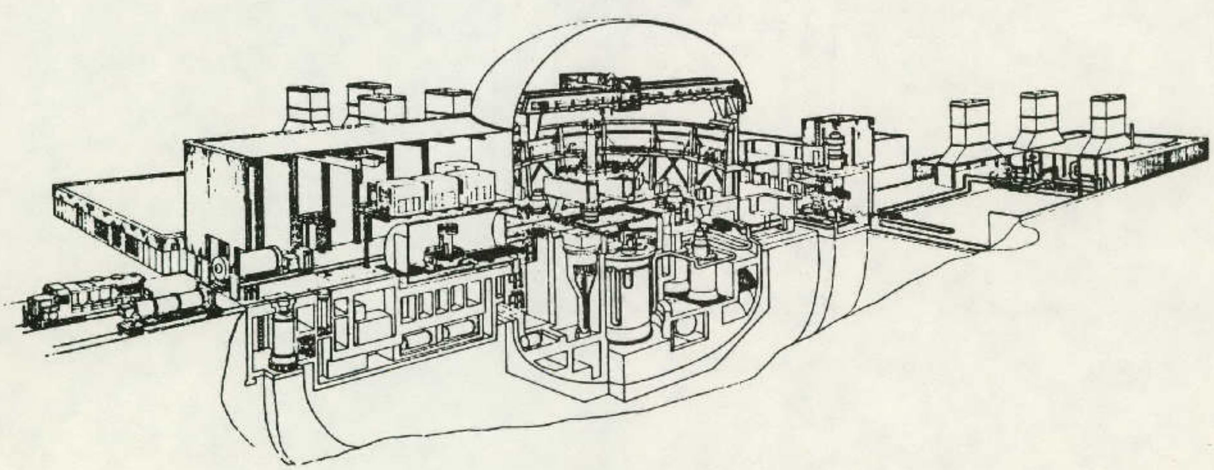
Energy: Most electric utilities use a sliding block approach for the energy charge, that is, so much per kWh for the first 100 kWh, so much per kWh for the second thousand, and so on. In most cases the more kWh you consume the less per kWh you pay.

Fuel Adjustment: Many electric utilities have imposed a fuel adjustment which reflects the increased cost of fuel. It can be a substantial charge. (Gas utilities have something similar called a purchased gas adjustment charge (PGA) which reflects adjustment to gas bills based on fluctuations in the wholesale cost of gas.)

Customer Related: Some utilities add what is called customer-related costs. These comprise a special charge which reflects part of the distribution investment, part of the operating and maintenance costs, costs for accounting and collection, and so on. If it isn't billed separately, it may be included with the energy cost.

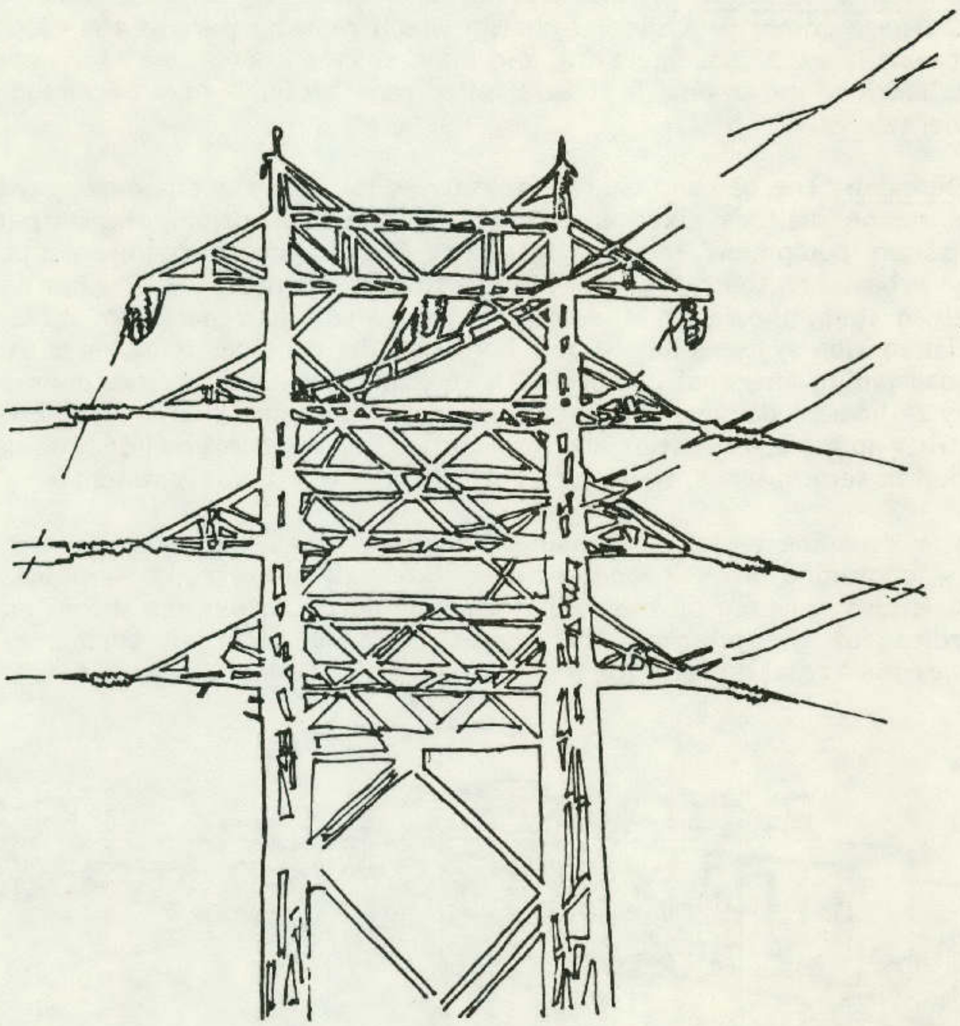
Demand: The demand charge is designed to make the customer pay his fair share of the utility's fixed investment in the production, transmission and distribution equipment required to meet his maximum requirements. The charge is based on the rates at which electricity is consumed. The more used at any given time, the larger the utility's investment in generation, transmission and distribution systems has to be. For example, consider two users: A and B, both consuming an equal number of kWh each day. User A consumes electric energy 24 hours a day and user B consumes it eight hours a day. User B requires the utility to have generating and distribution capacity three times the capacity requried to serve user A, so user B is billed for this extra investment.

The consumer's actual demand is computed as the average amount of energy consumed in a predetermined interval, usually 15 minutes (other intervals also are used by the utilities, particularly 30 minutes and 60 minutes). Regardless of the interval, the highest demand recorded during a month becomes the actual demand for the month.



Many utilities also employ a ratchet clause which states that no matter what your actual demand may be in any given month, the demand for which you are billed may be no less than a certain percentage of a demand recorded during the summer months.

Low Power Factor Penalty: Another charge sometimes applied, is a penalty for low power factor, a subject discussed below.



Power Factor

The power which must be supplied to any induction load such as induction motor, transformer, fluorescent lamp, etc., is made up of real and reactive power.

Real power, or the working power, is measured in kilowatts (kWs). The reactive, or magnetizing current, is required to produce the flux necessary for the operation of any induction equipment. Without magnetizing current, energy could not flow through the core of a transformer or across the gap of an induction motor. The unit used to measure reactive power is the kilovar or kVAR.

The vector sum -- not the arithemetical sum -- of the real power and the reactive power is the apparent power, measured in kilovolt-amperes or kVA.

Power factor is a ratio of real power (kW) to apparent power (kVA) or,

$$\text{Power Factor} = \frac{\text{Real Power (kW)}}{\text{Apparent Power (kV)}}$$

Electric utilities must provide both real and reactive power for their customers. Reactive power does not register on a kilowatthour meter, but producing it still requires the utility to put additional investment into generating, transmission and distribution facilities.

Many utilities make up for the expense of producing reactive power by including power factor provisions in their rates. As it so happens, many utilities are defining low power as naything less than .9. Thus, if a hospital consumes 10 million kWh per year at 3.5 cents per kWh and has a power factor of .87, its penalty would be:

$$\frac{\text{kWh/Yr}}{\text{Power Factor}} - \frac{\text{kWh/Yr}}{.9} \times \text{kWh rate}$$

$$\frac{10{,}000{,}000}{.87} - \frac{10{,}000{,}000}{.9} \times \$.035 \qquad \$13{,}409.03$$

Some power factor improvement will prove worthwhile if your electric use meets one or more of the following conditions:

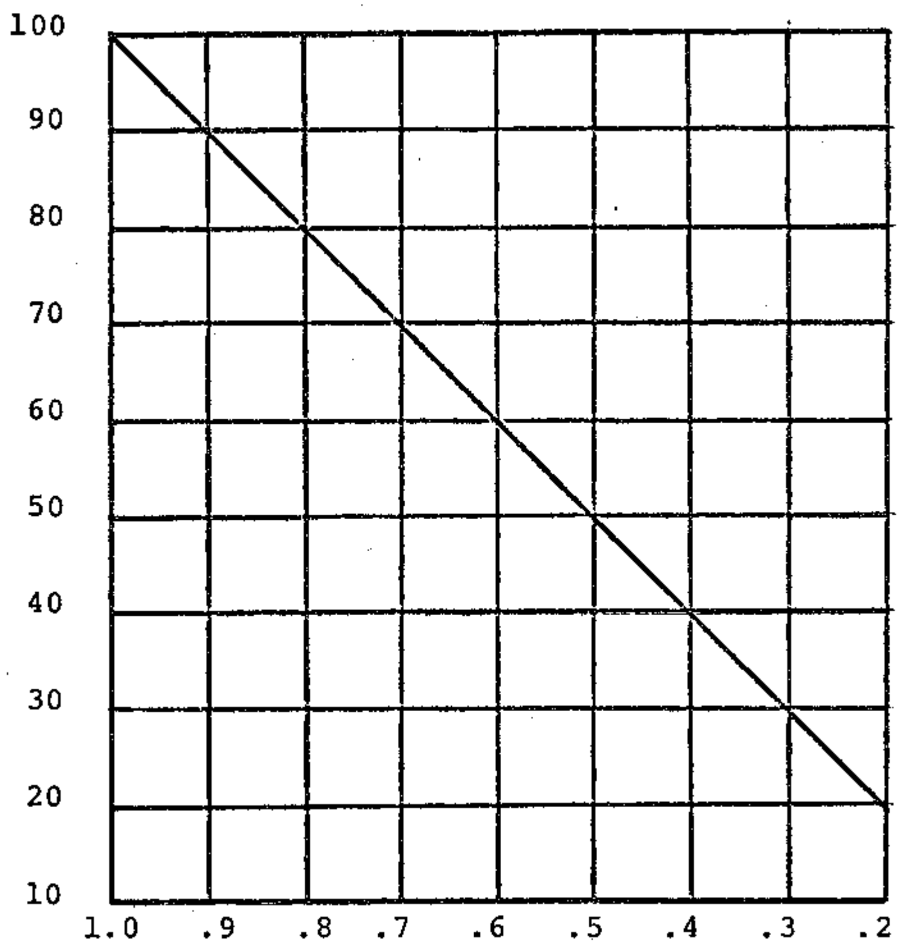
- -- power demand is recorded on bill (in kVA);
- -- electric rate has a kVAR or power factor penalty clause;
- -- there are problems with voltage regulation or chronic low voltage; or,
- -- load growth limits capacity and you need more capacity.

Causes for low power factor typically are lightly loaded motors which draw excessive amount of reactive power and increase energy losses in the overall distribution system. Power factor correction can be made through installation of capacitors. Costs of equipment and installation usually can be paid back quickly, if (and only if) the utility charges for reactive power supplied. It is advisable to review the need for and amount of power factor correction on specific types of loads with either the utility, equipment manufacturer, or your consultant.

Improving the power factor may provide economic advantages and/or system advantages.

1. ECONOMIC ADVANTAGES: Possible cost savings depend on the original power factor and the rate structure. Capacitors used for power factor correction commonly pay for themselves in one to three years. Each building power system must be studied separately.

2. RELEASE OF POWER SYSTEM CAPACITY BY POWER-FACTOR IMPROVEMENT: When power-factor correction is installed in a building having a low-power factor, the capacitors will balance the magnetizing or inductive current for motors, ballasts, and transformers. Reactive current for capicators will be 180 degrees out of phase with inductive currents. Therefore, current from the power company supply will be reduced. Less current means less KVA or load on transformers and main branch feeder circuits.



EFFECT OF LAGGING POWER FACTOR ON TRANSFORMERS

3. VOLTAGE IMPROVEMENT: Adding capacitors to a circuit or system to raise voltage levels due to reactive current balance is discussed above. The change is minimal, however, and it is never economical to use capacitors for voltage improvement alone.

In power factor studies, gathering data is essential to the selection of the proper size and location of the capacitors to be installed.

Obtain power factor readings from the previous year for the building being studied. If the electric company cannot meet your request, purchase or rent the necessary instruments.

Three different ways of determining your power factor are described below:

Method 1: (using a voltmeter and an ammeter)

For single phase systems and meters, power factor = $\frac{KW}{KVA}$. We will determine KW from the meter itself as follows:

Record the number of revolutions of the disc in a certain time interval, and use the following formula to determine the KW load:

$$KW = \frac{\text{Number of Revolutions} \times Kh \times 3.6}{\text{Time in seconds}}$$

The Kh factor will be stamped on the meter name plate inside the glass cover. Ten revolutions of the disc will give an accurate reading. Also check to see if the meter has a "multiplier"; it too will be stamped on the nameplate under the glass cover or on the cover itself. Such a multiplier will also be shown on your bill. If there is such a multiplier, multiply the Kh factor by the multiplier.

For example, assume the Kh = 1.8, the multiplier is 10, and 10 revolutions took 70 seconds:

$$KW = \frac{10 \times 1.8 \times 3.6 \times 10}{70} = 9.257$$

Now all that is needed is the KVA; we get that using the ammeter and the voltmeter. Read the voltage and amperage during the same 70 seond interval. For example, assume we read 115 volts and 115 amperes.

$$\text{Power factor} = \frac{KW}{KVA} = \frac{9.257}{(115 \times 115) \div 1000} = .7 \text{ or } 70\%$$

Let us look now at a meter that measures usage in a three phase system. Again the Kh = 1.8, the multiplier is 10, and 10 revolutions took 70 seconds. The demand in KW for the period is still 9.257 KW. But let us say now that reading the amperage and voltage during the 70 second interval gives us readings of 240 volts and 32 amperes.

$$\text{Power factor} = \frac{KW}{KVA} = \frac{9.257}{(1.732 \times 240 \times 32) \div 1000} = .69 \text{ or } 69\%$$

In this last instance we would have measured voltage and amperage in each wire of the three phase system, and for the computation we made to be accurate, the readings in each phase would have had to have been equal, providing a balanced load in all three phases.

Method 2: (using a wattmeter when KVA is recorded by the meter)
Where demand in KVA is recorded by the meter (as with Houston Light and Power), attach the wattmeter across the terminal of the meter and read resulting power in KW. At the same instant read KVA from the meter.

$$\text{Power factor} = \frac{\text{KW (from wattmeter)}}{\text{KVA (from demand register on meter)}}$$

Method 3: (using two demand meters, one with KW register and one with KVA register)
If there are two demand meters, one with a KW register and one with a KVA register, then:

$$\text{Power factor} = \frac{\text{KW demand}}{\text{KVA demand}}$$

ANALYZE THE POWER FACTOR READINGS: If the power factor is low enough to add a penalty to the power bill, expand the study to determine the cause. Two of the major contributors for low power factor are:

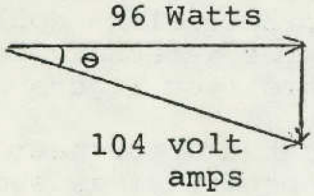
1. Induction motors running lightly loaded: If equipment is being driven by too large a motor, serious consideration should be given to replacing the oversized motor with a smaller motor. An improved power factor and a considerable savings in energy can result.

2. Flourescent ballasts that are still energized in fixtures that have had the flourescent tubes removed: Office buildings are prime candidates for this problem. In a two-tube fixture, when the tubes are removed while the ballast is kept energized, the power factor of the ballast may drop as low as .15 from a .92 value.

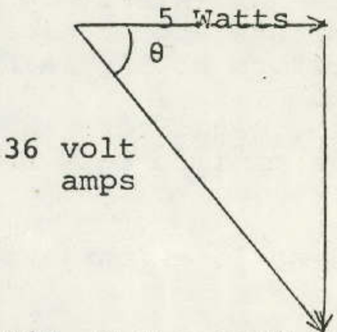
Flourescent lamps produce approximately two-thirds of the artificial light used in the United States today, largely because they produce more light per watt than either incandescent or mercury lamps.

Throughout the United States, millions of flourescent tubes have been removed from lighting fixtures while the ballast was left connected. When two tubes are removed from either a 2-lamp fixture or a 4-lamp fixture, the inactive ballast should be disconnected. A 2-tube, 48" rapid-start fixture with no tubes and an energized ballast consumes only 5 watts, but 36 volt-amps, with a power factor of 14%. Remembering the earlier graphical reproduction, shown below are vector presentations of a normal fixture with a power factor of .9 to .92, and a fixture with both bulbs removed, but with the ballast still active.

48" Fixture with 2 bulbs



48" Fixture with 2 bulbs removed, but with ballast connected



P.F. = $\cos\theta = \frac{96}{104}$ = .92 or 92% P.F.= $\cos\theta = \frac{5}{36}$ = .1388 or 14%

These graphical presentations show that someone with a KW demand meter will pay a penalty of only 5/96 or about 5% for leaving the ballast connected. But the firm with a KVA demand meter will pay a penalty of 36/104 or about one-third in the demand portion of their bill for leaving the ballast connected.

If 50% of the tubes in a building are removed and the ballasts are still energized, the power factor will drop from 90% to 72%, resulting in increased power factor charges wherever the rate schedule provides for such a penalty.

In addition to the demand penalty, there is a KWH cost for leaving the ballast connected. If the building uses lights 10 hours per day 250 days a year, the 5 watt consumption for each ballast would amount to 12.5 KWH for the year.

$(5 \times 10 \times 250) \div 1000 = 12.5$

HOW TO CORRECT FOR LOW POWER FACTOR: If the load causing the low power factor cannot be modified to achieve improvement, the inductive load is normally balanced with a capacitor. Note, however, that the National Electric Code requires that power capacitors, other than those directly connected across motor terminals, contain a separate disconnecting means. The code also requires that the continuous current-carrying capacity of the disconnecting device and circuit conductors be no lower than 135% of the rated current of the capacitor.

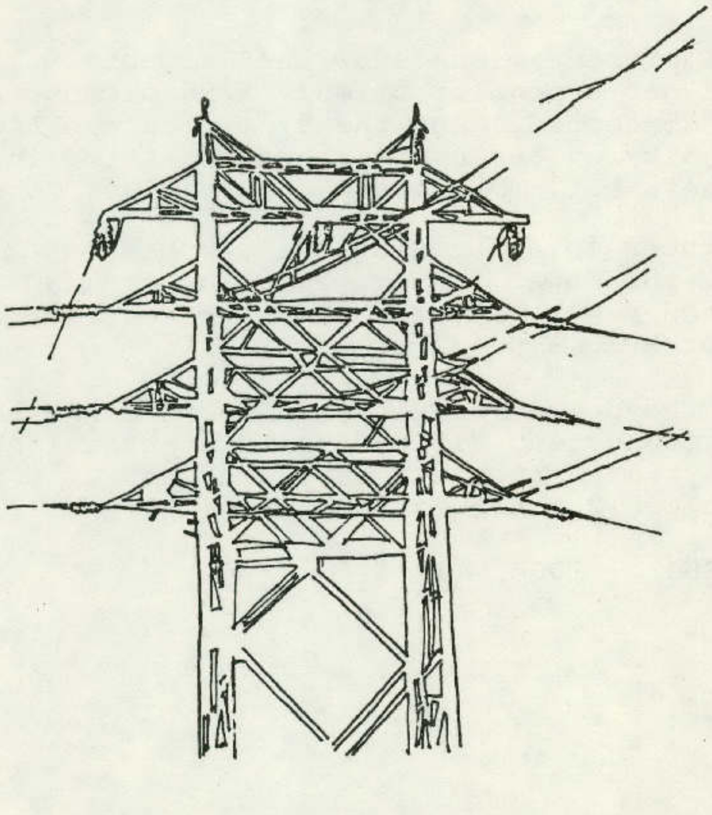
The most economical location of capacitors is directly across the terminals of large motors because this eliminates the cost of a separate switch. (see Figure 1-3).

For several small horsepower motors, connect the capacitors at the load center with an appropriate switching device which will serve as a disconnect for servicing or shedding when only one or two motors are on the line.

Many buildings contain a large number of small loads. Since capacitors are standard-sized, it may be impractical to apply the correct capacitors at each load. It may be necessary to install the capacitors at the main switchboard (see Figure 1.3).

When possible, capacitors should be located at or near the load to obtain the minimum cost and maximum benefits, as shown by C1.

The second best location is shown at C2. The least preferred is at C3.



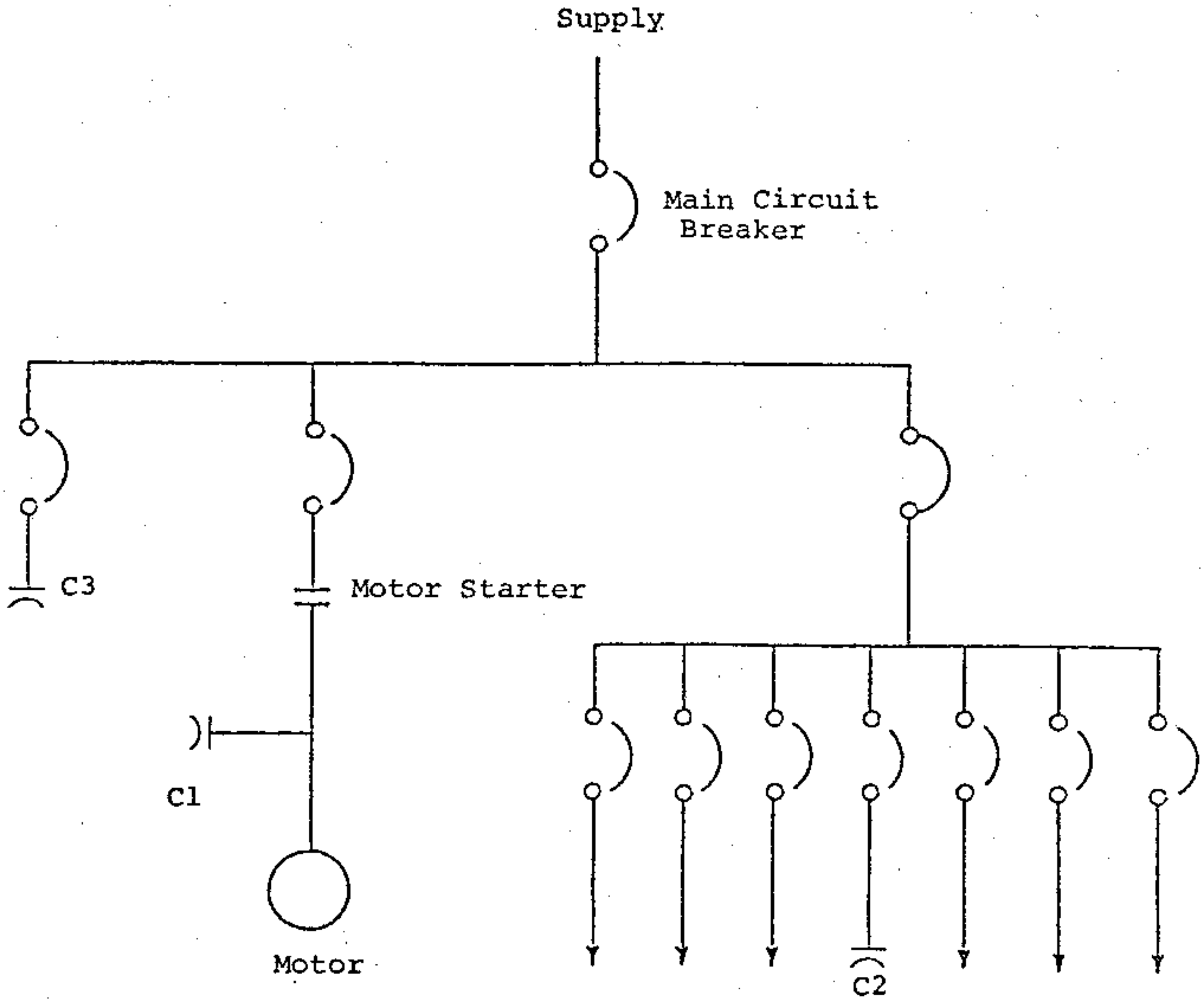


Figure 1-3

POWER FACTOR IMPROVEMENT

CAPACITOR MULTIPLIERS FOR KILOWATT LOAD

Original Power Factor: %	DESIRED POWER FACTOR %			
	100	95	90	85
60	1.333	1.004	0.849	0.713
62	1.266	0.937	0.782	0.646
64	1.201	0.872	0.717	0.581
66	1.138	0.809	0.654	0.518
68	1.078	0.749	0.594	0.458
70	1.020	0.691	0.536	0.400
72	0.964	0.635	0.480	0.344
74	0.909	0.580	0.425	0.289
76	0.855	0.526	0.371	0.235
77	0.829	0.500	0.345	0.209
78	0.802	0.473	0.318	0.182
79	0.776	0.447	0.292	0.156
80	0.750	0.421	0.266	0.130
81	0.724	0.395	0.240	0.104
82	0.698	0.369	0.214	0.078
83	0.672	0.343	0.188	0.052
84	0.646	0.317	0.162	0.026
85	0.620	0.291	0.136	
86	0.593	0.264	0.109	

Example:

Assume total building load is 200KW at 70% P.F. and you want to correct the power factor to 95%.

1. In the column marked "Original Power Factor," look up 70%.

2. Follow the figures to the right of the "70%" value until you reach the one under "95%" in the columns headed "Desired Power Factor: %". This figure is 0.691.

3. Multiply 0.691 by the kilowatt load.

4. 200 x 0.691 = 138.2 KVAR. 138.2 kilovars are needed to correct to 95% power factor.

MOTOR SPEED IN R.P.M.

Induction Motor Horse-Power Rating	3600 Capacitor Rating KVAR	3600 Line Current Reduction %	1800 Capacitor Rating KVAR	1800 Line Current Reduction %	1200 Capacitor Rating KVAR	1200 Line Current Reduction %
3	1.5	14	1.5	15	1.5	20
5	2	12	2	13	2	17
7½	2.5	11	2.5	12	3	15
10	3	10	3	11	3.5	14
15	4	9	4	10	5	13
20	5	9	5	10	6.5	12
25	6	9	6	10	7.5	11
30	7	8	7	9	9	11
40	9	8	9	9	11	10
50	12	8	11	9	13	10
60	14	8	14	8	15	10
75	17	8	16	8	18	10
100	22	8	21	8	25	9
125	27	8	26	8	30	9
150	32.5	8	30	8	35	9
200	40	8	37.5	8	42.5	9
250	50	8	45	7	52.5	8
300	57.5	8	52.5	7	60	8

Look up the motor speed and horsepower and read the required capacitor value in KVAR. The values will improve the motor power factor to 95%.

The line-current reduction will indicate the percent needed to reduce the thermal-overload relay if the capacitor is connected to the load side of the relay.

The chief disadvantage of individual capacitor correction is that the smaller capacitor units have a higher price per kilovar than the larger units. When many small motors need to be corrected, it may be more economical to install one larger capacitor at the motor load center. A common practice is to correct motors larger than 10 H.P. with individual capacitors and to correct smaller motors in group.

The power distribution losses in KW (I^2R) vary from 4 to 7% of the load. KWH losses are proportional to the square of the current and are directly proportional to the power factor improvement as the current is reduced.

$$\text{loss reduction} = 1 - \frac{(\text{Original P.F.})^2}{(\text{Improved P.F.})^2}$$

Consider a building with a power factor of .7 when the I^2R loss is 6% of the load. If the power factor is raised to .95,

$$\text{loss reduction} = 1 - \frac{(.7)^2}{(.95)^2} = .458$$

If the building loss is 6%, the loss reduction = 6%X.458 = 2.75%

ECONOMICS

In summary, when the serving utility rate contains a power-factor penalty clause, it is common for the capacitors to pay for themselves in one to three years. The rate of return depends on the cost of the capacitors and the charges for low-power factor. If the power factor in a building is below 86%, it is usually economical to install power-factor correction. Do not try to correct a power factor to better than 95%.

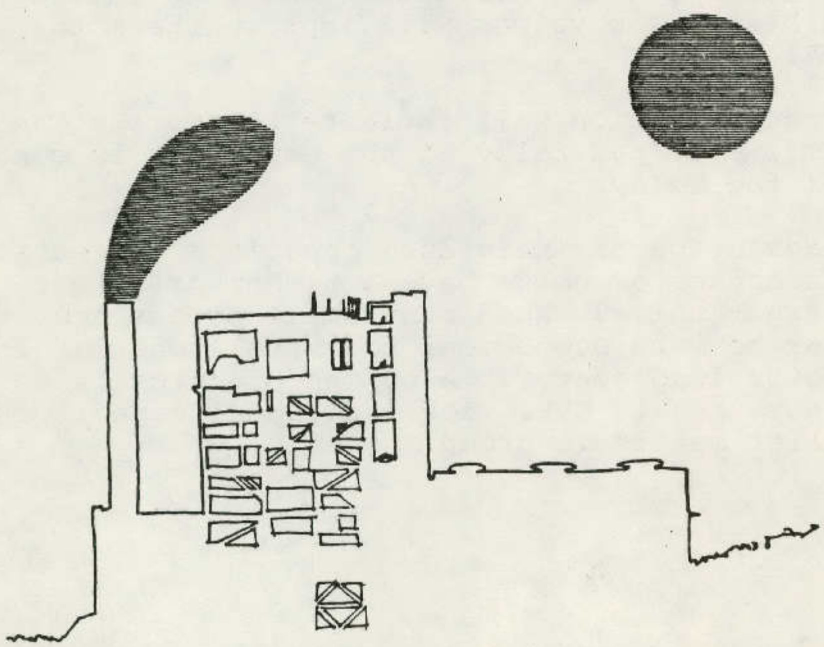
The average cost for low power factor in the United States is about 1-1½ percent of the total power bill.

REFERENCE SOURCES

1. D. Beeman, Industrial Power Systems Handbook, 1955.

2. Sprague Electric Co., A Guide To Power Factor Correction For The Plant Engineer, 1962

3. P.N. Silverthorne, "Power Factor Correction For Energy Conservation", ASHRAE Journal, May, 1975.



Building Utilization

Following is a building utilization study of one church with multiple buildings. By determining when your peak KVA demand is established, you can determine which equipment is operating and concentrate on a method of reducing loads to minimize the demand. By combining as much activity in as few buildings as possible and turning off the heating or air conditioning system in the unused areas, savings can be achieved.

SUMMARY OF EVENTS

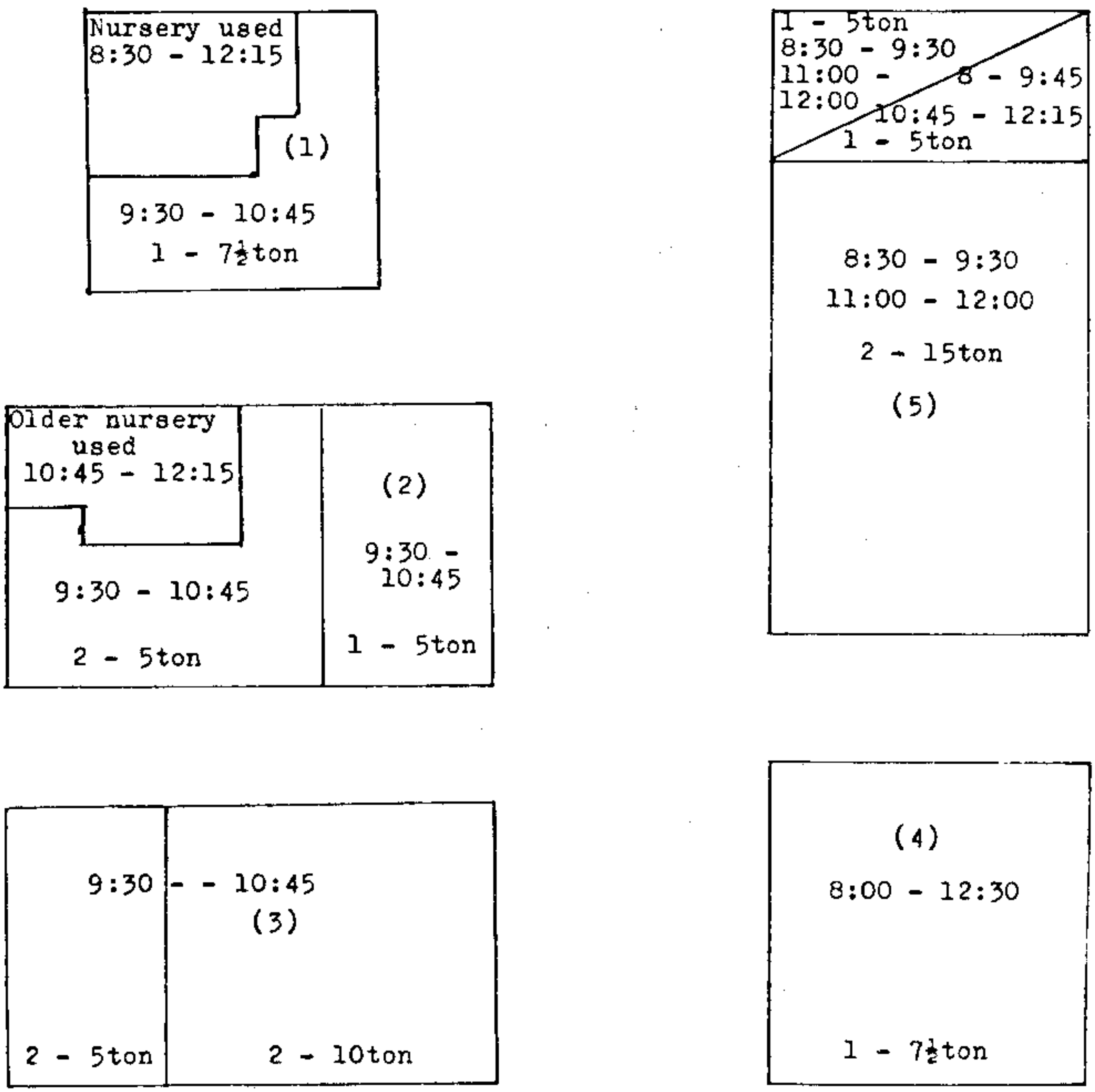
Peak Demand of month - 216 KVA

Demand	Time	Action
	6:00 a.m.	Sanctuary & office A/C automatically turned "on" by timers
	8:00 a.m.	Trustee turns on A/C units in all other buildings & unlock doors
	8:30 a.m.	First service begins
180 KVA	9:15 a.m.	
156 KVA	9:30 a.m.	First service ends
	9:45 a.m.	Sunday school begins
180 KVA	9:52 a.m.	
198 KVA	10:02 a.m.	
168 KVA	10:45 a.m.	Sunday school begins
204 KVA	11:00 a.m.	Second service begins (one A/C unit "off")
192 KVA	11:05 a.m.	
	12:00 noon	Second service typically ends - A/C units shut "off" in sanctuary automatically - temp. 73°
	12:15 p.m.	Temperature rise 2° with 250 people in building
66 KVA	12:20 p.m.	All systems "off" except for crib nursery and children's nursery

RECOMMENDATIONS FOR SUNDAY MORNING

1. Move older nursery to building # (1).
2. Turn off air conditioning units in buildings # (2) and # (3) at 10:45.
3. At 9:45 a.m. air conditioning in building # (5) could be turned "off" for about 30 minutes to avoid peak which potentially could have occurred at 10:00 a.m. (approx.)

RESULTS - Potential reduction of 45 ton, representing a demand (KVA) reduction of 60 KVA. Units have previously been left "on" during 11:00 a.m service.



You can reduce your KVA demand by improving power factor. Motors and other inductive equipment require both real, or working power, and non-usable, or reactive power. The reactive power provides the magnetic field which is necessary for the operation of an electric motor. Power factor is the ratio of working power (KW) to the total of working power and reactive power (KVA).

The following is a power factor study which illustrates the potential savings to a customer. A company that sells capacitors can help you determine if power factor correction would be advantageous to your church's operation.

Religious buildings typically have relatively few kilowatt hours for their high peak demand. Therefore, in about 25% of the churches surveyed, correcting power factor would not reduce operative costs. In another 25%, it would only marginally reduce operative costs.

Power Factor Correction

Month	Existing P.F.	Existing KVA	@ 100 KVAC Corrected KVA	@ 100 KVAC KVA Savings	@ 100 KVAC Corrected P.F.
4/78	83%	411	365	46	93%
3/78	83	342	298	44	95
2/78	80	344	295	49	93
1/78	76	306	253	53	92
12/77	84	460	414	46	93
11/77	83	472	425	47	93
10/77	83	726	675	51	89
9/77	82	721	669	52	88
8/77	72	463	400	63	83
7/77	72	453	391	62	83
6/77	82	580	529	51	89
5/77	82	495	446	49	91

Total Savings ---------------------------- 613

Savings @ $2.06/KVA ---------------------$1263----$12,630-10 yrs.

Cost @ 240 V. Service ------- $55/KVAC ----- $5500
Payback ----- 4.4 yrs

Cost @ 480 V. Service ------- $25/KVAC ----- $2500
Payback ----- 2.0 yrs

Adapted from: Texas Industrial Commission Energy Conservation Workbook on Life Cycle Costing and Peak Load Control

SECTION 5

COST SAVING IMPROVEMENTS REQUIRING MINIMAL CAPITAL INVESTMENT

Now we get to the good part: a chance to save money based on the information gathered from the energy audit.

The initial cost saving improvements should be determined on the basis of:

1) doing the best with existing equipment.
2) shortest implementation time.
3) greatest return on investment.
4) systematic improvement and resolution of the problem.

Always focus on ways that both KWH usage and KW demand can be reduced. The following ideas are directed towards maximum savings at minimum investment. Also they can be implemented fairly quickly, so as to encourage further energy management due to the record of past successes.

5-A. OPERATING PROCEDURES

It is ironic that one of the least expensive energy-saving improvements is also one of the most difficult to implement. This is generally true for revisions to operating procedures, for it involves the requirements that people alter their "way of doing things". You have to contend with the "but-we've-always-done-it-this-way" attitude. In addition operating personnel are going to resist changes because it may require closer operator control. You will have to get their confidence and work closely with them in implementing changes.

Be patient, but be firm, since the potential savings are very high as compared to the initial capital investment.

1. Equipment Shutdown. When a processing unit or system shuts down, building operators find it convenient to allow some of the electrical equipment to continue to run. Consequently the demand is not lowered when it should be.

These operating practices should be reviewed critically from an energy standpoint. Get input from the operators on how they would suggest minimizing energy usage. Review the necessity of installing or reactivating automatic interlocks that shutdown groups of equipment if any one piece is shutdown by the operator.

2. Equipment Startup. System startup presents the same types of opportunities to reduce electrical demand. Is equipment being started prematurely without the rest of the sequence of loads being ready? Is the above mentioned interlocking necessary?

3. Maintenance. Let's assume the maintenance personnel have just completed repairs on the bearings of a 50 hp air handler fan and decide to have a test run. It's 11:00 am and the full load test is run, at the time of the day when the electrical load is historically at maximum. The test could cost the company $250 in excess demand charges. If the supervisor had had a better understanding of how electrical demand affects the power bill, he could have deferred the test to a time when demand is at the minimum.

Although the above theoretical example appears extreme, it serves to illustrate the necessity of an education program on demand reduction.

5-B. LOAD PROFILE REVISION.

Load profile revision is another method of reducing demand charges. This energy management program is a concerted effort to shift blocks of loads from the period of peak demand to a period where demand is historically less. This method is really load scheduling, where personnel review the schedules, work shifts, and individual facility requirements to determine which loads can be scheduled during off-peak shift or times.

One pitfall to avoid is adversely affecting labor costs in order to lower demand. Review the effects of the load shifting on the labor assignment and costs before finalyzing the schedule.

5-C. LOAD SHEDDING.

Load shedding is the practice of interrupting non-essential loads for brief periods of time to lower the demand. The key work is non-essential loads; energy management must entail determination as to which loads are non-essential. That is why it is necessary for the energy audit to include an analysis as to the importance of the individual load to the overall process.

Non-essential loads generally consist of air-conditioning, exhaust fans, chillers, compressors, water heaters, incinerators, and other loads whose interruption would not cause shutdown of the process or create potential safety hazards. Essential loads generally include most lighting, elevators and other equipment needed to maintain normal work schedules.

Once the non-essential loads have been determined, they must be ranked in the order of priority. Those loads with the lowest priority are disconnected first and restored last.

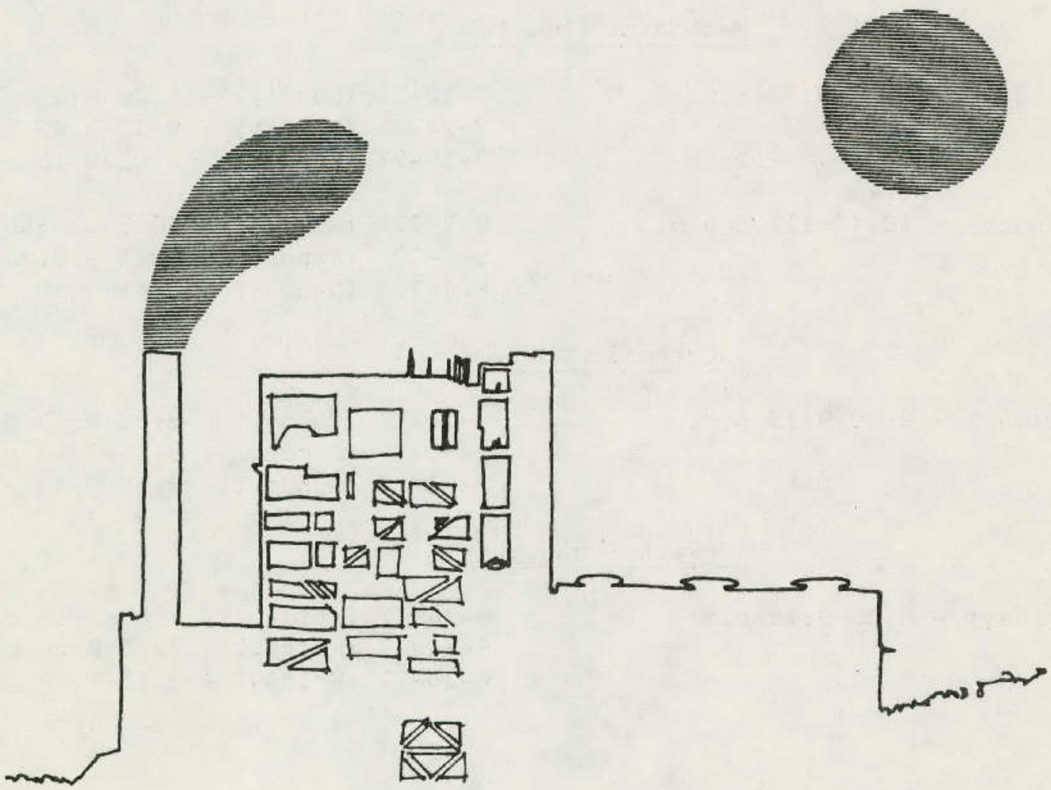
<u>Load Shedding Control.</u> Peak demand, although somewhat predictive, will most often occur randomly as a result of such variables as ambient temperature and building system demand. Consequently, manual corrective action can't be taken in time to prevent the demand peak, since manual response will invariably follow the peak--that's too late! Automation is needed so that the manual operation is removed from both demand control decisions and application of corrective measures.

The types of automated controls available run the gamut from extremely simple to highly sophisticated, with a cost range of a few hundred dollars to several thousands of dollars. Listed below are control systems requiring relatively low capital investment; Section 6 covers the more sophisticated controls

Time Switches--used to control loads that have reserve capacity, such as water heaters, duct heaters, ovens, etc. Time switches can be furnished with 24-hour dials, seven-day calendar dials, and combination photo-cell/timing capability for lighting control. Used for pre-programmed "off-on" control (master override of normal controls), they have a list cost of \$50-\$300.

Watthour Meter Accessories--Watthour meters can be furnished with pulse initiators, which can be used in conjunction with demand-limiting meters. The demand-limiting meter integrates KWH over the time interval to give a contact output which can be used to control a load. Some watthour demand meters can be provided with direct contact outputs which can control load shedding. The alarm contact is set to actuate for some lower value of demand than the predetermined maximum acceptable value.

Demand Controllers--The less expensive automatic demand controllers normally utilize ideal-rate control, which continuously measures and accumulates the energy consumed during a demand interval. The accumulation is compared with a theoretical rate of accumulation, based on the demand interval and the maximum allowable KW during that interval. When the difference between the actual consumption and the ideal rate reaches a preset minimum, a load is shed. When the difference between actual consumption and the ideal rate increases (a drop in consumption), a load is restored or added. Figure 5-1 illustrates ideal-rate control. This demand controller uses inputs from the utility's demand meter: KW counts or pulses and the timing (synchronizing) pulse; the timing pulse is used to make sure the controller maintains control over the same interval as the utility. This type of demand controller is relatively inexpensive ($5000-$10000 complete with a printer and alarm indication) and usually has the capability of controlling up to 10 load groups. It should normally be applied to simple systems having similar KW ratings.



Due to a church's unique operating characteristics, they typically will reach their highest KVA demand on the day of the church service.

Below is a sampling of nine churches and times when peak demands were established for billing.

Baptist Churches

Single High Peak KVA Date	3 Other Highest KVA Peaks Dates
8-14-77 (Sunday) - 9:30-9:45 a.m.	7-17-77 (Sunday) - 10:30-10:45 a.m. 7-17-77 (Sunday) - 9:15-9:30 a.m. 7-17-77 (Sunday) - 9:30-9:45 a.m.
8-14-77 (Sunday) - 9:45-10:00 a.m.	7-31-77 (Sunday) - 9:30-9:45 a.m. 7-24-77 (Sunday) - 9:15-9:30 a.m. 7-24-77 (Sunday) - 10:00-10:15 a.m.
7-31-77 (Sunday) - 10:30-10:45 a.m.	7-31-77 (Sunday) - 10:15-10:30 a.m. 7-31-77 (Sunday) - 10:00-10:15 a.m. 8-7-77 (Sunday) - 10:15-10:30 a.m.
7-24-77 (Sunday) - 9:45-10:00 a.m.	7-24-77 (Sunday) - 10:30-10:45 a.m. 7-24-77 (Sunday) - 10:00-10:15 a.m. 7-31-77 (Sunday) - 9:15-9:30 a.m.
7-31-77 (Sunday) - 10:00-10:15 a.m.	7-31-77 (Sunday) - 10:30-10:45 a.m. 7-17-77 (Sunday) - 10:00-10:15 a.m. 7-17-77 (Sunday) - 9:15-9:30 a.m.

Methodist Churches

7-10-77 (Sunday) - 9:15-9:30 a.m.	7-10-77 (Sunday) - 9:30-9:45 a.m. 7-24-77 (Sunday) - 9:30-9:45 a.m. 7-10-77 (Sunday) - 9:00-9:15 a.m.
8-7-77 (Sunday) - 10:45-11:00 a.m.	8-7-77 (Sunday) - 10:00-10:15 a.m. 8-7-77 (Sunday) - 10:15-10:30 a.m. 8-7-77 (Sunday) - 9:45-10:00 a.m.

Catholic Church

7-24-77 (Friday) - 9:00-9:15 p.m.	7-24-77 (Sunday) - 8:30-8:45 p.m. 7-24-77 (Sunday) - 8:45-9:00 p.m. 7-24-77 (Sunday) - 8:15-8:30 p.m.

Jewish Synagogue

6-24-77 (Friday) - 8:00-8:15 p.m.	6-24-77 (Friday) - 7:00-7:15 p.m. 6-24-77 (Friday) - 7:45-8:00 p.m. 6-24-77 (Friday) - 7:15-7:30 p.m.

TYPICAL ELECTRICITY COMPUTATIONS

December 1978 600,000 KWH
1,296 KW of Demand
$.0090660/KWH Fuel Adjustment
$14,510.50 Total Bill

		Energy Charge	Demand Charge
a.	2,500 KWH @ $.0336	$ 84.00	
b.	3,500 KWH @ $.022	77.00	
c.	154,320*KWH @ $.022		
	(1) 154,320 @ $.0188/KWH		$2,901.22
	(2) 154,320 @ $.0032/KWH	493.82	
d.	439,680** @ $.0032/KWH	1,406.98	
e.	$2.65/KW in excess of 10 KW		
	1296 - 10 = 1286 x $2.65		3,407.90
		$ 2,061.80	$6,309.12

Energy Charge	$ 2,061.80
Demand Charge	6,309.12
Fuel Charge	5,439.60
Customer Charge	9.00
Sales Tax	690.98
TOTAL	$14,510.50

*(1296 - 10)(120) = 154,320
**600,000 - 2500 - 3500 - 154,320 = 439,680
***600,000 @ $.0090660/KWH = $5,439.60

$$\text{Cost per KWH} = \frac{\$2,061.80 + \$5,439.60}{600,000} = \$.0125/\text{KWH}$$

$$\text{Cost per KWH} = \frac{\$6,309.12}{1,296} = \$4.87/\text{KW}$$

4

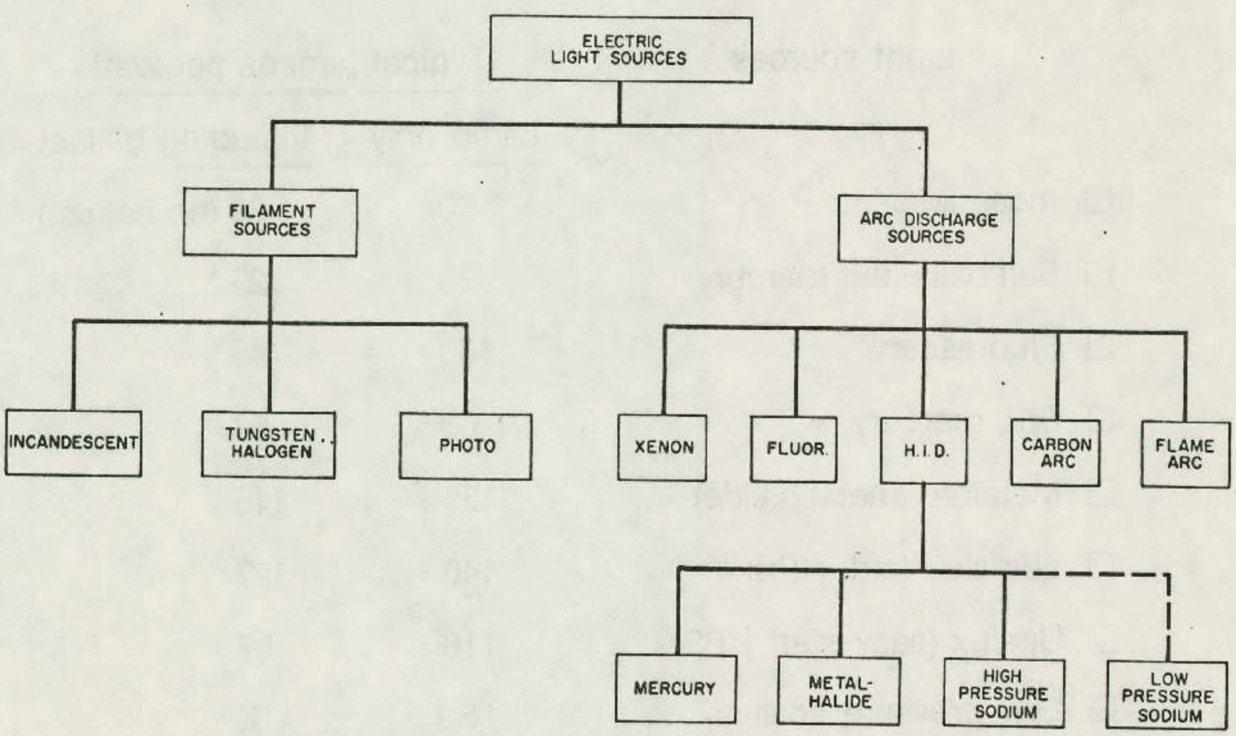
LIGHTING

LIGHTING

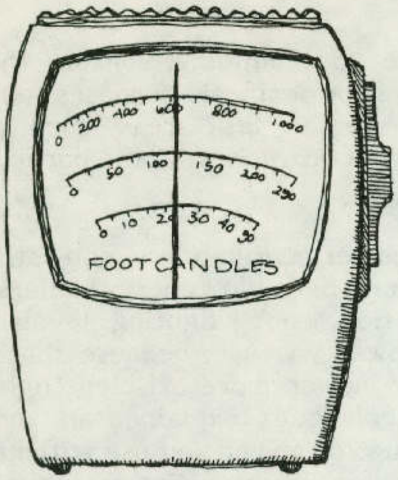
You use lighting both inside and outside your building. Inside the building you need lights for general illumination, for aesthetic purposes such as highlighting architectural features, and for special "task areas" such as desk. Outside, you may use lights for walkways, at entrances, in the parking spaces, or to illuminate the building itself.

Any place you can reduce lighting **power consumption** and still maintain the levels of illumination you need, you'll be saving energy dollars. Notice we used the phrase "power consumption," not "lighting levels." You're interested in reducing the amount of power you use, because that's what you're paying for every month. With the newer more efficient light bulbs now on the market, and with other techniques explained in this chapter, you should be able to reduce the amount of power you use **without** reducing lighting levels, although there may also be opportunities to reduce or totally eliminate illumination in areas which are overlit or where no lighting is needed.

Since lighting is a visible use of energy, reduction in its use has special significance: it will not only demonstrate your own commitment to conservation but will serve as a reminder to others that conservation is important and makes good sense. In this respect, few other elements of an energy conservation program will have as much impact as lighting.[6]



FAMILY OF COMMON ELECTRIC LIGHT SOURCES



Recommended Levels of Illumination

Area	Light Level (in footcandles)
Altar	100
Choir	30
Pulpit	50
Main Worship Area	15-30
Office	50
Classrooms	50
Lobby, Foyer, etc.	10
Auditorium	5-15
Parking Lot	1

Source: Lighting and Thermal Operations, Federal Energy Administration, Washington, D.C.; and IES Lighting Handbook, 5th Edition, 1972, Illuminating Engineering Society, New York.

What light Sources are available?

Light sources	Typical lumens per watt	
	Lamp only	Including ballast
☐ Incandescent	20	20 (no ballast)
☐ Self-ballasted mercury	25	25
☐ Fluorescent	100	85
☐ Std. mercury	63	58
☐ Metalarc (metal-halide)	125	115
☐ Lumalux (std. HPS)	140	127
☐ Unalux (easy start HPS)	116	97
☐ Low pressure sodium	183	150

WHAT YOU CAN DO

SURVEY WITH LIGHT METER
- REMOVE BULBS AND BALLASTS
- REMOVE FIXTURES
- REWIRE SWITCHES

CLEAN BULBS

CLEAN FIXTURES

SET UP RELAMP SCHEDULE

SET UP MANUAL LIGHTING SCHEDULE

USE TIMERS

GE's Energy-Efficient Light Sources can help you reduce your power/labor costs and effectively manage your energy resources.

Here's how:

When you own a lighting system, you are committed to three costs to operate that system.

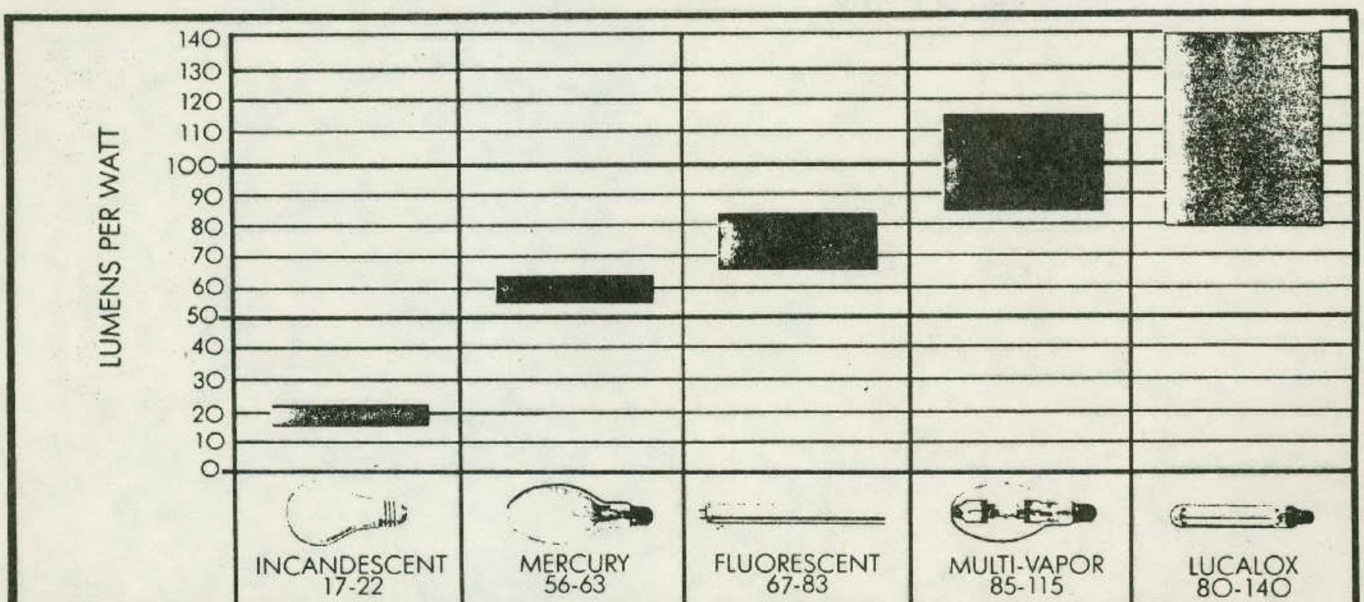
1. Replacement lamps
2. Labor to replace lamps
3. Electricity

Electricity is by far the major cost of operating a lighting system, and as power costs continue to rise, electricity cost will assume an even greater share of total lighting costs.

Example: Operating costs (for rated life of lamp)—one 40-watt fluorescent

	@ 2¢ per kwh	@ 3½¢ per kwh
Lamp	$ 1.25	$ 1.25
Labor	2.50	2.50
Electricity	20.00	35.00
	$23.75	$38.75

Some light sources convert electricity into light much more efficiently than others.



Energy-Saving Lighting–NOW!

Start saving energy and dollars now with GE retrofit lamp types. Simply take out your old lamps and replace them with Energy-Saving retrofits... and get more light immediately—with no capital investment.

WHERE YOU NOW USE	CHANGE TO THIS	GET THIS MUCH LIGHT	SAVE THIS MANY WATTS PER LAMP	GET THIS SAVING* PER LAMP
F40	F40 WATT-MISER®	SAME OR MORE†	7	$ 4.90
F96	F96 WATT-MISER	SAME OR MORE†	17.5	$11.03
F96 HO	F96 HO WATT-MISER	SAME OR MORE†	17.5	$11.03
F96 1500 MA	NEW F96 PG WATT-MISER	SAME OR MORE†	41	$21.00
100 WATT	50R20	SAME OR MORE **	50	$ 3.50
150 WATT FLOOD	75ER30	SAME OR MORE **	75	$ 5.25
200 WATT	120ER40	SAME OR MORE **	80	$ 5.60
150 WATT FLOOD	120ER40	UP TO 100% MORE **	30	$ 2.10
300 WATT FLOOD	120ER40	SAME OR MORE **	180	$10.50
175 WATT MERCURY	150 E-Z LUX®	UP TO 120% MORE	25	$10.50
250 WATT MERCURY	215 E-Z LUX®	UP TO 130% MORE	35	$14.70
400 WATT MERCURY	400 I-LINE M-V	UP TO 300% MORE	—	—
1000 WATT MERCURY	1000 I-LINE M-V	UP TO 440% MORE	85	$29.75

*Based on 3.5¢/kwh energy rate over average rated lamp life.
**Gives more light where you need it.

†Typically when older standard lamps are group replaced with watt-misers and fixtures cleaned.

Calculate your savings: ________ watts saved / socket x ________ hrs. / yr. x $O.__________ /kwh = $ __________ Annual Energy Savings

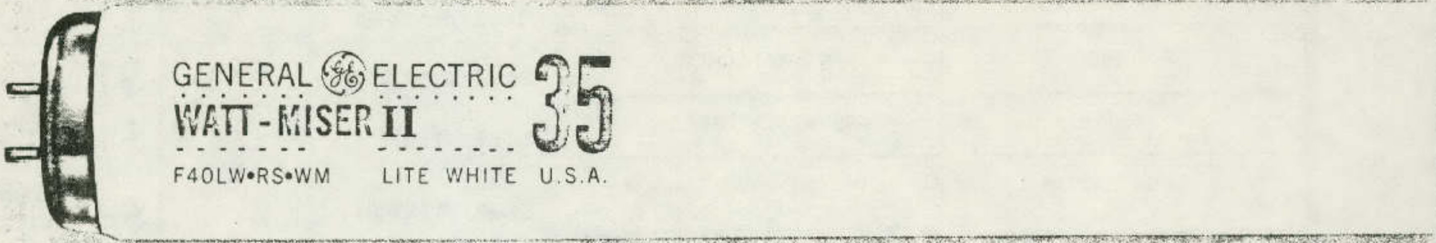
1000w / kw

$ ____________________ x ____________________ = $ __________ Total Annual Savings

Annual Energy Savings / Socket   Total Sockets

F40 Watt-Miser II

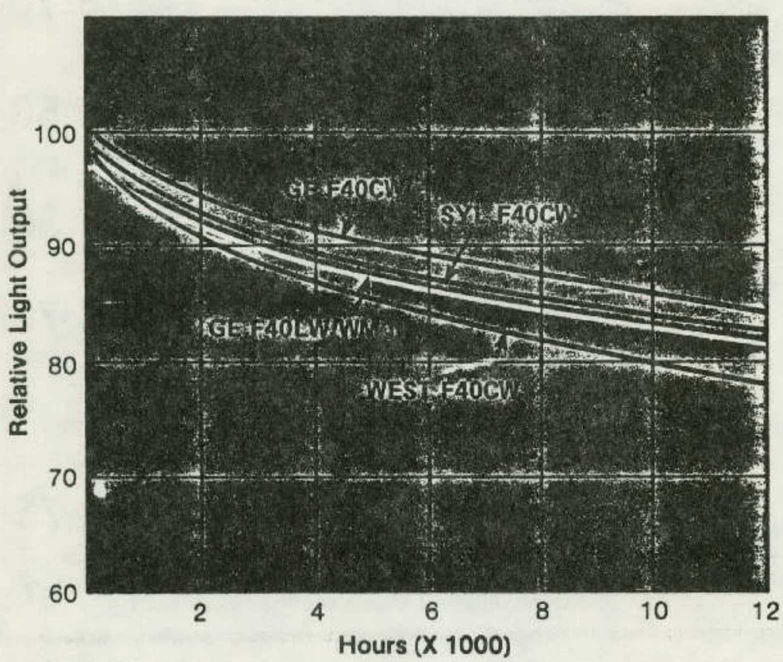
F40LW/RS/WM



For the first time in a single lamp for Rapid Start fixtures

* Lower energy consumption by 14%[1]
* High light output (3050 lumens)
* New high-efficiency white called Lite White

(1) In a typical two-lamp open Rapid Start fixture, 86 watts vs. 100 watts at 70° ambient temperature.



F40 Watt-Miser II

The "II" in the name means it's a second generation Watt-Miser — more light at reduced wattage. By using an improved phosphor blend, the Watt-Miser II will deliver almost the same amount (about 97%) of light as our standard F40CW, with about 14% lower power costs.

Competitive Light Story — The GE F40 Watt-Miser II at 35 watts nearly equals the lumen output of the 40-watt-consuming Sylvania standard F40CW, based on GE competitive tests. It surpasses the Westinghouse F40CW lumen output within 2000 hours of burning time, our tests show.

By simply relamping your existing F40CW luminaires with the F40 Watt-Miser II, you can lower your power costs and keep your light level high.

THE TYPICAL F40 WATT-MISER II USER WILL SAVE ABOUT 10 TIMES THE EXTRA LAMP COST IN ENERGY DOLLARS (BASED ON TYPICAL DISCOUNTS FOR VOLUME USERS AT NATIONAL AVERAGE ELECTRIC RATE).

What about removing lamps from sockets to save energy? Will this effect ballasts? [fluorescent - HID]

BALLASTS – THEY SHOULD BE BY-PASSED IF LAMPS ARE REMOVED . . . Not because it will necessarily damage the ballasts, but because a small amount of power will be consumed by a 2-Lamp Series, Rapid-Start Ballast left energized even if lamps are removed in pairs. In case you're curious about the "juice" that leaks, the table below gives typical values.

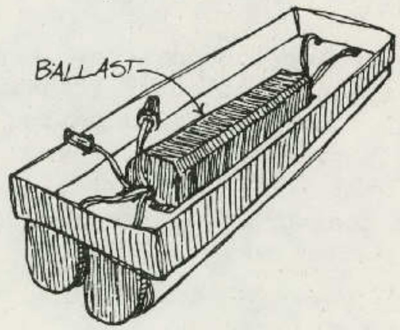
Circuit Type	Wattage** (Lamps Removed, Ballasts Energized)
2 – F40/RS	4-7
2 – F48/HO	8-10
2 – F48/VHO	10-13
2 – F96/HO	10-15
2 – F96/VHO	17-22

**Values are approximate, but typical. They vary with Ballast Manufacturers, ballast quality, and primary voltage to ballast.

* * * * *

HOW ABOUT HID LAMPS AND BALLASTS . . . Generally, HID lamps cannot be removed from ballasts left energized without damaging the ballasts. Never do it without by-pass wiring of Metalarcor Lumalux ballasts. With Mercury lamps the situation is somewhat different and it may be O.K. to do so. In the case of the single lamp, low power factor reactor it's fine, since no line current or watts are drawn. In the single lamp regulated ballast (constant wattage ballast) line current will still be approximately 50% normal and line watts will be 4-8% normal. In the single lamp-auto-regulated ballast (constant wattage auto transformer), line current will be approximately 15-30% normal and line watts will be 5-7% normal. It's best not to do it except for short periods of time (say, 6 months to less than 1 year). Longer periods may result in permanent ballast damage. If done, the customer's power factor will always be adversely affected.

* * * * *



Lighting Survey
St Phillips Methodist Church
5501 Beechnut

Classroom Lighting
Current: 92 - 200 watt silver bowl incandescent (lamp life - 1000 hours) in concentric ring fixtures
estimated foot candles in classrooms - 7.7 (including daylight - 35-45fc)
estimated annual operating cost - $933 (including lamp replacement cost)
Replacement: 2 - 4 foot fluorescent fixtures per classroom
Fixture type - Wright Lite C12 Series,
Model Number - CPA12-240-16
Lamp - F40T12/CW/WM (35 watt)
Capital Cost

Fixture	$53.60	@ (46)	$2466 (list price)
Lamp	1.52	@ (96)	146
Fixture Installation			1380
			$3992
Lamp replacement cost/year			$10.46
Estimated Annual operating cost			$160.00
			$170.40

The estimated annual operating savings per year is $762 and the payout is estimated to be 5.24 years. Every year after the first five a $762 savings would be realized. However, if the operating hours for the classrooms is increased the payout would be shorter and the operating savings increased.

The new fluorescent lamps will provide an estimated 10 foot candles or nearly the same illumination of the existing incandescent lighting system. It is suggested the number of fluorescent fixtures be increased to four per classroom or two 8 foot fixtures be used to increase the illumination levels to provide adequate light at night. Painting all of the walls a light color and maintaining a twelve month cleaning cycle will also increase the illumination levels in the classrooms.

Fellowship Hall
Current: 6 - 300 Watt incandescent
Recommendation: Installation of dimmer controls will allow variation of illumination for different types of events.

Exterior Walkways
Current: 60 or 100 watt incandescent lamps - (750 hour lamp life)
Recommendation: The lamp life can be extended by using 130 volt lamps or the 93 watt extended life lamps, (2500 hours lamp life).

Sanctuary and Foyer
Current: 150 watt PAR and Reflector incandescent lamps.
Recommendation: 120 watt elliptical reflector (ER) lamps in those fixtures where this lamp will fit. The illumination is nearly equal to the 150 watt Reflector lamp. Also the 100 watt PAR - 38 lamp can be used to replace the 150 watt PAR - 38 where illumination is not critical as this replacement does produce less lumens.

Lighting Survey
Westbury Church of Christ
10424 Hillcroft

Fluorescent Lamps

Current lamps used: F40T12CW (General Electric Mainliner - 40 watts)

Recommended replacement: F40T12/Cw/WM (35 watt energy efficient lamps such as General Electric's Watt Miser II). The lumen output is 3050 lumens rather than the 3150 lumens output of the current lamps. The new 35 W lamps can be used to replace the existing lamps as they burn out. However, the new lamps maybe considerably brighter than the older lamps (lumen output depreciates with age). In this case you may wish to change all of the lamps in a fixture when changing the burned out lamp.

Estimated annual operating savings: $237

Incandescent Lamps

1. Current: Standard 100 W A-19

   Recommended replacement: 90 or 93 watt extended life or 100 watt, 130 volt A-19 lamps be used to replace all 100 W A-19 incandescent lamps. The 100 watt, 130 volt will also extend the lamp life. The standard lamp has a life of 750 hours and 2500 hours for the extended life lamp.

   Estimated annual operating savings: $68

2. Current: 150 Watt Reflector Flood lamps

   Recommended replacement: 120 watt elliptical reflector lamps (ER). The improved design of the lamp provides essentially equivalent illumination as the 150 watt reflector lamp with a 30 watt per lamp savings.

   Estimated annual operating savings: $15.22

3. Current: 150 watt PAR Lamps

   Recommendations: Westinghouse has on the market the following replacements 55 watt for 75 watt, 100 watt for 150 watt and a 200 watt for a 300 watt lamp. However, the lumen output and illumination is decreased for these lamps. If current illumination is more than adequate these replacements may be considered. I have enclosed a product brochure.

Exterior Lighting

Current: 400 Watt quartz, 1000 and 300 watt incandescent

Recommended Replacement:

	Quartz	Incandescent		High Pressure Sodium	
Watts	400	1000	300	100	70
lumens	10,950	23,740	6,360	9500	5800
life	2,000 hours	1000	750	20,000	20,000 hours

While the initial cost for lamp, ballast and fixture is fairly high for the high pressure sodium lighting system the operating costs are substantially lower and the lamp life is more than 20 times greater. For example, assuming a dusk to dawn operation for the existing lamps the estimated annual operating cost is $1,080. The high pressure sodium lamps producing approximately the same lumens would cost $194 annually to operate for a savings of $886 per year.

Based on this cost savings it is recommended that the high pressure sodium lamps be considered for existing and new exterior lighting.

Maintenance: A twelve monthly cycle for cleaning and dusting lamps and fixtures generally increase illumination by 10 to 12 percent. This can be important where illumination is critical such as in the classroom areas.

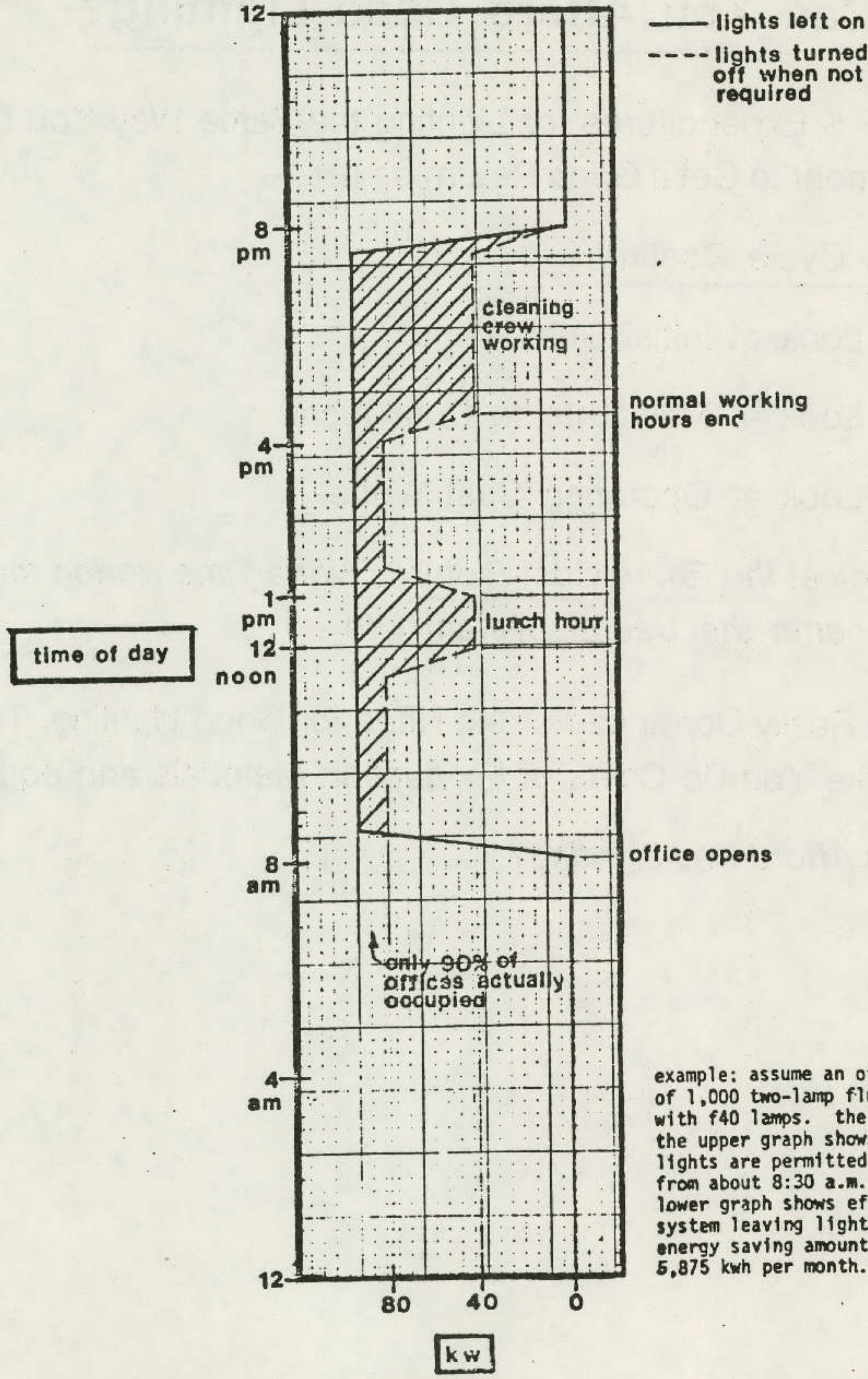
Effect of Lighting Load on Air Conditioning

Lighting Load Watts/Sq. Ft.	Energy Cost/Yr.	A/C Capacity Tons	A/C Capital Cost	A/C Operating Cost/Yr.
3	$71,886	171	$308,000	$15,000
6	$143,772	342	$615,000	$31,000

For: 200,000 Sq./Ft. Store - Boston Area
Based on $.032/KWH for 3,700 Hrs./Yr.
A/C Sizes for Lighting Only

lighting

the effect of turning off unnecessary lights on power consumption



example: assume an office lighting syste of 1,000 two-lamp fluorescent luminaires with f40 lamps. the full system uses 92 the upper graph shows typical usage whe lights are permitted to burn continuousl from about 8:30 a.m. to 7:30 p.m. the lower graph shows efficient use of the s system leaving lights on only when used. energy saving amounts to 262.5 kwh dail 5,875 kwh per month.

Can You Afford Good Lighting?

- ☐ Consider $ Expenditures for Lighting the Same Way You Do Any $ Investment to Get a Good Return on It.
- ☐ Use Life Cycle Costing —
  - Don't Look at Initial Cost Alone
  - Don't Look at Maintenance Cost Alone
  - Don't Look at Operating Cost Alone
  - *Do Look at the Entire Cost Picture Over a Time Period that Best Represents the Useful System Life*
- ☐ If You're Really Convinced of the Need for Good Lighting, Treat It's Costs Like You Do Costs of Production Materials and equipment
- ☐ *Can You Afford Bad Lighting?*

COMPARISON OF COMMON LIGHT SOURCES

LAMP TYPE	DESIGNATION	NOMINAL WATTAGE	INITIAL LUMENS	INITIAL LPW (1)	INITIAL LPW (2)	COLOR TEMP. °K	COLOR RENDERING INDEX	RATED AVE. LIFE (3)
METALARC CLEAR	M400	400	34,000	85	75	4,500	65	15,000
METALARC COATED	M400/C	400	34,000	85	75	3,800	70	15,000
SUPER METALARC CLEAR	MS400	400	40,000	100	88	4,500	65	15,000
SUPER METALARC COATED	MS400/C	400	40,000	100	88	3,800	70	15,000
MERCURY CLEAR	H33CD-400	400	20,500	51	46	5, 00	22	24,000
MERCURY DELUXE WHITE	H33GL-400/DX	400	23,000	57	51	4,000	45	24,000
MERCURY WARMTONE	H33GL-400/N	400	19,500	48	43	3,300	52	24,000
LUMALUX CLEAR	LU400	400	50,000	125	107	2,100	20	24,000
LUMALUX COATED	LU400/D	400	47,500	119	102	2,100	20	24,000
UNALUX CLEAR	ULX360	360	38,000	105	95	2,060	20	16,000
UNALUX COATED	ULX360/D	360	36,000	100	90	2,060	20	16,000
LOW PRESSURE SODIUM	SOX-180	180	33,000	183	136	1,750	0	18,000
FLUORESCENT	F40CW	40	3,150	78	67	4,300	67	26,000
FLUORESCENT	F96T12CW	75	6,300	84	63	4,300	67	18,000
FLUORESCENT	F96T12CWX	75	4,400	59	44	4,100	86	18,000
INCANDESCENT	300/IF	300	6,000	20	20	2,900	97	1,000

(1) Lamp only

(2) Lamp and ballast losses, where applicable

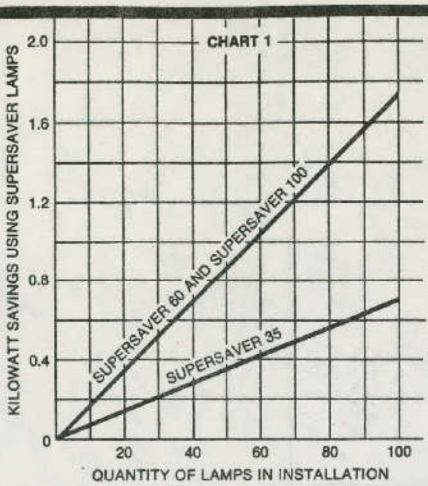
(3) At 10 hrs. per start

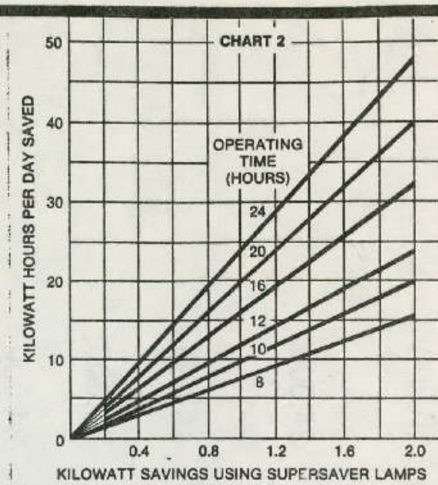
FLUORESCENT SUPERSAVERS

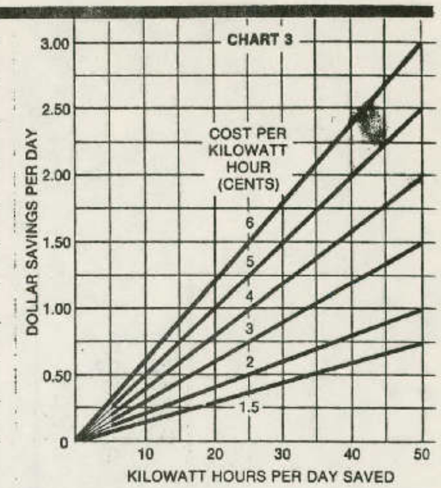
Type	Wattage	Per Lamp (1) Watts Saved	Lumen Reduction (2)	Savings over Lamp Life @ $.035/kwh
F30T12/RS/SS	25	7	12%	$ 3.68
F48T12/SS	32	10	16%	$ 3.15
F40/RS/SS	35	7	12%	$ 4.90
F96T8/SS	41	10	13%	$ 2,63
F96T12/SS	60	17.5	18%	$ 7.35
F90T17/SS	85	7	6%	$ 2.20
F96T12/HO/SS	100	17.5	12%	$ 7.35
F96T12/VHO/SS	195	17.5	10%	$ 6.13

(1) Watts saved per lamp on two lamp ballast - includes savings on ballast losses

(2) Lumen loss compared to a new standard lamp - actual light level may be higher with SuperSavers if present lamps are old.







KILOWATT SAVINGS

1. Start with Chart 1 to calculate the number of kilowatts you save with SuperSaver lamps. First, select the type of SuperSaver lamp which matches the lamp in your installation. On horizontal scale of Chart 1 determine number of lamps in your installation and read up to point on SuperSaver lamp type you would use in your installation. Read across to left to determine the Kilowatt savings.

For example: You have 688-F40 lamps. Using 10 multiplier, in Chart 1, read 68.8 lamps up to SuperSaver 35 line, then across to get total kilowatt savings. It is .48 KW for 68.8 lamps which is 4.8 for our 688 lamps example.

KILOWATT HOUR SAVINGS

2. Next, go to Chart 2 to determine how many kilowatt hours a day you save with SuperSaver lamps. Find Kilowatts saved (from Chart 1) on horizontal scale in Chart 2 and read up the line that shows the number of hours per day your installation operates. Read directly across to the left to determine how many kilowatt hours you save a day with SuperSaver lamps (remember to use the same 10 times multiplier if you used one for Chart 1).

Using our example, .48KW for 68.8 lamps, operating at 12 hours per day saves 5.8 Kilowatt hours or (X10) 58 kilowatt hours per day with 688 lamps.

Lighting Center, Danvers, Massachusetts 01923

DOLLAR SAVINGS

3. Finally, use Chart 3 to determine your dollar savings. Taking the kilowatt hours per day saved (from 2 above), find the savings on horizontal scale in Chart 3 and read up until you find the proper line for your cost per kilowatt hour. Then read directly across to the left to find your savings per day (again, remember to use any 10 times multiplier used in steps 1 and 2). To determine your annual savings with SuperSaver lamps, multiply your daily savings times the number of days per year that your installation is in operation.

Finishing our example, the 5.8 kilowatt hours per day at 4¢ per KWH saves about 23¢ per day. Using the 10 multiplier to get our 688 lamps we actually save $2.30 per day. And if the lamps are on for 250 days per year, an annual saving of $575.00 will be gained.

SYLVANIA SUPERSAVER LAMPS — TECHNICAL INFORMATION

Watts	Bulb	Base	Lamp Ordering Abbreviation	Std. Case Qty.	Description	Hours Life*	Approx. Initial Lumens
35	T12 48"	Bipin	F40/CW/RS/SS	24	Cool White Low Wattage	20,000	2850
35	T12 48"	Bipin	F40/CWX/RS/SS	24	Dlx. Cool White Low Wattage	20,000	2000
35	T12 48"	Bipin	F40/WW/RS/SS	24	Warm White Low Wattage	20,000	2900
35	T12 48"	Bipin	F40/D/RS/SS	24	Daylight Low Wattage	20,000	2350
60	T12 96"	Single Pin	F96T12/CW/SS	12	Cool White Low Wattage	12,000	5600
60	T12 96"	Single Pin	F96T12/CWX/SS	12	Dlx. Cool White Low Wattage	12,000	3800
60	T12 96"	Single Pin	F96T12/WW/SS	12	Warm White Low Wattage	12,000	5600
60	T12 96"	Single Pin	F96T12/D/SS	12	Daylight Low Wattage	12,000	4700
100	T12 96"	RDC	F96T12/CW/HO/SS	12	Cool White Low Wattage	12,000	8400

*Engineering design evaluations based on 3 hours per start.

Comparison Of Typical Discharge Lamp Performance

Lamp Type		Initial			End of Life**		Rated Average Life
			Lumens Per Watt				
		Lumens	Lamp	Lamp/Ballast	Lumens	Lumens per Watt*	
Low Pressure Sodium	180W	33,000	180	150	33,000	117	18,000
High Pressure Sodium	400W	50,000	125	106	35,000	76	24,000
Super Metalarc	400W	40,000	100	88	27,200	60	15,000
Metalarc	400W	34,000	85	75	22,500	50	20,000
Mercury	400W	23,000	57	51	15,700	35	24,000
Fluorescent VHO	2/215W	32,000	74	71	21,760	48	15,000

*Includes ballasts losses.

**Operated on 10 Hour Burning Cycle.

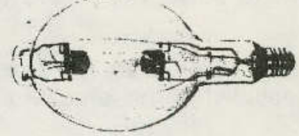
For Maximum Savings... a new lighting system

A new Lucalox or Multi-Vapor lighting system will often save enough in lamp, labor and electricity costs to pay for itself within a short period of time.

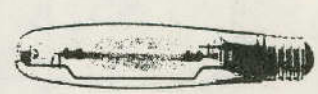
Here's how:

Converting an Existing System to a More Efficient One*

Changing from 1000-watt Mercury to 1000-watt Multi-Vapor or 1000-Watt Lucalox

	 1000W Deluxe Mercury	 1000W Multi-Vapor	 1000W Lucalox
	238 Fixtures	94 Fixtures	75 Fixtures
Initial Installation Costs	0	$36,096	$38,775
Annual Operating Costs Lamps & Labor Electricity	 $ 1,190 $35,985	 $ 2,256 $14,214	 $ 1,000 $11,865
Annual Operating Costs	$37,175	$16,470	$12,865
Operating Cost Savings	0	$20,705	$24,310
Payback on Investment	0	1.7 years	1.6 years
Return on Investment	0	57.4%	62.7%

Installing a New Lighting System—Which is Best?*

	 1000W Deluxe Mercury	VS.  High Output Fluorescent	VS.  400W Lucalox
	238 Fixtures	621 Fixtures (2 Lamp)	210 Fixtures
Initial Installation Costs	$ 75,302	$ 82,593	$ 63,420
Lamps & Labor Electricity	$ 1,190 35,985	$ 3,587 $ 22,604	$ 1,750 $ 13,965
Annual Operating Costs	$ 37,175	$ 26,191	$ 15,715
20 Years Operating Costs + Initial Investment	$818,802	$606,431	$377,720

Energy-Saving Lighting saves well over $400,000 over the life of the lighting system, and will save even more if power and labor costs rise as predicted.

*100 Footcandles, 50,000 sq. ft., 3½¢/kwh, $10/hr. labor costs

Focus on Energy and Dollar Savings with Westinghouse H.I.D. Lamps

Significant savings in annual operating costs can be realized by using more efficient, long life Westinghouse High Intensity Discharge lamps.

The cost studies in this brochure illustrate the savings available by substituting new fixtures with these economical light sources for present less efficient lighting. These cost studies also show the time required to pay back fixture and installation costs from savings realized in reduced power costs.

In addition, savings in fixture power usage and improvements in illumination level are shown for most areas studied.

A detailed cost study can be made using the specific cost for your lighting installation on the Cost Comparison Worksheet included in this brochure.

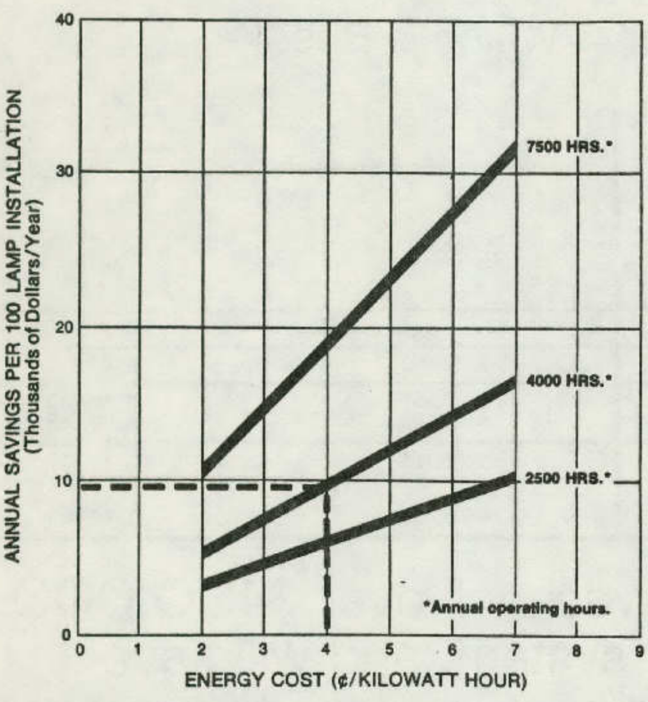
COVER:

BEFORE Photograph — 178 mercury lamps, 1000 watt size, light this plant area.

AFTER Photograph — 178 Ceramalux high pressure sodium lamps, 400 watt size, deliver same maintained light using 60% less power. (Mercury fixtures disconnected but not removed.)

1. Annual Savings for Replacement of 750 Watt Incandescent Lamps with 150 Watt Ceramalux™ Lamps.

Lighting System	Present	Proposed
Lamp Type	Incandescent	Ceramalux™
Designation	750	C150S56
Lamp Wattage	750 Watts	150 Watts
Maintained lumens	13920	14400
Ratio to present lumens	—	104%
Installated cost per fixture	—	$146
Power savings per fixture[1]	—	570 Watts

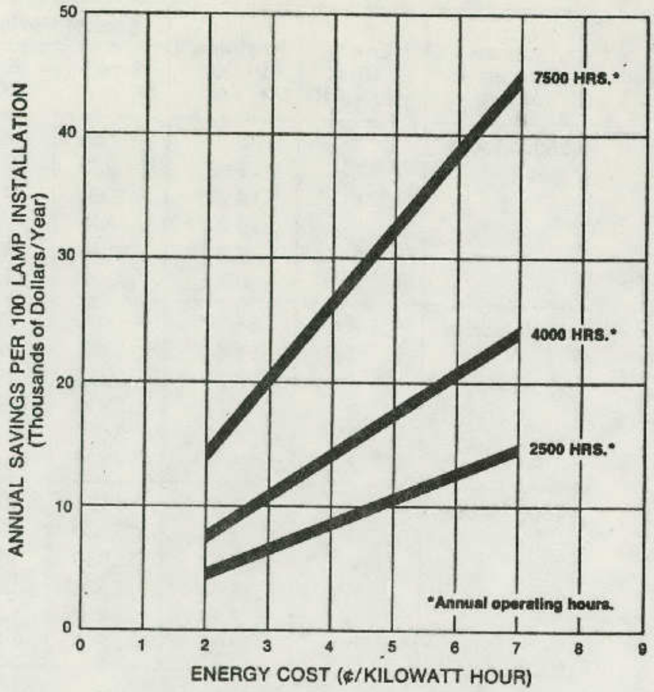


Annual Operating Hours	Energy Cost (¢/KWH)	Payback[2] Period (Year)	Annual Savings[4] Cost[3] $	Annual Savings[4] Energy KWH
2500 Hours	2	4.6	3150	142500
	3	3.2	4570	142500
	4	2.4	6000	142500
	5	2.0	7420	142500
	6	1.7	8480	142500
	7	1.4	10270	142500
4000 Hours	2	2.8	5200	228000
	3	2.0	7580	228000
	4	1.5	9860	228000
	5	1.2	12140	228000
	6	1.0	14420	228000
	7	0.9	16700	228000
7500 Hours	2	1.4	10350	427500
	3	1.0	14630	427500
	4	0.8	18900	427500
	5	0.6	23180	427500
	6	0.5	27450	427500
	7	0.45	31730	427500

Example: The dotted line above traces to the $9,860 savings available for an energy cost of 4¢/KWH and 4,000 annual operating hours in a 100 lamp installation. The shaded area in the table also shows a 1.5 year payback period for fixture and installation costs and the 228,000 KWH in annual energy savings.

2. Annual Savings for Replacement of 1000 Watt Incandescent Lamps with 150 Watt Ceramalux™ Lamps

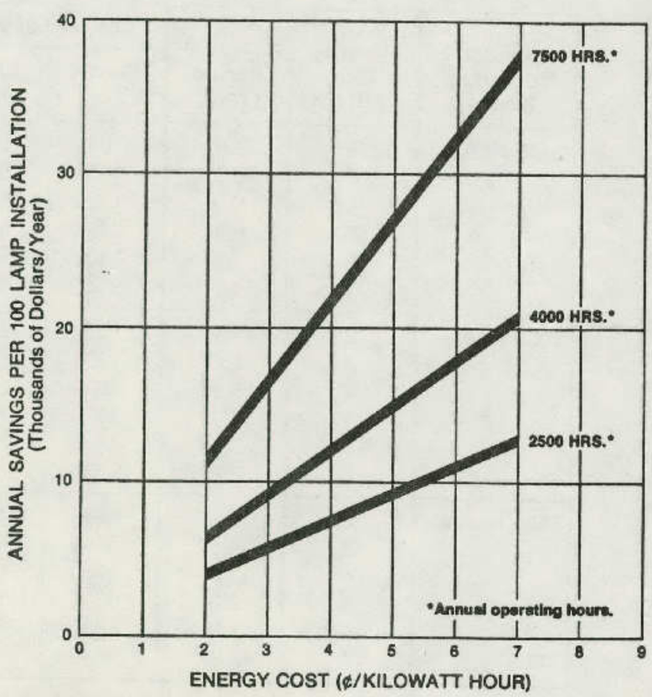
Lighting System	Present	Proposed
Lamp Type	Incandescent	Ceramalux™
Designation	1000/99	C150S56
Lamp Wattage	1000 Watts	150 Watts
Maintained lumens	16617	14400
Ratio to present lumens	—	87%
Installated cost per fixture	—	$146
Power savings per fixture(1)	—	820 Watts



Annual Operating Hours	Energy Cost (¢/KWH)	Payback(2) Period (Year)	Annual Savings(4)	
			Cost(3) $	Energy KWH
2500 Hours	2	3.3	4427	205000
	3	2.25	6475	205000
	4	1.71	8525	205000
	5	1.38	10580	205000
	6	1.15	12530	205000
	7	0.99	14680	205000
4000 Hours	2	1.98	7350	328000
	3	1.37	10630	328000
	4	1.05	13910	328000
	5	0.85	17190	328000
	6	0.71	20470	328000
	7	0.61	23750	328000
7500 Hours	2	1.03	14195	615000
	3	0.72	20345	615000
	4	0.55	25495	615000
	5	0.45	32645	615000
	6	0.38	38795	615000
	7	0.32	44945	615000

3. Annual Savings for Replacement of 1000 Watt Incandescent Lamps with 250 Watt Ceramalux™ Lamps

Lighting System	Present	Proposed
Lamp Type	Incandescent	Ceramalux™
Designation	1000/99	C250S50
Lamp Wattage	1000 Watts	250 Watts
Maintained lumens	16600	24750
Ratio to present lumens	—	149%
Installated cost per fixture	—	$155
Power savings per fixture(1)	—	700 Watts



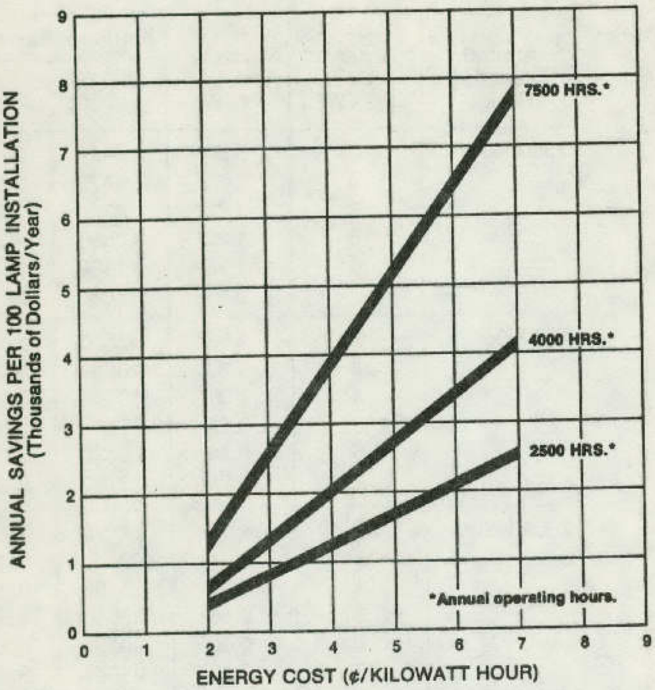
Annual Operating Hours	Energy Cost (¢/KWH)	Payback(2) Period (Year)	Annual Savings(4)	
			Cost(3) $	Energy KWH
2500 Hours	2	4.1	3780	175000
	3	2.8	5530	175000
	4	2.1	7280	175000
	5	1.7	9030	175000
	6	1.4	10780	175000
	7	1.2	12530	175000
4000 Hours	2	2.6	6050	280000
	3	1.75	8850	280000
	4	1.33	11650	280000
	5	1.07	14450	280000
	6	0.90	17250	280000
	7	0.80	20050	280000
7500 Hours	2	1.36	11365	525000
	3	0.93	16615	525000
	4	0.70	21865	525000
	5	0.57	27115	525000
	6	0.48	32365	525000
	7	0.41	37615	525000

Footnotes:

(1) Includes ballast losses.
(2) Payback period = total installation cost ÷ annual savings in operating expense.
(3) Annual savings = annual operating cost of present system — annual operating cost of proposed system.
(4) All savings calculated for a 100 lamp installation. Costs include: labor, hardware, fixture and lamp, but do not include cost of capital.

4. Annual Savings for Replacement of 400 Watt Mercury Vapor Lamps with 250 Watt Ceramalux™ Lamps

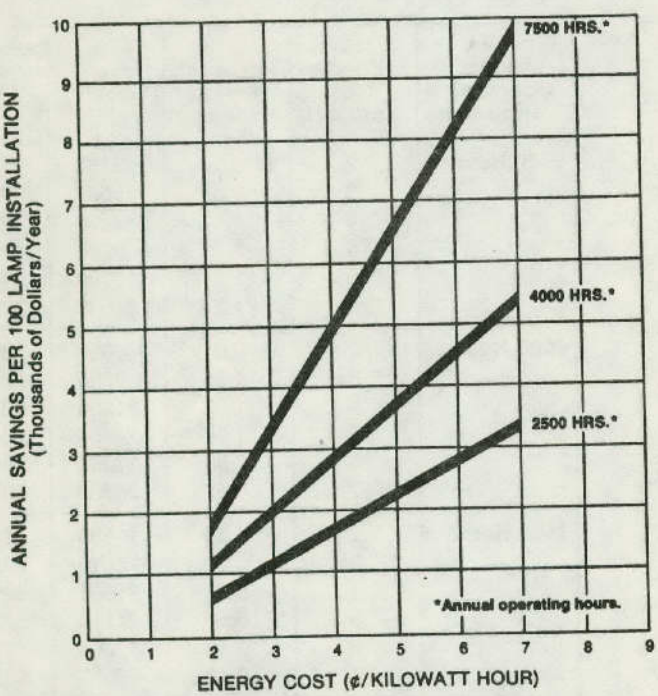
Lighting System	Present	Proposed
Lamp Type	Mercury	Ceramalux[tm]
Designation	H33GL-400/DX	C250S50
Lamp Wattage	400 Watts	250 Watts
Maintained lumens	18400	24750
Ratio to present lumens	—	135%
Installated cost per fixture	—	$155
Power savings per fixture[(1)]	—	172 Watts



Annual Operating Hours	Energy Cost (¢/KWH)	Payback[(2)] Period (Year)	Annual Savings[(4)] Cost[(3)] $	Annual Savings[(4)] Energy KWH
2500 Hours	2	38	400	43000
	3	19	830	43000
	4	12.3	1260	43000
	5	9.2	1690	43000
	6	7.3	2120	43000
	7	6.1	2550	43000
4000 Hours	2	23	660	68800
	3	11.5	1350	68800
	4	7.6	2040	68800
	5	5.7	2730	68800
	6	4.5	3415	68800
	7	3.8	4100	68800
7500 Hours	2	12.4	1250	129000
	3	6.1	2540	129000
	4	4.0	3830	129000
	5	3.0	5120	129000
	6	2.4	6410	129000
	7	2.0	7700	129000

5. Annual Savings for Replacement of a Two Lamp 1500MA Fluorescent Fixture with a 250 Watt Ceramalux™ Lamp Fixture

Lighting System	Present	Proposed
Lamp Type	Fluorescent	Ceramalux[tm]
Designation	Two F96 1500 ma	C250S50
Lamp Wattage	430 Watts	250 Watts
Maintained lumens	22000	24750
Ratio to present lumens	—	112%
Installated cost per fixture	—	$155
Power savings per fixture[(1)]	—	216 Watts



Annual Operating Hours	Energy Cost (¢/KWH)	Payback[(2)] Period (Year)	Annual Savings[(4)] Cost[(3)] $	Annual Savings[(4)] Energy KWH
2500 Hours	2	24.0	645	54000
	3	13.0	1185	54000
	4	9.0	1725	54000
	5	6.8	2265	54000
	6	5.5	2800	54000
	7	4.6	3345	54000
4000 Hours	2	14.4	1070	86400
	3	8.0	1935	86400
	4	5.5	2800	86400
	5	4.2	3665	86400
	6	3.42	4530	86400
	7	3.87	5390	86400
7500 Hours	2	8.4	1840	162000
	3	4.5	3460	162000
	4	3.0	5080	162000
	5	2.3	6700	162000
	6	1.9	8320	162000
	7	1.6	9940	162000

Footnotes:

(1) Includes ballast losses.

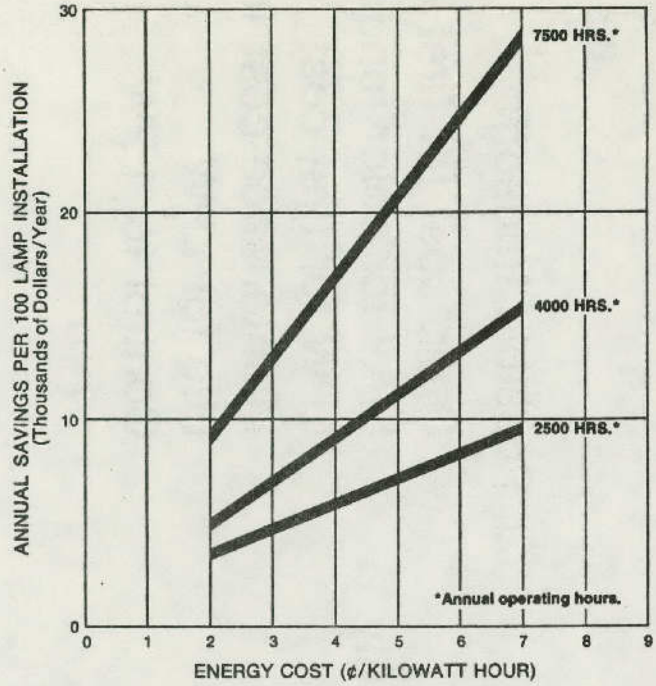
(2) Payback period = total installation cost ÷ annual savings in operating expense.

(3) Annual savings = annual operating cost of present system — annual operating cost of proposed system.

(4) All savings calculated for a 100 lamp installation. Costs include: labor, hardware, fixture and lamp, but do not include cost of capital.

6. Annual Savings for Replacement of 1000 Watt Incandescent Lamps with 400 Watt Metal Halide Lamps

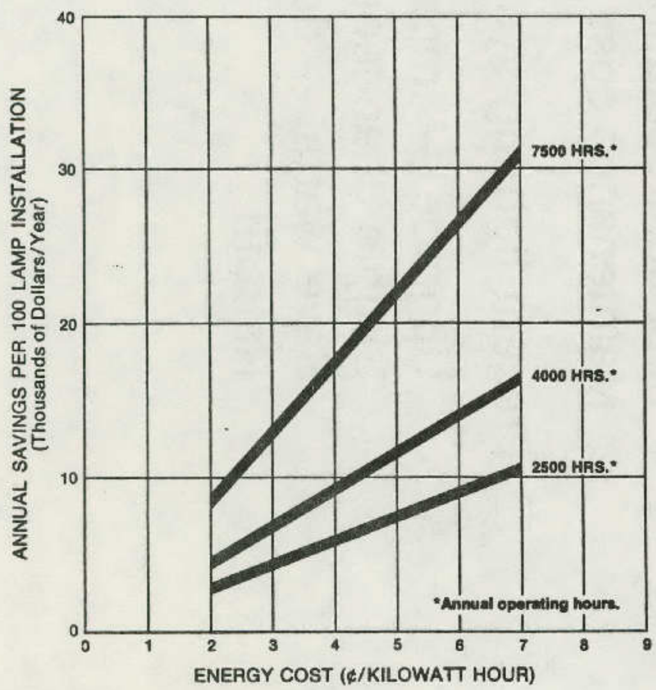
Lighting System	Present	Proposed
Lamp Type	Incandescent	Metal Halide
Designation	1000/99	MH400-BU/C
Lamp Wattage	1000 Watts	400 Watts
Maintained lumens	16600	23200
Ratio to present lumens	—	140%
Installated cost per fixture	—	$120
Power savings per fixture[1]	—	520 Watts



Annual Operating Hours	Energy Cost (¢/KWH)	Payback[2] Period (Year)	Annual Savings[4] Cost[3] $	Annual Savings[4] Energy KWH
2500 Hours	2	3.9	3045	130000
	3	2.8	4345	130000
	4	2.1	5645	130000
	5	1.7	6945	130000
	6	1.5	8245	130000
	7	1.26	9545	130000
4000 Hours	2	2.5	4875	208000
	3	1.7	6955	208000
	4	1.3	9035	208000
	5	1.1	11115	208000
	6	0.9	13195	208000
	7	0.8	15275	208000
7500 Hours	2	1.31	9155	390000
	3	0.9	13055	390000
	4	0.7	16955	390000
	5	0.6	20855	390000
	6	0.5	24755	390000
	7	0.4	28655	390000

7. Annual Savings for Replacement of 1000 Watt Mercury Vapor Lamps with 400 Watt Ceramalux™ Lamps

Lighting System	Present	Proposed
Lamp Type	Mercury	Ceramalux™
Designation	H36GW-1000/DX	C400S51
Lamp Wattage	1000 Watts	400 Watts
Maintained lumens	44700	45000
Ratio to present lumens	—	100%
Installated cost per fixture	—	$182
Power savings per fixture[1]	—	602 Watts



Annual Operating Hours	Energy Cost (¢/KWH)	Payback[2] Period (Year)	Annual Savings[4] Cost[3] $	Annual Savings[4] Energy KWH
2500 Hours	2	6.6	2760	150500
	3	4.3	4265	150500
	4	3.2	5770	150500
	5	2.5	7280	150500
	6	2.1	8780	150500
	7	1.8	10290	150500
4000 Hours	2	4.1	4440	240800
	3	2.7	6850	240800
	4	2.0	9260	240800
	5	1.6	11665	240800
	6	1.3	14070	240800
	7	1.1	16480	240800
7500 Hours	2	2.2	8290	451500
	3	1.4	12800	451500
	4	1.0	17320	451500
	5	0.8	21835	451500
	6	0.7	26350	451500
	7	0.6	30965	451500

Footnotes:

(1) Includes ballast losses.
(2) Payback period = total installation cost ÷ annual savings in operating expense.
(3) Annual savings = annual operating cost of present system — annual operating cost of proposed system.
(4) All savings calculated for a 100 lamp installation. Costs include: labor, hardware, fixture and lamp, but do not include cost of capital.

How to choose the BEST Light Source & Lighting System for YOUR application?

- ☐ Performance Characteristics of sources/lighting equipment

  LPW efficiency (lumens per watt)
  Life
  Color rendition
  Maintained light output
  Compact→good control
  First cost/operating cost
  Maintenance cost

- ☐ Present lighting systems

  Upgrade — improve
  Simple changeout — lamp only
  Save watts — dollars
  Retrofit

- ☐ New installations or complete rennovations

  More of the same kinds of considerations!

- ☐ Possible tradeoffs

  Oper. cost for first cost
  LPW for color rendition
  LPW for first cost
  Maintenance cost for LPW
  Life for LPW
  Control for LPW

APPLICATIONS
LIGHT SOURCE SELECTOR GUIDE

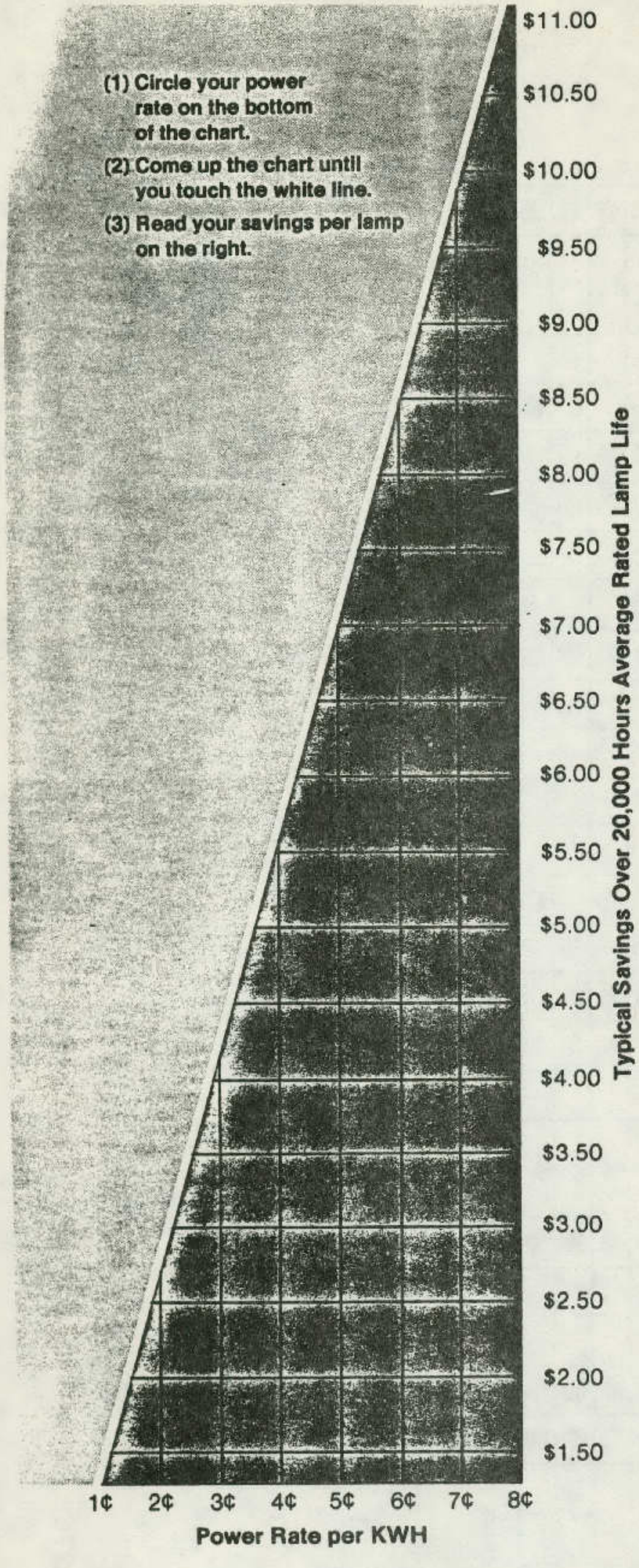
CHARACTERISTICS OF SOURCES	HIGH COLOR FIDELITY (color rendering)			EFFICIENCY (lumens per watt) (initial)			LUMEN MAINTENANCE (mean lumens)			RATED AVG. LIFE (hours)			DEGREE OF LIGHT CONTROL			INPUT POWER REQ'D. (for equal light)				SYSTEM OPERATING COST (for equal light)			INITIAL EQUIPMENT COST (for equal light)			TOTAL OWNING & OPERATING COST		
RELATIVE RATINGS OF SOURCES	VERY IMPORTANT	IMPORTANT	UNIMPORTANT	HIGHEST (80 UP)	MEDIUM (50-80)	LOWEST (15-50)	HIGHEST (85% UP)	MEDIUM (75-85%)	FAIR (65-75%)	SHORTEST (5000 or less)	INTERMEDIATE (5000-15000)	LONGEST (15000-25000)	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	HIGH	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST
INCANDESCENT	●					●		●		●			●			●				●					●	●		
TUNGSTEN-HALOGEN	●					●	●			●			●			●				●					●	●		
FLUORESCENT	●				●			●				●			●			●			●			●			●	
CLEAR MERCURY			●		●			●				●	●				●				●			●			●	
COATED MERCURY		●			●			●				●		●			●				●			●			●	
CLEAR METALARC	●			●				●			●		●						●			●		●				●
COATED METALARC	●			●					●		●			●					●			●		●				●
CLEAR LUMALUX			●	●			●					●	●						●			●	●					●
COATED LUMALUX			●	●			●					●		●					●			●	●					●
CLEAR UNALUX			●	●			●				●		●						●			●		●				●
COATED UNALUX			●	●			●				●			●					●			●		●				●

NOTE: DOT INDICATES THAT THE LIGHT SOURCE EXHIBITS THE LISTED CHARACTERISTICS

HOW TO USE THE SELECTOR GUIDE:

1. Determine which characteristics are important.
2. Example . . . "How important is good color rendition (high color fidelity)"?
3. Repeat this procedure for each characteristic which you feel is necessary or desirable for your application.
4. Select the source or sources which exhibit most or all of the characteristics which you have specified.
5. Make trade offs; i.e., longer life for lower efficiency or poorer color fidelity for higher efficiency, when you feel this makes more sense.

NOTE: The selector guide does not cover all lamps in each product family but rather indicates characteristics of those sources most widely used in commercial and industrial application.



FIND YOUR OWN ENERGY SAVINGS

Energy savings per lamp (from chart at left) $________

Cost of new F40 Watt-Miser II $________

(subtract from Energy Savings) $________

Net savings per lamp $________

Net savings per lamp times number of lamps ($________) gives

TOTAL NET SAVINGS $________

APPLICATION RECOMMENDATIONS

F40 Watt-Miser lamps are intended for use on single lamp and two-lamp indoor rapid start lead-circuit high power factor ballasts in lamp ambients of 60° F or higher. Operation on low power factor ballasts, dimming systems, emergency lighting systems, and reduced current/reduced light output ballasts is not recommended. Lamp flickering may occur in installations where lamp ambient temperature is below 60° F or where strong air drafts blow directly on bare bulbs.

PERFORMANCE DATA

Ordering Code	Nominal Watts	Initial Lumens	Standard Package	Nominal Length	Average Rated Life (2) @ 3 or more hrs/start
F40LW/RS/WM	35	3050	24	48"	20,000

(2) Life ratings are estimated, based on engineering design evaluations.

A CHECKLIST FOR ENERGY SAVING

WHAT TO LOOK FOR:

A. INCANDESCENT IN GENERAL LIGHTING

1. Replace long life lamps with next lower wattage standard life lamps for a wattage reduction of 15-25%.
2. Use ER-30 or ER-40 instead of 150 watt or 300 watt R40 flood with black shielded downlights for a wattage reduction of 50% (ER-30) to 60% (ER-40).
3. Replace Standard A-line bulbs in fixtures with no reflectors with R, ER, or PAR lamps of lower wattage to get same light for a wattage reduction of 40-80%. The 30 watt and 50 watt R20 lamps are useful where low light levels are needed.
4. Use Warm Deluxe Mercury instead of incandescent for a wattage reduction of 30-50%. It's almost as warm in color as incandescent.
5. Use Multi-Vapor instead of incandescent for a wattage reduction of 60-70%. It's a cooler color source but still good color rendering. Smallest size is 175 watts which may not be small enough for lower ceiling applications.
6. Use Lucalox instead of incandescent for a wattage reduction of 70-85%. Its color rendition may not be good enough but it's worth a try. Size goes as low as 70 watts.
7. Use fluorescent instead of incandescent for a wattage reduction of 70%. The effect will be different but low brightness fixtures will give a subdued effect and Deluxe Warm White lamps will give the warm color comparable to incandescent.

8. Use convenient switching to encourage turning lights off and using only what's needed. Use dimmers properly, not just to get long life; use lower wattage lamps if less light is acceptable.

B. FLUORESCENT LIGHTING

1. Replace lamps with Watt-Miser for a wattage reduction of 10-20%. There's a comparable light loss, so use a cleaning program to make it up.
2. Check the reflecting surfaces and shielding materials in any structural lighting to keep light absorption minimized.

C. HID LIGHTING

Replace mercury exterior lighting with Lucalox lighting for a 50% reduction. The color is usually pleasing outdoors.

D. MAINTENANCE

1. A cleaning and relamping program usually increases efficiency enough to permit the use of lower wattage lamps.
2. Replacing with the proper lamp means getting the proper lighting effect and not damaging the fixture due to heat or ballast failure.

Will you maintain your lighting system

so it remains 'good'?

☐ **Cleaning — Dirt - Lost light - $ down the drain**

☐ **Relamping - Group relamping vs. spot replacement, compare the economics**

USE LIGHTING ENERGY WISELY . . . Keep your lighting system maintained. Dirty fixtures, old lamps, poor room reflectances all rob the worker of light for which the watt meter is spinning at the same rate as if the installation were new. Clean the fixtures and pick up as much as 20% additional light . . . install new lamps and increase your lighting by as much as 20% . . . paint room surfaces and gain as much as 15%. All without a single added watt of energy.

Lighting System Maintenance

Maintaininng your lighting system-cleaning, replacing deteriorated lamps, etc.--is important and can be cost-effective in enabling you to have sufficient light levels at minimum cost.

Light output can be diminished by as much as 20% if lamps and fixtures are dirty and diffusers have yellowed. As fluorescent lamps age, their light output diminishes; toward the end of their life, light output can be 20% less than when new. Energy consumption, however, does not decrease. For maximum light output, all lamps should be replaced simultaneously through a group relamping program. Major lighting companies, with the use of computer program, can help you determine the best time to make this change.

12 IES recommendations as they apply specifically to lighting, design, operation and maintenance

To help make the most of lighting energy without reducing the quality of lighting design, the Illuminating Engineering Society makes 12 recommendations. They apply to the selection of lighting equipment, the design of lighting for new construction or renovation work, and the operation and maintenance of lighting systems.

12 recommendations

1. Design lighting for expected activity (light for seeing tasks with less light in surrounding non-working areas).
2. Design with more effective luminaires and fenestration (use systems analysis based on life cycle).
3. Use efficient light sources (higher lumen per watt output).
4. Use more efficient luminaires.
5. Use thermal controlled luminaires.
6. Use lighter finish on ceilings, walls, floor and furnishings.
7. Use efficient incandescent lamps.
8. Turn off lights when not needed.
9. Control window brightness.
10. Utilize daylighting as practicable.
11. Keep lighting equipment clean and in good working condition.
12. Post instructions covering operation and maintenance.

Optimizing the uses of energy for lighting

An amplification of 12 IES recommendations as they apply specifically to lighting design, operation, and maintenance.

Designing lighting for the optimum use of energy

Each of the 12 recommendations should be considered in the design process for both new construction and renovation along with current IES quality and quantity recommendations. The latter recommendations are continually being revised to reflect current research, and direct themselves to the fundamental seeing needs of people more than lighting solutions. In this way the designer can develop new approaches that will be more esthetically pleasing or lower in cost, or lower in energy use, than conventional approaches.

Design lighting for expected activity

The designer needs to determine what types of activities will occur, their duration, and their specific locations. Lighting should be provided for the seeing tasks with appropriate lower levels in nonworking areas such as corridors, storage and circulation areas. There should be the capability to relocate or alter lighting equipment when and where changes in the use of the space are anticipated.

Where task positions are fixed and known, the lighting should be designed accordingly. However, seeing task locations are not always known so that it often becomes necessary to install task lighting at all probable task locations using a general overall lighting system.

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

Design with more effective luminaires and fenestration

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

Luminaires that consume equal wattage and provide equal illumination levels may not provide equal visibility of seeing tasks. As an aid, two IES reports have been published to help in the evaluation of the visual effectiveness of lighting systems.[1,2]

Use efficient light sources

The various lamps available have different characteristics that must be considered (color, life, physical size, and light output per watt input), and the choice should be the most efficient source that is appropriate to the application. For incandescent, fluorescent, and HID (high pressure sodium and metal halide) lamps, the higher the wattage, the more efficient the lamp [2]. For overall design, prime consideration should be given to the more efficient sources such as fluorescent and HID.

Use more efficient luminaires

Efficient luminaires produce a greater amount of light on the task with less wattage. For example, in a given room, incandescent, indirect luminaires may require a load of 11 watts per square foot of floor area to produce a 50 footcandle level [3]. However, direct fluorescent troffers may only require a load of 2.5 watts per square foot. Special consideration must also be given to ease of cleaning and relamping the luminaire, as well as to such other factors as veiling reflections and glare.

Use thermal controlled luminaires

Recognize that lighting produces heat. Using luminaires with air or water heat-transfer capabilities permits heat from luminaires to be exhausted before entering an occupied space in warm weather. Conversely, the heat can be utilized in the occupied space in cold weather. Integrating the lighting and air conditioning systems means less room heating and cooling load will be required. The IES report "Lighting and air conditioning"[3] covers the theory and application of heat transfer lighting equipment.

Use lighter finishes on ceilings, walls, floors, and furnishings

Dark finishes absorb light that could be utilized, whereas light finishes can cause glare. In selecting a light finish for offices and schools, for example, the reflectances should be in the following ranges:

Ceiling finishes	80–90 per cent
Walls	40–60 per cent
Furniture	25–45 per cent
Office machines and equipment	25–45 per cent
Floors	20–40 per cent

The upper limits have been selected to avoid excessively bright surfaces that are uncomfortable or reduce visibility by producing disability glare.

In one particular installation studied, the ceiling, walls, and floor were repainted, and the furniture was refinished in a lighter color. The average illumination level increased from less than 10 footcandles to over 40 footcandles.

Use efficient incandescent lamps

Higher wattage general service lamps are more efficient than the lower wattage lamps. Thus, using fewer higher wattage lamps may save power. One 100-watt lamp produces more light than two 60-watt lamps (1740 vs 1720 lumens).

If you compare the same wattage lamps, the general service are more efficient than the extended service lamps. A 100-watt (750 hr) general service lamp produces 17.4 lumens/watts input while a 100-watt (2500 hr) extended service produces only 14.8 lumens/watt input. To obtain equal lighting results, 17.5 per cent more lamps and power are required when using these extended service lamps.

Of course, extended service lamps are used where maintenance labor costs are high or where lamps are in inaccessible locations.

Provide flexibility in the control of lighting

Use separate and convenient switching or dimming devices for areas that have different use patterns. It is always more economical to turn off incandescent lighting when a working or living space is empty, secure and not used for display or observation. Where off-time is more than a few minutes, fluorescent and high-intensity discharge lighting should be turned off too.

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

Design fenestration to control heat-producing radiation

The requirements for good lighting design can be achieved by skillful application of daylighting techniques.[4] To reduce air conditioning requirements, control heat-producing radiation entering a space by such means as reflective glass coatings and sun screening. Redirect available light for better interior distribution and utilization as with venetian blinds. Limit the brightness of fenestration within comfortable limits (the same criteria as used for electric sources) by using such devices as shades, screens, blinds, and low transmission glasses.

Design fenestration to utilize daylighting as practicable to produce the required illumination either alone or with an electric lighting system

The levels of illumination recommended by the Society are not based on electric lighting exclusively. The *Recommended Practice of Daylighting* and the daylighting design data in the *IES Lighting Handbook* are published by the Society as guides to the utilization of daylight. However, because of the wide variation in daylight (from several thousand footcandles down to zero), an adequate electric lighting system should be provided.

Select luminaires with good cleaning capability and lamps with good lumen maintenance

Studies have shown that good lighting maintenance procedures provide better utilization of the lighting system. The correct lighting service plan will minimize light loss during operation and reduce the number of luminaires required. A study of one fluorescent lighting system, in which different maintenance procedures were used, showed the difference [4].

- When luminaires were cleaned and relamped once every three years, the illumination dropped to 60 per cent of the initial after three years.
- For luminaires cleaned every one-and-a-half years and relamped every three years, the illumination dropped to 68 per cent of the initial after three years.
- For luminaires cleaned once a year and one third of the lamps replaced once a year, the illumination dropped to only 78 per cent of the initial after three years and to 75 per cent even after 12 years.

Operating and maintaining lighting for the optimum use of energy

Only six of the twelve recommendations are related to the operation and maintenance of a lighting system. No matter how well a lighting system is designed, its effective utilization of energy consumed will primarily be determined by the operating and maintenance procedures covered in these six points.

Use efficient incandescent lamps for replacements

As mentioned before, the less efficient long life types have their use, but consume more energy than the general service lamps for the same light output.

Turn out lights when not needed

Institute a program that will remind occupants to turn off lights as they leave an empty room or when daylighting is adequate.

Control window brightness during daylight hours

Redirect and utilize the available light; limit glare and heat producing radiation to reduce the air conditioning requirements.

Keep lighting equipment clean and in good working condition

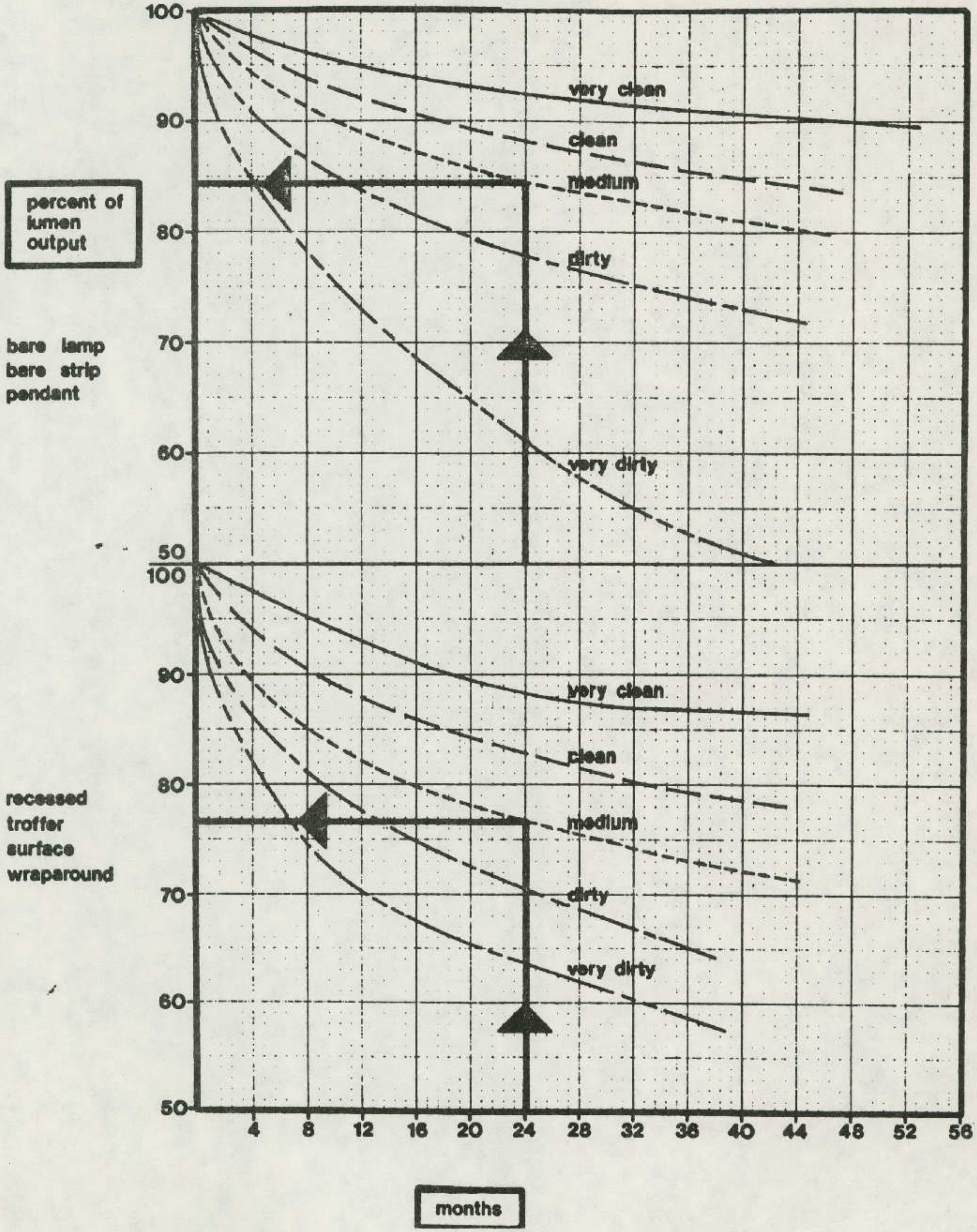
Establish a well-planned program of regular cleaning, relamping, and servicing. Periodically inspect the lighting system to determine if it should be replaced with newer, more efficient equipment.

Post instructions covering operation and maintenance

Initial instructions should be based on the design criteria, but may be modified later as newer equipment is installed. Also, as activity locations change, modify the lighting system and instructions accordingly.

lighting

fixture cleaning cycle



5

HVAC

General: Heating

Four central goals are to be sought in the prudent and conservationally sound use of heating equipment:

1. Provide adequate minimum temperatures for all times when the religious facility is occupied, varying temperatures according to activity.
2. Avoid excessively high temperatures.
3. Permit selective heating of portions of religious facility during partial occupancy.
4. Avoid redundant heating when solar or internal gain will maintain adequate temperature without mechanical support.

There are a number of sources of heat which result from the normal activities which take place within a building. These include heat released by occupants and heat produced by the use of any electrical equipment such as lights, motors, appliances, etc. In one sense, this is free heat since the expenditure of energy which generates this heat is required to operate the building in any case. It is important to remember, however, that the devices which are producing this heat are not specifically designed for that use. The heat which results from required lighting reduces the load on a building's heating plant but the increase of light levels far beyond needs in order to provide all heating from this source results in great increases in overall fuel use. This is due to the following factors. First, light fixtures are not designed as heaters and therefore frequently do not deliver heat where, when or in the exact quantities needed. Second, the use of electricity to produce heat is inherently inefficient (see discussion of conversion of fuel to heat which follows). For example, if lighting is the only source of heat, heat required at window areas where heat loss is greatest will necessitate the use of large numbers of fixtures at these areas. These areas, though, generally have adequate natural light so, for lighting purposes, the fixtures are unnecessary. These fixtures will produce about one BTU of heat for every four BTU of energy consumed at the generator and this heat will probably not be delivered to where it is actually needed. A conventional heating system, however, will deliver one BTU for every one and a half or two BTU input and will deliver heat to where it's needed. The introduction of lighting above required levels in order to supply all required space heating should be avoided.

In most cases, the heat sources described above are not adequate to provide for the total needs of a building. When this occurs, additional input will be required from a heating plant. Where systems are controlled by local, interior thermostats, the heating system will deliver only the heat that is required to make up the difference between the demand and the available "free" sources. The provision of the make-up heat is the subject of this section.

Conversion of Fuel to Heat

Most processes in which fuel is used to generate energy start with the production of heat. Where the final form of energy desired is also heat, it is generally more efficient to use the original heat directly rather than to convert it to some other form of energy such as electricity. The major difficulty with the direct use of heat is that it is relatively inefficient to transport energy as heat for any long distance. For space heating, the basic available heat sources are locally generated heat, generally carried in steam or hot water; centrally generated heat, generally district steam; and electricity. The first two are direct heat sources and range from about 50 percent to about 80 percent efficient. Electrical generation uses heat to create steam which in turn drives the generators' turbines. The generation and distribution processes result in a delivered efficiency for electricity of about 25 percent. Because of this low return of heat energy compared to fuel input, electric heating should be avoided except where the direct use of heat energy is not feasible.

Where practical, consideration should be given to economizer cycle operation during mild weather and for exhaust air, and to energy recapture through the utilization of air to air, air to water heat exchangers.

Heating Plant Operation

Provide as part of the maintenance offices, a plan and document room, with sets of mechanical (and other) drawings on cloth. Provide a clear operating manual in non-professional language. Mark and identify each valve and control point clearly and permanently. Mount permanent, clearly printed instructions on the use and maintenance of equipment near the equipment.

General: Ventilation

In the case of ventilation there are five central goals to be sought:

1. Provide adequate ventilation at all times for the health of the occupants.

2. Avoid introduction of excessive outside air at times when inside air is being heated or cooled.

3. Avoid introduction of outside air to spaces which are unoccupied.

4. Utilize non-mechanical, energy-free means of providing ventiliation wherever possible.

5. Design ventilation systems to insure that basic outside air requirements for metabolic well being are provided. Outside air for cosmetic odor and thermal control will not be included in this basic level. Supplemental outside air for these applications may be introduced by two stage controls on the primary system or by secondary systems.

Item "4" may be in partial conflict with items "2" and "3" in that it is more difficult to control exact air flow with non-mechanical means. One basic approach to this situation is to use mechanical means to insure basic adequate ventilation and operable windows to supplement this when higher levels are desired on the assumption that when the occupants of the room desire additional outside air, it is due to the fact that the outside air is closer to desired conditions than inside. When this is the case, thermostatic controls, if working properly, will not be calling for heating or cooling or, if they are, the outside air will be between the inside air conditions and the desired conditions and will therefore reinforce rather than interfere with the mechanical conditioning system.

This approach involves the education and cooperation of the occupants of the spaces. It seems reasonable that as public awareness of the problems of energy use increases, the willingness to cooperate will increase as will social and administrative pressures. If this turns out not to be the case, mechanical and electronic devices can be installed to override the various local options in system operation. These might include an interlock system which would prevent windows from being opened while mechanical heating or cooling was taking place. Because of the inherent problems associated with complex systems and the added cost, if cooperation can be achieved, the non-automated approach seems preferable.

Effect of Ventilation on Fuel Use

Ventilation has an effect on energy use in schools in two areas. It uses electrical energy directly to operate fans and motors. This amounts to about 25% of the electricity used. It discharges heated or cooled air to the outside in order to admit the quantity of air called for, for ventilation. Additional energy is required to heat or cool the replacement air. This is responsible for about 65% of the heating or cooling load.

Research and observation indicate several important aspects of ventilation as it is currently provided:

Ventilation Standards

1. Standards for minimum quantities of outside air are far in excess of actual requirements averaging about three times more than necessary based on 5 cfm/occupant for sedentary uses and 15 cfm/occupant for high activity areas. Adoption of these basic standards would result in an immediate savings of almost 45% on the heating load. In a typical new building, this would mean a savings of about 225 gallons of oil per year per msf of building. At current prices, this would yield an annual savings of about $75. The electric savings would not be in direct relation to the reduction of fan sizes but a reduction in load of 30% can be anticipated. This would yield a saving of about 290 kwh/yr/msf or $21/yr/msf. Thus, a reduction in outside air requirements or two-thirds the current standards would yield a saving of about $100/yr/msf.

VENTILATION RECOMMENDATIONS

Office Buildings	
Work Space	5 CFM/person
Heavy Smoking Areas	15 CFM/person
Lounges	5 CFM/person
Cafeteria	5 CFM/person
Conference Rooms	15 CFM/person
Doctor Offices	5 CFM/person
Toilet Rooms	10 air changes/hour
Lobbies	0
Unoccupied Spaces	0
Retail Stores	
Trade Areas	6 CFM/customer
Street level with heavy use (less than 5,000 sq. ft. with single or double outside door)	0
Unoccupied Spaces	0
Religious Buildings	
Halls of Worship	5 CFM/person
Meeting Rooms	10 CFM/person
Unoccupied Spaces	0

Reduce Cooling Load Due to Ventilation

Analyze and consider the following measures to further reduce energy consumption for ventilation:

1. Rebalance air supply system to provide a maximum of 1 cfm per square foot of supply air to toilet rooms and adjust the exhaust system accordingly. Refer to ASHRAE Standard 62-7 2-73.

2. Install charcoal filters or other air treatment devices in the exhaust air systems and circulate treated air back into the space to reduce the amount of outdoor air required for make-up for all systems handling 2,000 cfm or more. Supply slightly more outdoor air than exhaust air to pressurize the conditioned space. It is necessary to obtain approval of code administrating agencies having jurisdiction in the location of the building when reducing outside air quantities below code requirements.

3. Install damper and controls to permit the ventilation system to delay the introduction of outdoor air for one hour in the morning and shutting it off ½ hour before closing time. A seven-day timer can be used in department stores to reduce or shut off ventilation automatically for periods during the day with light occupancy.

4. Refer to Section 8A "Solar Energy" for opportunities to use solar heat to preheat outdoor air for ventilation.

5. Modify duct systems and hoods and introduce untreated outdoor air directly to the exhaust hood. Weigh this against changing hoods to new high velocity hoods which require less makeup air.

6. Install heat reclaim devices between the exhaust and supply air ducts.

<u>Install Controls and Operate on Economizer Cycle and/or Enthalpy Control</u>

1. Install dampers in the fresh air duct and the return air duct at air handling units and interlock dampers, so that one opens when the other closes. Provide control to open the outdoor air damper when the outdoor temperatures are 5^{o} or more below indoor conditions.

2. Install enthalpy control to open outside air damper during occupied periods with the refrigeration equipment in operation when the outdoor wet bulb temperature is below 65^{o}F and the dry bulb temperature is below 85^{o}F.

3. Install exhaust fan, relief louvers or for large multi-floor buildings, a return air -- exhaust air fan, with dampers in the exhaust duct interlocked with the fresh air and return air dampers. (An analysis should be made to determine that the relative humidity in the space will not drop so low as to require a greater amount of energy for humidification than is saved by reducing the refrigeration load.

<u>Recirculate Exhaust Air Using Activated Carbon Filters</u>

The quantity of air exhausted from a building often exceeds the minimum outdoor air requirements and requires excess outdoor air to be introduced to makeup the difference and maintain the pressure balance of the building.

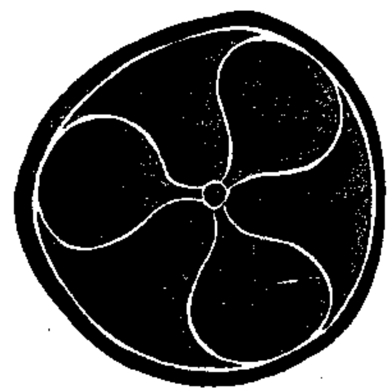
To balance the minimum outdoor air requirements and the total air exhausted from the building, the quantity of exhaust air may be reduced either by reducing the rate of exhaust or by retaining the same rate of exhaust but recirculating a proportion of the air back into the building.

Recirculating untreated exhaust air is often unacceptable because it contains unpleasant odors. This air, however, can be treated by passing it through activated carbon filters which will remove the odors. Candidates for such treatment are central exhaust systems from toilet areas, dining rooms, lounges, etc.

To recirculate the air, ducting must be installed to connect from the discharge side of the exhaust system into the return air of the HVAC system. This ductwork should contain the activated carbon filters. Recirculate that portion of the quantity of total exhaust air for the building which exceeds 90% of minimum outdoor air requirements.

ENERGY SAVING EXAMPLE

Recommendation: **Reduce Time That Kitchen and Restroom Fans Operate**



A church which has ventilating fans that run continuously in two restrooms, is wasting electricity as well as heated and cooled air. These fans can be rewired so that they would turn on with the restroom lights. This relatively simple electrical change can be accomplished by the maintenance person, thus keeping costs to a minimum.

Ten year savings would amount to over $3,000.

1st Year Savings	$ 210
10 Year Savings	$3,190
Capital Costs	$ 20
Payback Period	1 month

Extracted from: Reducing Energy Cost in Religious Buildings by Massachusetts Energy Office.

Activated carbon filters remove odors from air by absorption and after a period of time they become saturated and their performance falls off. At this point, the filters must be removed and either regenerated in-house or be replaced with freshly regenerated filters supplied by the manufacturer. Heat energy is required for regeneration but can be derived from a waste heat source.

The length of time the filters can remain in service depends on the circumstances of each particular case; manufacturer's advice should be sought on this point. The cost of installing the recirculating ductwork and filters will vary for each particualr case depending on the disposition of exhaust and HVAC systems and quantity of air handled. To obtain an accurate assessment, designs should be prepared and quotations solicited from local contractors.

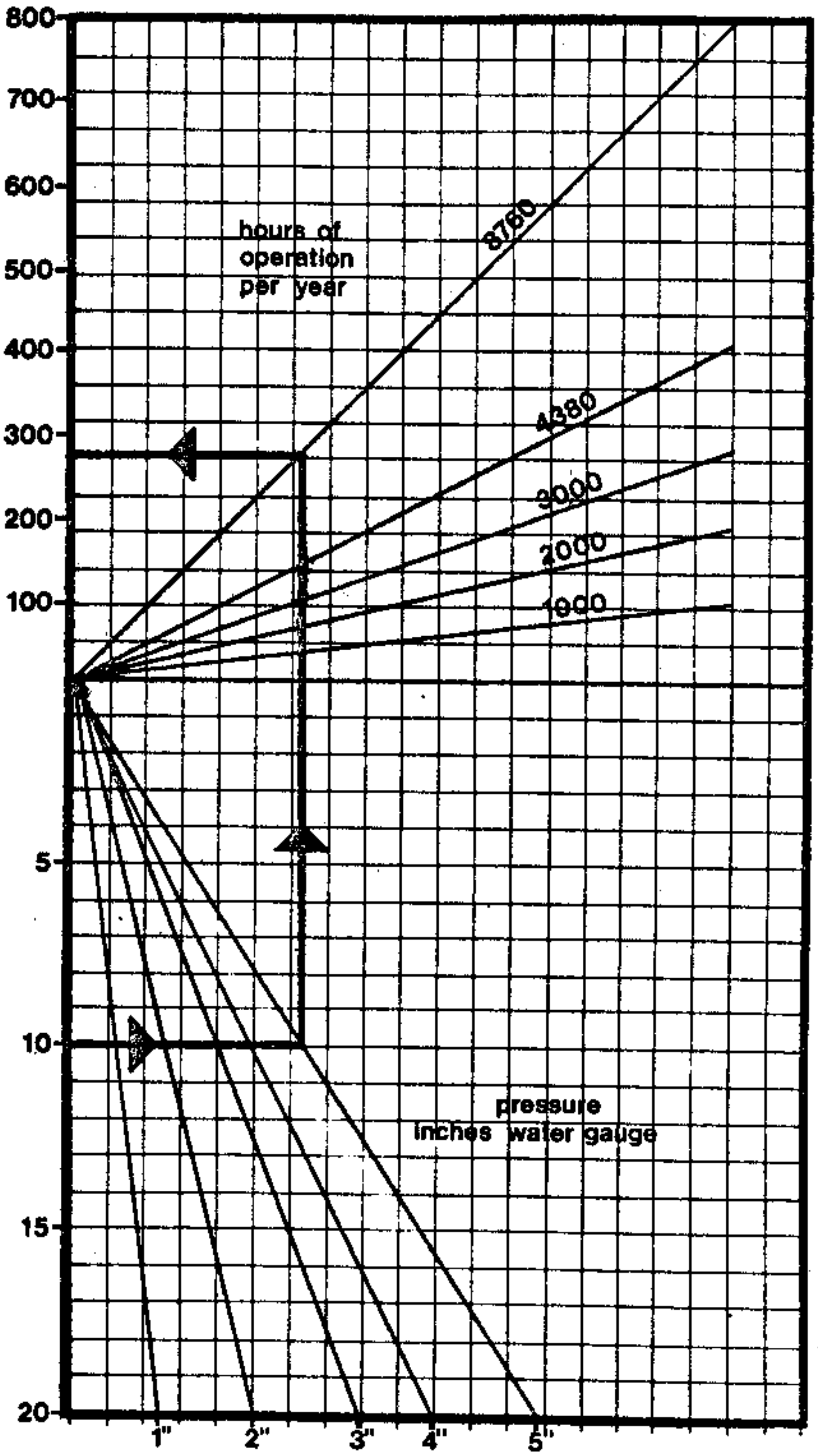
ventilation

yearly energy consumed
centrifugal fans
forward curve blades

prorate input/output scales
for larger volumes

energy consumed
btu x 10^6
per year

fan volume
cfm x 10^3



ventilation

yearly energy consumed
centrifugal fans
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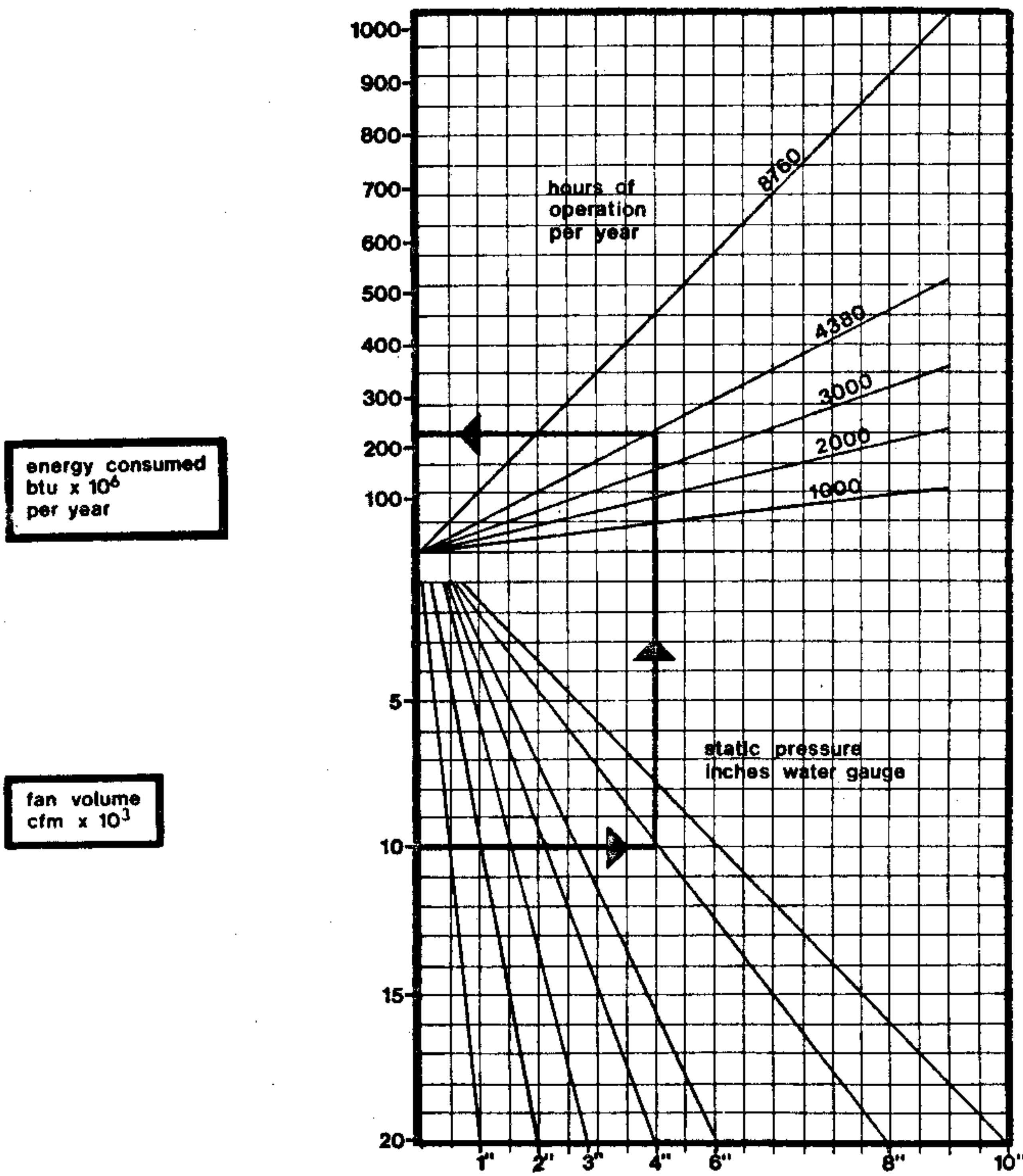


Total or Selective Energy

A total or selective energy system is one in which electricity is generated locally and the heat which is normally wasted is used for heating, domestic hot water and absorption cooling. In buildings where size and demand make this approach feasible, it should be evaluated for the specific instance on the basis of fuel use and economic factors.

Heat Recovery

In smaller projects which cannot support consideration of total or selective energy, other forms of utilizing what is normally waste heat should be evaluated. These include the use of heat exchangers to pre-heat incoming air, or supply radiant panels, and also heat pumps to take heat from one area where cooling may be required and transfer it to a zone with a heating demand.

The Equipment: State of the Art[18]

Considerable research effort has been directed in recent times to improving the cost/benefit ratio of HVAC systems so that the energy they use will be optimized. The goal of this research, stated in simple terms, is to get the most heating (and cooling) for the fewest BTUs.

One approach to this problem is to reduce a building's HVAC energy demand by designing the building for lower heat gains and losses in the first place. The designers clearly should be credited with the new emphasis placed on design decisions involving thermal insulation, ventilation rates, types of window glass, ratio of glass to opaque wall area, solar shades and screens and the orientation of a structure on its site. This general orientation to conservation will be considered in the next section on cooling and ventilation.

The second approach taken by designers in response to their awareness of the need to optimize HVAC energy has been to seek new systems and equipment. Although some of the developments evolving from this search are remarkably ingenious and complex, their common aim is a simple one: reclaim energy that might otherwise be wasted and put it to good use. What follows is a conceptual review of the state of the art of HVAC systems and components that have come out of the continuing efforts toward more efficient use of energy through technology.

Obviously most of these systems serve the purposes of cooling <u>and</u> heating; the same dual functionality will be true of the air conditioning equipment discussed in the section (D3) which follows. It is imperative, therefore, for administrators and others responsible for HVAC conservation management programs to consider both sections in making their decisions.

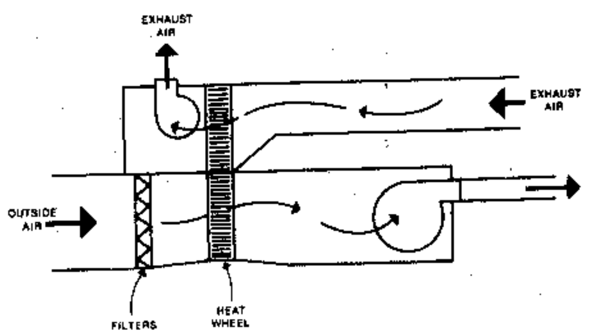
Exhaust Air Heat Recovery: Heat Wheels

Powered ventilating systems exhaust conditioned air from inside a structure and replace it with up to 100 percent outside air, which must then be treated to bring it within the design limits for temperature and humidity. This exchange of conditioned inside air for outside air represents a considerable expenditure of energy, particularly in buildings such as schools and hospitals that may require one of more total air changes every hour. And in well insulated structures, in which heat gains and losses through the exterior of the structure are diminished, ventilation losses loom proportionately larger. There are, therefore, decided economic advantages to be realized by providing some means for reclaiming the conditioning effect of exhaust air. Numbered among the proven methods for so doing are those employing heat wheels, runaround systems, static heat exchangers and heat pipes.

There are two types of heat wheels: the first transfers only sensible heat while the second handles latent heat as well. Each consists of a motor-driven wheel frame packed with a heat-absorbing material such as aluminum or stainless steel mesh, or a corrugated asbestos-type material. The wheels are designed to be installed in the ventilation air system, with the outside and exhaust air being kept separate.

As it turns, a sensible heat wheel continuously transfers heat from the warmer stream to the cooler one. The construction of the wheel is such that cross-contamination is normally low enough for most applications, but a purging section can be incorporated to reduce contamination even further. Purging is accomplished by returning a portion of the makeup air to exhaust after it has passed through the wheel.

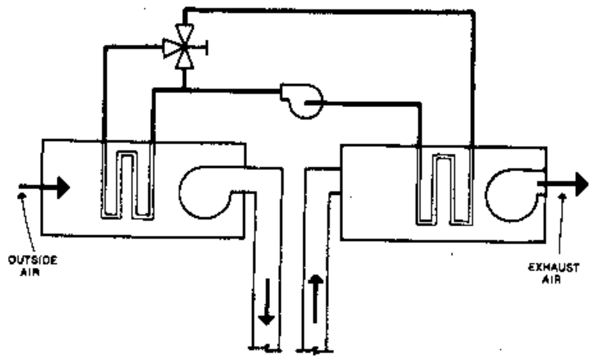
A total heat wheel, which employs a filler of lithium chloride-impregnated asbestos, makes it possible to more fully utilize the concept of energy optimization under summer conditions by using conditioned exhaust air to cool and dehumidify makeup air. Lithium chloride is a desiccant which absorbs moisture as well as heat, thus achieving the transfer of both latent and sensible heat.



Heat wheel

Exhaust Air Heat Recovery: Runaround System

A limitation in the application of the exhaust air heat recovery concepts covered thus far is that inlet and exhaust ducts must be close to one another. This proximity requirement is avoided in the runaround system which employs two heat exchangers connected to one another by a loop of pipe. As shown in the sketch one unit is installed in the exhaust duct and the second, in the outside air inlet. A motor-driven pump continuously circulates an anti-freeze solution of ethylene glycol and water through the heat exchangers. The exhaust air that is drawn over finned coils in the first unit warms or cools the solution, while in the makeup air unit the process is reversed. The runaround system can be as efficient in energy transfer as the heat wheel provided the heat exchangers have sufficient capacity. However, if a heat exchanger's capacity is increased by adding rows of finned tubing, the pressure drop through it increases considerably. The gain in efficiency, therefore, may be partially offset by the higher fan power required.

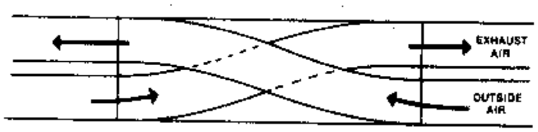


Runaround system

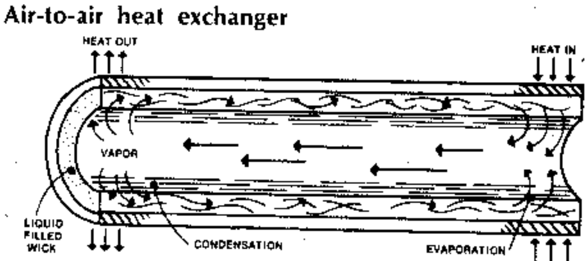
Exhaust Air Heat Recovery: Air-To-Air Heat Exchangers; Heat Pipes

The air-to-air heat exchanger, which has no moving parts, represents a static means for transposing heat between exhaust and outside air streams which pass through it in counterflow fashion. It resembles an open-ended steel box with a rectangular cross section that is compartmented into a multiplicity of narrow passages in a cellular format. Every other passage carries exhaust air, alternating with those carrying makeup air. On the heating cycle, energy is transferred from the exhaust air streams to the makeup air streams by conduction through the walls of the passages so that contamination of the make-up air cannot occur.

A transfer of energy between incoming and outgoing air can be accomplished by banks of devices known as heat pipes which are installed through the adjacent walls of inlet and outlet ducts and which have their opposite ends projecting into each air stream. A heat pipe consists essentially of a short length of copper tubing, sealed at both ends, which contains a snug-fitting porous cylindrical wick and a charge of refrigerant. A temperature difference between the ends of the pipe causes the liquid in the wick to migrate by capillary action to the warmer end where it evaporates and absorbs heat. The refrigerant vapor then returns through the hollow center of the wick to the cooler end where it gives up this heat, condenses and starts to repeat the cycle. These units promise to be highly efficient and, because they are sealed and have no moving parts, maintenance should be minimal.



Air-to-air heat exchanger



Heat pipe

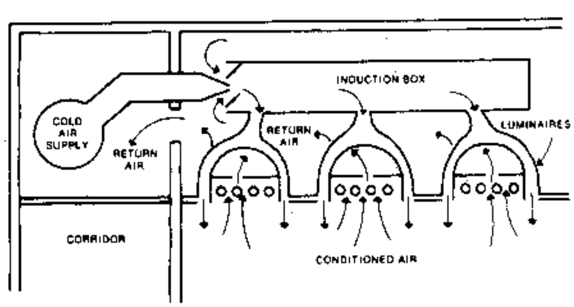
Recovering Lighting Heat

Ducted air systems can be designed to provide a direct means for controlling and redistributing heat dissipated by lighting fixtures, which are the prime sources of internal gains. What makes this possible is a lighting fixture provided with slots through which return air is drawn into the ceiling plenum. As it passes over the lamps, ballasts and sheet metal of the luminaire, the air picks up as much as 80 percent of dissipated heat and carries it into the plenum. The addition of the lamp heat raises the cavity temperature above that of the occupied space. Some heat is lost through the ceiling to the cooler space below; some escapes through the building floor above; and some is lost to the cold ducts within the plenum. Despite these losses, 50 to 65 percent of the lamp heat is retained above the ceiling.

There are many ways in which plenum heat can be put to use in space conditioning systems. In a double-duct system, for example, the plenum can be the source of air for the hot deck, with supplementary heat being supplied by duct heaters or water coils piped to the space conditioning water side of a double-bundle condenser. The diagram shows a portion of a single-duct heat recovery system as it could be installed in the interior zone of a building requiring simultaneous wintertime heating and cooling. A key element in this system is the induction box with thermostatically controlled dampers. The velocity of the air in the cold duct, combined with the damper arrangement, enables this unit to induce up to 50 percent warm cavity air.

When full cooling is required, 100 percent cold primary air is delivered to the space. When warmer air is indicated, warm air from the ceiling cavity is gradually induced into the unit and is mixed with a correspondingly reduced quantity of cold primary air. The plenum air may also be used for heating the perimeter zones of the building, aided again by some type of supplementary heaters. This arrangement is well suited for controlling interior zone temperatures in systems that employ outside air for wintertime cooling.

The use of air return fixtures can be beneficial in summertime conditions also because lighting heat can be drawn off and vented to the outside, thus reducing the cooling load. This benefit may result in economies in the sizes of ducts and chillers. An added advantage is that, because the lighting fixtures operate at lower temperatures, they produce up to 13 percent more light output for the same energy input. The two basic approaches to the venting of lighting heat are designated as the total return and the bleed-off systems.



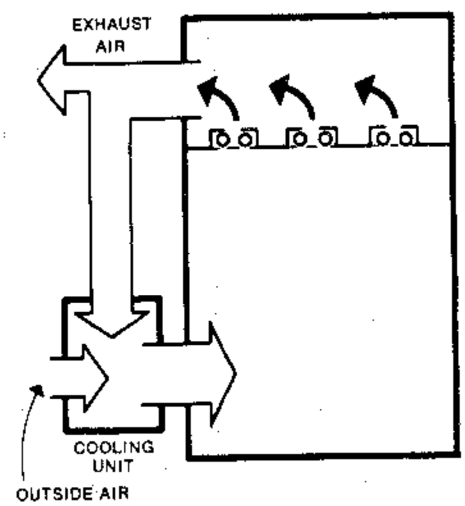
Recovering Lighting Heat: Total Return System; Bleed-off System

In a total return system, air is introduced into the room through conventional air diffusers and all of it is returned through the luminaires. A fixed portion of the return air is exhausted to the outside for ventilation purposes, while the remaining air may be recycled or exhausted, all or in part, depending on outdoor temperature and humidity conditions.

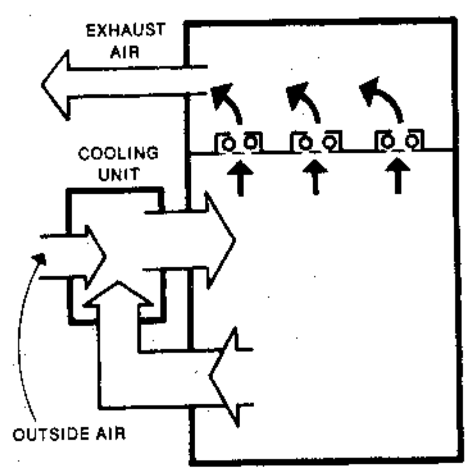
Total return has the advantage of maximizing light output from fluorescent fixtures while reducing the temperature of the liminaire surfaces thus minimizing radiant heating effects. This is accomplished with little change in the cooling tonnage required from that of a conventional ducted air system.

In a bleed-off system most of the air entering a space is returned to the air handling unit directly through conventional registers. Only a portion is drawn off through the lighting fixtures and this is vented directly to exhaust. This bleeding-off of ventilation air through the lighting fixtures offers the greatest potential reduction in cooling capacity of all air handling methods, especially in those applications where high ventilation rates are required. Lighting efficiency is increased and radiant heating effects diminished but not as much as in total return systems. Both total return and bleed-off systems usually permit a reduction in the number of air changes because of the direct removal of lighting heat, which may be translated into economies in air handling and distribution equipment.

TOTAL RETURN SYSTEM



BLEED-OFF SYSTEM



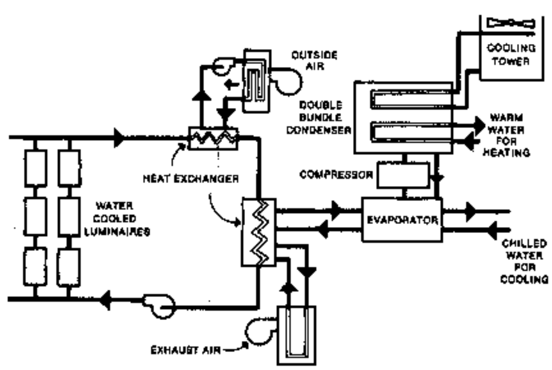
Recovering Lighting Heat: Water-Cooled Luminaires

Water is another medium that has proven practical for effective transfer of heat energy from lighting fixtures. Hydronic systems employ special luminaires equipped with aluminum reflector housings that are formed in such a way as to provide integral water passages. The liquid circulating through these passages absorbs heat from the lamps and ballasts and carries it away.

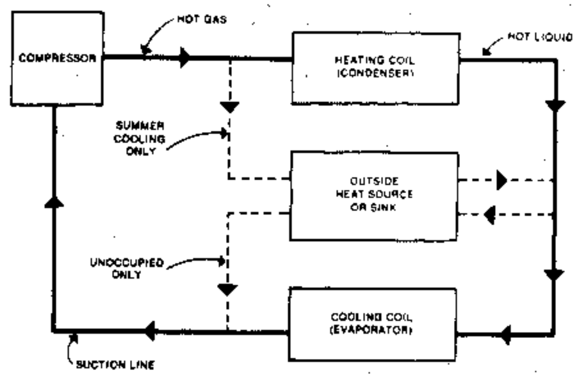
The water-jacketed fixtures transfer about 70 percent of the lighting load to the circulating liquid. In one type of hydronic system, the fluid is pumped through an evaporative heat exchanger to dissipate this energy and minimize internal heat gain during the cooling season. If, for example, lighting accounts for 50 percent of the total heat gain, then the 70 percent absorption of lighting heat directly from the fixtures is translated into a 35 percent reduction in the total load. This permits the use of smaller fans, ducts and refrigeration equipment and results in lower operating costs.

With this type of system the circulating pump can be stopped during the winter and all of the lighting heat allowed to enter the space. In a more sophisticated hydronic system the pumps operate year round and the luminaires can be used in conjunction with aluminum water-filled louvers installed across windows of a building, usually on the sunny sides. In the cooling season, a pump draws water from both louvers and luminaires and delivers it to a cooling tower. The cooling tower serves to maintain water temperature in the 75°F to 85°F range by removing excess heat and venting it to the atmosphere. The benefit of this arrangement is that it limits solar heat gain as well as that from the lighting.

During the winter, the cooling tower is isolated from the circuit and water flows from the luminaires directly to the louvers. The warm water moving through the louvers offsets heat loss through the window areas and minimizes drafts.



The diagram shows an air-to-air heat pump applied as a heat recovery machine in a double-duct system capable of simultaneous heating and cooling. In this mode of operation the compressor delivers hot gas to a heat exchanger (condenser) in the hot deck where the refrigerant condenses, then passes through the cold deck heat exchanger (evaporator) and returns to the compressor via the suction line. The effect of this cycle is to recover heat from the cold deck and deliver it to the hot deck. During unoccupied times when there is no surplus internal heat to be recovered, the refrigerant circuit is automatically switched from the cold deck to a roof-mounted heat exchanger (evaporator) and heat is abstracted from the atmosphere. For summertime cooling the refrigerant circuit is automatically switched again, this time from the hot deck to the roof-mounted heat exchanger which then serves as a condenser rejecting heat to the atmosphere. No hydronic circuits are involved because all heat transfer is accomplished directly through the refrigerant.

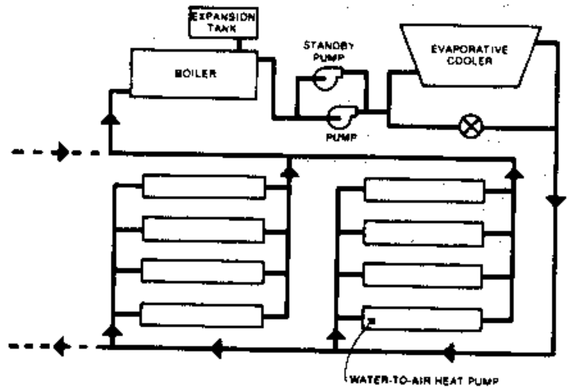


Refrigeration-Type Heat Recovery: Water Source Heat Pump Transfer System

Water-to-air heat pumps are the key elements in a space conditioning system designed specifically for optimizing energy use in multiple zone structures. The system is actually a hybrid configuration; while it has some of the characteristics of a decentralized system with independeht in-zone heating/cooling units, it also requires some remote equipment that is common to all of the zones.

In this system there is a heat pump unit in each zone of the building. The water-to-refrigerant heat exchangers of all of these units are connected together by a closed loop of circulating water. Heat is rejected into the water by heat pumps on the cooling cycle and absorbed from the water by units on the heating cycle. Also connected into the water loop at a central location are a boiler and an evaporative cooling tower, which operate as necessary to maintain loop water temperature between 60°F and 95°F year round. Water at temperatures within this range makes possible very efficient and reliable performance of the heat pumps.

A major advantage of this system is that it recovers excess heat from one zone and transfers it to another that requires it. Since no exposure to outside air is needed, there is great latitude in locating the heat pumps. The system provides all the operating flexibility of three-or four-pipe systems with only two pipes, which require no insulation because of the moderate water temperature in the loop. The choice of temperature in each zone is completely independent regardless of the season or mode of operation in other spaces.



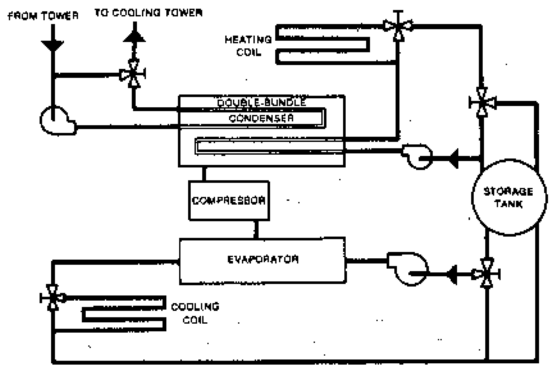
Refrigeration-Type Heat Recovery: Chiller As Heat Recovery Machines

To appreciate the prominence that chillers have achieved as heat transfer machines consider an ordinary application where chilled water is pumped through fan/coil units to cool a building by carrying off unwanted heat. As the water circulates the absorbed heat is brought to the evaporator section where it is removed and transferred by the refrigeration process to the condenser. At this point the hot refrigerant comes in contact with a bundle of water tubes located within the shell of the condenser. Condenser water is circulated through a cooling tower where the heat removed from the building spaces is finally dissipated into the atmosphere.

Now consider the case of a building that at certain times has some spaces that require cooling while other spaces are calling for heat. Btu's must be subtracted from some and added to others. It can easily be visualized that if both the evaporator and condenser sides of a refrigeration machine are piped to appropriately located fan/coil units, the same machine can supply both cooling and heating needs simultaneously. This is exactly what is done in a refrigeration-type heat recovery system although in an actual application, the refrigeration machine is equipped with a refinement known as a double-bundle condenser.

In certain heat recovery applications the amount of heat it is possible to reclaim during occupied hours may exceed the daytime heating requirements of the perimeter zones. This excess heat can be stored for release during times when the building is unoccupied. A system for doing this would include a water storage tank as shown in the diagram. The temperature of the condenser water is held at about 100°F by mixing storage tank water with return water. Some hot return water flows through the tank and some is bypassed and mixed with cold water withdrawn from the tank. This continues until the tank reaches its maximum design temperature, whereupon it is locked out of the circuit. If the system continues to supply an excess of reclaimed heat, condenser water is pumped to the tower for cooling.

At night the water in the tank is pumped through the evaporator where it serves as a "false" heating load on the refrigeration machine. When the tank temperature drops to a predetermined point, the refrigeration machine is shut down and the boiler energized to provide hot water directly.



The Equipment: The Future

On the near horizons are new developments in technology which may soon prove to be economically viable. The HVAC systems of the future include:

Rotary Heat Exchangers - These are similar in appearance to a squirrel-cage centrifugal fan, but with hollow, curved blades through which fluid can be pumped. As the unit rotates there is a rapid heat exchange between the fluid and the surrounding air. Rotary heat exchangers transfer energy two or more times more effectively than static heat exchangers of equivalent size. Among applications contemplated for the rotary heat exchangers is an air-to-air heat pump with two of the units, serving as condenser and evaporator, mounted on a common motor-driven shaft. The rotating heat exchangers would themselves provide all of the required air flow without auxiliary fans or blowers.

Screw Compressors - The screw or helical rotary compressor shows promise of exerting a major influence on refrigeration machinery design. It consists of two helically cut rotors, one male and one female, operating within a stator housing. As the enmeshed members counterrotate, they pump a refrigerant gas from inlet to outlet ports, compressing it in the process. The screw compressor combines the positive displacement benefit of the reciprocating machine with the low-friction operation of the centrifugal compressor and is easily modulated for varying loads.

Water-Cooled Transformers - The distribution transformers leading to the electric load centers of large buildings are sources of appreciable heat that normally is dissipated into the atmosphere. Water cooling these transformers could reclaim energy for domestic water heating or space conditioning.

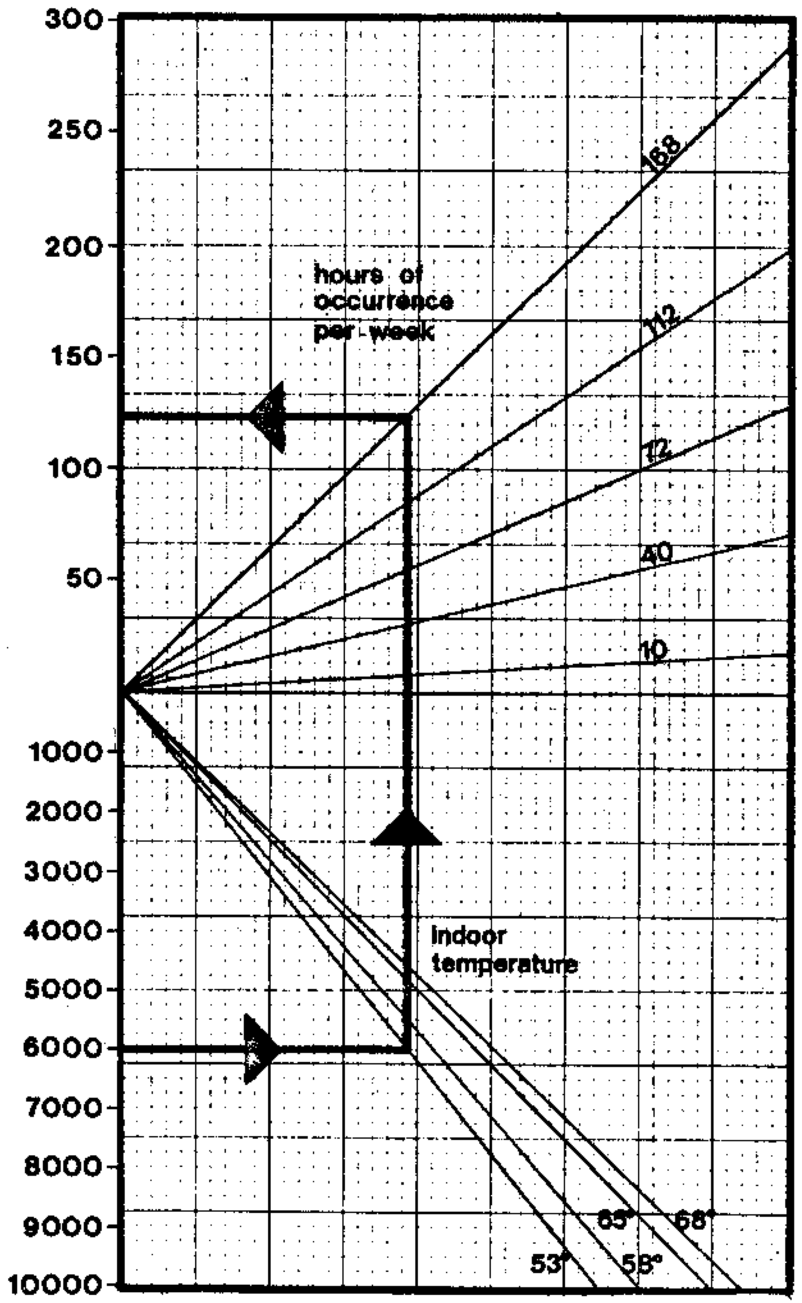
Waste-Water Heat Recovery - Heat exchangers installed in soil pipes exiting from buildings could serve as an economical means for reclaiming the heat content in waste water, particularly in larger structures.

heating

yearly energy used
per 1000 cfm
outdoor air

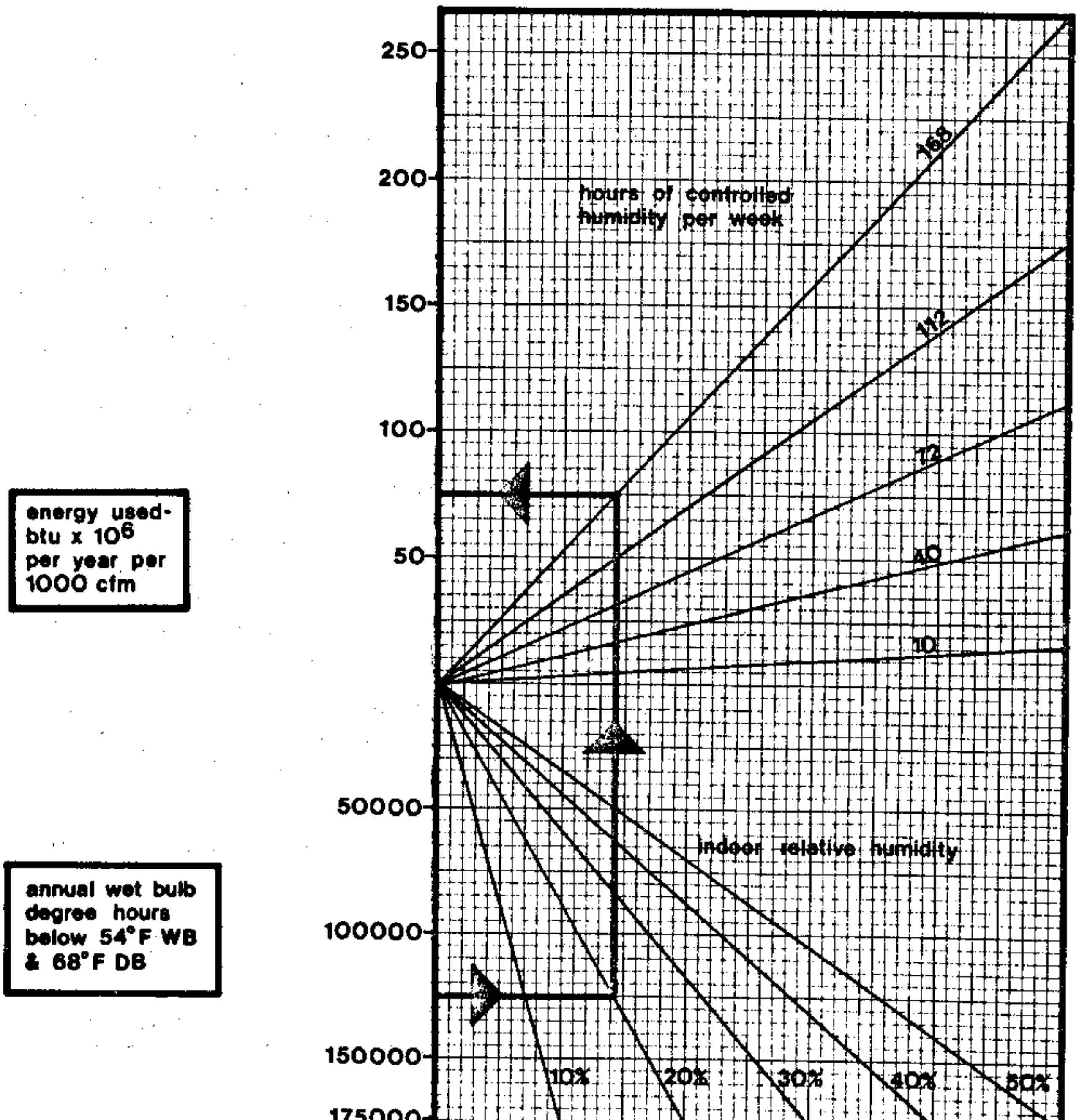
energy used-
btu x 10^6
per year per
1000 cfm

degree days



heating

yearly energy used
per 1000 cfm
to maintain various
humidity conditions



Heating Equipment

There are numerous kinds of heating systems installed in existing churches. Certain common maintenance guidelines so improve efficiency of operation include the following:

Boilers (General)

Minimal Expense

1. Inspect boilers for scale deposits, accummulation of sediment or boiler compounds on water side surfaces. Rear portion of the boiler must be checked because it is the area most susceptible to formation of scale. (Scale reduces the efficiency of the boiler and possibly can lead to overheating of furnace, cracking of tube ends and other problems.)

2. Fireside of the furnace and tubes must be inspected for deposits of soot, flyash and slag. Fireside refractory surface also must be observed. Soot on tubes decreases heat transfer and lowers efficiency. (If your boiler does not now have one, consider installation of a thermometer in the vent outlet. It can save inspection time and often can prove to be more accurate than visual inspection alone.) If gas outlet temperature rises above normal, it can mean that tubes need cleaning. Evidence of heavy sooting in short periods could be a signal of too much fuel and not enough air. Adjustment of the air/fuel ratio is required to obtain clean burning fire.

3. Inspect door gaskets. Replace them if they do not provide a tight seal.

4. Keep a daily log of pressure, temperature and other data obtained from instrumentation. This is the best method available to determine the need for tube and nozzle cleaning, pressure or linkage adjustments, and related measures. Variations from normal can be spotted quickly, enabling immediate action to avoid serious trouble.

5. Note firing rate when log entries are made. Realize that even a sharp rise in stack temperature does not necessarily mean poor combustion or fouled waterside or fireside. During load change stack temperatures can vary as much as 100°F in five minutes.

6. Inspect stacks. They should be free of haze. If not, it probably indicates that a burner adjustment is necessary.

7. Inspect linkages periodically for tightness. Adjust when slippage or jerky movements are observed.

8. Observe the fire when the unit shuts down. If the fire does not cut off immediately, it could indicate a faulty solenoid valve. Repair or replace as necessary.

9. Inspect nozzles or cup of oil-fired units on a regular basis. Clean as necessary.

10. Check burner firing period. If it's improper, it could be a sign of faulty controls.

11. Check boiler stack temperature. If it is too high (more than 150F above steam or water temperature) clean tubes and adjust fuel burner.

12. Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks; repair and seal as necessary.

13. Replace all obsolete or little used pressure vessels.

14. Clean mineral or corrosion build-up on gas burners.

Boilers (Electric)

Minimal Expense

1. Inspect electrical contacts and working parts of relays and maintain in good working order.

2. Check heater elements for cleanliness. Replace as necessary.

3. Check controls for proper operation. Adjust as necessary.

Central Furnaces, Make-Up Air Heaters and Unit Heaters

Minimal Expense

1. All heat exchanger surfaces should be kept clean. Check air-to-fuel ratio and adjust as necessary.

2. Inspect burner couplings and linkages. Tighten and adjust as necessary.

3. Inspect casing for air leaks and seal as necessary.

4. Inspect insulation and repair or replace as necessary.

5. Follow guidelines suggested for fan and motor maintenance.

Radiators, Convectors, Baseboard and Finned Tube Units

Minimal Expense

1. Inspect for obstructions in front of the unit and remove whenever possible. Air movement in and out of convector unit just be unrestricted.

2. Inspect for leaky valves that fail to shut off when thermostat is satisfied.

3. Air will sometimes collect in the high points of hydronic units. It must be vented to enable hot water to circulate freely throughout the system. Otherwise, the units will short cycle (go on and off quickly), wasting fuel.

4. Heat transfer surfaces of radiators, convectors, baseboard and finned-tube units must be kept clean for efficient operation.

Electric Heating

Minimal Expense

1. Keep heat transfer surfaces of all electric heating units clean and unobstructed.

2. Keep air movement in and out of the units unobstructed.

3. Inspect heating elements, controls and, as applicable, fans on a periodic basis to ensure proper functioning.

4. As appropriate, check reflectors on infrared heaters for proper beam direction and cleanliness.

5. Determine if electric heating equipment is operating at rated voltage as necessary.

6. Check controls for proper operation.

Humidification and Dehumidification Equipment

To maintain peak operating efficiency, the following maintenance guidelines should be followed:

Minimal Expense

1. Removal lint and dust periodically from air dampers, fan parts, spray chamber and diffuser, controls starter, and eliminator.

2. Check equipment for carry-over. Carry-over may be eliminated by adjusting eliminator seal gap, altering damper position, or changing air velocity.

3. Follow guidelines suggested for "Fan and Motor Maintenance."

COOLING & VENTILATION

General: Cooling

The object of a religious building's cooling plant is to maintain an acceptable comfort level for people during those warm months of the year. To accomplish this objective and conserve energy as well, churches should:

1. Utilize systems which can discharge excessive internal heat to the outside by non-mechanical means whenever inside temperatures are higher than outside.
2. Where mechanical refrigeration is used to provide space cooling, provide systems which are supplements to natural cooling systems and which will be deactivated whenever natural cooling can be achieved.

Interior spaces must be cooled when build-up of heat from interior sources occurs faster than the loss to the outside or when heat flows from the outside to the inside because the outside temperature is greater than the inside. In the first case, the ability to "dump" heat to the outside by non-mechanical means will often be sufficient to maintain acceptable temperatures. This requires that the outside temperature be no higher than the inside. (Heat will only flow from bodies with higher to bodies with lower temperature). If it is desired to lower the inside temperature below the outside temperature, mechanical cooling must be provided. An additional aspect related to ambient cooling is local cooling resulting from surface evaporation on the occupants' skin resulting from air movement.

Outside Air Cooling

The basic aim of non-mechanical cooling is to prevent inside temperatures from rising much above outside temperatures. If there is a tendency for internal heat gains to raise inside temperatures above outside, conduction will generally be unsatisfactory as a method for rejecting this excess heat. This is due to the fact that the rate of conducted loss through a given material is a function of the temperature differential which, when overheating is a problem, is apt to be quite small. Instead, the actual exchange of inside and outside air will permit movement of large amounts of heat. In order for the exchange to take place, some force must induce the air to move. Two basic natural conditions--wind pressure and gravity--will in most cases act to this end.

Wind Pressure. There is almost always some outside air movement which will cause different exposures of a building to experience different air pressures. If a space has openings to two exposures, air will flow from the higher pressure through the space and out through the opening at the lower pressure. (One of the exposures can be a roof as well as a wall surface. It is also possible to have different exposures on a single wall surface resulting from the treatment of openings.)

Gravity. Hot air weighs less than cooler air and therefore tends to rise in the presence of cooler air. When inside temperatures are higher than outside, an opening at the top and the bottom of the space will permit the hot air to rise and escape from the higher opening causing cold air no be drawn in through the bottom. The force acting to cause this flow is a function of the temperature differential and height between the openings. Since it is desirable to have air change taking place at the smallest temperature differential, it is desirable to increase the height between the openings. The utilization of height to promote air movement due to temperature differential is referred to as the "stack effect". It is also possible to increase the temperature differential without adding unwanted heat into the interior environment. This is done by heating the air after it leaves the occupied space but before it is freed into the outside environment. This is the basic principle behind the summer mode of the thermo-siphoning wall panel described in the section below on building design.

Evaporative Cooling

When moisture evaporates, there is sensible cooling resulting from the change of sensible to latent heat in the process. If this is surface moisture on the skin, a relatively small actual heat change can result in a large difference in comfort due to the fact that the temperature drop occurs right at the occupant. Air movement will promote evaporation by preventing moisture concentrations from building up around each occupant. This air movement can be totally internal as induced by local fans, or can result from air passing through a space. Circulating inside air is advantageous when outside temperatures are higher than inside. Of course at some point, the concentration of moisture in the air builds to a point that evaporation will not occur. However, the normal minimum requirements for outside air will prevent this from occurring.

At times when outside temperatures are lower than inside, the conversion of sensible to latent heat carried by evaporated moisture will increase the effectiveness of the air as a medium for removing heat from the environment.

Mechanical Cooling

The selection of indoor conditions is based on a fair degree of comfort. It is recommended that all fully air-conditioned churches utilize the same piping system for both heating and air-conditioning, therefore, hot water is to be circulated during the winter, and chilled water during the summer months. This may be accomplished through utilization of low-pressure steam boilers connected with steam to hot water converters. In the winter months, hot water is pumped to respective zones and individually controlled as previously stated. In the summer months in totally air-conditioned buildings, chilled water may be obtained through the operation of steam absorption refrigeration equipment with the steam obtained by operating the boiler plant during the summer months.

To optimize efficiency of the refrigeration plant operation, the equipment should be selected so that each refrigeration unit will provide 50 percent of the total required capacity. Churches in the 40,000 to 55,000 sf gross area range should consider reciprocating type of chilling equipment which is available in smaller capacity ranges and will optimize plant efficiency. Large air-conditioning distribution systems for places of assembly, such as sanctuaries and fellowship halls should utilize cycles which permit the utilization of 100 percent outside air whenever weather conditions permit. Controls should be actuating dampers to reduce the amount of outside air to a minimum required for health standards, whenever the mixed air temperature exceeds 80°F. Above 80° mixed air temperature air dampers maintain minimum position and the chilled water valve to the cooling coil shall open. For extensive air distribution systems, utilize single duct variable volume low pressure air systems. These minimize the fan horse-power required to deliver the cooling air and avoid the necessity for reheat of chilled air to maintain comfort conditions within the space. Wherever distribution systems are contemplated exceeding 150 to 200 feet in length consider multiple fan rooms served from a central chilled water plant. A full analysis should be made of fan room locations to minimize energy consumption.

Partial air-conditioning. Where limited areas only are to be conditioned, consideration should be given to window or through-wall air-conditioning units for single rooms and/or "package-type" air-conditioning equipment distributing chilled air. Consideration should also be given in more extensive systems to the utilization of heat pumps using cooling tower water for chilling or condensing mediums.

Exhaust systems. Where areas are mechanically cooled, the amount of fresh air to be introduced is mainly through infiltration through windows except for air-conditioning of large assembly spaces, where considerable fresh air must be introduced under peak occupancy conditions. The exhaust system should contain a heat exchanger such as a thermal wheel or counter-flow device for air to air heat transfer or an air to water to air loop to permit the regain of energy that would otherwise be wasted.

The Equipment: All Air Systems

The optimum solution for an air conditioning application results from analyzing a number of factors and designing a system of components that will provide the required air conditioning most effectively and economically. These factors include:

1. External environment variations of temperature, humidity, sun, shade, and wind;

2. Diversity of internal load due to variations in occupancy, lighting, and other processes of heat exchange;

3. Capability for storage of heating gains, and necessity and capacity for precooling and/or preheating;

4. Physical aspects of building to accommodate equipment, system and balanced operation at partial load;

5. Requirements of local building codes and regulations;

6. Installation cost (first) and operating cost.

For easier understanding, all-air systems of air conditioning can be divided into five types with common names as follows:

1. Single duct with reheat

2. Single duct with variable volume

3. Double duct

4. Multi-zone

5. Dual conduit

Each of these systems has identifiable variations and certain functional or economic advantages for particular applications. All of the systems are capable of satisfying the comfort factors listed in our definition of air conditioning. All of them not only clean the air, but also heat or cool, humidify or dehumidify. At the same time, they provide benefits of ventilation, sound pollution control, flexibility of control and operation and permanency with low maintenance.

With all-air systems, the conditioning apparatus is usually located in a central station remote from the conditioned space. Service and maintenance are easy to accomplish in centrally located, easily accessible machine rooms, without disturbing building occupants.

Treated air is distributed from a central station to the conditioned spaces by means of duct systems, with air flow velocity and volume controlled by fans and dampers. The great majority of duct systems are fabricated from galvanized sheet steel, according to specificationj of the Sheet Metal and Air Conditioning Contractors' National Association. SMACNA Standards are the basis for many building code requirements and steel ducts fabricated in accordance with them provide many years of trouble-free service. These air distribution systems incorporate modern smoke and fire protection features.

As each of the five all-air systems is described and illustrated, it will be seen that the duct systems and controls provided for air distribution are the basis for their classification. Each air conditioning application should be evaluated on the basis of careful analysis of all of the variable factors, including economics in terms of the owner's objectives. A responsible designer will analyze all factors, determine the requirements or each job and will then design the environmental control system which in his judgment best meets the requirements. Each basic system is best when it best meets the requirements of a particular job.

Single Duct with Reheat: Description

Single-duct terminal reheat systems use heating coils in the duct system or in room terminal units to reheat air as necessary to handle individual room loads. The primary air is supplied at constant volume from a central point through various duct branches to small reheat coils located adjacent to the controlled space in the distribution branch duct or located in room terminal units.

These systems, known as straight reheat, induction reheat and reheat induction systems, have become increasingly sophisticated in recent years. When properly engineered, they can provide excellent control of humidity and temperature, even for very small zones.

Terminal reheat systems can be applied effectively in almost any multi-room, multi-story building, although operating costs in certain applications may be somewhat higher than for other all-air systems. For many projects, such as schools, slightly higher operating cost might be incidental to the system's fine characteristics.

The straight reheat system takes air from the central apparatus at about 55°F, passes it through a reheat coil to emper it as required and discharges it into the conditioned space. One fan unit with a single reheat coil may supply a duct distribution network for a selected zone or a centrally located fan unit may have many reheat coils remotely located in duct branches.

As the cooling load in a room drops, the reheat coil warms the supply air as needed to prevent overcooling and to provide heat in winter. Then when the load reverses, the amount of reheating is reduced. Under full cooling load, no reheat is used.

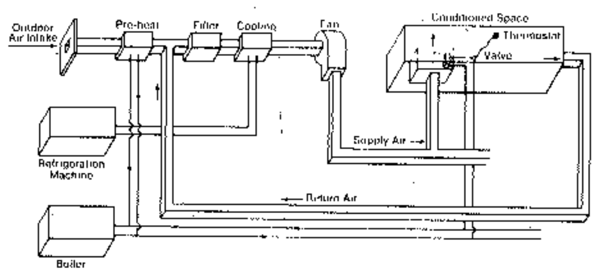
The induction reheat system has one basic difference from straight reheat; primary air is delivered to a terminal unit that contains induction nozzles. As the primary air discharges through these nozzles, it induces an approximately equal part of room (secondary) air across the reheat coil. This combined air circulation results in controlled room air movement.

Induction reheat systems can provide convection heating when air moving equipment is off during nights and week-ends.

The reheat induction system employs some features of both straight reheat and induction reheat systems. The reheat coil is encased and placed upstream of the induction area. Since the inducted air does not flow across the coil, airflow is freer at higher induction ratio and maximum room air circulation is provided.

With this system, less air needs to be circulated by the central apparatus in a building. This makes it possible to use smaller air handling equipment, smaller refrigeration machines, and smaller ducts.

Single duct reheat systems are highly flexible; they can provide a narrow variation of temperature in rooms or zones having a wide range of load requirements. The refrigeration machine can be shut down when the temperature of outdoor air is below the required supply air temperature, thus providing low cost cooling in winter.



Single Duct with Reheat: Conservation Considerations

Although this system probably offers the best combination for temperature and humidity control, from the point of view of conservation, it is probably the worst. It first cools all incoming air to the lowest demand of any interior space. Then it compounds the energy waste of this excessive cooling by reheating large amounts of air circulated in spaces with lower cooling demand, or even a heating demand. The additional heat generated by this excessive cooling (in the refrigeration cycle) is usually wasted. In extreme cases, a reheat HVAC system can double the energy consumption of a more efficient system.

There are only two successful ploys in reducing energy consumption of this kind of system: (1) reduce the air volume of single zone units; and, (2) if close temperature and humidity control are not required, convert the system to variable volume by adding variable volume valves and eliminating terminal heaters.

Single Duct with Variable Volume: Description

The variable volume system compensates for varying cooling load by regulating the volume of cooling air supplied through a single duct. Special zoning is not required because each space supplied by a controlled outlet is a separate zone.

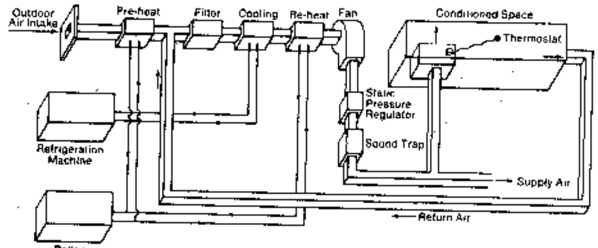
Significant advantages of the variable volume system are low initial cost and low operating costs. The system is far lower in first cost in comparison with other systems that provide individual space control, because it requires only single runs of duct and a simple control at the air terminal. Also, where diversity of loading occurs, smaller equipment can be used.

Operating costs are generally lowest of all the air systems, and savings of as much as 35 percent in energy costs are possible. Since the volume of air is reduced with a reduction in load, the refrigeration and fan horsepower follow closely the actual air conditioning load of the building. During intermediate seasons, outdoor air can be used for economy in cooling. In addition, the system is virtually selfbalancing.

Until recently variable volume systems were not recommended for applications with loads varying more than 20 percent for two reasons. First, throttling of conventional outlets down to 50 or 60 percent of their maximum design CFM might result in loss of control of room air motion with noticeable drafts resulting. Secondly, use of mechanical throttling dampers produces noise, which increases proportionally with the amount of throttling.

Improvements in volume-throttling devices and aerodynamically designed outlets have helped overcome these problems and extended the potential application of variable volume systems. One such volume-throttling device employs two internal bellows for air-volume control. As the load decreases in the room, the pressure in the bellows increases, causing reduced airflow while maintaining low sound level. This system can now handle interior areas as well as building perimeter areas where load variations are greatest, and where throttling to 10 percent of design CFM is often necessary.

Single duct variable volume systems should be considered in applications where full advantage can be taken of their low cost of installation and operation.



Single Duct with Variable Volume: Conservation Consideration

At slight sacrifice in comfort control, a variable volume systems offers far greater operating economy and may save up to 50% over the single duct reheat system. The major loss in environmental control which results from its use concerns humidity more than temperature. Comfort tests indicate a fairly wide tolerance in relative humidity. In view of this, it may be wasteful to control humidity as precisely as a single duct reheat system does.

Certain conservation techniques may be applied to this kind of system:

1. Reduce the volume of air handled by the system to that point which is minimally satisfactory.

2. Lower air supply temperature to that point which will result in the VAV box serving the space with the most extreme load being fully open.

3. Consider installing static pressure controls for more effective regulation of pressure bypass (inlet) dampers if none now exist.

4. Consider installing fan inlet damper control systems if none now exist.

Double Duct: Description

In the double duct system, the central station equipment supplies warm air through one duct run and cold air through the other. The warm and cold air streams are combined at remote mixing boxes to supply tempered air as needed through conventional room outlets.

A thermostat in the conditioned space controls the delivered air temperature by increasing or decreasing the volume of the warm air stream while making an opposite adjustment in the volume of the cold air stream. For best performance, some form of constant volume regulation should be incorporated into the system to maintain a constant flow of air. Without this, the system is difficult to control because of the wide variations in system static pressure that occur from the normal demand from load changes.

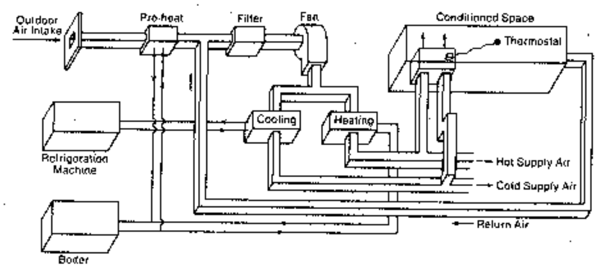
Many double duct systems are installed in office buildings, hotels, hospitals, schools and large laboratories. A common characteristic of these multi-room buildings is their highly variable sensible heat load, which a properly designed double duct system can handle very well. With the simultaneous availability of cold and warm air at each terminal unit at all times, this system provides great flexibility in satisfying multiple loads and in providing prompt and opposite temperature response as required.

Space or zone thermostats may be set once, to control year-round temperature conditions. Starting and stopping of the refrigeration machine and boiler are the only normally required adjustments for extreme changes in outdoor temperature. All outdoor air can be used when the outdoor temperature is low enough to handle the cooling load.

The choice of medium or high velocity air transmission can be made on the basis of economics and building requirements.

Double duct is a good system to use for controlling individual room temperature, and is frequently used in laboratories, offices, commercial buildings and other multi-room buildings that have extremes of load.

Cost and space required for double duct distribution systems can become major considerations when many small spaces require individual control.



Double Duct: Conservation Considerations

Double duct systems obviously waste energy by mixing cold and hot air and thus negate part of the effect which two energy systems have worked to achieve. If the school, however, wishes to continue to use the system as a dual duct conditioner, two conservation steps may be taken: (1) reduce air flow to all boxes to minimally acceptable levels; and (2) lower the hot deck temperature and raise the cold deck temperature.

A more radical suggestion, but wiser in conservation terms, is to convert the system to a dual single duct arrangement. That is, when no cooling load is present, close off the cold ducts and shut down the cooling system. Reset the hot deck according to heating loads and operate as a single duct system. When no heating loads are present, following the same procedure for heating ducts and hot decks. It should be noted that operating a double duct system as a dual single duct system reduces air flow, resulting in increased energy savings through lowered fan speed requirements.

Multi-Zone: Description

From central station (built up or packaged) apparatus, the multi-zone system distributes a single air stream to each room or zone through separate ducts. The central station apparatus includes dampers that pre-mix the proper amounts of cold and warm air for each duct and is controlled by room and apparatus thermostats. The system conditions groups of rooms or zones by means of a blow-through central apparatus having heating and cooling coils in parallel downstream from the fan.

In summer, if heat is maintained on the heating coil, the unit may function as a zoning reheat unit. The heating coil may also be made inoperative and a face and bypass control may be utilized. In this case, the path through the heater coil serves as a coil bypass.

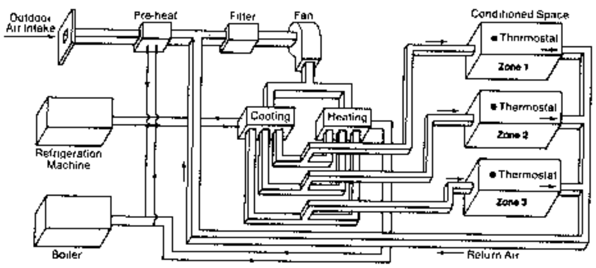
Since the blow-through fan unit may be used either as a centrally located zoning reheat unit or zoning face and bypass unit, it is well adapted to multi-room applications. Properly engineered and installed, it gives excellent control of temperature and humidity in individual spaces.

In typical summer operation, the minimum outside air damper is open, the refrigeration is on, the maximum outdoos and exhaust air dampers are closed and the return air damper is open.

Normally, the chilled water temperature is maintained at a constant level and the full design quantity of water is continuously circulated through the cooling coils. This allows the apparatus dewpoint temperature to fall at partial load conditions, and the reduced temperature helps to maintain better humidity conditions as the zone loads and sensible heat ratios fall.

When outdoor air temperatures are below the design cold deck supply temperatures, the refrigeration source is shut down. A thermostat modulates the outdoor, return and exhaust air dampers to maintain the desired cold plenum temperature. The cool outdoor air is thus used to provide economical cooling during marginal and winter weather.

The multi-zone, blow through system is essentially applicable to locations and areas having high sensible heat loads and limited ventilation requirements. The use of many duct runs and control systems can make initial costs of this system high compared to other all-air systems. Also, to obtain very fine control, this system might require larger refrigeration and air handling equipment, which should be considered in estimating both initial and operating costs.



Multi-Zone: Conservation Considerations

Multi-Zone systems may be made more efficient in three ways:

1. Reduce hot deck temperatures and increase cold deck temperatures. While this will lower energy consumption, it also will reduce the systems's heating and cooling capabilities as compared to current capabilities.

2. Install demand reset controls which will regulate hot and cold deck temperatures according to demand. When properly installed, and with all hot deck or cold deck dampers partially closed, the control will reduce hot and raise cold deck temperatures progressively until one or more zone dampers is fully open.

3. Consider converting systems serving interior zones to variable volume. Conversion is performed by blacking off the hot deck, removing or disconnecting mixing dampers, and adding low pressure variable volume terminals and pressure bypass.

Dual Conduit: Description

The dual conduit system is a modern, central station system that can be applied to multi-zone buildings such as schools. It is especially suitable for areas that have a reversing transmission load and require individual room temperature control. It can be adapted easily to areas that have variable cooling and heating requirements caused by sun, outdoor temperature and internal loads. Generally, its application is similar to the dual-duct system, but with more economical first cost.

Dual conduit is a high-velocity air system in which a central air-treating plant supplies two air streams to each ro m or zone--a primary supply and a secondary supply.

The primary air stream is variable temperature, constant volume. The temperature ranges from 55° to 115°F according to outside air temperature. This air stream handles perimeter transmission gains or losses.

The secondary air stream, variable volume at a constant temperature, normally selected from 50° to 55°F, handles the internal loads from lights, people and the sun.

Various central station arrangements can be used to provide the air temperatures and volumes required. However, best results are usually obtained with a central system having a separate fan and air conditioning apparatus for each air stream.

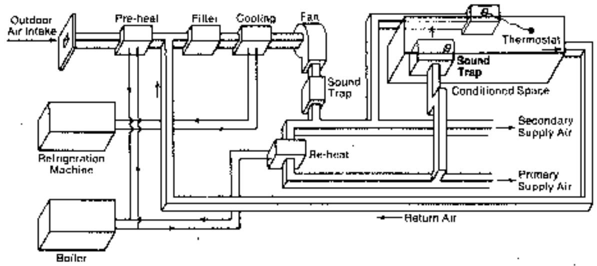
In such a separated system, the primary air apparatus conditions the air and supplies a constant volume mixture of outdoor and return air to the room terminals. The apparatus contains filters, preheat coils (as required), a humidifier (if desired), and a dehumidifier to remove excess moisture and cool the supply air. This primary air stream also contains a reheat coil controlled by a thermostat to adjust the air temperature to match the cooling load.

The separate, secondary air apparatus conditions the air for internal loads and supplies all return air, a mixture of outdoor and return air, or all outdoor air, depending on the season. The apparatus contains filters and a dehumidifier. In winter, refrigeration equipment is shut down and a thermostat (located in the fan discharge) modulates the outdoor and return air dampers to maintain a constant mixing temperature of 50° to 55°F.

Air from both the primary and the secondary apparatus is delivered to the room terminal units through galvanized steel ducts. A high velocity air distribution system is used for the primary air and either a high or a medium velocity system is used for the secondary air.

In winter, greater economy may be obtained by operating the primary apparatus with return air. Outdoor air for ventilation is available from the secondary air system.

Instead of having separate fans and air treating equipment for each air stream, a dual conduit system can be designed r ith one set of conditioning apparatus and two fans, or with one set of apparatus and one fan. Although these arrangements have lower first costs, they generally sacrifice ventilation air at partial loads, and they have slightly higher operating costs.



Dual Conduit: Conservation Considerations

Some experts advise against the use of high velocity, high pressure air distribution, because it requires greater fanpower than a low velocity system to overcome the greater frictional losses of the smaller, high velocity ducts. But there are offsetting advantages to the high velocity system. For one thing, there is less conductive heat loss (or heat gain) through the smaller ducts of the high velocity system. And in a high velocity system, the induced air flow past the water heated (or cooled) coils increases the convective heat flow as a direct consequence of the high velocity air delivery. Thus, though it is probably true that high velocity delivery systems generally use more energy than low velocity systems, the church administrator with professional counsel should investigate his own special situation.

Methods for conserving energy with this system include:

1. Set primary air volume to original design values when adjusting and balancing work is performed.

2. Inspect nozzles. If metal nozzles, common on most older models, are installed, determine if the orifices have become enlarged from years of cleaning. If so, chances are that the volume/pressure relationship of the system has been altered. As a result the present volume of primary air and the appropriate nozzle pressure required must be determined. Once done, rebalance the primary air system to the new nozzle pressures and adjust individual induction units to maintain airflow temperature. Also, inspect nozzles for cleanliness. Clogged nozzles provide higher resistance to air flow, thus wasting energy.

3. Set induction heating and cooling schedules to minimally acceptable levels.

4. Reduce secondary water flow during maximum heating and cooling periods by pump throttling or, for dual pump systems, by operating one pump only.

5. Consider manual setting of primary air temperature for heating, instead of automatic reset by outdoor or solar controllers.

The Equipment: Central vs. Packaged Systems

Within the past ten or twelve years, packaged, multi-zone HVAC systems have begun competing with central systems, which formerly dominated the HVAC market for large structures. The new packaged units are especially well adapted to modular systems buildings. The advent of packaged HVAC units complicates the mechanical engineer's problems, since his choice of basic HVAC, for large buildings, was formerly limited to central systems.

Packaged HVAC systems differ from central systems in the location of the basic equipment (furnace, refrigeration units, circulating fans or pumps). Instead of centralizing this equipment, the packaged HVAC system spreads it around the building in compact ("package") units. These packages contain a furnace, refrigeration compressor, condenser, and fan-coil unit designed to air-condition (i.e., to heat, cool, humidify, or dehumidify) a specified zone as large as four standard classrooms. Whereas central systems may exceed 20,000 tons or refrigeration capacity, packaged units seldom exceed 50 tons.

Though the final choice of packaged vs. central air-conditioning normally requires analysis of local factors, there are nonetheless several general criteria that can guide the designer in his quest for long-term economy. As their basic advantage, packaged, rooftop units often permit large savings in fan power required to move conditioned air to distant spaces. (Electric fan energy accounts for up to 45% of a building's total electric consumption.) Thus packaged units are best suited to low, sprawling buildings and small buildings whose total heating and cooling loads would not justify the heavier capital investment in a central HVAC system.

Central HVAC systems are most efficient in compact, multi-story buildings where fanpower requirements to circulate treated air are relatively low. Moreover, the higher the heating and cooling loads, the more efficient the central plant.

Electrical distribution also favors central systems; it is easier and more economical to bring electric power to a central point than to many packaged units. Gas pipes for heating pose an even greater problem in economical distribution for packaged HVAC.

According to Fred Dubin, a central HVAC plant is normally 10 to 15% more efficient than packaged HVAC units for two reasons: First, its equipment is generally of higher quality and durability. Second, it has an intrinsically more efficient condensing apparatus. In standard compressor refrigeration cycles, the refrigerant (the basic cooling agent) must be condensed from gaseous to liquid state after it cools the water or air used as the cooling medium. In central HVAC units, the condenser uses water to condense the refrigerant. But for rooftop packaged units, the necessarily light condenser normally uses air, a much less efficient cooling medium than water for absorbing the heat of condensation. It requires much more fan power to draw air through the air-cooled condenser than to pump water to a cooling tower. Packaged HVAC systems with air-cooled condensers thus start out with an intrinsic energy-consuming handicap in their competition with central HVAC systems.

A central HVAC unit offers several other advantages:

* It can burn cheaper fuels

* It can be designed for lower total capacity than packaged or window units distributed around a building, and usually for greater overall operating efficiency.

* It can be more readily designed for energy-saving, waste-heat recovery features, which may be impracticable for smaller packaged units.

* It is more adaptable to automatic computer control and maintenance economy.

For large installations over 300 tons of refrigeration capacity or thereabouts, central HVAC systems offer advantages over packaged units for such maintenance jobs as routine equipment inspection and repair, belt tightening, lubricating, replacement of minor parts, and monthly filter service. Based on first cost, annual maintenance expenditures of 3-4% for central HVAC systems and 5-6% for packaged HVAC systems are estimated by mechanical engineer F. T. Andrews. Each system should, of course, be investigated for its own special or unique characteristics. A modernization project might favor packaged HVAC, because of its generally easier installation in existing structures. A high load factor (air-conditioning energy used/total capacity) would favor central HVAC.

The Equipment: Conservation Summary

Buildings in many parts of the country require simultaneous heating and cooling during much of the year. Providing it at the same time and in the same space is extremely wasteful and must be avoided. More careful temperature, humidity, and ventilation control will realize a major windfall in energy savings with negligible or no loss in occupant comfort.

Systems that allow simultaneous heating and cooling also waste fan HP because of the higher CFM requirement. With these systems, cool air not needed in one space is mixed with hot air and thereby is not available for cooling in other spaces. Care should be exercised so heating does not blend with cooling in an adjacent space. Larger zones help reduce this blending of hot and cold air. Interior spaces (with properly insulated roofs) require cooling only and should not have heating available.

All thermal reheating systems use more energy than alternative systems for the same systems characteristics. Excess energy is always used when air is either cooled and reheated, or heated and re-cooled. Multi-zone units with hot and cold decks waste energy by mixing hot and cold air and by increasing fan HP to meet higher CFM requirements. Multi-zone units with face/bypass controls waste energy in their winter cycle--common 55^{o} mixed air must be heated in zones not requiring cooling. Hot and cold double duct systems waste energy by mixing hot and cold air, especially when serving two or more zones from the same air handling unit; while terminal preheat systems are even more energy intensive. Generally, variable air volume systems use less energy than constant volume systems for the same system static pressure.

Humidity control can be obtained without simultaneous heating and cooling. Maximum relative humidity can be controlled by passing supply air through a cooling coil and thereby simultaneously achieving a fixed temperature and dehumidification of the air. The supply air CFM is then varied to maintain the space temperature. Since most computers and electronic systems have constant heat outputs while operating and require a constant ambient temperature, the CFM of supply air to these spaces will also remain constant and require no reheat.

Space requiring humidification ususally requires cooling year 'round. Humidification is usually needed only in winter when outside air is used for cooling. Minimum humidity can be obtained by evaporating water and the evaporative cooling effect would also reduce the quantity of outside air required. (Steam humidification in spaces requiring cooling is very wasteful.)

Ventilation systems in existing buildings are sometimes operated continuously and often without conscious planning to respond to actual need. Operating ventilation systems only as needed in response to known building occupancy schedules could save energy, calling for investigation into the need for zoning in ventilation. A much lower level of outdoor air can be used during heating and cooling seasons to check rising energy costs required to pre-condition incoming air. Opening windows can provide cooling without expenditure of energy when the outside temperature is below the interior temperature. Use of smoke and odor removal systems will reduce outside air requirements. Also, with proper engineering, humidity can be controlled quite accurately using outside air for cooling:

1. Cold/dry outside: Relative humidity of interior space will drop. To increase RH, introduce water evaporation so evaporative cooling effect will reduce outside cooling air required.

2. Humid outside: The outside dry bulb must be above 55°F to reach a point where dehumidification is needed. Whenever the dry bulb is above 55°, mechanical refrigeration may be required.

Most equipment requires more energy input at part-load conditions than at full capacity. Matching the equipment to the load without using excessive safety factors conserves energy. Listed here are some practical methods for reducing cooling and heating capacities when load is reduced, without wasting energy:

1. Varying fan speeds

2. Cycling fans

3. Using single zone fan coil units with face/bypass control or on/off control. (Face/bypass control will waste some fan energy.)

4. Large air handling units with fixed air temperature (55°F) may be used with manual balancing damper to compensate for load variations.

Heating and cooling equipment will utilize energy more efficiently if it is designed to operate closer to maximum capacity more days of the year. This can be achieved by allowing design conditions to be exceeded some of the time.

These opportunities exist for designing systems to operate at or near optimum efficiency with reduced building loads:

Multiple compressor systems: Sequence so each compressor is 100% loaded before next compressor is brought on line. Select and circuit auxiliary equipment so it will be sized for compressor full load and cycled with compressor. This includes such items as condenser fans, chilled water and condenser water pumps.

Single compressor systems: Maintain efficiency by cycling at full load (with auxiliary equipment) or reduce auxiliary equipment capacity along with compressor.

Cycling fans, pumps and compressor at full load has proved a very good method of obtaining optimum efficiency. Tests and actual operation show that concerns about stagnant air, building static pressure control and temperature variations are of minor importance in most applications. We have found that systems can be cycled on a reasonable duty cycle and reasonable temperature variation at light and equipment heat concentrations of 20 watts per sq. ft. or less.

Considerable energy saving equipment is available which will not involve an increase in first costs; some other more expensive systems would pay for themselves in reduced operation costs over the life of the building. Situations will arise in which increased initial costs in dollar terms will yield more effective results in energy terms. Here are some factors which should be identified during early stages of a project:

1. Select condensers for low head pressure to reduce compressor HP.

2. Select evaporator surfaces to reduce compressor HP.

3. Design air handling system for lowest practical static pressure to reduce fan HP.

4. Size piping and heat exchangers for lowest practical pressure loss to reduce pump HP.

5. Design to reduce GPM's and CFM's during light loads to reduce fan and pump HP.

6. Evaluate refrigeration systems such as compressor vs. absorption, considering quantitiy of basic energy expended (gas, oil, electricity, nuclear).

7. Return relief air fans can be eliminated with properly designed return air system and proper location of relief louvers to outside.

8. Select systems for smallest expenditure of "new energy," as well as energy expended transporting "new energy."

The Equipment: The Future

Though there is great potential for economical design in existing hardware, the quest for HVAC economy extends into new technology as well. Because heavy air-conditioning loads are the chief source of electric power interruptions, research is under way on cooling storage or "thermal energy storage" (TES). TES would flatten the utility's electric power demand curve, smoothing the jagged afternoon peak. These afternoon peaks cause brownouts, blackouts, and energy waste. TES, achieved through nighttime off-peak operation of refrigeration equipment, would conserve energy in two basic ways:

1. It would permit more efficient utility power generation, since the power company would operate its best generating equipment, without needing to put old, inefficient turbogenerators on the line.

2. It would increase the efficiency of the refrigeration cycle, because the atmospheric (i.e., heat sink) temperature is lower at night, thus increasing the thermodynamic efficiency of the refrigeration process.

According to University of Pennsylvania researchers, a tested prototype TES system, now ready for commercial application, reduces peak demand by 50% and energy consumption by 6%. Designated the "Recondenser" system, this method of TES works as follows: Instead of one evaporator (cooling component) and one condenser (heat-rejecting component), the Recondenser TES system has two evaporators, one condenser, and one refrigerant/TES heat exchanger, which can function as either condenser or evaporator. In the first evaporator, the refrigerant evaporates at 60^{o}F. After passing through the refrigerant/TES (the "recondenser"), the refrigerant is again cooled (rejecting heat to the TES material, in this case, water in the storage unit). Passed through the second evaporator at 40^{o}F, the refrigerant again cools the air, thus doubling the amount of cooling obtained per lb. of refrigerant.

A low-capacity compressor, designed for continuous, 24-hour operation supplies the TES unit with cooling energy for use during peak hours. At additional capital cost, for increasing the compressor's size and the TES unit's capacity, this recondenser system could be improved to use even less power during the day and more during the night, when utility rates are generally lower. A compressor about 35% to 50% smaller than a conventional system's compressor would, however, promote maximum economy.

An alternative method for cooling-energy storage has been thwarted by the failure to find a chemically stable material with the proper heat of fusion at convenient storage temperatures. Heat-of-fusion TES works as follows: When the air-conditioning equipment is operating, refrigerant at 50^{o}F or so flows from the evaporator through a thin, lightweight panel of ribbed aluminum and plastic containing a phase-changing material that freeze solid at 55^{o}F. Offpeak, nighttime operation of the refrigeration machinery builds up "ice" in the TES unit. When high cooling loads occur, the melting (i.e., heat-absorbing) materials replaces or assists, the evaporator as the cooling source, relieving the power load on the compressor. By evening, when the "ice" has all melted, the compressor starts up again, renewing the air-conditioning cycle.

The bug in this beautifully simple solution to the problem of TES is the failure of previously used TES storage material (sodium sulfate decahydrate) to retain its heat of fusion. After repeated 24-hour freezing-thawing cycles, this particular salt hydrate loses its original heat of fusion: it drops from 78 Btu/lb. to less than half this value. This loss obviously impairs its cooling capacity.

Researchers continue seeking a suitable material for a heat-of-fusion TES system. Water, though far from ideal, has been used in existing installation.

Personal HVAC units promise more dramatic savings in the more remote future. According to mechanical engineer Preston E. McNall, Jr., a liquid or air-cooled hood, covering head and neck, can effectively cool a person working in a hot environment. This cooling hood allows good freedom of movement and permits unimpeded sweating (i.e., evaporating body cooling), which is inhibited by liquid-cooled suits and other systems of total body cooling. Each individual unit might be powered by a small refrigeration unit, like a household refrigerator's. Because it would reduce total load so drastically, people-oriented cooling would save tremendous quantities of energy.

In a far-ranging projection of broader scope, consulting engineer Gershon Meckler sees HVAC systems following the electrical wave of the energy future.

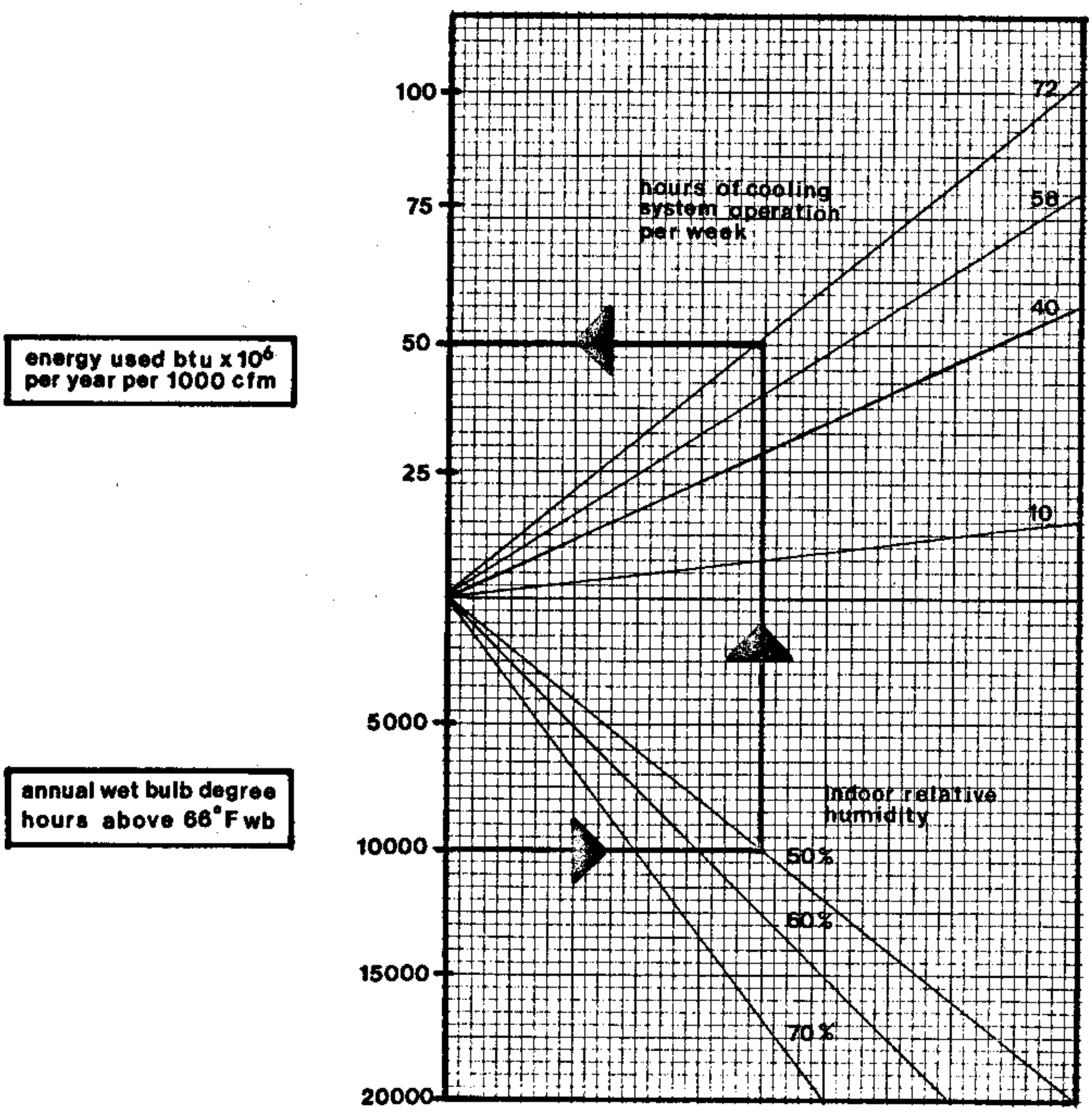
> "The versatility, flexibility, and convenience of electrical energy already explain why the electrical segment of the total energy market has grown more than 50% faster than other forms of energy over the past several decades. In the late nineteenth century, the electric motor revolutionized industrial plant design by freeing industry from the need to plan factories around a central steam-powered drive shaft. With the advent of the electric motor, industrialists could plan their factories around the flow of work rather than proximity to the drive shaft. In the same way, advanced electrical technology can free the architect/engineer from dependence on central mechanical equipment. Electrical devices for heating and cooling, integrated into building components, will replace the clumsy pipes and ducts now needed to deliver hot and cold air and water. As an example, electrified thin films or semi-conductors incorporated into glass walls could convert them into major heating and cooling elements, like radiant panel ceilings, thus turning a perennial energy-conservation problem into a solution."

Complementing the foregoing user advantages are some developments on the supply side. The continuing trend toward urbanization, with denser residential, commercial, and industrial development dictated by continuing increases in land costs, favors continued growth in electrical energy, for it is most efficiently generated and distributed in large quantities. Development of more efficient forms of generating electricity--magnetohydrodynamics, breeder reactors, and ultimately fusion reactions--will intensify the trend toward even faster growth in the electrical segment of our national energy supply.

In the meantime, however, designers need not await such spectacular developments to achieve substantial energy savings. They have barely begun to exploit the energy-conserving potential of current technology.

cooling

yearly energy used
per 1000 cfm to maintain
various humidity conditions



6

BUILDING STRUCTURE

BUILDING STRUCTURE

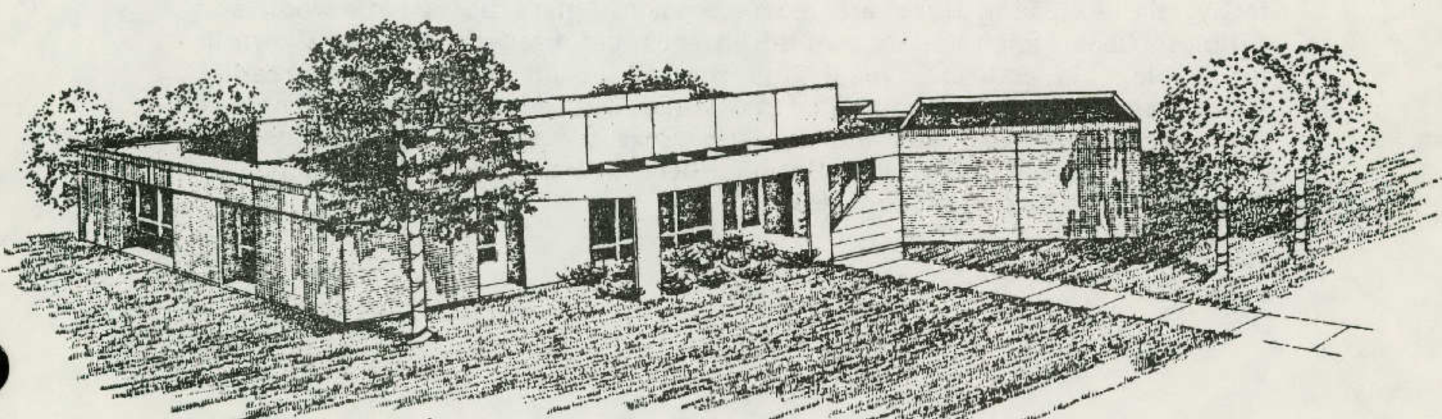
The building skin, the facade, is the most visible part of the building, and is the most expressive of the whole design approach. While it has had the historic role of allowing light and air into the interior of the building when required, keeping in desirable heat and keeping out unwanted heat, in recent years it has been drastically simplified to accommodate techniques of construction and performance requirements have been minimized since mechanical systems were considered totally capable of providing a satisfactory interior environment. A fundamental reexamination of the requirements and performance of building skins promises to allow major reduction in energy demands.

In the complete pattern of energy use in a typical church, the building skin is responsible for about 35 percent of the heat or air conditioning required to maintain prescribed conditions. This figure may be reduced by improving the thermal characteristics of both the glazed and opaque sections of the skin (including the roof).

Consider the following example: If the overall U-factor (including glass) is .44, by adding insulation in a cavity masonry wall, by increasing insulation in a curtain wall from 2" to 4" and by adding insulation between a masonry wall and the interior finish, the U-factor in opaque walls can be improved to .1. By going from single glazing to double glazing, the U-factor of the glazed areas can be improved from 1.13 to .67. These changes would improve the overall U-factor to about .22.

Energy Transmission and Resistance

The utilization of a large surface between inside and outside in order to reduce source energy utilization requires that the membrane that defines this surface be able to both transmit and restrict a number of different forms of energy flow depending on the availability of the various sources in the natural environment and the demand for these services at the building interior. In general, transmission is easier to achieve than resistance for conducted and convected energy transfer. Transmission is much more difficult in the case of radiated energy. If the building skin is to respond to varying situations it must, as stated above, modify these energy flow characteristics.



Extracted from: Reducing Energy Cost in Religious Buildings
by Massachusetts Energy Office.

Roofs, Ceilings, Walls, and Floors

A well-designed and constructed building "envelope" acts as a selective filter beween interior and exterior climates. It regulates the flow, into and out of your building, of light, heat, air and water vapor. The better the building envelope, the less you'll need to spend on energy.

Designing a new building with a good envelope, however, historically resulted in higher initial construction costs. Designs therefore were often "economized" by leaving out components such as insulation. While this did lower the initial construction cost, it also increased the annual operating costs. As long as energy remained inexpensive, the life cycle cost, or the sum of all construction, maintenance, operating, and demolition costs over the life of a building, was not dramatically impacted. But today, with energy costing over five times what it cost before the oil embargo, investing in a good building envelope makes much more economic sense. Improving the envelope of an existing building is also an excellent way to save energy dollars, although some improvements would require such expensive alterations that they would not be cost-effective.

In the section on air conditioning we've already discussed heat losses and gains through a poorly designed and operating ventilating system. Two other areas of great importance in your building are heat loss (or gain) by conduction through uninsulated exterior surfaces and by air infiltration through cracks around doors and windows.

Much of this discussion focuses on insulation, but there are other things you can do, too. Obviously, if there are openings caused by missing shingles or siding or any other kinds of holes in outside walls, they should be patched. Ventilation openings in attic areas however, should remain open as they are needed for adequate air circulation. Cracks in old floors may be covered over with linoleum, carpet, or some other floor covering.

Heat losses (and gains) through floors, walls, and ceilings can be substantially reduced by adding insulation. Of the many materials available today, the following three are most common: glass fiber, rock wool, and cellulose fiber. Each has its own advantages and disadvantages, as shown in the Table. In addition, you'll find that: not all materials are readily available everywhere; the price of the same material can vary substantially from one area to another; and actual savings for a given material depend greatly on the quality of installation (there are at present few standards regulating installation procedures).

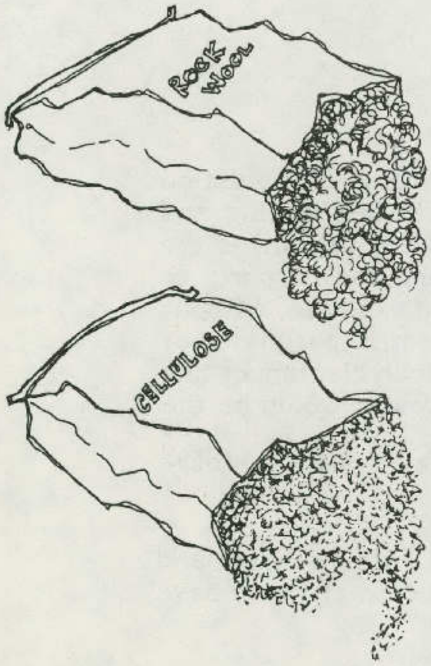
Savings From Installing Insulation

Area Insulated	Energy Cost Savings*
Floor	5%
Wall	10%
Ceiling	15%

*% of total heating and cooling costs

Savings achieved by insulating specific areas will depend on many factors. However, here are some rule-of-thumb savings stated as a percentage of total heating and cooling costs:

Adding insulation is not always feasible for architectural reasons. For instance, a cathedral ceiling constructed of exposed wood roof planks prevents the interior application of insulation for aesthetic reasons. If the roofing is old and is scheduled for replacement in the near future, it may be feasible to add insulation when the roofing is changed. Snow may also be a problem. A professional engineer should be consulted to be certain that the roof will be able to support the weight of snow that will accumulate when the interior heat no longer can melt the snow.



Characteristics of Insulation

Insulating Material	Thermal Resistance (R-Value* per Inch)	Fire Resistance	Adverse Effect of Abnormal Moisture
Glass Fiber (Batt)	3.1	Glass will not burn; backing will	Serious, but recovers well
Glass Fiber (Blown-in)	2.3	Non-flammable	Serious, but recovers well
Rock Wool	3.0	Non-flammable	Serious; recovers, but not as well as fiberglass
Cellulose (shredded newsprint)	3.7-4.2	Non-flammable Class I	Worst (will recover more slowly than others)**

*R-Value—a measure of resistance to heat flow. The higher the R-Value, the better the insulating value.

**Fire-retardant chemicals may be leached out by water.

When preservation of the existing building design prevents the addition of insulation, as in the case of many sanctuaries, the best way to save energy will be to control temperatures carefully, perhaps with a clock thermostat, so that heating or cooling is supplied only when the space is occupied. Actually, you should be doing this regardless of whether there is insulation.

Windows and Doors

Windows and doors deserve primary attention in any conservation program because together they can account for over half the heating and cooling load of a typical building. Air infiltration (air in and air out) is the major problem, because of settling or aging of the building and its parts or because of tolerances used in original construction. For example, without any weatherization there may be open spaces around the entire perimeter of a window. In a typical window, this may amount to 1/16 inch clearance; this may not sound like much, but for just one 3 x 5 foot window it would be the equivalent of a 12 square inch open area!

There are several things you can do to reduce the energy lost through windows and doors:

-- Replace loose caulking and putty around both inside windows and storm sashes (except for weep holes) and ensure that doors have adequate weatherstripping.

-- Install storm windows and doors.

-- Consider replacing existing windows with double or triple glazed sash.

-- Install automatic closers on frequently used exterior doors.

-- Turn off heating units in vestibules.

Special Consideration: Security Glazing

An unfortunate commentary on our society is the necessity to protect windows, and particularly stained glass windows, from vandalism. The most effective material which offers impact protection, full visibility from outside, and freedom from shadows from inside is polycarbonate, generally marketed under the General Electric tradename, "Lexan". Lower priced transparent acrylics such as methylmethacrylate, sold commercially as "plexiglass" or "lucite" are not sufficiently resistant to breakage in economical thicknesses to warrant their consideration. Further, they have a tendency to craze with age and exposure to sunlight, giving a translucent appearance.

If security glazing is contemplated, it will be economically advantageous to design the panel to perform double duty as a storm sash. A wood or aluminum frame, properly sealed to the building and with suitable weep holes to prevent condensation between the panes, will provide additional insulation at a low additional cost.

Will it be Cost-Effective?

As with any conservation measure, the financial implications of implementation should be considered. The level of investment that is economically justifiable depends to a large extent on how often the building is occupied. For instance, it would take longer to recoup storm window costs in fuel savings for a classroom than it would for an apartment because the classroom is used less frequently; the greater the use, the shorter the payback period.

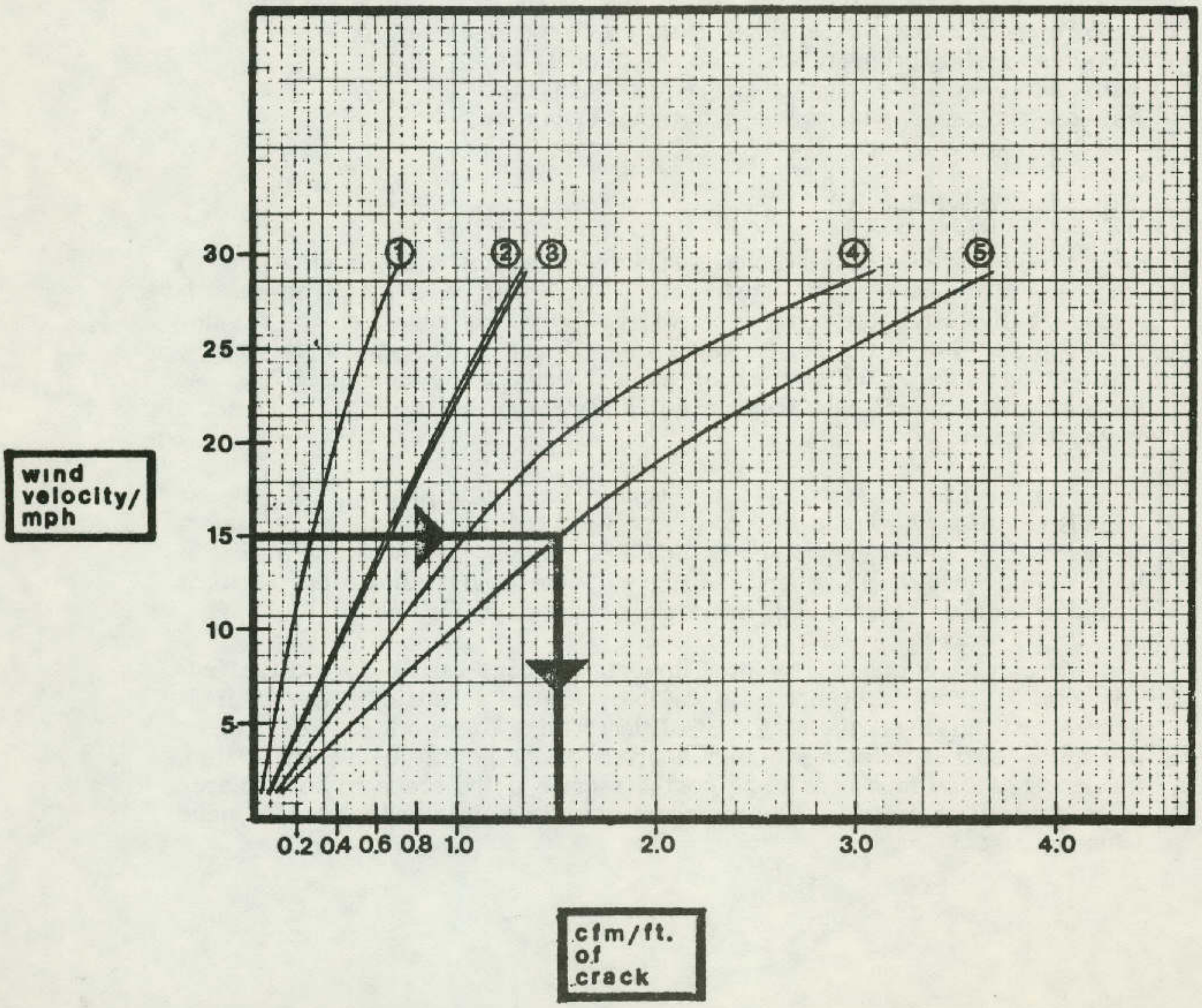
Some options, such as using double or triple glazing, may be so expensive that you would not consider them unless you had to replace a deteriorating building component (such as a window with a rotted frame) or unless you were building an addition. Some things, however, such as caulking and weatherstripping, are always cost-effective.

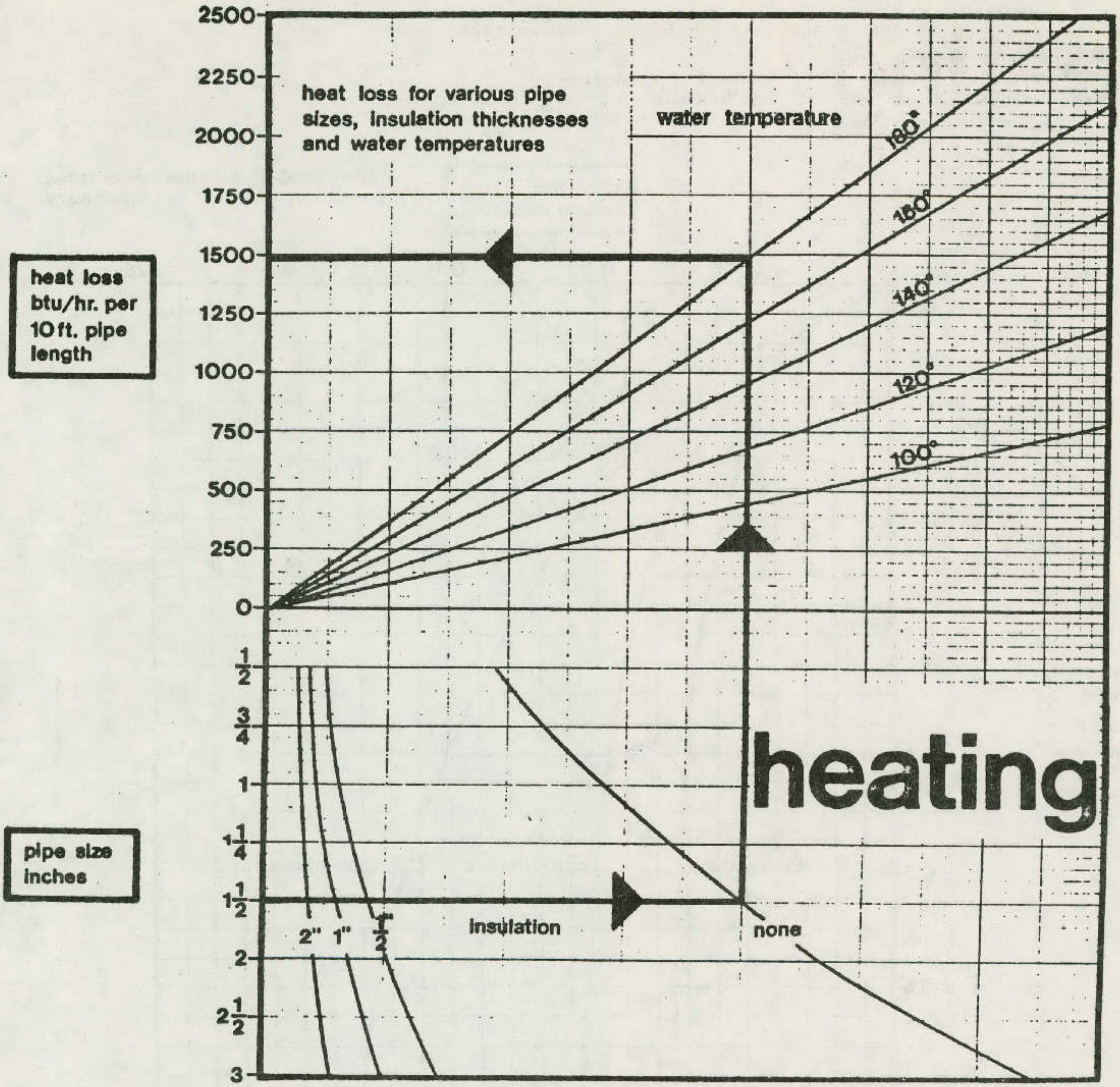
Insulating is one of the most important things to test for cost-effectiveness. Loose insulation can be blown into an attic space if it is accessible. However, the high cost of performing this work (25 to 50 cents per squre foot) requires a thorough analysis of the potential savings. Often, insulating will be found not to be cost-effective if the space to be insulated is used infrequently and if low temperatures are maintained when the space is unoccupied.

infiltration

rate of infiltration thru window frames

key to window infiltration chart (leakage between sash & frame)				
	type	material	weatherstripped?	fit
①	all hinged	wood	yes	avg.
		metal	yes	avg.
②	all hinged	wood	no	avg.
		metal	no	avg.
	dbl. hung	steel	no	avg.
③	all	wood	yes	loose
	dbl. hung	steel	yes	avg.
④	casement	steel	no	avg.
⑤	all hinged	wood	no	loose



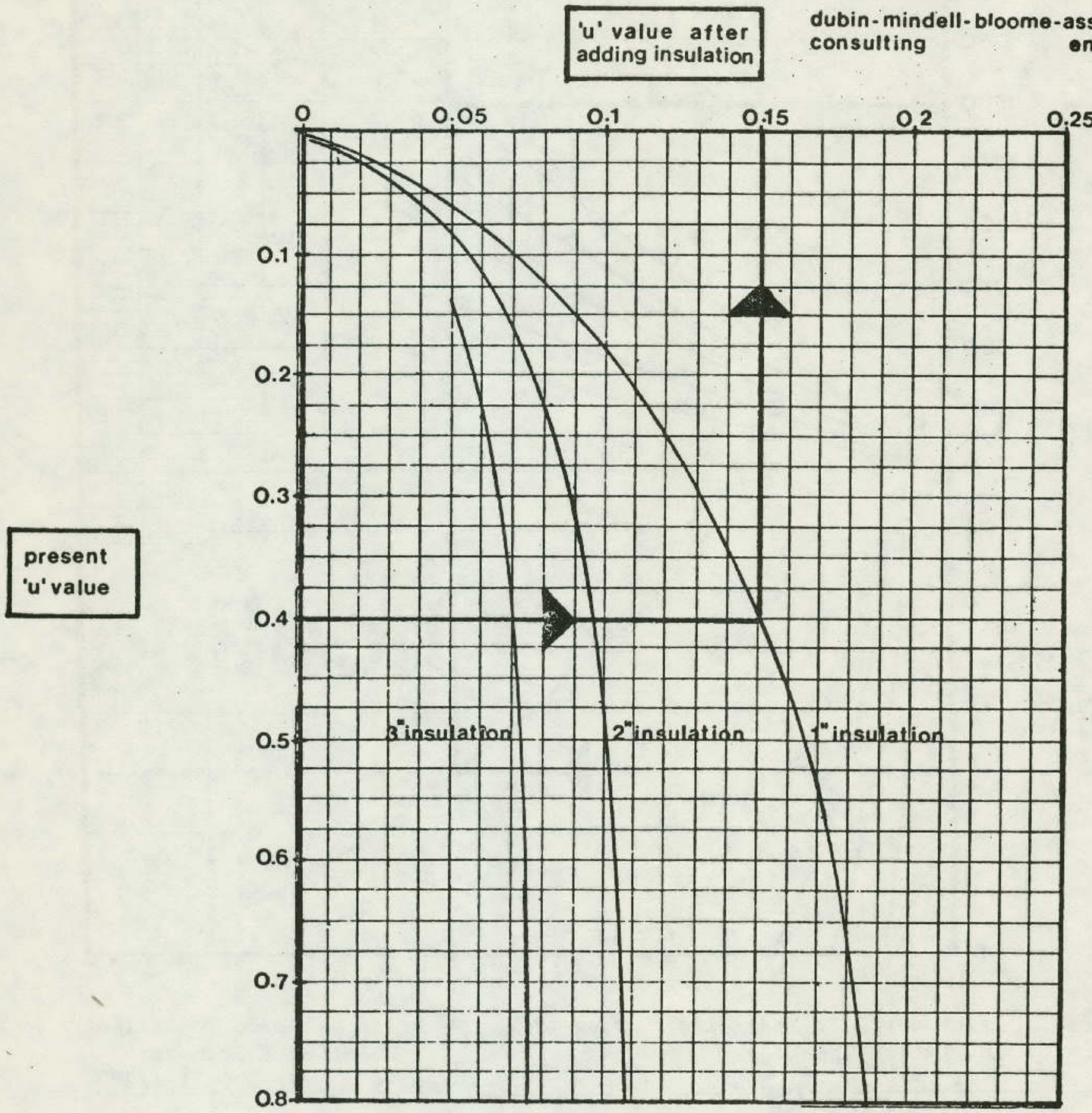


Pipe Sizes	Price per L.F. Installed Insulation Thickness: 1"	1-1/2"	Pipe Sizes	Price per L.F. Installed Insulation Thickness: 1"	1-1/2"
1/2"	$1.35	$2.05	6"	2.55	3.30
3/4"	1.40	2.10	8"	3.15	4.20
1"	1.45	2.15	10"	3.85	5.00
1-1/4"	1.50	2.20	12"	4.50	5.60
1-1/2"	1.55	2.25	14"	5.20	6.45
2"	1.60	2.35	16"	6.00	7.20
2-1/2"	1.65	2.45	18"	6.70	7.60
3"	1.70	2.50	20"	8.25	8.50
4"	2.00	3.05	24"	9.00	9.70
5"	2.25	3.15			

heating

effect of insulation on 'u' value

dubin-mindell-bloome-associates consulting engineers



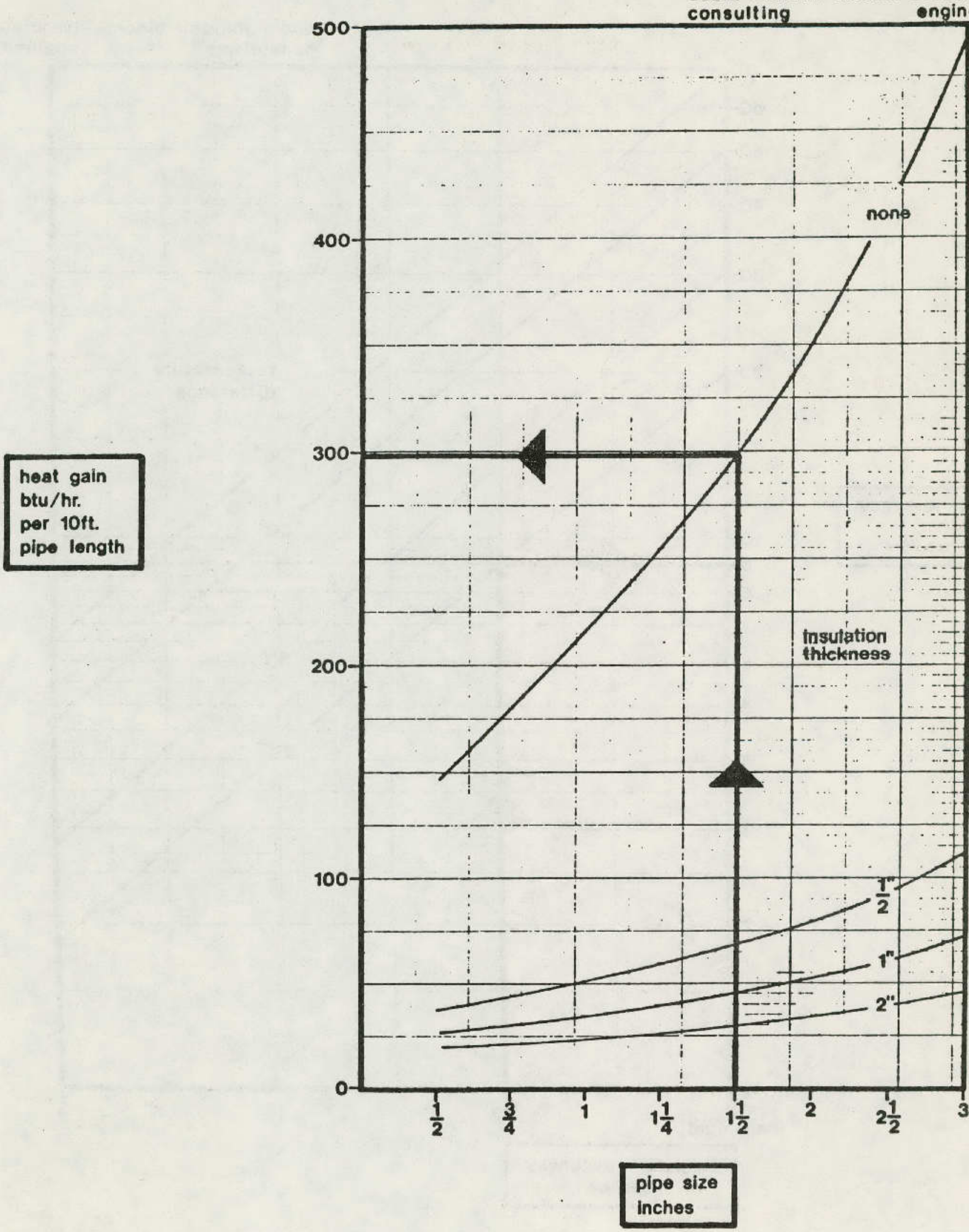
Approximate Insulation Costs for Walls

Rigid insulation on interior surface	$1.06/sq.ft.
Rigid insulation on exterior surface	1.80/sq.ft.
Rigid insulation on exterior surface with stucco finish	3.20/sq.ft.
Cavity fill mineral fiber	1.70/sq.ft.
Cavity fill plastic foam	.80 sq.ft.
External epoxy coating	.42 sq.ft.

cooling

heat gain for various pipe sizes and insulation thicknesses 45° water

dubin-mindell-bloome-associates consulting engineers



duct insulation

heat loss/gain
for various
insulation thicknesses

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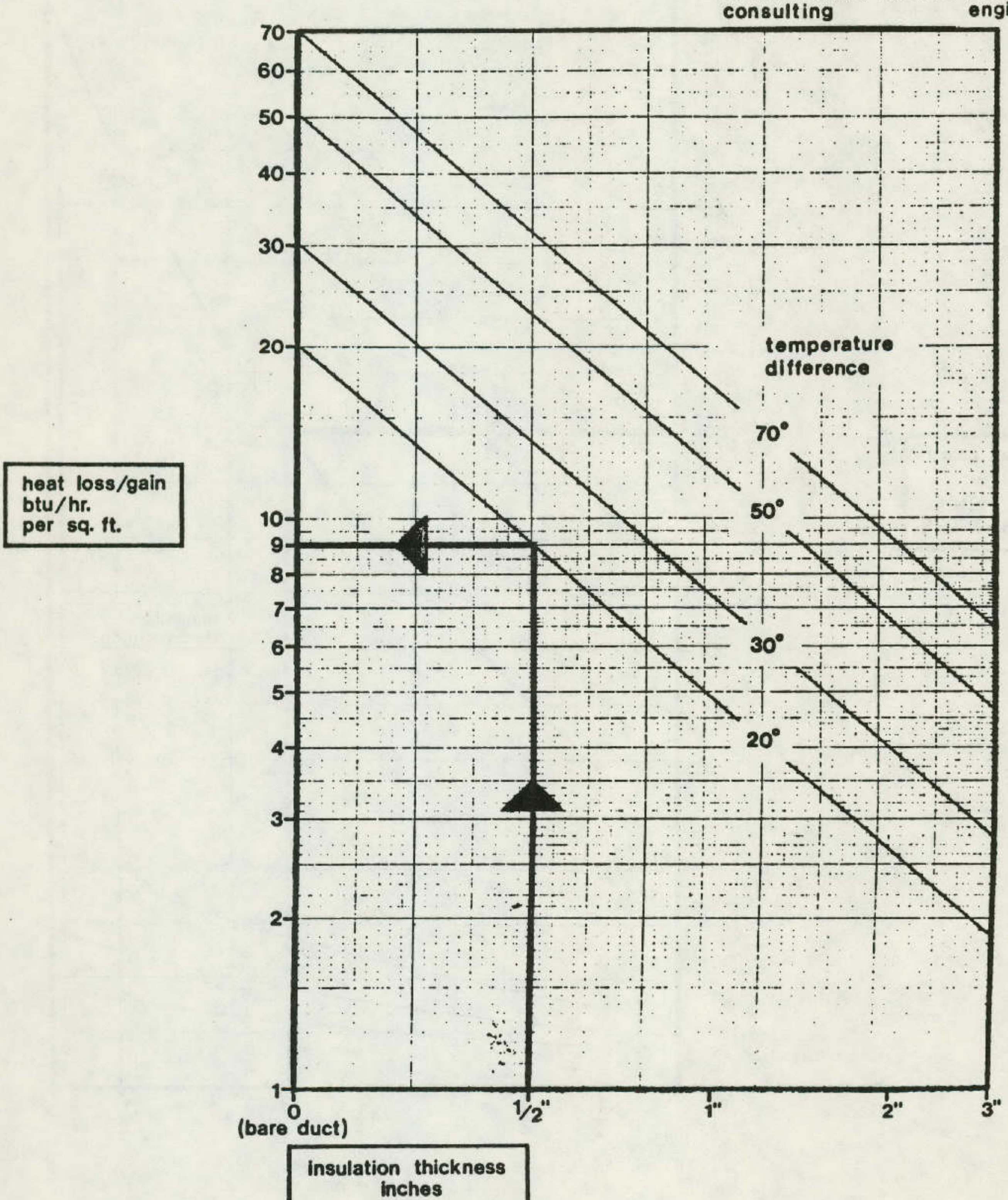
consulting engineers



• heating

yearly heat loss through windows - latitude 25°N-35°N

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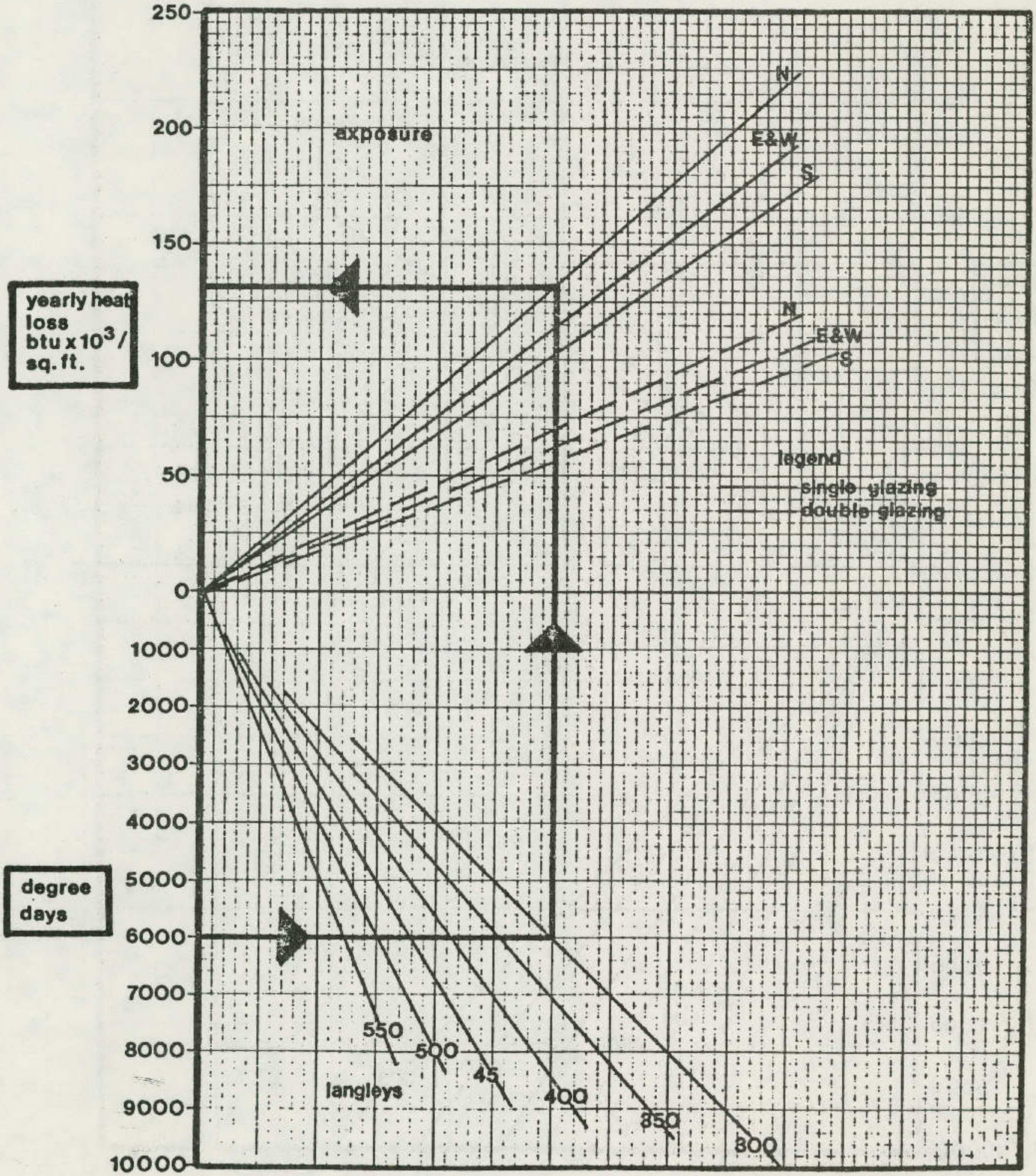

heating

yearly heat loss
through windows -
latitudes 35°N-45°N

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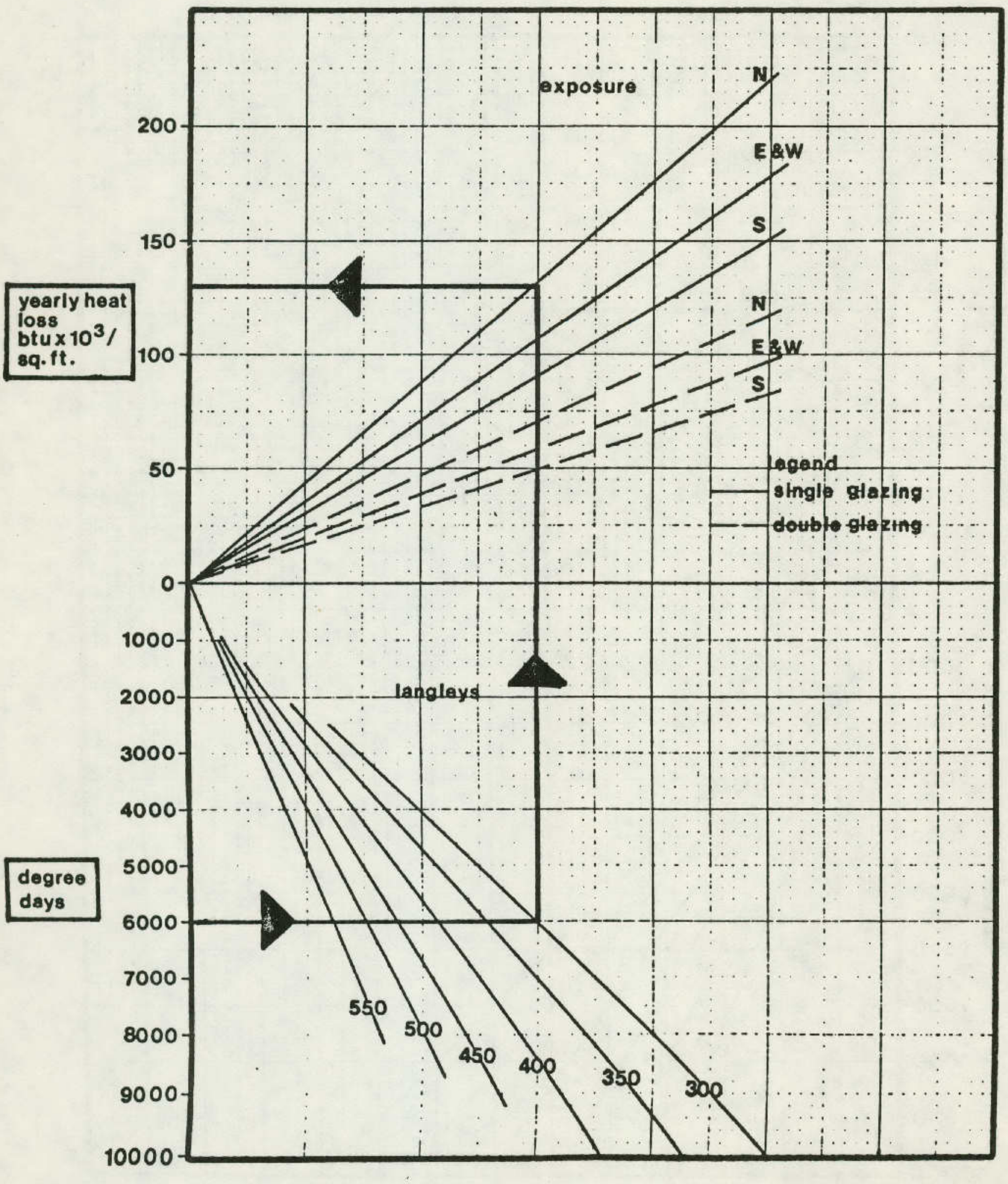

cooling

yearly solar heat gain
through windows
latitude 25°N–35°N

fig. 49

dubin-mindell-bloome-associates
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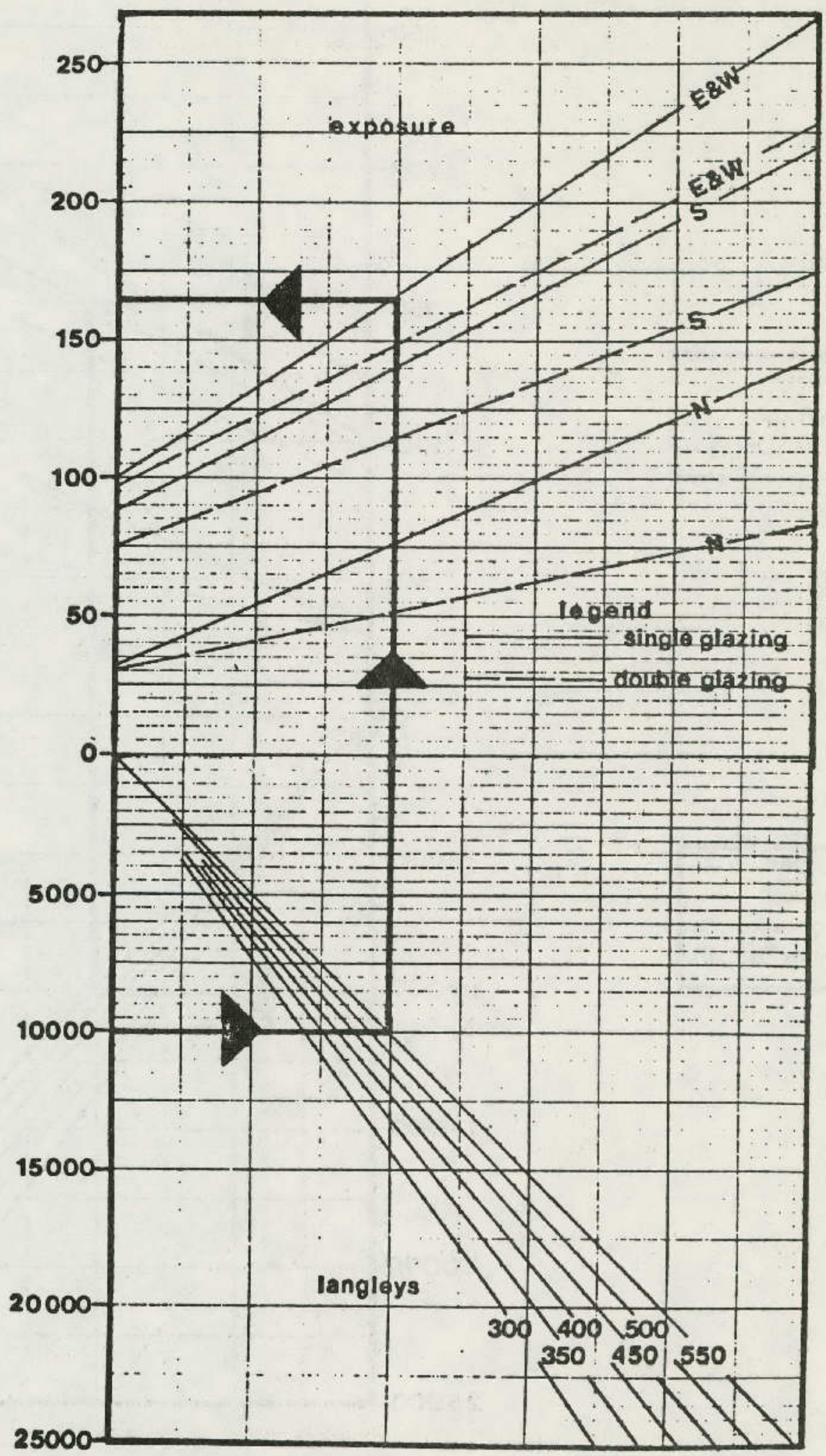
yearly heat gain btu x 10^3/sq.ft.

annual dry bulb degree hours above 78°F db



cooling

yearly solar heat gain through windows latitude 35°N–45°N

fig.50

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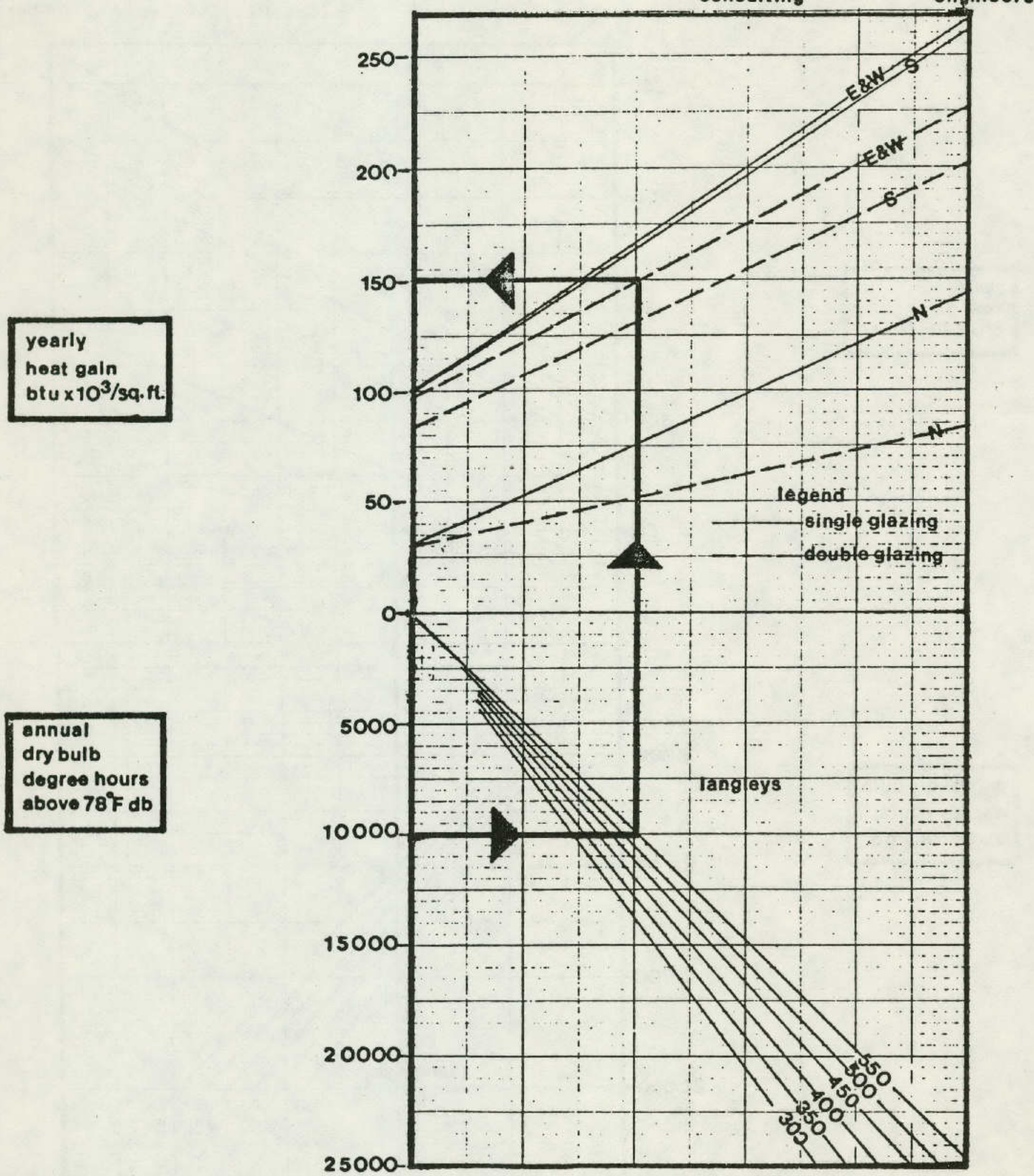

cooling

yearly conduction heat gain through windows

fig.51

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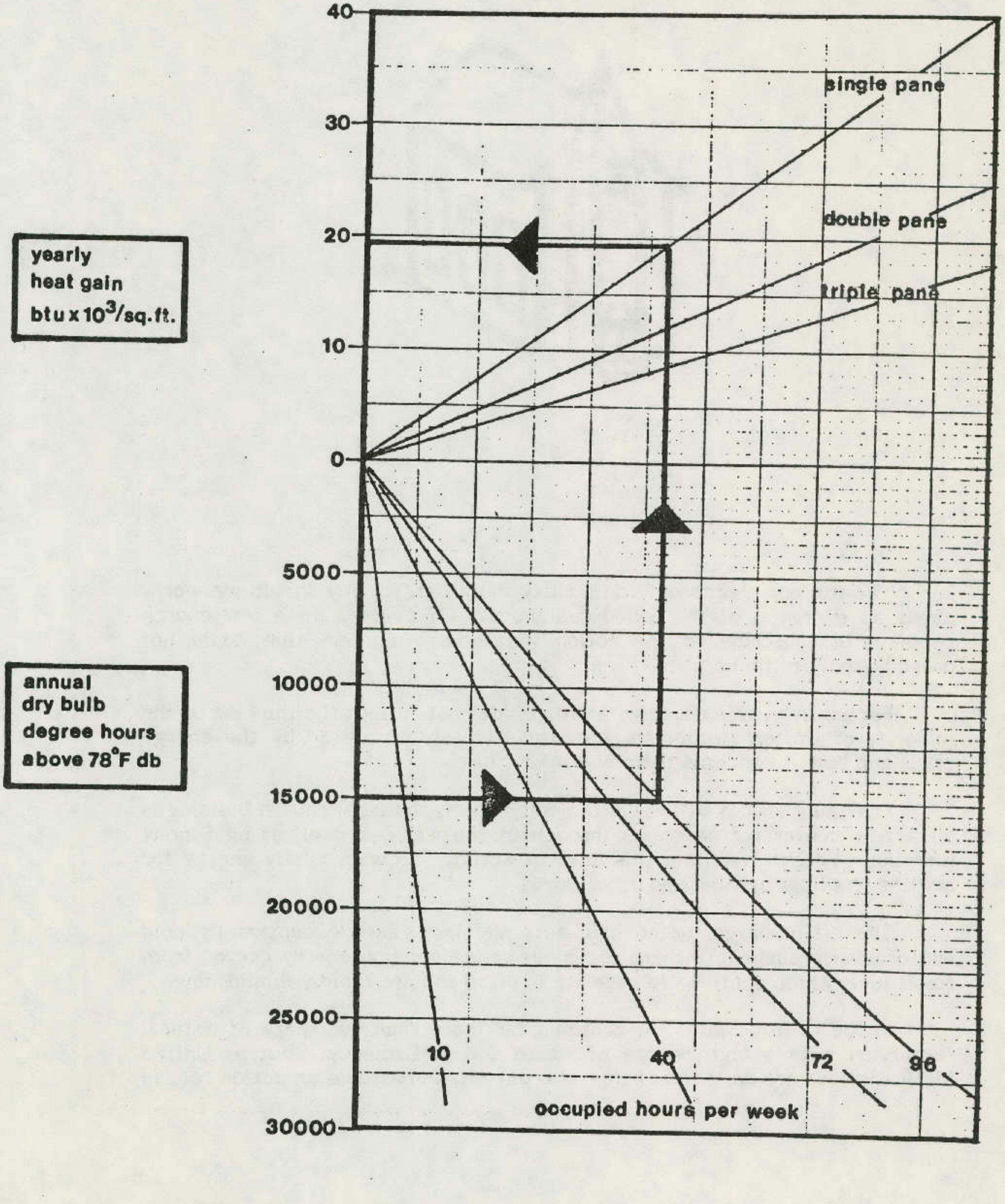
consulting engineers



YOUR CHURCH AND ENERGY

"We use our church only on Sunday mornings, so why should we worry about an energy crisis?" Sound ridiculous? Of course, but a few church people still subscribe to the notion that energy conservation could not possibly apply to them.

Fortunately, this negative attitude does not reflect the thinking of the majority of United Methodists who are sincerely perplexed by the energy crisis and how it concerns them and their church.

Providing visible witness in the community, the local church building is an active center for programs throughout the week, as well as on Sunday morning. Yet, to maintain this level of activity requries costly energy for heating, cooling, lighting and other needs.

The oil embargo, urban blackouts and last year's exceptionally cold winter have brought into sharp focus our dependence on energy derved from fossil fuels which continue to escalate in price and are rapidly diminishing.

In the United States we consume far more than our share of natural resources, with a high degree of waste and inefficiency. But as United Methodists we are called to change this pattern and assume an action role in creating the kind of world our Social Principles (1976 Discipline, paragraphs 70, 70B) indicate:

> All creation is the Lord's and we are reponsible for the ways in which we use and abuse it. Water, air, soil, minerals, energy resources, plants, animal life, and space are to be valued and conserved because they are God's creations and not solely because they are useful to human beings. Therefore, we repent of our devastation of the physical and non-human world. Further, we recognize the responsibility of the church toward life style and systematic changes in society that will promote a more ecologically just world and a better quality of life for all creation....Further, we urge the development of renewable energy sources, that the goodness of the earth may be affirmed.

While we must promote development of alternative, non-polluting, non-depletable energy sources such as solar power, we must also conserve the energy we now use.

Conservation Now!

How can this be translated into local church action? First, many church buildings are notoriously uneconomical from an energy perspective. Many older structures "leak" heat like a sieve. Providing this to correct that situation is the focus of this article.

Second, local church Trustees frequently are uninformed or indecisive about remedial, energy-saving applications. While they may be the first to express concern over high fuel bills, they often are reluctant to make the necessary investment for energy conservation.

For example, an ecumenical seminar on church energy conservation last fall drew a lower turnout than expected because many churches balked a the "high" registraiton free of $45 per person.

Yet, information provided at the seminar demonstrated how three church buildings could reduce their current costs for electricity, gas and oil by 15 to 30 percent annually with a minimum or no expenditure. Those attending were quick to confirm the usefulness of the seminar in their evaluations.

Assuming interest and concern exist, what are the best ways to reduce energy costs? The answer is, quite simply, "reduce": reducing **inefficiencies** in the heating, cooling and distribution systems; reducing **demand** for heat and energy by lowering temperatures and turning off unnecessary equipment; and reducing the building **load** by insulating against conduction and infiltration losses through the building. These are the primary and most effective methods for conserving energy in buildings.

Reducing Inefficiency

According to a recent government publication, a periodic checkup and maintenance of home heating and cooling equipment can reduce fuel consumption by 10 percent. That figure will increase in most chruches, since few churchboilers are as routinely checked or maintained as home furnaces. Locating a good heating/cooling specialist, following recommendations and having ongoing service are good ways to insure that mechanical equipment stays in top fuel-saving condition.

Contact local fuel suppliers or heating/cooling repair specialists for further information on servicing and tuning of your system. Many of these companies offer service contracts for an annual fee that provide routine inspection and repair services. This keeps equipment running efficiently, reduces fuel consumption and diminishes the possibilities of component part failure or repair.

Since each mechanical system differs, there are different procedures for keeping them at operating efficiency. Generally speaking, these items need attention: burners, dampers and draft regulators, blowers, filters, pumps, fans, thermostats, radiator valves, flow and safety control valves.

Do-it-yourself maintenance can include "bleeding" air from hot water systems, draining excess water from steam systems, changing or cleaning air conditioning filters (every 30 to 60 days) and cleaning condenser coils. However, most servicing requires a qualified person skilled in heating and cooling equipement repair. Do not attempt repairs or adjustments of equipment without expert advice.

Maintenance of the distribution system also affects heating and cooling efficiency. With hot water and steam heating, regular service and repair of radiators is critical to operating efficiency. Uninsulated pipes in unused spaces also result in a heat loss.

Reducing Demand

Obviously, the least expensive way to realize energy savings with most systems is lowering the thermostat temperature in the winter and raising it in the summer. The English and Europeans have long since adapted to cooler indoor winter temperatures and warmer summers. Generally, a range of 65-68 degrees Fahrenheit is recommended for winter and 75-78 degrees in summer.

As a relative guide, the following chart and map estimate savings in fuel costs for homes in different areas of the country by turning down temperatures five to eight degrees. The charts are from **In the Bank...Or Up the Chimney?** a publication of HUD (Housing and Urban Development), a department of the federal government.

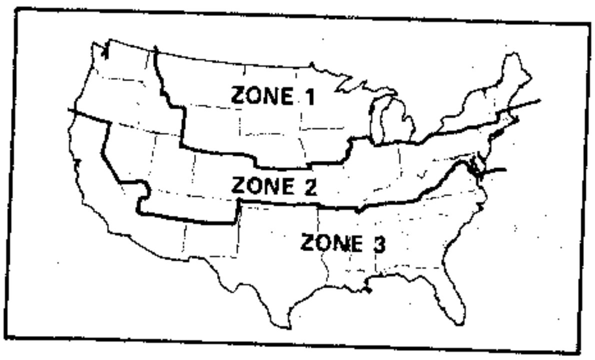
In a study conducted on three church buildings of different sizes in Springfield, Mass., the average annual savings by reducing temperatures to 65 degrees when in use and 55 degrees when not in use was about $450 for the two smaller churches. For the larger church, a 10 degree night setback, coupled with calibrated thermostats and regular boiler maintenance, would realize a savings of $2,400 annual.

NOTE: Since many building mechanical systems installed in the past wp years are based on a "design temperature" of 72 degrees Fahrenheit, it is not always wise simply to change the thermostat setting. In these systems, changing the setting can be self-de feating, since this will introduce outside air to raise or lower the room temperature to the new setting. Consult a mechanical engineer before changing the temperature in newer systems.

Perhaps the most inefficient consumption of energy in church buildings is due to inadequate or nonexistent zoning of heat and cooling. For example, many older church buildings have the entire heating system operted by one thermostat. It is necessary to heat the entire building (including the sanctuary with its higher ceiling-) simply to warm a classroom or the pastor's study.

Given the variabe use patterns of most church buildings, it is unwise to rely on single zone heating. New construction should have a variety of zones with individual thermostatic control. In existing buildings it is generally cost-effective to add zone capacities or to install electric heating (or cooling) units in the areas used most frequently. Through-the-wall heat pump units are particularly useful in the pastor's study since they provide both heating and cooling in a single, self-contained unit.

Increasing the efficiency of the heating and cooling systems, and reducing the demand through temperature lowering will not produce significant savings if the building "leaks" all that efficiency through conduction and infiltration. If you have taken steps described above, you now need to protect the building thermally. This can be accomplished with insulation, weatherstripping, storm doors and windows, shading, shutters and/or outdoor landscaping.



The table below tells you what percent of your heating bill you'll save by turning down your thermostat. Look at the map above to see which zone you live in. Read the column in the table for that zone. Circle either the top or bottom number in that column -- you'll need it after you figure out your heating bill.

Circle the top number if you want to see what you'll save with a 5-degree turn-down from your usul setitng.

Circle the bottom number if you want to see what you'll save with an 8-degree turn-down from your usual setting.

	ZONE 1	ZONE 2	ZONE 3
5° turn-down	14%	17%	25%
8° turn-down	19%	24%	35%

Table 1

Insulation

Heat naturally rises and in an uninsulated building the ceiling only briefly interupts that flow. While this may eliminate the need to shovel snow off the church roof, it does little to save on fuel costs.

The Springfield survey found heat loss through the roof varied from 20 to 36 percent of total building heat loss. Adding ceiling or roof insulation to the smaller churches is projected to save about $300 annually, while in larger churches it could be almost $2,000.

The same argument applies for air conditioning. The amount of ceiling insulation needed varies with the climate, type of construction and amount of existing insulation. In most areas of the coutnry, it is not cost effective to add if there are already six or more inches of insulation. The exceptions are with electric heat systems and in particularly cold climate regions.

In the three churches studied, the initial cost of roof insulation would be offset within two years in the large church and in six to eight years in the smaller churches.

Wall insulation is generally more difficult to add in existing buildings, particularly those of solid masonry construction. Again, need will fluctuate with the same conditions as with ceiling insulation. While ceiling insulation often can be accomplished with do-it-yourself labor, wall insulation frequently requires subcontracting. This noticeably increases the cost.

Basement and solid masonry walls can be insulated from the inside with rigid insulation or with furring strips and batt-type insulation. Then a new wall finish material is applied over this, creating an entirely new furnished room. Carpeting basement floors helps provide a thermal barrier that does not reduce fuel bills, but does increase comfort.

Another area for insulation is under floors with crawl spacs. Although heat loss here represents a small proportion of the total buildings loss, this thermally protects the buildings and elimiantes cold floor surfacs and drafts. Warm air and air conditioning duct work and hot water pipes exposed in crawl spaces should also be thoroughly insulated to prevent losses.

Weatherstripping

Not surprisingly, a good deal of our hard-earned money goes out the window. Building heat loss through glass areas can be significant and, in some cases, greater than any other place. Infiltration or air leaks through cracks around windows, doors, eaves and direct transmission through glass areas represented an average of 28 percent of the total heat loss of the three churches studied.

Weatherstripping doors and windows and caulking around frames would seem a reasonable cost effective intervention. As it turned out, caulking and weatherstripping all windows was only cost effective in the large church where a $4,000 investment would render a $2,400 yearly savings in fuel costs. While caulking and weatherstripping were not as cost effective in the smaller churches, this was due in part to substantial savings through boiler maintenance and zoned heating.

For the majority of church buildings, caulking and weatherstripping are easily performed by a volunteer labor force. An ambitious Saturday work crew could feasibly complete the entire task in a single day. A good job of installation will have a life span of seven to ten years.

The more expensive alternative for preventing heat loss through glass area is additional layers of glass or plastic, commonly known as storm windows. Air space between layers creates the thermal barrier, so that the storm window can be be as simple as a sheet of six mil thickness polyethylene plastic stapled to the outside window frame.

Permanent storm windows added to existing buildings seldom have a desirable benefit/cost ratio because of the high initial investment cost. However, when you are repairing broken windows, you should consider the possibility of replacement with "thermalpane" or similar double glazed windows. There is the aditional consideration of breakage or vandalism with large stained glass areas. Often heavy gauge, unbreakable plexiglass overcomes this dilemma by providing a vandal-proof thermal barrier.

Less costly than storm windows, but in some cases just as effective, is a variety of window thermal barriers such as shutters and thermal curtains. Tight-fitting shutters constructed as sandwich panels with rigid insulating board will provide an adequate barrier to heat loss. For convenience these are best located on the inside of the building.

Shutters hung outside the windows could be lined with a reflective surface that would maximize solar heat gain when open and exposed to the sun and act as a better insulator when closed.

Thermal curtains serve essentially the same function and can have the additional feature of enhancing the appearance of the room. Since many church heating systems are designed with radiators or heat supply ducts under windows, thermal curtains must be arranged in a fashion that keeps heat from being trapped behind the curtain rather than inside the room.

Landscaping

Stepping outside the building for a minute, we find a variety of landscaping techniques that not only enhance appearance but also reduce the building's exposure. Planting shrubbery and evergreens along the building facade which receive the prevailing winter winds (generally the north and west sides), will protect the building and lessen heat demand inside. Planting deciduous trees along the eastern, southern and western facades will shade the building in the summer and expose it to the sun's warmth in the winter.

Since the sun appears lower on the horizon during the winter, southern glass exposure allow solar heat gain. This is essentially the principle of a passive solar heating system. A shading device or building overhand will prevent undue heat gain in the summer.

Building Use

Scheduling activities in the building spaces should follow a common-sense approach corresponding with the seasons.

During the winter, rooms along the east and south should be used for morning activities, and rooms long the south and west for afternoon and evening programs. In the summer, the process is reversed.

Implementing an Energy Program

While lowering building temperatues can be done immediately, raising our energy consciousness require a lot of work! For local church groups a carefully-planned and executed program of research, training and financial investment will insure a good process for the task.

Here is Help

The National Division (Board of Global Ministries) Office of Architecture responds to the energy issue for church buildings on two levels: energy conservation in existing and new buildings, and solar energy installations for churches.

An energy conservation manual for church buildings will soon be completed and should be available for distribution this spring. The office is also sponsoring a variety of energy-saving seminars and training ventures for local church Trustees.

In the field of solar energy, the National Division has offered donations of up to $5,000 for eight selected United Methodist churches utilizing solar energy installations. This is part of an ecumenical project sponsored by the Joint Strategy and Action Committee (JSAC). Other participating denominations are the American Baptist Churches and American Lutheran Church.

Recipient churches are being selected form a broad range of geographical locations, social environments and economic capabilities. There will be at least one solar project in each of the four climatic zones of the United States: Cool (North Central; Temperate (Mid-Atlantic, Midwest and Western); Hot-Wet (Southeast); and Hot-Dry (Southwest).

For further information, contact: Office of Architecture, National Division, 475 Riverside Dr., Room 307, New York, N.Y. 10027.

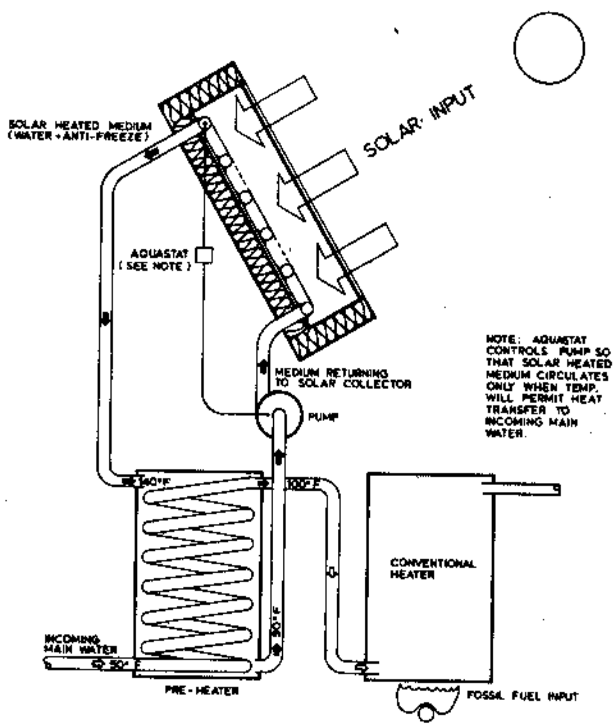
SOLAR ENERGY SYSTEMS

SOLAR ENERGY SYSTEMS

Solar energy obviously has tremendous potential because the energy is free. Unfortunately, the systems required to harness that energy are not free. In fact, the cost of these systems in past years has kept solar energy more of a concept than a practicality. Now that the cost of energy has risen so dramatically, however, the cost of solar energy systems have become more realistic. The fact that the energy source itself is both infinite and pollution free are two additional positive factors.

Engineering feasibility studies of solar energy systems can be performed by qulified consultants who can select equipment for analysis, estimate costs, and predict annual performance. Because the initial investment required to install one of these systems is significantly higher than that required for conventional systems, special care is necessary to ensure that life-cycle cost economics are determined accurately.

At present, solar energy is used primarily for domestic hot water heating and, to a lesser extent, space heating.



1. Domestic Hot Water Heating: Solar water heaters have been used for more than 30 years throughout the world, especially in Israel, Australia, and Japan. Current high costs of energy now have awakened far more general interest. Solar water heaters may be economically feasible in some hospitals and/or hospital-related buildings, such as a nurses' quarters. Generally speaking, however, it usually is not economically feasible to use a solar system for 10% of domestic hot water requirements unless:

   -- the collector is used for additional services;

   -- hot water temperature requirements do not exceed 90F;

   -- an existing storage tank is oversized for the building requirements, and the building is located in a temperate or hot climatic zone.

   Solar water heaters are commercially available in the United States as components offered separately or together in a complete package. Components include a flat plate collector, storage tank (existing storage tanks can be used), piping, controls, circulating pump and, in climates where the collector is subjected to freezing weather, a heat exchanger with a secondary pump, piping circuit and anti-freeze.

   The thermal performance of a solar water heating system depends upon:

   -- climatological and meterological conditions;

   -- solar collector size, design, and construction;

   -- orientation of the collector and tilt angle with the horizontal;

   -- size of the storage tank; and

   -- temperature of the domestic hot water.

   For normal hot water use, approximately one square foot of collector per one gallon of hot water used per day is adequate. If kitchens or other processes require hot water at elevated temperatures, collector area required is from 25% to 50% more. The solar collector can be mounted on the main roof, on the roof of a building extension, on spandral beams, or off-site. Although each installation must be considered a unique subsystem, the following solar collector installation guidelines should be considered:

   a. Provide adequate structural support to carry the dead weight (12 lbs./sq. ft.) of the collector plus wind loading.

   b. Orient the collector 10^{o} west of due south if possible, but 20^{o} either side of due south will not materially affect the performance. If the orientation must be farther to the east or west, plan on additional collector area.

c. If the collector is used solely to supply hot water, a fixed tilt of latitude plus 10^{o} will usually be optimun -- variations of 10^{o} up or down will not seriously affect yearly performance.

d. Collector must not be shaded more than 10% of the time, or a larger collector area will be required.

e. Provide approximately one square foot of collector and one gallon of hot water storage capacity per 16 gallons of hot water used per week.

If kitchens or other processes require hot water at elevated temperature, provide one square foot of collector per 20 gallons of hot water used per year.

f. The existing domestic hot water heating system, even though inefficient or undersized, will usually be adequate when supplemented by the solar collector system.

2. Space Heating and Cooling: Prior to 1972, only about twenty solar-heated buildings were erected in the United States. Of those, only one was an institutional building. Since 1972 there has been a proliferation of solar energy activity in the United States, for both new buildings and existing buildings.

The hardware for solar space heating and cooling includes solar collectors, piping, controls and storge systems which are similar to those used for domestic hot water heating, but with the following major differences:

-- The required collector area and storage volumes must be larger and are more costly.

-- Collectors must produce hotter water temperatures for space heating, and hotter still for cooling. Temperatures up to 180F are desirable, but lower temperatures can be used. The orientation of the collector is more critical.

Absorber plates with reflective surfaces rather than flat black coating are more economically feasible for heating and cooling applications than for solar water heating alone.

Interface with existing heating and/or cooling system is critical.

-- Storage systems must have a greater heat storage capacity per square foot of collector.

-- Rocks of phase changing salts can be used for thermal storage instead of water in some cases.

-- Collectors can be air instead of liquid heating types in selected applications.

-- A full sized back-up heating system is required to supplement the solar system.

In most areas of the country, the cost of retrofitting a 100% solar energy heating and/or cooling system into an existing religious facility is presently prohibitive. However, using solar systems to supplement by a conventional system may be highly cost effective. In either event, capital investment and health care requirements demand that a comprehensive feasibility study be conducted first to establish both cost-effectiveness and reliability of a solar or solar-assisted system.

National Division Solar Energy Program

The Congregational Development Program Unit of the National Division is participating in the J.S.A.C. Church Development Task Force program for Conservation of energy in Chruch Buildings through:

1. A survey of churches in each of the climatic zones of the United States to determine the impact of rising fuel and building maintenance expenditures upon chruch programs, and

2. Providing donation funds of up to $5,000 to each of eight (8) selected local church projects (new construction or renovation that include a supplementary heating system which uses non-fossil fuel, or utilizes a fossil fuel system which is efficient and well integrated into a solar heating system. Selection criteria for the projects are to be administered by the Office of Church Extension and the Office of Architecture. Participating churches must be willing to cooperate with the evaluation procedures and promotional efforts of the J.S.A.C. Task Force.

Participation Cost:	$ 1,000	for J.S.A.C. administration
	100	for survey
	40,100	for donations for churches to absorb some of the additional costs related to solar design, hardware, and construction.
	$41,100	TOTAL
In-Kind Funding:	Staff travel and time for monitoring projects.	
	Program promotion and interpretation through chruch periodicals.	

Rationale:

One of the problems confronting the world today is the need to conserve the natural resources of energy that exist. This need interacts with other world-wide problems such as food production, shelter, population control, employment, pollution, transportation and other related human needs. This proposal recommends utilization of alternative energies that are recyclable, non-polluting, efficient and cost effective -- solar and wind energy.

Utilization of solar and wind energy holds the promise of a harmonious relationship between humankind and its environment. For too many years we have held onto the concept that humankind has dominion over the remainder of creation, and, therefore, can exploit nature to its own end. It is suggested that our attitudes and our lifestyles and thus theology and philosophy, need new direction. Scarcity will lead to an enlightened understanding of the stewardship of God's creation and how our individual and corporate lives impact that creation.

The cost of fossil fuels has doubled in the last four years. Studies indicate that the cost may well double again in the next four years and increase an equal amount in the four years after that. This proposal sets forth a challenge to our denomination to work collaboratively on the national problem of energy conservation within the context of the institutional chruch.

Solar Building Work Group -- A JSAC Related Committee

Criteria for Project Selection

1. That there be a regional distribution of projects selected to cover all four climate types of "cool, temperate, hot-dry and hot-wet." Additional projects should be distributed as widely as possible geographically and climatically.

2. That there be a cross section of churches by location such as urban, suburban and rural; and also by project size of small (5,000 to 7,000 square feet), medium (7,000 to 9,000 square feet), and large (9,000 to 12,000 square feet).

3. That the regional, state and national staff executives of the participating denominations be involved in the process through joint sponsorship.

4. That the owners of each demonstration project accept the goal and objectives of this project.

5. That the financial feasibility of each project is assured.

Further, that these design criteria be met by each participation church project:

1. Reduction of heat loss in each building to 50% of FAH "minimum property standards" for the area through increased insulation and reduction filtration.

2. Utilization of solar energy in the demonstration project as the major source of energy for space and water heating for at least 50% of the design heat loss.

3. That a supplementary heating system be provided which uses non-fossil fuel if possible, or utilizes a fossil fuel system which is efficient and well integrated into the solar heating system.

4. That the solar heating system be designed so that it is capable of keeping the building about 32°F. in severe weather without the supplementary heat.

5. Ventilation which utilizes environmental conditions in such a way that air conditioning is not needed, or a solar powered air conditioning system. (This requirement given the present state

of solar cooling technology will be very difficult in the hot-humid region and may be modified to allow the use of a heat pump for air conditioning if it is integrated into the solar system.)

6. Maximum utilization of space, thereby limiting the size of the building. Multi-purpose planning is essential in relating design to program.

7. If feasible, wind energy should be used to supply electrical needs.

8. If acceptable with local code regulations, the use of water should be reduced either by installing low water consumption toilets (using 3 to 3½ gallons per flush) or by the use of alternative waste disposal systems such as bio-gas, composting, or other forms of recycling.

To insure full partnership and to allow the SBWG to secure the necessary information for evaluation, it is agreed:

1. That the congregation be willing to accept denominational participation and partnership for the duration of the project planning, construction and follow through evaluation.

2. That the congregation be willing to accept the intrusions of being a demonstration project over a period of five years.

3. That as a part of the partnership described above, that the congregation be willing to select architects, engineers and contractors acceptable to the SBWG.

4. That the congregation evidence their acceptance of participation in the demonstration project through affirmative congregational action.

Goals:

The goals of this project are:

1. to identify the trends since 1971 of escalating fuel costs and their effect on the program, maintenance costs, and mission giving of local congregations of our denominations in all parts of the U.S.A.;

2. to produce reliable and consistent knowledge for congregations building new buildings regarding:

   a. the efficiency and cost effectiveness of solar and wind energy systems as compared to traditional energy systems, and

   b. the reduction of energy consumption and costs;

3. to provide resources to congregations with existing buildings:

   a. to enable them to reduce consumption of fossil fuels, and

   b. to assist them to "retrofit" for solar energy.

ENERGY AND THE CHURCH

The Lord's finite creation is in increasing evidence today. We are faced with diminishing fossil fuels, and our technologies have polluted our ground, water and air. Yet wanton consumption of non-renewable energy sources escalates despite the warnings of limited supplies and an endangered environment. Increased cost has always been an inducement to change behavior. In the Christian context, however, more than simply self interest prompts responsible action. Because our Master is the "Man for others" we are called to consider the costs of an action, behavior, or policy upon others.

This is especially urgent in this time of scarce resources. Christians must look beyond the market system for allocating basic life commodities. Jesus taught that man does not live by bread alone. He also symbolically used bread to affirm that one reality which binds all human life together ("I am the bread of life," "Eat this bread in remembrance"). Humanity does not live by energy alone, but in our moment in history, it is that which brings East and West, rich and poor nations to one table. Human fulfillment will be in proportion to the energy consumed.

Rich nations continue to control the capital resources of the world. We enjoy the luxury of being able to accommodate to higher prices caused in part by our dependence upon imported petroleum. For the immediate future we can even afford to make some minor adjustments, such as turning down the thermostats in our homes and churches. But in poor nations, sacrifice is the way of life. While we accommodate to fewer creature comforts, they give up fertilizers and food production, falling deeper into the cycle of poverty, hunger, illness and death.

The Christian ethic compels the faithful to prevent the heaviest burdens of shortages from falling on those who have the least. The United Methodist Social Principles suggest two courses for responsible action. We are called to work for "systematic change" in society that would bring about a more just world. To this end, the church must remain active in public policy processes to provide an equitable distribution of the earth's vital resources among all God's people. Far less complex and more direct is the challenge to change "life styles". Individuals, families, and churches can significantly reduce energy consumption through affirmative steps in shifting our dependence from depletable to non-depletable energy sources.

The Rays of the Future: Solar Energy

While many technologies have been devised to offset our dependence upon fossil fuel energy sources, those that maximize our use of renewable natural sources (such as sun and wind) must be developed as alternatives. Local churches now have the opportunity to pioneer in the research and development of such a renewable "income" energy source: solar energy. Utilizing solar power for heating, cooling, lighting and energy demands can be our future with careful planning and a commitment to end our short--sighted drain of fossil fuels.

The earth receives a daily drenching of the sun's energy equivalent of several thousand times as much energy as we consume. The solar energy reaching the earth every three days is greater than the estimated total of all the fossil fuels on earth. If solar collectors could efficiently collect the solar energy available, the average church would receive many times more than the amount needed to meet its annual heating and cooling demand.

With all this potential, real progress in the solar industry has been stalled by the reluctance of architects, engineers, manufacturers and builders to shift from conventional to solar powered systems. Nor have prospective solar building clients been particularly encouraged when faced with the high initial cost of equipment and installation, and limited data on investment return. People are reticent to shed tested methods for heating and cooling, even though they may recognize the inefficiency of these systems and their dependence on a dwindling fuel supply.

Fortunately, the federal government, universities, big businesses and some enterprising citizens have taken a more active role in supporting solar research through funding and/or experimental projects. The probability of soalr powered residences, businesses and churches will soon be a reality as more people become familiar with solar heating systems, as fossil fuel prices escalate, and as test project data becomes widely available.

Before converting from conventional heating and cooling systems churches should plan study sessions with members to analyze the cost of different installations, architectural design, and types of systems.

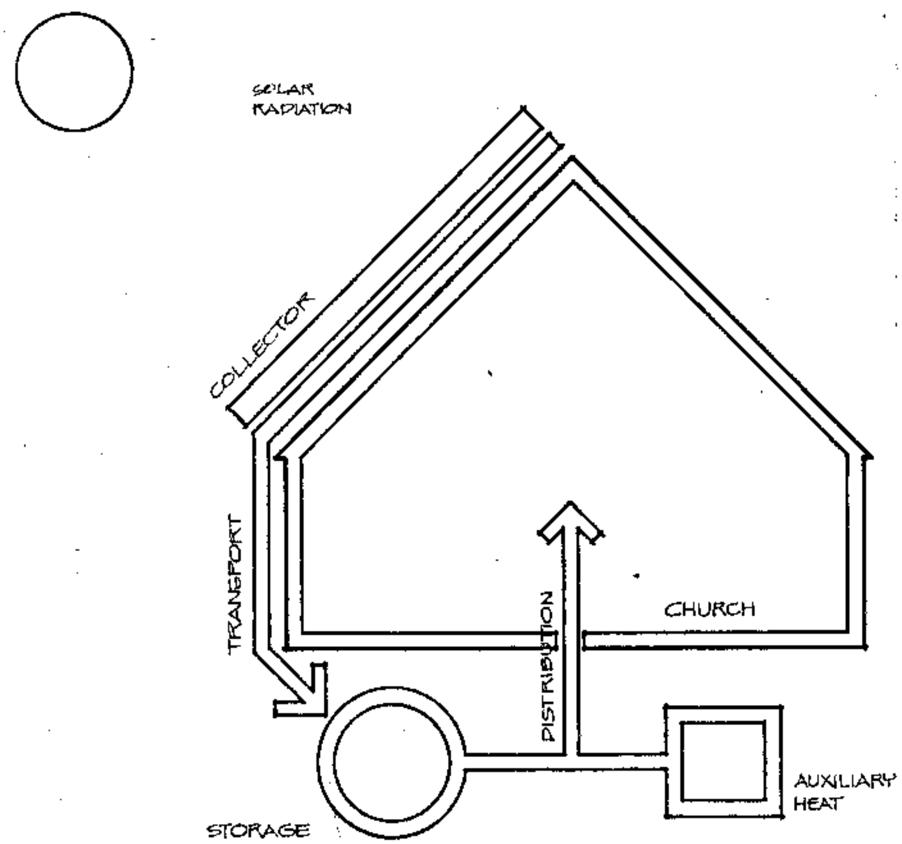
The cost of a solar installation is impossible to predict, varying with local energy need, technologies and equipment available, and type of installation. While solar space and hot water heating systems have a high initial cost, they promise lower maintenance costs and dramatically reduced fuel bills. Even with the high installation costs, solar heated residences have proved financially successful within 15-20 years. Studies are now being conducted to determine a "payback" period for solar installations in church buildings.

Architecturally, pitched roof church buildings lend themselves to solar installations. With southern orientation and a roof angle of inclination determined by the season of greatest need (a 60 degree angle from the horizon has proven the best angle for all seasons) a church can be designed to accommodate solar collectors. The possibility for installing solar collecting panels on existing churches depends on the solar orientation of the roof slopes, availability of storage area, and the aesthetics of an installation.

The type of solar installation must be determined by local conditions, including orientation, location, season, time of collection, and the prevailing climatic conditions. The sun's energy can be harnessed through two methods of collection: active or passive. Both solar collecting systems focus on careful site orientation to maximize the use of sun and wind energy.

A passive system generally consists of south facing glass walls shaded with building overhangs to allow exposure to the sun in the winter and prevent it in the summer. Often this south wall of glass is placed a few feet in front of a heavy, internal masonry wall to form a "thermal trap." The sun's rays passing through the glass are trapped in the airspace and "collected" by the masonry. For immediate heating needs, fans can pass the hot trapped air through the building to the desired space. The heat stored in the masonry will begin to radiate later in the evening as the adjoining spaces cool down. Coupled with the thorough insulation and weatherstripping needed for our buildings today, the passive systems can be very effective in reducing energy consumption, particularly during the milder seasons of fall and spring.

Active solar collecting systems can store heat for several days use and assume a greater percentage of a building's space and hot water heating demands. While it is technically possible to achieve almost 10 percent solar heating, a more realistic and economically feasible goal with today's solar technology would be 70 percent solar space heating and about 90 percent hote water heating.



The primary solar heating components are the collector, storage and distribution systems. This involves the additional considerations of transport between collector and storage, auxiliary heating source and thermostatic controls. While the concept of solar collecting and heating remains simplistic, the controls governing collection, transport, distribution and the introduction of the auxiliary heat source are often complicated.

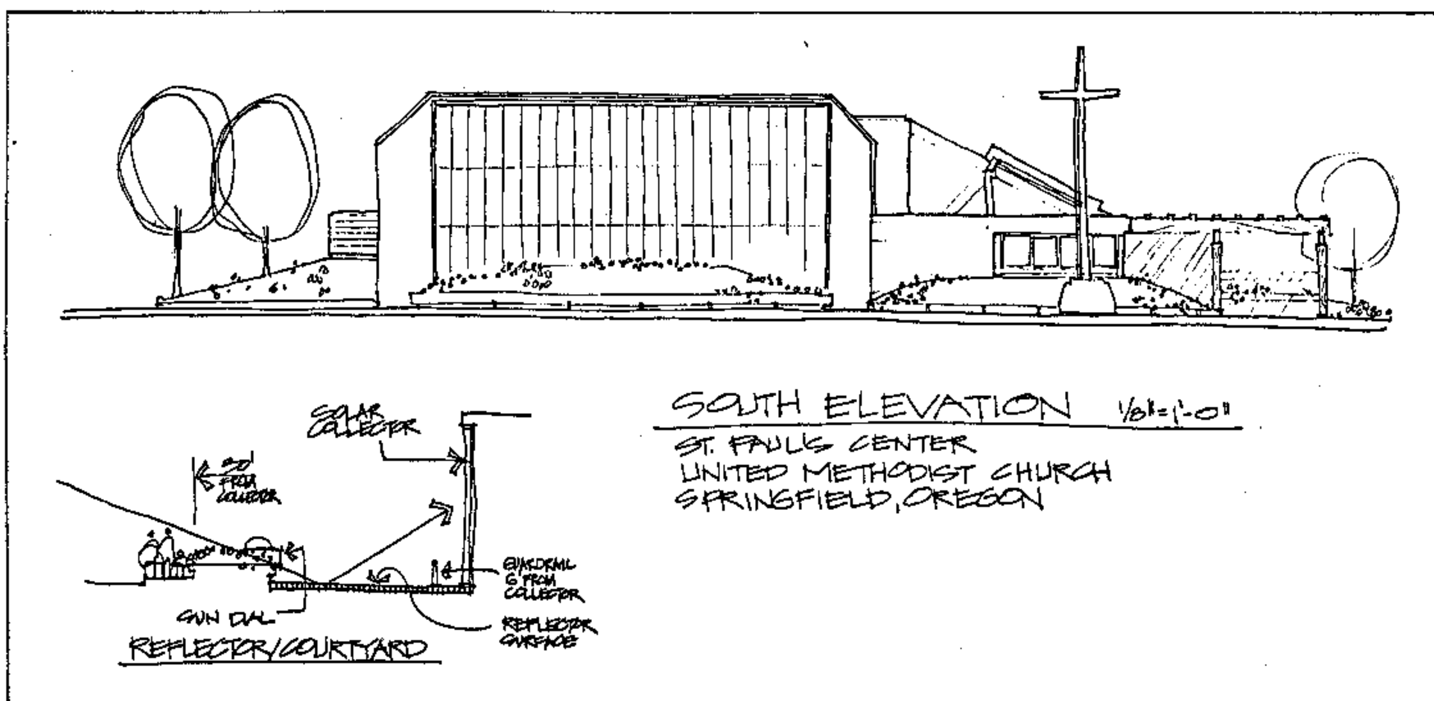
The Most Popular Model

The solar colector most widely used is the "flat-plate" collector, with water or air used as the collecting medium. A flat-plate collector has an outer cover of glass or plastic over a flat metallic surface that is blackened to increase heat absorption. Either air or water is passed through the collector and when sufficiently heated, transported to the storage tank.

The storage component of a solar system is a reservoir capable of storing thermal energy. Generally, storage is accommodated below ground or in a basement, and may take the form of a tank filled with water, gravel or glauber salts. Heat arriving from the collector is transmitted to the storage area and the cooled transporting medium returns to be reheated in the collector.

When the thermostat indicates the needs for space heating, the distribution system is activated. Again, either forced air or circulated water carries the heat from the storage area to the building spaces. If the temperature of the stored heat is not warm enough to heat the building, the auxiliary heat source makes up the difference. Thus, even on cold days the auxiliary system does not supply all the heat, but works with the solar powered system to produce comfortable temperatures.

In accepting the challenge to explore solar energy, local churches become actively involved in reducing the demand upon our diminishing global energy supplies.



A proposal for a passive solar collector on St. Paul's Center in Springfield, Oregon

To provide an incentive for local churches to consider solar heating, the National Division of BOGM has offered donations of up to $5,000 for eight selected United Methodist Churches utilizing solar energy installations. This is in conjunction with an ecumenical project sponsored by the Joint Strategy for Action Committee (JSAC) to promote solar energy for local churches. Other participating denominations are the American Baptists and the American Lutheran Church.

Recipient churches are being selected from a broad range of geographical locations, social environments and economic capabilities. Between the three participant denominations there will be at least one solar project in each of the four climatic zones of the United States: Cool (North Central), Temperate (Mid-Atlantic, Mid-West, and Western), Hot-Wet (Southeast), and Hot-Dry (Southwest). The intent of selecting from this cross section of locations and communities is to provide a full range of data on solar energy for church buildings.

There are numerous variations on this theme, as well as alternate non-fossil fuel heating systems. Each must be tailored to local building needs, and determined by access to materials, technology, and the amount of available sun and wind energy. Because of the rapidly expanding interest in this field, solar heated buildings are appearing all over the country in a variety of building types and sizes. In accepting the challenge to explore solar energy, local churches become actively involved in reducing the demand upon our diminishing global energy supplies. Tense solar powered church buildings will offer workable alternative for recognition by public policy makers and demonstrate the Church's commitment ot the larger community.

8

LIFE CYCLE COSTS

LIFE CYCLE COSTING

Life Cycle Costing is a method of making economic evaluations. As the name implies, it is a way in which total costs over the course of the expected life of a system, device, or product can be estimated.

It is intuitively understandable that first costs are not the only determinant in making economic judgements between two or more options. It is clear that, in some cases, a higher first cost is justifiable if there are greater savings throughout the life of a product. For example, most people would agree that a more expensive refrigerator expected to last 15 years is a "better buy" than a slightly less expensive one which only lasts five years.

Factors such as the expected costs of maintaining the product over its life and annual operating costs are commonly considered in everyday decision-making. Given two refrigerators, equal in other ways, one using less electricity every year is clearly "worth" some additional first cost. This is a simple example of the concept of life cycle costing; complexities come in attempting to make precise distinctions between the cost of various options over their expected lives. The method of life cycle costing described here is a way to refine these distinctions.

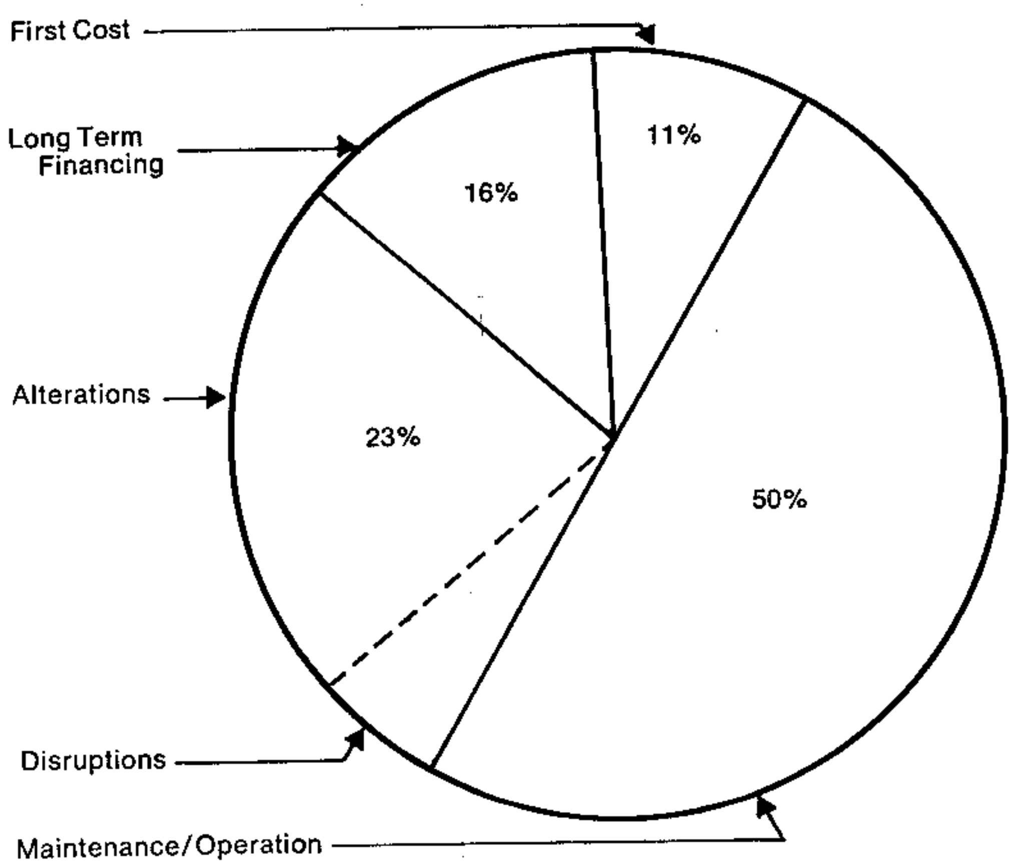
In making determinations of the relative cost-effectiveness of various weatherization, energy conservation, or solar energy applications, the factors to be considered are the following:

1. What is the first cost of the application?
2. How long will it last?
3. What is the cost of maintenance and repair throughout the life of the application?
4. What fuel cost savings can be expected from this application?
5. What salvage value will there be at the end of the life cycle?

With energy costs predicted to escalate at a rate of 20% per year, energy is becoming less and less a viable substitute for labor, thermal efficiency and durability in the construction of religious facilities and equipment. We have two choices: (1) we can seek another substitute, or (2) we can include the cost of energy and other First Cost reduction costs over the entire life of a facility. At this time, this writer knows of no other substitute that would take the place of our past reliance on energy. Therefore, our only viable alternative is the use of Life-Cycle Costing in the planning of religious facilities.

Life Cycle Costing is an extension of the decision-making time frame from First Costs to an inclusion of the dimension of future time. It recognizes that various operational elements within a building system are interrelated over time. That is, decisions made in the present time frame regarding building materials, building characteristics, equipment characteristics, will not only impact on each other in their present everyday functioning, but will impact on the total economic decision making process.

FIGURE 1



BUILDING LIFE COSTS

For instance, the insulating quality and thermal charcteristics of a building shell will not only impact on the capacity of the HVAC system, and hence the amount of energy consumed now, but will also impact on the escalating energy, maintenance and operations costs of the future. Life-Cycle Costing, in its inclusion of the dimension of future time, adds a proactive factor to religious facility planning. An expansion of the time frame from the present into the future also expands the planning frame of reference and introduces elements into our facility planning decisions that are not immediately apparent if only First Costs relationships are considered. A telescopic lens cuts across great distances and brings a distant object up close enough to scrutinize in greater detail. Life-Cycle Costing techniques likewise cut across time and bring distant future elements up close enough to be scrutinized and considered in present planning and decision making. A number of life-cycle costing techniques will be presented within the context of this section.

Present Worth Analysis does for the future what a telescopic lens does to distance. It brings the future up to the present, thereby allowing future costs to be brought into consideration in present economic facility planning. That is, the present worth of escalating energy costs, maintenance and operation costs and interest costs can be computed for each of the various building types, characteristics, HVAC systems; and compared. Just as First Cost bids have been compared and decisions made according to the lowest First Cost bid, the present value of the costs of a facility, or piece of equipment over its lifetime can now be compared on a competitive basis and decisions made according to the lowest Life-Cycle Cost bid. A number of other valuable costing techniques are also presented for the reader to use at various levels of financial decision making.

Present Worth Analysis

The concept of Present Worth Analysis in life-cycle costing is based on the simple assumption that monies that are borrowed always carry an interest charge for their use. Unused or saved monies always carry the potential of earning interest. Present Worth Analysis provides us with a vehicle for reducing future annual savings to a common, or equivalent, basis with current savings. Such a reduction of future savings to an equivalent comparison with current savings is necessary because a dollar saved today is worth considerably more than a dollar saved some years from now. This is a result of the discounting effect of interest potentially earned on current savings versus interest potentially lost in favor of investing in future savings. Present Worth Analysis takes these future interest losses into account and provides us with a means of comparing future savings with current savings.

In summary, Present Worth Analysis can tell us how much future annual savings would be in terms of current dollars saved. It allows us to ask the question, "How much money would future savings, accrued in energy, operating and maintenance costs, be equal to, in order to make an equivalent, interest-earning investment of that amount right now?"

In describing Present Worth Analysis a 10% interest or discount rate is being used; however, sufficient tables are available for application to any number of interest or discount rates. **Table 1,** Column A is a list of the future values of $1.00 invested at a rate of 10% annual interest, $1.00 invested at a 10% annual interest compounded annually will be worth $1.10 in a year. (1 x 1.1); $1.21 at the end of two years (1.1 x 1.1); $1.33 after three years (1.21 x 1.1); and so on up to $6.67 after 20 years.

TABLE 1
PRESENT WORTH ANALYSIS

A Future Value of $1.00 at 10%	Year	B Present Value of $1.00 at 10%	C Present Value of $1.00 Received Annually for "N" Years at 10%
1.10	1	.91	.91
1.21	2	.83	1.74
1.33	3	.75	2.49
1.46	4	.68	3.17
1.61	5	.62	3.79
1.77	6	.56	4.35
1.94	7	.51	4.87
2.13	8	.46	5.33
2.34	9	.43	5.76
2.57	10	.38	6.14
2.83	11	.35	6.49
3.11	12	.31	6.80
3.42	13	.29	7.09
3.76	14	.27	7.36
4.14	15	.24	7.60
4.55	16	.22	7.82
5.01	17	.20	8.02
5.51	18	.18	8.20
6.06	19	.16	8.36
6.67	20	.15	8.51*

Present Worth Analysis reverses this examination process by stating that at a 10% interest rate, $1.10 received one year from now has a **present value** of $1.00; $1.21 received two years from now has a **present value** of $1.00; $1.33 received three years from now has a **present value** of $1.00; and $6.67 received 20 years from now has a **present value of $1.00** also.

Using the same process as above, at a 10% interest rate, $1.00 received one year from now has a present value of $.91 (1 :- 1.1). That is, $.91 invested at 10% interest will be worth $1.00 in one year. Similarly, $1.00 received two years from now has a present value of $.83. That is $.83 invested at 10% interest will be worth $1.00 in two years. **Table 1, Column B,** follows this process for 20 years, indicating that $1.00 received 20 years from now has a present value of $.15. That is, $1.00 received 20 years from now, discounted at a rate of 10% per year, has a present value of $.15.

It is valuable to consider what this process means in terms of varying interest rates over a 20 year period. It is wise to notice that at an interest rate less than the 10% rate used in the sample text, the amount of money that $1.00 will earn after 20 years is less than the $6.67 earned at the 10% interest rate. Therefore, employing the telescoping discounting process of present worth analysis, at a lower discount rate, the present worth of $1.00 received after 20 years will be greater than $.15. This small point becomes very valuable to an administrator who is attempting to compare investments in energy-efficient materials or equipment that are initially more costly than comparable energy-wasting items.

The reason for this is that the additional investment in energy-efficient materials or equipment must be compared to the next best investment for the additional expenditure of funds. For instance, if the additional monies are part of a loan at a 10% annual rate of interest, and the spending of these additional monies promises to save $1.00 in energy costs each year, then it can be seen that each $1.00 in energy savings 5, 10, or 20 years from now has a present value of $.62, $.38, and $.15. However, if the next best investment for those additional monies only yields 5% interest, then each one of those dollars saved in energy or maintenance 5, 10, or 20 years from now has the greater present discounted values of $.78, $.61, and $.37, respectively. Therefore, if the next best investment for additional monies that would yield future savings in energy, maintenance, or whatever, is less than the interest rate paid to borrow those additional monies; the present worth or value of each future dollar saved is even greater than if the next best investment yielded a discount rate identical to the borrowing interest rate.

The reader should already be arriving at some clues to the potential usefulness of present worth analysis as a tool for convincing members of how, considering only initial investments in material or equipment, may waste rather than save future energy and maintenance dollars. In addition, this analysis has not taken into consideration the escalation of future energy and/or maintenance costs.

Since tax dollars are accumulated annually, the concept of present worth analysis has application to these future dollars coming in on an annual basis. Taking the figures listed in **Table 1, Column C** and adding them for a given number of years in the future results in the amount of money that would be needed to invest now at 10% interest in order to receive $1.00 each year for the given number of years. For instance, in a effort to determine how much money would be needed to invest now at 10% interest in order to yield $1.00 each year for the next two years, it is only necessary to add $.91, and $.83 for a total of $1.74. That is, to invest $1.74 now at an interest rate of 10% annual interest would permit extraction from our account $1.00 each year for the next two years.

Table 1, Column C is a list of those initial investments that would need to be made at 10% annual interest in order to yield $1.00 per year for the given number of years. It can be determined that investing $8.51 now at 10% annual interest would yield $1.00 each year for the next 20 years. Of course, if the next best investment concept described earlier is applied, then a lower annual interest rate would require greater initial investment of monies. That is, if the next best investment only yielded a 6% annual interest rate, it would take about a $11.47 investment at 6% annual interest to yield $1.00 per year for the next 20 years.

An application of the above concept can be made using the following hypothetical situation:

Total First Cost of System A	$18,000	
Total First Cost of System B	20,000	
System B exceeds System A by		$2,000
Annual Operating, Maintenance and Energy Cost of System A	1,600	
Annual Operating, Maintenance and Energy Cost of System B	1,000	
System A exceeds System B by		600

In the above situation System B initially costs $2,000 more than System A. However, System B will save $600 more per year in annual operating, maintenance and energy costs. It should be remembered that no attempt has been made to deal with any escalation in annual operating, maintenance, or energy costs. Assume that both System A and System B have a useful life of 20 years, and that investing in either system would be accomplished with a loan at a 10% annual interest rate.

It is obvious that investing in System A is presently worth an initial $2,000 savings over an investment in System B. But, in order to compare the future saving of both it is necesssary to apply present worth analysis to each. That is, it is necessary to use this mathematical telescopic lens to bring the future savings of each into the present in order to compare them.

Investing the additional $2,000 in System B at 10% per year for 20 years will cost us approximately $234.92 per year. Or, investing in System A will save us $234.92 per year for the next 20 years. Investing in System B will save $600 in annual operating, maintenance, and energy costs. To be future-oriented in educational investment decisions, this comparison in future annual savings would be as far as we would need to go. But, as indicated much earlier, dependence on voter approval for the expenditure of tax monies has required that education be present-oriented, or First-Cost oriented. Therefore, it is imperative to bring both future savings into the present.

From **Table 1, Column C,** it can be recalled that investing $8.51 now at 10% annual interest rate would permit the withdrawal of $1.00 per year for the next 20 years. That is, 8.51 becomes a factor that can be used to multiply annual savings of more than $1.00.

Therefore, applying the Present Worth Factor of 8.51 to the anticipated annual savings of both System A and System B will permit a determination of the **present value** of the future annual savings of each.

Again, investing in System A would save $234.92 in interest payment per year by not investing in System B. Applying the Present Worth Factor of 8.51 yields:

$234.92 X 8.51 = $2,000 (approximately)
(Original First Cost Savings)

Applying the Present Worth Factor of 8.51 to the $60 annual savings in operating, maintenance and energy costs from an investment in System B yields:

$600.00 X 8.51 - $5,100 (approximately)

It is now possible to compare the **present value** of the future annual savings of both System A and System B. That is, investing in System B is **presently worth** $3,100 more than investing in System A. Further, investing the additional First Cost of $2,000 will pay annual dividends in energy savings equivalent to investing $5,100 at a 10% annual interest rate; $600 per year. Or, investing in System B is **presently worth** 2.55 times as much as investing in System A.

As it will be seen later, the figure 2.55 is also the Benefit/Cost Ratio. Present Worth Analysis allows us to place a **present dollar value** on such ratios, and present dollar for dollar comparisons are the tools that will sell board members and taxpayers on the present economic value of future savings.

It should be remembered that all the preceding calculations exclude escalating costs for energy or escalating operating and maintenance costs. When such escalations are included **present worth** comparisons exemplify what a poor economic perspective an emphasis on First Costs can actually be. For ease of calculation the Present Worth Factors shown in **Table 2** will be used initially. However, the mathematical formula for calculating Present Worth Factors is presented later for use with those Present Worth Factors not included within **Table 2.**

For a further hypothetical situation an economic life of 20 years for both System A and System B, and a 10% annual interest/discount rate is being assumed. In addition, it will be assumed that the annual rate of energy price increase is 10%. In examining **Table 2,** observe that, for an

TABLE 2
PRESENT VALUE OF $1.00 RECEIVED ANNUALLY FOR N YEARS

Years (N)	6%	8%	10%	12%	14%	16%	18%	20%
1	0.94	0.93	0.91	0.89	0.87	0.86	0.85	0.83
2	1.83	1.78	1.74	1.69	1.65	1.61	1.57	1.53
3	2.67	2.58	2.49	2.40	2.32	2.24	2.17	2.11
4	3.46	3.31	3.17	3.04	2.91	2.80	2.69	2.59
5	4.21	3.99	3.79	3.61	3.43	3.27	3.13	2.99
6	4.92	4.62	4.35	4.11	3.89	3.68	3.50	3.33
7	5.58	5.21	4.87	4.56	4.29	4.04	3.81	3.60
8	6.21	5.75	5.33	4.97	4.64	4.34	4.08	3.84
9	6.80	6.25	5.76	5.33	4.95	4.61	4.30	4.03
10	7.36	6.71	6.14	5.65	5.21	4.83	4.49	4.19
15	9.71	8.56	7.60	6.81	6.14	5.56	5.09	4.67
20	11.47	9.82	8.51*	7.47	6.62	5.93	5.35	4.87
25	12.78	10.67	9.08	7.84	6.87	6.10	5.47	4.95
30	13.76	11.26	9.43	8.05	7.00	6.18	5.52	4.98
40	15.05	11.92	9.78	8.24	7.10	6.23	5.55	5.00

economic life of 20 years and no annual increase in energy costs, the Present Worth Factor is 8.51. This is the factor that was originally used in the Present Worth Analysis calculations. However, from **Table 3** the Present Worth Factor increases to 20.00 when a 10% annual increase in energy costs is included.

First, it should be noted that escalating energy costs are not expected to change the annual payback of $234.92 on the initial $2,000 additional investment in System B. Investing in System A still saves us $234.92 per year in interest payments. Therefore, it is necessary to apply the original Present Worth Factor of 8.51 again as follows:

$234.92 X 8.51 - $2,000 (approximately)

Second, since the future savings are a result of investing in System B which includes energy savings, the original Present Worth Factor of 8.51 if the rate of increase in energy costs is predicted to be 10% is no longer applicable. Also, for simplicity's sake a breakdown of the $600 in annual savings from System B from operating, maintenance and energy costs into the amounts saved annually by each was not used. Therefore, in order to emphasize a point here, it is necessary to assume that all the elements accounting for the annual savings of $60 will escalate at the annual rate of 10%. Applying the Present Worth Factor of 20.00 from **Table 3.**

$600.00 X 20.00 = $12,000

It is now possible to compare the **present value** of the future annual savings of both System A and System B when the elements accounting for the savings in System B are expected to escalate at a rate of 10% per year. It can be seen that investing in System B is now **presently worth** 6 times as much as investing in system A. Again, investing the First cost of $2,000 will pay annual dividends in energy savings equivalent to investing $12,000 at a 10% annual interest rate at a 10% escalation rate in energy costs.

TABLE 3
PRESENT WORTH FACTORS
(at 10% DISCOUNT RATE)

ECONOMIC LIFE

ANNUAL RATE of ENERGY PRICE INCREASE (P)	5	10	15	20	25
0%	3.79	6.14	7.61	8.51*	9.08
2%	4.01	6.76	8.64	9.93	10.82
4%	4.24	7.44	9.86	11.69*	13.07
6%	4.48	8.20	11.30	13.87	16.00
8%	4.73	9.05	12.99	16.59*	19.87
10%	5.00	10.00	15.00	20.00*	25.00
12%	5.28	11.06	17.38	24.30	31.87

The actual rate of escalation in the cost of energy is presently being predicted at 20% per year. **Figure 2** presents the mathematical formula for determining the Present Worth Factor when the price of energy is expected to escalate. **Figure 2** also shows the application of the formula to an annual rate of energy price increase of 20%. The formula is applicable to any escalating annual price increase, not just escalation of energy costs.

FIGURE 2
PRESENT WORTH ANALYSIS WITH ANNUAL RATE OF ENERGY PRICE INCREASE OF 20%

When $D \neq P$,

$$PWF = \left[\frac{1+P}{D-P}\right]\left[1 - \left[\frac{1+P}{1+D}\right]^{L}\right]$$

Sample:

D = 10%, P = 20%, L = 20 Years

$$PWF = \left[\frac{1+.20}{.10-.20}\right]\left[1 - \left[\frac{1+.20}{1+.10}\right]^{20}\right]$$

$$= \frac{1.20}{-.10}\left[1 - \left[\frac{1.20}{1.10}\right]^{20}\right]$$

$$= (-12)\,[1 - (1.09)^{20}]$$

$$= (-12)\,[1 - (5.69)]$$

$$= (-12)\,(-4.69)$$

$$= 56.38$$

When the calculated Present Worth Factor of 55.2, from **Figure 2** is applied to our $60 annual savings for System B, the following is obtained:

$600.00 X 56.38 = $33,828.00

A comparison can be made of the **present value** of $33,828.00 for System B at an escalation rate of 20% with the original First Cost savings of $2,000 for System A. The point being, that the telescopic lens effect of Present Worth Analysis can be used effectively to amplify a potentially absurb adherence to First Costs over Life-Cycle Costs by zooming in on, and bringing those future savings into the present for a critical analysis.

Figure 3 is presented as a further example of applying Present Worth Analysis to escalating Operation/Maintenance Costs alone. In actual practice, annual Energy Costs, Operation/Maintenance, and other annual costs should be sorted out and their respective escalation rates applied individually. An initial understanding of the process of applying the concept of Present Worth Analysis is critical.

FIGURE 3
OPERATION/MAINTENANCE COSTS

Assumptions:

- 20-year life for a piece of equipment
- 10% Discount Rate
- O/M Cost = $1,000 per year
- 4% Annual Rate of O/M Cost

Present Worth of O/M Cost = Annual O/M Cost X PWF
= $1,000 × 11.69
= $11,690.00

Interrupted Annual Increase in O/M Cost:

$$\text{Present Worth of O/M Incurred in Nth Year} = \frac{\text{O/M Cost in the Nth Year}}{(1 + \text{Discount Rate})^{N}}$$

However, should there be a need to calculate annual energy and fuel costs assocaited with propsoed bids in heating and air conditioning system sthe formulae in **Figure 4** should be helpful. Inthe formulas, "day operation" includes building and outside air (OA) requirements; "night operation" includes building requirements only. Consequently, the total number of degree days is divided into the respective hours of "day operation" and "night operation." Also, "bldg Btuh" refers to the heat loss from a particular building per hour.

APPLICATION #1: PRESENT WORTH ANALYSIS

Present Worth Analysis is not only valuable for comparing the life-cycle cost of different systems being considered for installation. It can be used to determine the present value of any investment that will save annual operating, maintenance and energy costs, as compared with making no investment at all. That is, when comparing the First Cost of insulation in order to achieve future annual savings in energy and energy costs as compared with spending nothing now, it would be valuable to establish a present value of future energy savings and compare it with the present value of not purchasing insulation.

The present costs of adding two inches of insulation at $7,600 in a religious building can be compared with the present value of the future energy savings resulting from the addition of that insulation. If the present annual cost of heating fuel is $11,300 and the projected annual costs with the two inches of insulation is $9,550 the projected future savings would be $1,750 per year. The present value of not investing in the insulation is the First Cost of $7,600. However, applying our Present Worth Factor of 8.51 for 20 years at a discount rate of 10% annually, the present value of the future energy savings would be:

$$\$1,750 \times 8.51 = \$14,893$$

As a result, it is possible to compare a present First Cost value of $7,600 with a present Life Cost value of $14,893. Including 10% and 20% escalations in energy costs, the First Cost value of $7,600 can easily become overshadowed by the present Life Cost values of $35,020 and 98,665. That is investing $7,600 in two inches of insulation in this case would pay annual dividends to the church equivalent to investing $14,893; $35,020; or $98,665 depending on the rate of escalation of energy cost.

APPLICATION #2: PRESENT WORTH ANALYSIS

Another capital expenditure that demonstrates the usefulness of Present Worth Analysis concerns investments in materials and equipment in order to accrue significant savings in electrical costs. Some electrical utility companies penalize churches (and its other consumers) by the addition of a demand charge for electricity used during the peak demand period of a 24 hour day. This is a charge over and above the normal electric rate in order for the electric utility company to maintain sufficient electrical generating capacity to meet the increased electrical demand during peak periods of the day.

It would be economically beneficial to reduce the electrical demand in a given church during the peak period. There are a number of ways of shifting a portion of a building's electrical demand to periods of a 24 hour day other than the peak demand period. Later start-up and earlier shut-down of heating and cooling equipment is one management technique. Investing in demand limiters is another. However, for the purpose of demonstrating the potential value of Present Worth Analysis, investing in a Thermal Storage Plant that can easily be installed beneath a parking lot of a church will be considered.

A concrete-vented thermal storage plant would save money in a number of ways because it would permit the electrical heating of hydronic systems during a non-peak period of the day; from 12:00 midnight to 6:00 a.m., for instance. The heated water could be circulated through the building during the peak period of the day for heating and domestic hot water use. That would be shifted from the period of peak electrical demand, thus avoiding the demand for electrical power during that peak period and avoiding the large electrical demand charges.

Besides a significant savings in electricity costs, thermal storage would also save a church monies in a number of other ways. Because there would be no periods of immediate, surging demand for space heating from 12:00 midnight to 6:00 a.m., lower capacity heating equipment could be operated more efficiently at full capacity. This would reduce the initial costs of heating equipment as well as operating energy because of the increase in efficiency. Also, electric service switch-gear could be reduced in size because of the lesser electric load. Further, because the storage tanks are concrete-vented, the cost of the inspection required for pressurized tanks would be eliminated. However, with the consideration of these significant savings in operation, it is possible to deal with the savings in electrical demand charges alone with our concept of Present Worth Analysis.

Make the assumption that the First Cost of installing a thermal storage plant as described to be $65,000. In many cases it would be very difficult to convince a congregation of the need to spend $65,000 as opposed to spending nothing in initial costs. However, with Present Worth Analysis it is possible to demonstrate that spending $65,000 in initial costs for a thermal storage plant is equivalent to investing a great deal more in the annual accrued savings in electrical demand charges.

Further assume that installing the designated thermal storage plant on a church site would reduce its electrical demand charges by $12,900 annually. Of course, the present value of not installing the thermal storage plant would be the initial $65,000. However, a comparison of this to the present value of the annual savings of $12,960 at a 10% annual discount rate for a 20 year life-cycle by applying our Present Worth Factor of 8.51 yields:

$12,960 X 8.51 = $110,290

Therefore, with no escalation in electrical energy rates, investing the $65,000 would pay the church annual dividends in electrical demand savings equivalent to investing $110,290 at a 10% annual interest rate. At a 6% annual rate this would become even more significant.

$12,960 X 11.45 = $148,650

Comparing the results for the present value of the annual savings in electrical demand charges with the First Cost of $65,000 not only amplifies the present worth of such an investment to the church but it makes one question the integrity of continuing to waste church monies for electrical demand charges if it is as potentially unnecessary as it appears in this hypothetical example.

APPLICATION #3: PRESENT WORTH ANALYSIS

This example is being presented in order to demonstrate the usefulness of Present Worth Analysis for differing escalation rates of energy costs, and operating/maintenance costs. The initial capital costs of two systems, both having an economic life of 20 years are:

Initial Capital Cost	
System A	$50,000
System B	56,000
System B exceeds System A by:	$ 6,000
Annual Costs	
System A	
Energy	$ 3,200
Operation/Maintenance	2,000
System B	
Energy	2,400
Operation/Maintenance	1,300
System A exceeds System B by:	
	800 (energy)
	700 (operation/maintenance)

Assume a 10% annual interest rate on the additional $6,000 for an investment in System B over System A and annual escalation rates of 8% for energy costs and 4% for operation/maintenance costs. The Present Worth Factor can be found from **Table 3** to be 16.59 for energy savings and 11.69 for operation/maintenance saving of System B. The present value of the future savings in energy costs and operation/maintenance can be computed to:

Present Worth of Future Energy Savings
$800 X 16.59 = $13,272

Present Worth of Future Operation/Maintenance Savings
$700 X 11.69 = $8,183

Therefore, the present value of the total future savings in both energy costs and operation/maintenance costs is $13,272 + $8,183) $21,455. When compared with the present value of the current savings of $6,000 in initial costs, System B shows a substantial advantage over System A.

Payback Period Analysis

In making a determination whether or not to make a capital investment in equipment, materials, etc., based on future savings in energy costs and/or operation and maintenance costs, it is helpful to know how long it will take for the projected annual savings to equal the single total or additional comparative investment. For instance, in the case of adding the insulation in Application #1, how long would it take for the annual savings in energy costs of $1,750 to pay for the initial investment of $7,600? Or, how long would it take for annual savings of $12,960 in the electrical demand charges to pay for an initial investment of $65,000 in a storage plant? It is tempting to simply take the initial cost (c) and divide it by the annual savings (s) and arrive at the number of years (n) to payback. This would provide the cost-saving ratio (c/s) but neglects to include the interest (r) to be paid on the initial costs. The following formula will provide an answer that does include the interest to be paid on the initial loan.

$$n = \frac{\log \frac{s/rc}{s/rc-1}}{\log (1 + r)}$$

Where:

c = capital cost
s = annual savings in energy, operating or maintenance costs
r = interest rate
n = number of years to achieve payback

However, the mathematically simplified presentation in **Figure 4** provides a graphic means of estimating the payback period. The two curves in **Figure 4A** are graphic representations of various Cost-Savings Ratios (c/s) plotted against the payback period in years (n) for both 10% and 12% interest rates (r). Use of this table reduces calculations to determining the Cost-Saving Ratio in a particular case and finding the resulting c/s ratio on the vertical axis. Then it is necessary to draw a horizontal line from that point on the vertical axis until it meets the curve representing the appropriate interest rate. Taking that point on the interest curve and dropping a vertical line from it down to the horizontal axis, will provide the payback period in years where the vertical line meets the horizontal axis.

For instance, the Cost-Savings Ratios (c/s) for the two cases cited above are calculated as follows:

FIGURE 4

(1) Heating Energy: Based on 12 hours Day and 12 hours night cycles

(a) Fuel Oil

$$\frac{[(\text{D.D. x Bldg Btuh}) + (\text{D.D. x Bldg \& OABtuh})] \text{ x \$.40/gal}}{\text{140,000 Btuh/gal x 60\%}}$$

(b) Natural Gas

$$\frac{[(\text{D.D. x Bldg Btuh}) = (\text{D.D. x Bldg \& OABtuh})] \text{ x \$2.00/mcf}}{\text{1,031,000 Btuh/mcf x 70\%}}$$

(c) Electricity

$$\frac{[(\text{D.D. x Bldg Btuh}) + (\text{D.D. x Bldg \& OABtuh})] \text{ x \$.04/kwh}}{\text{3413 Btu/cwh x 95\%}}$$

(2) Cooling Energy: Based on equivalent full load hours; 430 hours for a central system and 290 hours for individual self contained rooftop system

(a) Fuel Oil

$$\frac{\text{Plan tonnage x 19 lbs steam/ton/hr x 430 hr x \$.40/gal}}{\text{140,000 Btuh/gal x 60\%}}$$

(b) Electricity

1. Central aircooled:

   Plan tonnage x 1.8 kw/ton x 4e0 hr x $.04/kwh

2. Central Watercooled:

   Plan tonnage x 1.2 kw/ton x 430 hr x $.04/kwh

3. Individual contained rooftop:

   Plan tonnage x 1.8 kw/ton x 290 hr x $.04/kwh

(3) Auxiliary Equipment: Based on 8 months of heating and 4 months of cooling operation with 12 hours Day and 12 hours night cycles

(a) Evaporation Fans:
Bid motor Hp x 3450 hr x $.04/kwh

(b) Heating Pumps:
Bid motor Hp x 5800 hr x $.04/kwh

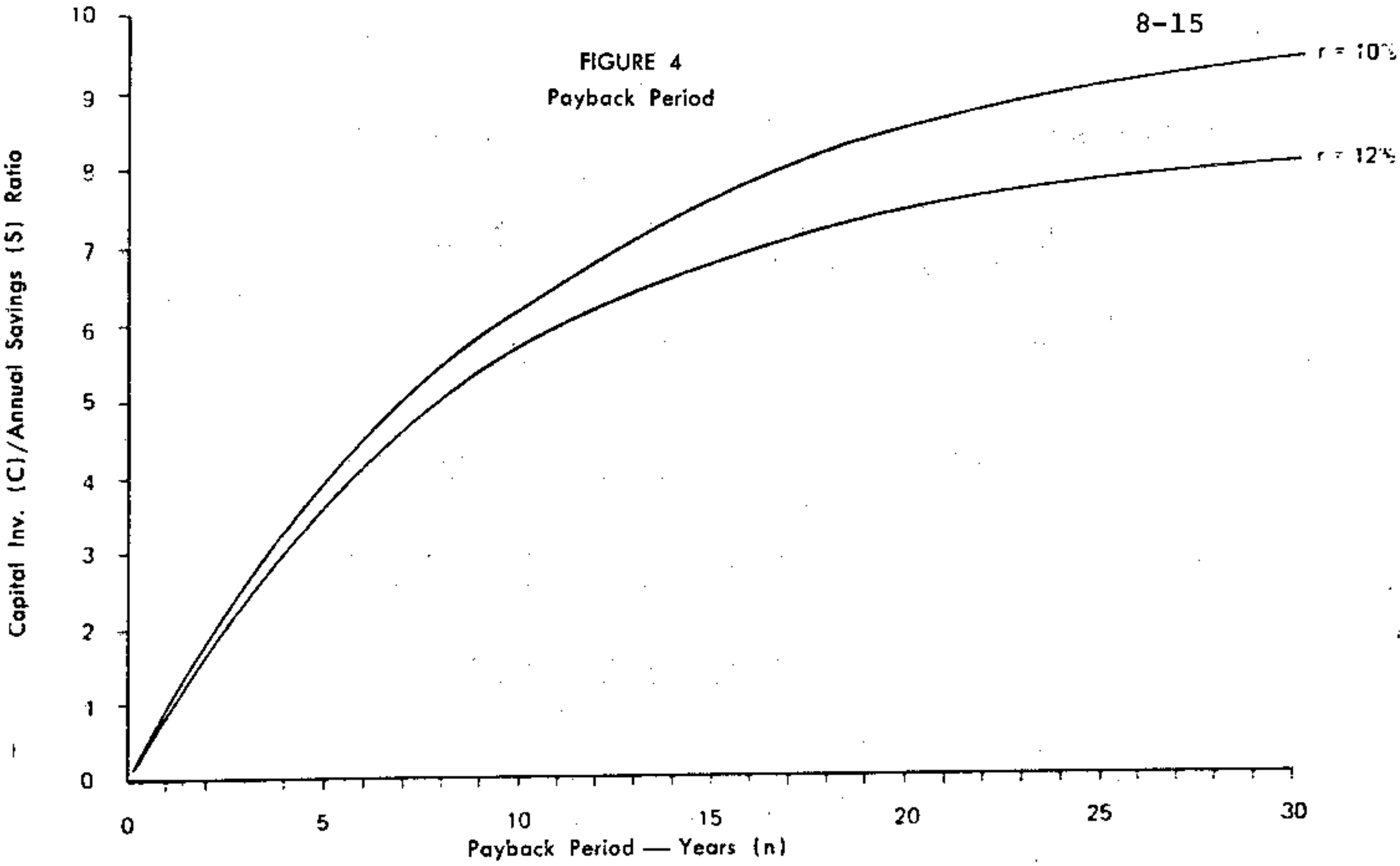
(c) Cooling Pumps:
Bid motor Hp x 1150 hr x $.04/kwh

(d) Cooling Tower:
Bid motor Hp x 1150 hr x $.04/kwh

(e) Air Cooled Condenser:
Bid motor Hp x 1150 hr x $.04/kwh

Source: Edward Stephen, "Use Life-Cycle Costing to Analyze Bids," American School & University (April 1975), p. 34.

FIGURE 4
Payback Period



Insulation Investment

Cost-Saving Ratio (c/s) = $\frac{\$7,600}{\$1,750}$

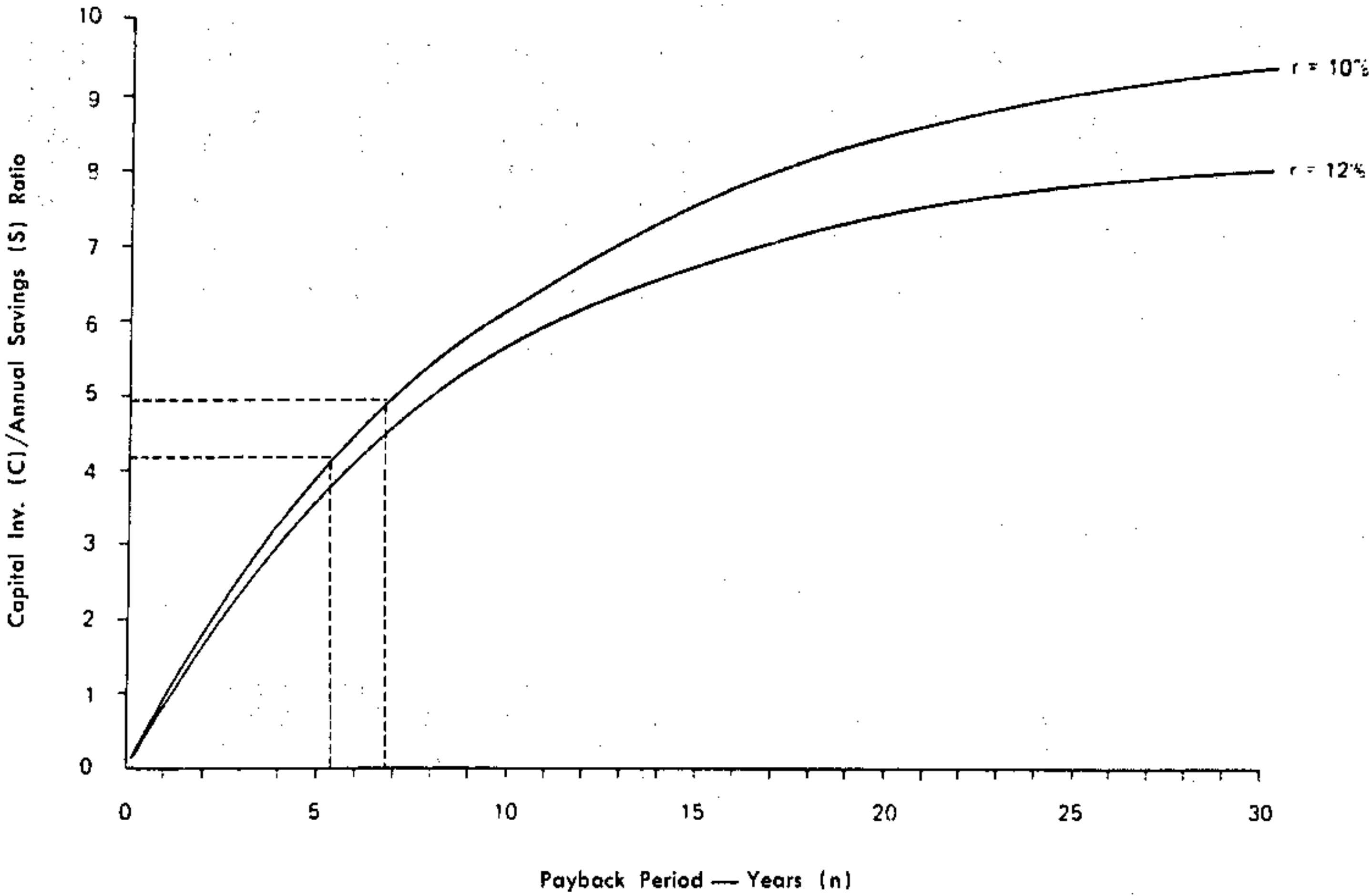
= 4.3 (approximately)

Thermal Storage Investment

Cost-Saving Ratio (c/s) = $\frac{\$65,000}{\$12,960}$

= 5.0 (approximately)

Figure 5 demonstrates how both of these Cost-Saving Ratios are applied to the 10% annual interest rate curve. Observe from **Figure 5** that the payback period resulting from annual savings in fuel costs of the initial $7,600 investment in insulation is a little more than five years. Also, the payback period resulting from annual savings in fuel costs for the initial $7,600 investment in insulation is a little more than five years. Also, the payback period resulting from annual savings in electrical demand charges for the initial $65,000 investment in thermal storage is just under seven years. This means that investing the $7,600 in insulation will pay for itself in annual fuel savings in a little more than five years. Likewise, the investment of the $65,000 in thermal storage will pay for itself in annual electrical demand savings in less than seven years. It should be pointed out that in both cases, escalation in energy costs were not included. As energy costs increase, the annual savings in energy dollars will likewise increase; thereby, reducing the payback period.



Therefore, in determining the payback period on an initial capital investment in materials, equipment, etc. two basic elements must be included in the decision-making process:

(1) Amortization (principal and interest) of capital cost debt, normally financed by a bond issue; and

(2) Estimated annual energy, operation and maintenance costs.

Annaul Debt Service (Amortization)

The annual debt service is the amount of money that must be paid each year in order to repay a loan over a given number of years. It is usually based on the estimated useful or economic life of a facility or piece of equipment. The annual debt service is calculated simply by multiplying the total principal by the capital recovery factor for the specific rate of interest and paybck period.

The capital recovery factor for a specific rate of interest on a loan can be computed with the following formula:

TABLE 4
CAPITAL RECOVERY FACTOR

	INTEREST RATE, r							
Years	4.0	5.0	6.0	7.0	8.0	10.0	12.0	15.0
5	0.2246	0.2310	0.2374	0.24389	0.25046	0.26380	0.27741	0.29832
10	0.1233	0.1295	0.1359	0.14238	0.14903	0.16275	0.17698	0.19925
15	0.0899	0.0963	0.1030	0.10979	0.11683	0.13147	0.14682	0.17102
20	0.0736	0.0802	0.0872	0.09439	0.10185	0.11746	0.13388	0.15976
25	0.0640	0.0709	0.0782	0.08581	0.09368	0.11017	0.12750	0.15470
30	0.0578	0.0651	0.0726	0.08059	0.08883	0.10608	0.12414	0.15230
40	0.0505	0.0583	0.0665	0.07501	0.08386	0.10226		

Table footnote

d = Debt service constant, a factor that multiplied by the total loan amount or total principal, yields the annual debt service payment.

$d = \frac{r(1+r)^n}{(1+r)^n - 1}$ in which r = interest rate   n = number of years to repay loan

$$d = \frac{r(1+r)^n}{(1+r)^n - 1}$$

Where,

d = capital recover factor

r = interest rate

n = number of years to repay loan (economic life)

or, from **Table 4.** It can be seen from **Table 4** that the capital recovery factor for a 20-year loan at an annual interest rate of 7% is 0.09439. Applying this capital recovery factor of 0.09439 to a capital investment of $100,000 results in an annual debt service of:

$100,000 X 0.09439 = $9,439

That is, a loan of $100,000 at 7% annual interest will require payment of $9,439 per year for 20 years.

One final note, when comparing items with differing economic lives, it is necessary to reduce all costs to the same economic life in order to uniformly compare each item on the same level. For instance, suppose it becomes necessary to compare the annual costs (or savings) of a central HVAC system with a 20-year economic life with a packaged HVAC system with a 10-year economic life. In order to compare the two systems on the same annual level, it becomes necessary to include the anticipated cost replacement of the packaged HVAC system after 10 years and include this cost in the calculation of that system's annual debt service.

For instance, suppose that a $70,000 central HVAC system with a 20-year economic life is being compared with a $50,000 packaged HVAC system with a 10-year economic life. Further, it is estimated that the packaged HVAC system requires an anticipated cost replacement of 70% of its originally installed equipment after 10 years. Then, the annual cost necessary to finance the packaged HVAC system over 20 years must be added to the basic annual debt service in order to equate comparative costs.

As a result, a much truer comparison in Annual Debt Service for the two HVAC systems can be made on the uniform annual level computed over the same 20-year period.

Without including the anticipated costs replacement of the packaged HVAC system, a comparison made on the basis of the first costs of each system alone would be economically deceiving. That is, one would be comparing a first cost of $70,000 with one of $50,000, and the additional $20,000 for the central HVAC system could become the sole focus in the final purchasing decisions. However, when one compares the present value of the current savings of $20,000 with the present value of the future savings in annual debt service over 20 years, a decision can more effectively be made in terms of the life-cycle of each system. Also, a life cycle frame of reference will have been established for the decision-making process; a frame of reference that should prove to be more conducive to comparative decision-making on the basis of other differences in future annual savings between the two systems, such as annual savings in energy costs and operation/maintenance costs.

Benefit/Cost Ratio

Establishing a Benefit/Cost Ratio is simply a means of expressing the relationship between the level of performance or benefit of a facility or piece of equipment, etc., and the price required to achieve that level of performance or benefit. **Figure 6** is a graphic representation of this two-faceted relationship.

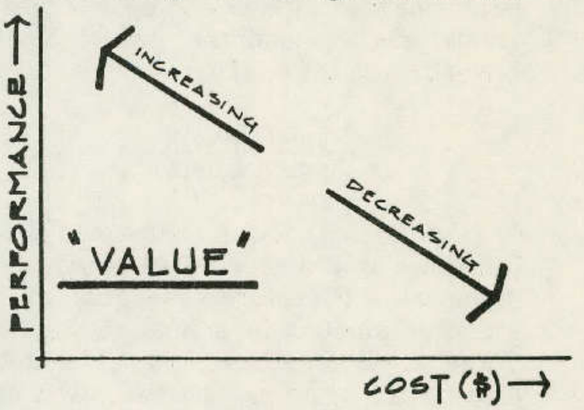


FIGURE 6

Either implicity or explicity performance criteria and cost targets become established in economic decision-making. That is, as in **Figure 7**, minimum levels of performance must be established, below which it will not be permitted to go. These are referred to as various types of specifications: religious, architectural, engineering. Also, established cost targets, beyond which it will not be permitted to go. As indicated in **Figure 8**, those items which fall outside the ranges of our performance criteria (C, from **Figure 8**) are relatively easy to eliminate at a preliminary level of decision making. However, those items that fall within both our ranges for performance criteria and cost targets (B and D from **Figure 8**) require a higher level of decision making in order to decide between, or among, them at this higher level of decision making. Therefore, it is necessary to use a more refined measure of choosing

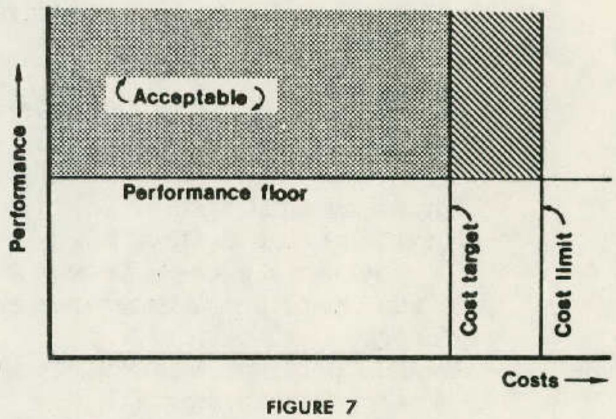


FIGURE 7

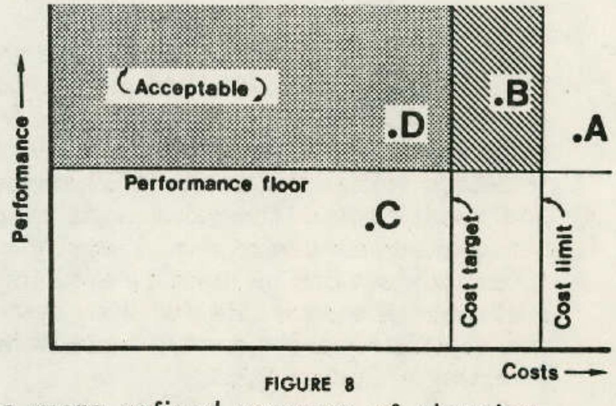


FIGURE 8

among competing items. Benefit/Cost ratios provide us with a vehicle for measuring the relationship between the performance (benefit) and the cost of each item. The item with the most beneficial relationship or benefit/cost ratio is allowed to emerge.

Establishing benefit/cost ratios is not new to education officials. However, the traditional application of our benefit/cost analyses has been limited to initial performance and initial costs. Vision has been somewhat myopic in order to keep first costs as low as possible. The intent here is simply to extend the application of benefit/cost analysis from one in which the emphasis is on first costs to an emphasis on the life cycle costs of a facility or system. To do this it is necessary to establish a definition of "benefits" in terms of annual savings, and of "costs" in terms of annual costs. In choosing among several alternative systems that fall within our performance criteria and cost target; the system that provides the greatest annual savings and the lowest annual costs will emerge with the largest benefit/cost ratio. That is,

$$\frac{\text{Annual Savings}}{\text{Annual Costs}} = \begin{array}{c}\text{Benefit/Cost Ratio} \\ \text{(B/C Ratio)}\end{array}$$

A B/C Ratio of 1.00 would mean that for every dollar spent annually (cost) we would receive an **equal** amount, one dollar, back in annual savings (benefit). Therefore, the goal of benefit/cost analysis is to obtain the greatest amount in annual savings for every dollar spent in annual costs. There is no steadfast rule-of-thumb to strive for regarding a number of alternative systems, the B/C ratio of each system or bid must be evaluated in terms of every other system or bid. As a result, the final decision as to what numerical B/C ratio is satisfactory will be with the church membership.

Using the figures from an earlier example it will be possible to clarify the meaning of benefit/cost analysis.

Total First Cost System A	$18,000	
Total First Cost System B	20,000	
System B exceeds System A by		2,000
Annual Operating, Maintenance and Energy Cost, System A	1,600	
Annual Operating, Maintenance and Energy Cost, System B	1,000	
System A exceeds System B by		600

In this case the annual savings that would be obtained by investing in System B would be $600. However, System B costs $2,000 more than System A. Therefore, in order to obtain the $600 in Annual Savings from System B an investment of an additional $2,000 in first cost must be made. In order to determine the B/C ratio, it is necessary to first define the current $2,000 additional cost in the same units as our benefit; otherwise, the resulting ratio would be meaningless. Therefore, a conversion of the $2,000 **first** cost to annual cost can be made by applying a capital recovery factor. Assuming a 20-year economic life for both systems and a 10% annual interest rate, the capital recovery factor from **Table 4** is 0.11746. The annual cost of investing in System B is:

$\$2,000 \times 0.11746 = \$234.92$

Now that both the benefit and the cost are defined **annually** it is possible to determine the benefit/cost ratio.

$$\frac{\text{Annual Savings}}{\text{Annual Cost}} = \frac{\$600}{\$234.92} = 2.55$$

The benefit/cost ratio of 2.55 means that for every dollar spent **annually** to repay the additional $2,000 **first** cost of System B, a receipt of $2.55 in annual savings in operating, maintenance, and enrgy costs are ralized.

In summary, establishing benefit/cost ratios requires a determination of annual savings and annual costs for each investment alternative under consideration. The following worksheets developed by Educational Facilities Laboratories, Inc., permit the user to record the information needed to arrive at B/C ratios for a number of alternative investment plans. Reproducible forms are included in the Appendix for the reader to use in his/her own situation. The following completed forms are included here for clarification purposes and include data on four alternative plans for insulating a sample facility.

Worksheet A

Worksheet A permits the user to record basic cost information. Sample information is included for the following alternatives:

Plan A -- add no insulation
Plan B -- add 2 inches of insulation
Plan C -- add 4 inches of insulation
Plan D -- add 6 inches of insulation

Cost effect(s) on other system. This includes accommodations needed to install each system under consideration. For instance, if installing a rooftop HVAC system, it may be necessary to include the cost of strengthing the roof structure. Or, with a Central HVAC system, it may include the cost of boiler room. In this sample, the costs are assumed to be zero.

Fees and overhead. Legal, achitectural, engineering, etc. In this sample, fees and overhead are included in the cost of the insulation.

Total First Cost

Plan A	0
Plan B	$ 7,600
Plan C	$15,200
Plan D	$22,800

Annual Costs -- Operations

Salaries -- additional salary expenditures as a result of system or element under consideration. For instance, for a new HVAC system that required a higher level of operational expertise, the additional salary would be included here. In this sample, no additional salaries are needed.

Worksheet A includes the following categories:

First Costs

Element or system	*Sample costs*
Plan A	0
Plan B	$ 7,600
Plan C	$15,200
Plan D	$22,800

WORKSHEET A
INFORMATION REQUIRED FOR ECONOMY STUDIES

			PLAN A	PLAN B	PLAN C	PLAN D
FIRST COSTS		Element or System Cost	0	$ 7,600	$15,200	$22,800
		Cost Effect(s) on other Systems	—	—	—	—
		Fees and Overhead	—	INC	INC	INC
		1. Total First Cost	0	7,600	15,200	22,800
ANNUAL COSTS	OPERATIONS	Salaries	—	—	—	—
		Heating Fuel	$11,300	$ 9,550	$ 9,300	$ 9,240
		Utilities	—	—	—	—
		Other	—	—	—	—
		2. Total				
	MAINTENANCE	Salaries	—	—	—	—
		Other	—	—	—	—
		3. Total	—	—	—	—
		4. Other Costs	—	—	—	—
		5. Total Annual Costs (2 + 3 + 4)	11,300	9,550	9,300	9,240
OTHER		6. Salvage or Residual Value at end of Period	0	0	0	0
		7. Useful life of System or Element (Years)	20	20	20	20

Heating Fuel -- This is the anticipated annual cost for fuel with a new system or element. In this sample the annual fuel costs are computed to be:

Plan A	$11,300
Plan B	$ 9,550
Plan C	$ 9,300
Plan D	$ 9,240

Utilities --Anticipated electrical expenditures. In this sample, this is zero.

Other -- One might consult ASHRAE 90-75 figures, manufacturers figures, etc., for other annual maintenance costs with system or element under consideration. In this sample, zero.

Other Costs -- Any other annual costs not yet included.

Total Annual Costs -- The sum of 2 + 3 + 4.

Plan A	$11,300
Plan B	$ 9,550
Plan C	$ 9,300
Plan D	$ 9,240

Other

Salvage or residual value at the end of economic life. This pertains to the salvage or residual value of the system or element under consideration. In this sample, assume zero.

Useful Life of system or element in years. This is the Anticipated Economic Life. In this sample, twenty years is assumed.

WORKSHEET B

Worksheet B includes two tables with directions for completion.

Annual Cost Table -- This table directs the user through the calculations of annual costs from the information of Worksheet A.

Total First Cost

Plan A	0
Plan B	$ 7,600
Plan C	$15,200
Plan D	$22,800

Capital Recovery Factor -- This is calculated or taken from a Capital Recovery Factor Table for the particular annual interest or discount rate and the economic life of the systems or elements under consideration. In this sample the Capital Recovery Factor was determined for a 6% annual interest or discount rate and a 20 year economic life to be 0.08718.

Annual Debt Service -- This is determined by multiplying the Total First Cost of each system or element by the Capital Recovery Factor. In this sample the calculations are:

WORKSHEET B
ANNUAL COSTS

1. Enter the Total First Cost and the Total Annual Cost from Worksheet A on the appropriate lines of this worksheet.
2. From a standard table, obtain the value of the capital recovery factor for the given interest rate and study period. Enter this value on the appropriate line.
3. Multiply the Total First Cost by the Capital Recovery Factor to obtain the Annual Debt Service.
4. Determine the differences between the Annual Debt Service and Total Annual Cost by performing the subtractions indicated in Section II of this worksheet. Retain any negative signs which result from these subtractions.

I. ANNUAL COST TABLE

	PLAN A	PLAN B	PLAN C	PLAN D
Total First Cost	0	$ 7,600	$15,200	$22,800
Capital Recovery Factor Discount = 6% Period = 20 years	.08718	.08718	.08718	.08718
Annual Debt Service	0	663	1,330	1,990
Total Annual Cost	11,300	9,550	9,300	9,240

II. ANNUAL COST DIFFERENCES

	Annual Debt Service	Total Annual Cost
PLAN B — PLAN A	663	1,750
PLAN C — PLAN A	1,330	2,000
PLAN D — PLAN A	1,990	2,060
PLAN C — PLAN B	667	250
PLAN D — PLAN B	1,327	310
PLAN D — PLAN C	660	60

Plan A -- 0 X 0.08718 = 0

Plan B -- $7,600 X 0.08718 = $663

Plan C -- $15,200 X 0.08718 = $1,330

Plan D -- $22,800 X 0.08718 = $1,990

The annual Debt Service recorded is the amount of money needed to pay back a loan equal to the Total First Cost over the economic life of the system or element.

Total Annual Cost -- This is the total annual cost from Worksheet A. In this sample, this cost is:

Plan A	$11,300
Plan B	$ 9,550
Plan C	$ 9,300
Plan D	$ 9,240

Annual Cost Differences -- This section permits the user to calculate the differences in Annual Debt Service and Total Annual Cost between each alternative system or element. In the left-hand column, write out all the possible differences between any two alternative that are possible and for which financial differences will be sought. Simply perform the subtractions indicated for Annual Debt Service and Total Annual Cost from the Annual Cost Table. Only one sample calculation is included below.

Plan B--Plan A
Annual Debt Service
$663 (b) - $0 (A) = + $663
Total Annual Cost
$9,550 (b) - $11,300 (A) = - $1,750

WORKSHEET C

Worksheet C includes the actual Benefit/Cost calculations. This first section includes the determinations of the Benefit/Cost ratio of each alternative system or element compared to Plan A, the existing or do-nothing situation.

Annual Cost Savings over Plan A (Benefits) from Worksheet B

Plan B	$1,750
Plan C	$2,000
Plan D	$2,060

Annual Debt Service in Excess of Plan A (Costs) from Worksheet B

Plan B	$ 663
Plan C	$1,330
Plan D	$1,990

Benefit Cost Ratio Compared to Plan A

Plan B

$$\frac{\$1,750}{\$\ 663} = 2.64$$

Plan C

$$\frac{\$2,000}{\$1,330} = 1.50$$

Plan D

$$\frac{\$2,060}{\$1,990} = 1.04$$

In this sample, Plan B emerges as the system or element with the greatest Benefit/Cost Ratio over Plan A. For every dollar invested, $2.64 is returned in annual savings. Or, each dollar invested in Plan B earns $1.64 in annual savings.

WORKSHEET C
BENEFIT/COST ANALYSIS

1. Enter alternative Plans B, C and D in the following table in order of increasing annual debt service. Plan A is the existing or do-nothing situation. Enter the annual cost savings on the first line and the annual debt service on the second line.
2. Calculate the B/C ratio for each plan relative to Plan A. Any plan with a B/C ratio of less than 1.00 may be rejected.

Alternative

	PLAN B	PLAN C	PLAN D
Annual Cost Savings Over Plan A (Benefits)	1,750	2,000	2,060
Annual Debt Service in Excess of Plan A (Costs)	663	1,330	1,990
Benefit/Cost Ratio Compared to Plan A	2.64	1.50	1.04

9

CASE STUDIES

ENERGY AUDIT

of

Hyde Park Baptist Church
3901 Speedway
Austin, Texas

Prepared as a Case Study

Planergy, Inc.
901 W. M.L.K. Blvd.
Austin, Texas 78701
512/477-8012

May 1979

This case study was funded in part by a grant from the U.S. Department of Energy.

TABLE OF CONTENTS

Energy Management

Energy management in a large religious complex such as Hyde Park Baptist Church should be an ongoing project with the church staff involved on a daily basis.

Even though, Hyde Park has instituted an energy management program, there are still some improvement that can be made to reduce further energy consumption within this religious complex.

While the 33 1/3% reduction in energy use suggested in this report would entail major efforts it is certainly a reasonable goal to strive for.

Even though energy costs are rising quite rapidly it still may be possible to only off set a portion of the energy price increase through energy management. Whatever the case may be, conservation actions as long as they are cost effective should be prioritized, considered and implemented where justified.

Energy Utilization Index (EUI)

Analyses of the gas and electricity bill information was performed and the calculation and graphical representation of these data are included in the body of this report.

The results of that analysis indicates energy use of 60,000 BTU/Sq.Ft./Year for the 12 month period from January through December 1978.

If consumption were reduced from 60,000 BTU/Sq.Ft./Year to 40,000 BTU/Sq.Ft./Year a realistic target which we believe could be achieved through some operating procedures modification and recommended retrofits, a 33-1/3% savings would be realized.

$$\begin{array}{r l} 60{,}000 & \text{BTU/Sq.Ft./Year} \\ \underline{-40{,}000} & \\ 20{,}000 & \text{BTU/Sq.Ft./Year} \end{array}$$

The cost of electricity and gas for the 12 month period analyzed was $53,772.38. The savings which would result from this reduction of 20,000 BTU/Sq.Ft./Year energy savings would amount to nearly $18,000.00,

$$\frac{20{,}000}{60{,}000} \times 53{,}772.38 = \$17{,}928.13$$

if the rate structure for electricity and gas were flat. Since they are "declining block" rates, the actual savings would be somewhat less than this if the necessary rates levied by the utilities companies are neglected.

ENERGY USE IN BTUs PER SQUARE FOOT

Hyde Park Baptist Church--1978

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST				
	KWH	MILLION BTU	ACTUAL	BILLED	TOTAL	PER KWH**	MCF	MILLION BTU	TOTAL	PER MCF**	MILLION BTU	TOTAL COST	BTU PER SQ.FT.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN	56,800	194			$2153.81	.038	861	887	2117.93	2.46	1,081	4271.74	10,000
FEB	62,400	213			2392.56	.038	783	806	2123.74	2.71	1,019	4516.30	10,000
MAR	61,200	209			2228.82	.036	369	380	1065.66	2.88	589	3294.48	5,000
APR	72,000	246			3979.52	.055	77	79	246.36	3.20	325	4225.88	3,000
MAY	40,182	137			2232.39	.056	73	75	204.03	2.80	212	2436.42	2,000
JUN	361***	1			42.27	.117	75	77	192.09	2.56	78	234.36	1,000
JUL	390***	1			43.29	.111	136	140	352.21	2.59	141	395.50	1,000
AUG	176,800	603			9536.07	.054	174	179	463.12	2.66	782	9999.19	6,000
SEP	215,200	734			11771.62	.055	228	235	624.22	2.74	969	12395.84	7,500
OCT	99,200	339			3483.56	.035	89	92	262.14	2.95	431	3745.70	3,000
NOV	88,400	302			2856.26	.032	276	284	807.15	2.92	586	3663.41	4,500
DEC	71,200	243			2586.26	.036	685	706	2007.30	2.93	949	4593.56	7,000
TOTAL	944,133	3,222			43306.43	.046	3826	3940	10462.95	2.74	7,162	53772.38	60,000

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

Total Square Feet 128,482

Comments:

* BTU per Square Foot: Divide column 12 by number of square feet of conditioned (heated and/or cooled) space in building or facility metered for gas and electricity.

** Columns 7 and 11, designated "cost per KWH" and "cost per MCF" respectively, are intended to designate the average monthly cost of energy actually consumed by the church's building systems. The values presented in these columns include the costs of consumption, fuel adjustment, etc., and thus, do not correspond with consumption charges denoted in the utility rate structures applicable to this building. The values are depicted only as a means of generalization to show the overall cost for the energy received and should not be construed as representative of utility rate structure.

*** The number of KWHs of electricity listed for the months of June and July is not an accurate reflection of the actual number of KWHs consumed during those months. These amounts indicate a billing error resulting from utility company personnel not using the KWH multiplier. An attempt to compensate for the error is made during the months of August and September. The KWH consumption during these months reflect actual consumption for August and September plus KWH adjustments for June and July.

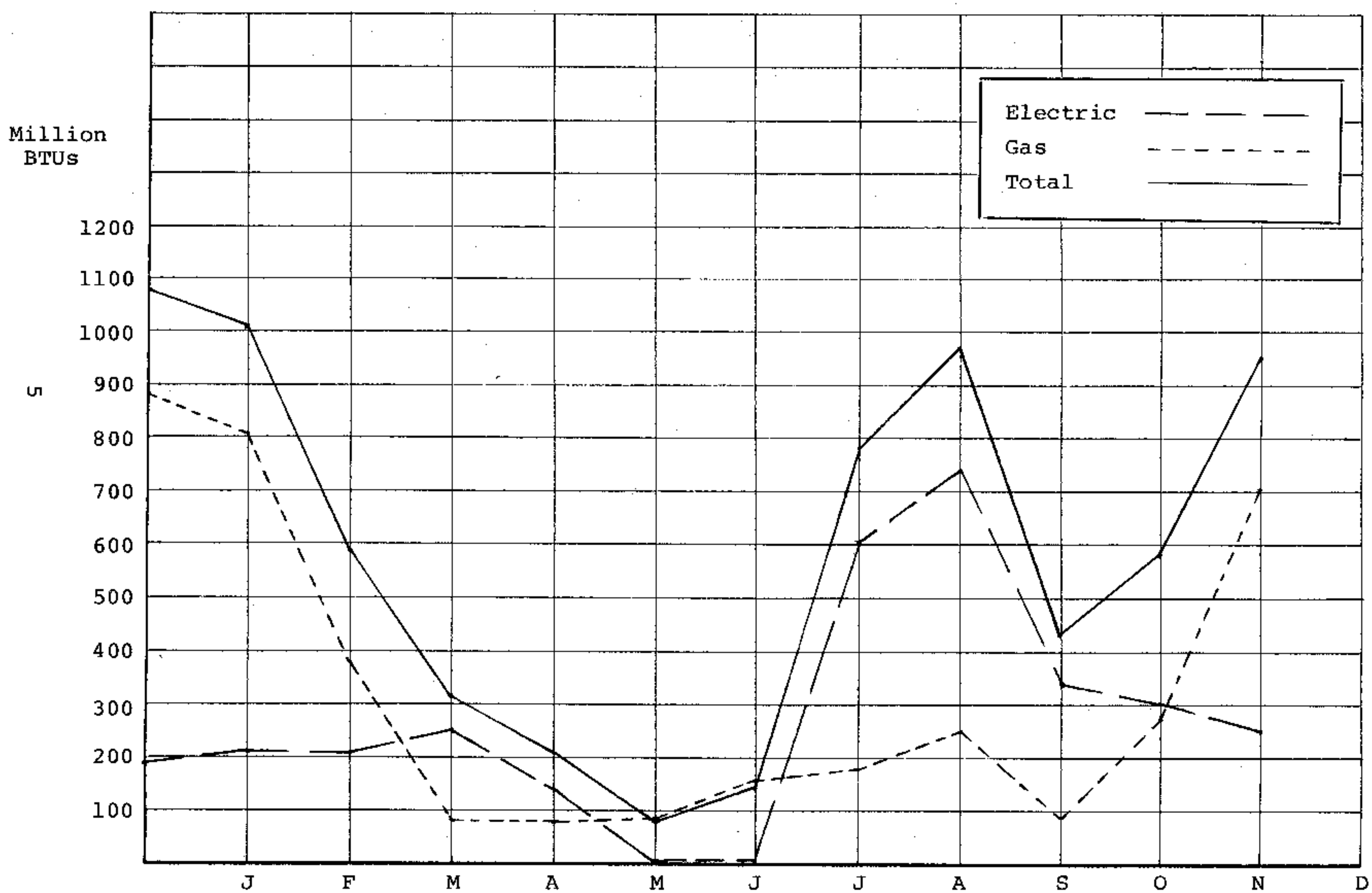
BTU/Sq.Ft./Year

Hyde Park Baptist Church

	Actual Energy Use January 1978 -- December 1978	Recommended Target After Retrofit
Hyde Park Baptist Church	60,000	40,000

ENERGY CONSUMPTION

Hyde Park Baptist Church



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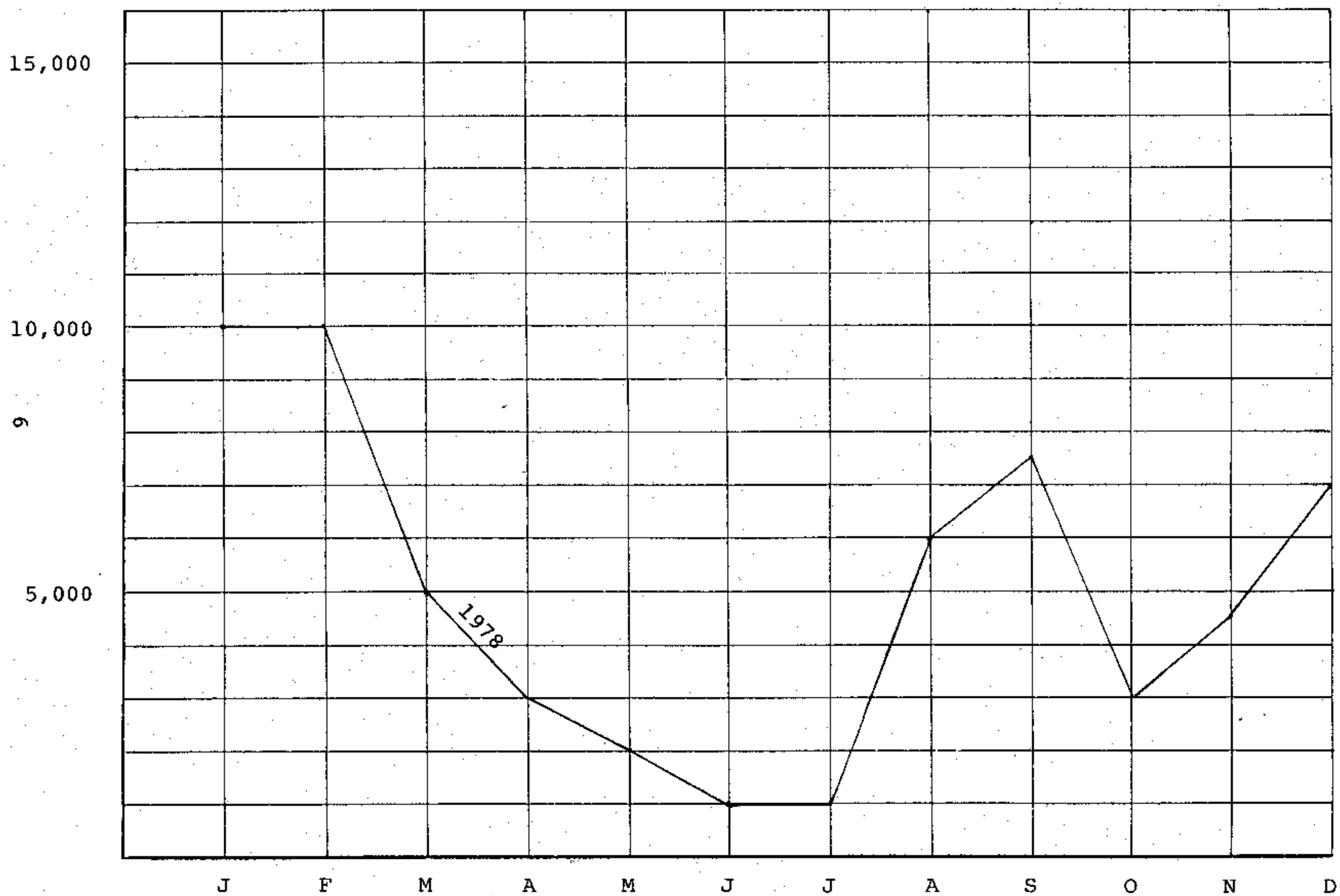
ENERGY CONSUMPTION
Per Square Foot

Hyde Park Baptist Church

BTU/Sq.Ft.



Demand Audit

There is no demand charge for the service category in which Hyde Park Baptist Church is a part.

Therefore no analysis in this area will be made.

It would, however, be wise on the part of Hyde Park personnel to start managing energy use at the religion complex as if demand charges were being applied by the utility company.

Electricity Bill Analysis

The electricity bill for February 1979 has been computed by increments as provided in the City of Austin rate structure and both are provided in Appendix B. The total electrical charge for this month was $2,503.87.

As long as this rate structure is in effect, savings in energy should result in subsequent cost savings.

NO/LOW COST RECOMMENDATIONS

A. Building Occupancy and Use

The use patterns at Hyde Park Baptist Church are somewhat complex. With the exceptions of the parlor, chapel and to a lesser extent the fellowship hall, the patterns of use at this religious facility are routine in nature as is suggested by the following:

Sanctuary -- The sanctuary is used primarily on Sundays for four hours during the morning and two hours in the evening. No change or modification in pattern of use in this space is recommended.

Parlor and Chapel -- The parlor is used primarily on Sunday mornings. It is sometimes used for special occassions such as weddings, etc. No change or modification in pattern of use in these spaces is recommended since these spaces can be cooled and/or heated independently of all other spaces in the religious complex.

East Education Complex -- This complex including the Fellowship Hall serves a multiplicity of educational and administrative functions. The complex is composed of three distinct areas or spaces which are identified as 1) East Education Building, 2) South East Education Building, and 3) the Fellowship Hall.

1) East Education Building. This building contains three floors and is approximately 49,000 sq.ft. in area.

   The hours of occupancy and use in this building varies from one floor to another. The greatest use occurs on the first floor (approximately 60 hours/week). The second floor is used on an average of about 17% less than the first floor. The third floor is used nearly three-fourth less than the first floor.

   Maximize use on the two lower floors to greatest extent possible in order to reduce heating and cooling requirements for the third floor since it is used less frequently.

2) South East Education Building. This building contains some 20,000 sq.ft. of area and also has three floors. The first floor is composed of nursery and pre-school age classrooms and is used Tuesdays, Fridays and Sundays. Floors 2 and 3 are used on Sundays primarily.

   During the day of this audit, none of the floors were being used, however there were several rooms with lights on. Exterior lights at entrances to this building were also on.

3) Fellowship Hall. The fellowship hall is used primarily for very large gatherings, mainly on Wednesday evenings and occasionally on Saturday for special functions.

West Education Building -- This building is used primarily from Monday through Friday for administrative offices and other educational purposes. This building contains nearly 30,000 sq. ft. No modification in use pattern in this building is recommended. However, as the energy management program evolves, consolidating or grouping as many activities and functions in as small a number of buildings of the complex as possible would produce significant savings.

B. Heating, Ventilating and Air Conditioning (HVAC)

Sanctuary

A time clock has been installed on the HVAC system for the sanctuary. The time clock is set to turn the system in the sanctuary on at 1:00 a.m. Sunday morning and turn the system off at 10:00 p.m. Sunday night.

The temperature that is maintained during occupied hours is 70°F in both the heating and cooling season.

- Recommendations:
  * Check cooling coils
  * Reset time clock to turn HVAC system on 2 hours prior to time of use and turn system off at 9:00 p.m. instead of 10:00 p.m.
  * Increase temperature in sanctuary by four degrees F during cooling season and decrease sanctuary temperature by two degrees. The use of T.V. lights during telecast will probably boost this sanctuary temperature somewhat during telecast.
  * Turn off boiler's pilot lights during cooling season since water heaters are used for domestic water heating.

Parlor and Chapel

The parlor and chapel are heated and cooled with individual package units. These units are not operated unless the space they serve are being used.

- Recommendations:
  * Improve maintenance procedures on these units.
  * Filters should be changed on a regular basis (filters were very dirty).
  * Reduce to the minimum extent possible outside air intake.
  * The motor on the air handling unit serving the chapel has loose fan belt. Appropriate adjustment should be made.

East Education Building

This building is equipped with time clocks on all air distribution equipment serving each of the three floors of the building. Automatic dampers and controllers have also been installed. Manual override switches are also available for use if the need to use them arise.

Work is underway to increase further the degree of flexibility in controlling the various zones in this building.

- Recommendations:

  * Reconnect damper linkage on air handler on third floor.
  * If manual override switch is to be used for janitorial maintenance etc. purposes, the switch should be turned off when space being used is vaccated.
  * Clean fire side of boiler. A large accumulation of soot had built up. (On the day of the audit the temperature outside was very mild but the boiler was firing. The boiler temperature was being maintained at $142^{o}F$.

Fellowship Hall

This space is conditioned by the use of roof top package units (50 tons cooling).

- Recommendations:

  * Continue effective maintenance practices and procedures.

C. Lighting

Lighting is a major load at this religious complex. Savings in the lighting area could be achieved primarily through two methods: 1) delamping and 2) relamping with energy efficient almps.

The prevalent light source in use at Hyde Park Baptist Church is fluorescent. Fluorescent lamps and fixtures are used in all the spaces except in the Sanctuary and Fellowship Hall. Energy consumed by fluorescent lamps is converted into light and heat. G.E. test data suggests that 70% of this energy results in added heat load.

Sanctuary

The sanctuary utilizes incandescent lights on dimmers for illumination. There are 9,750 watts of installed lighting in this space.

- Recommendations:
  * Keep light levels as low as possible by use of dimmers.
  * During regular janitorial activities use only a minimum number of lights to perform the tasks.

Parlor and Chapel

The Chapel contains both fluorescent and incandescent lights. The incandescent however is the primary source, provided through decorative multi-lamp fixtures suspended from the vaulted ceiling. These fixtures are on dimmers.

- Recommendations:
  * Remove down light (flood 300 watt) from fixtures since the amount of light provided benefits the person sitting or standing directly beneath it.
  * Clean fluorescent lamps and fixtures.
  * As fluorescent lamps burn out relamp with energy efficient lamps.

East Educational Building

Several spaces in this building had measured light levels that exceeded 100 foot candles.

- Recommendations:
  * Reduce lighting levels to fall within the 50-70 foot candle range.
  * Replace burned out lamps with energy efficient lamps.

* Turn off lights when spaces are not occupied (during the lighting survey lights were on in several rooms containing no occupants).

West Building

- Recommendations:

  * Relamp with energy efficient lamps

Since a large number of fluorescent lamps are used at Hyde park Baptist Church, and the fact that the bulbs are replaced periodically by maintenance workers, the initiation of group relamping is recommended.

All of the major lighting manufacturers have available energy efficient lamps. These lamps use 35 watts instead of 40 watts or about 14% less energy with lumens reduced by only 5%, from 3,150 to 3,050.

For this computation, we will assume all lights are being turned off from 5 p.m. to 8 a.m. This is important from the standpoint of relamping costs. Two major lighting manufacturers recommend relamping at 60-70% of rated life. We recommend 70%, or at 17,000 of the 20,000 hours of rated life. Therefore, with 40 watt fluorescent lamps burning constantly, their rated life would be (20,000) ÷ (24 x 365) = 2.28 years. With the lights off at night (generally) and Saturdays the rated life would be 20,000 ÷ (8 x 6 x 52) = 8.01 years.

Using the relamping period of 70% of rated life would give:

$$(20{,}000)(.7) \div (8 \times 6 \times 52) = 5.6 \text{ years}$$

Let's assume relamping will be necessary every 6 years and prorate the relamping and labor cost over that period.

Cost of Lamps

A Sylvania F40CW, or cool white, has an average rated life of 20,000 hours, lumen output of 3,150, and a suggested retail price of $2.13. The F40W/RS/SS, or Lite White, has the same life, lumen output of 3,050 and a suggested retail price of $2.95 or $.82/bulb more.

There are approximately 280 fluorescent bulbs in the West Building. The cost difference of $.82 will be used here, even though purchase in quantity should reduce this difference.

280 x .82 = $229.60 added cost for Super Saver II this group relamping

Since the life of the bulbs as currently operated would be about 2.28 years. We will calculate the cost to group relamp only 1.25 years of existing bulbs which are thrown away.

$$\frac{2.28 - 1.00}{2.28} (280) = 156.8 \quad 157$$

Savings (Labor Costs)

The attached sheet shows Sylvania's estimate of labor savings of group relamping compared to "one-at-a-time" replacement. It shows a savings of $88.35 per 100 lamps. Considering a relamping period of 6 years and the fact that this amount would be saved over that period. $88.35 ÷ 6 or $14.73 per 100 lamps would be saved each year.

With 280 lamps involved, the labor cost savings per year would be

14.73 x 2.80 = $41.24

Energy Savings

The 280 lamps burning 48 hours per week for 52 weeks would use:

$$\frac{280 \times 50 \text{ watts}}{1{,}000} \text{ (includes ballast)} \times 48 \times 52 = 34{,}944$$

KWH of electricity.

The Supersaver II or Watt-Miser II will save 14% of this amount of 4,892 KWH.

The KWH saving for the year would at current rates amount to:

Energy Charge	4,892 KWH @ 0.12¢	=	$ 58.70
Fuel Charge	4,829 KWH @ 0.2411	=	$117.95
			$176.65

The KWH saving, added to the labor saving

$$\begin{array}{r} \$\ 41.24 \\ 176.65 \\ \hline \$217.89 \end{array}$$

gives an annual saving of 217.89.

<u>Saving/Cost Ratio</u>

The saving to cost ratio would be

$$\frac{\$217.89}{\$334.41} = .65$$ with simple payback of

about 18 months.

D. Building Structure

The general condition of the building envelope at Hyde Park is very good as is evidenced by the recommendations.

Sanctuary

The walls (interior and exterior) ceiling windows and doors of the sanctuary were tight fitting and in a very good state of repair.

No recommendations for retrofit are suggested at this time for this area of the religious facility.

Parlor and Chapel

A similar condition exist in the parlor and chapel as in the sanctuary.

No recommendations for retrofit are suggested at this time.

Educational Building

Recommendation:

1) All exterior doors need weatherstripping.

West Building

Recommendation:

1) Upgrade weatherstripping at all exterior doors.

Appendices

A - Electricity Use (Historical)

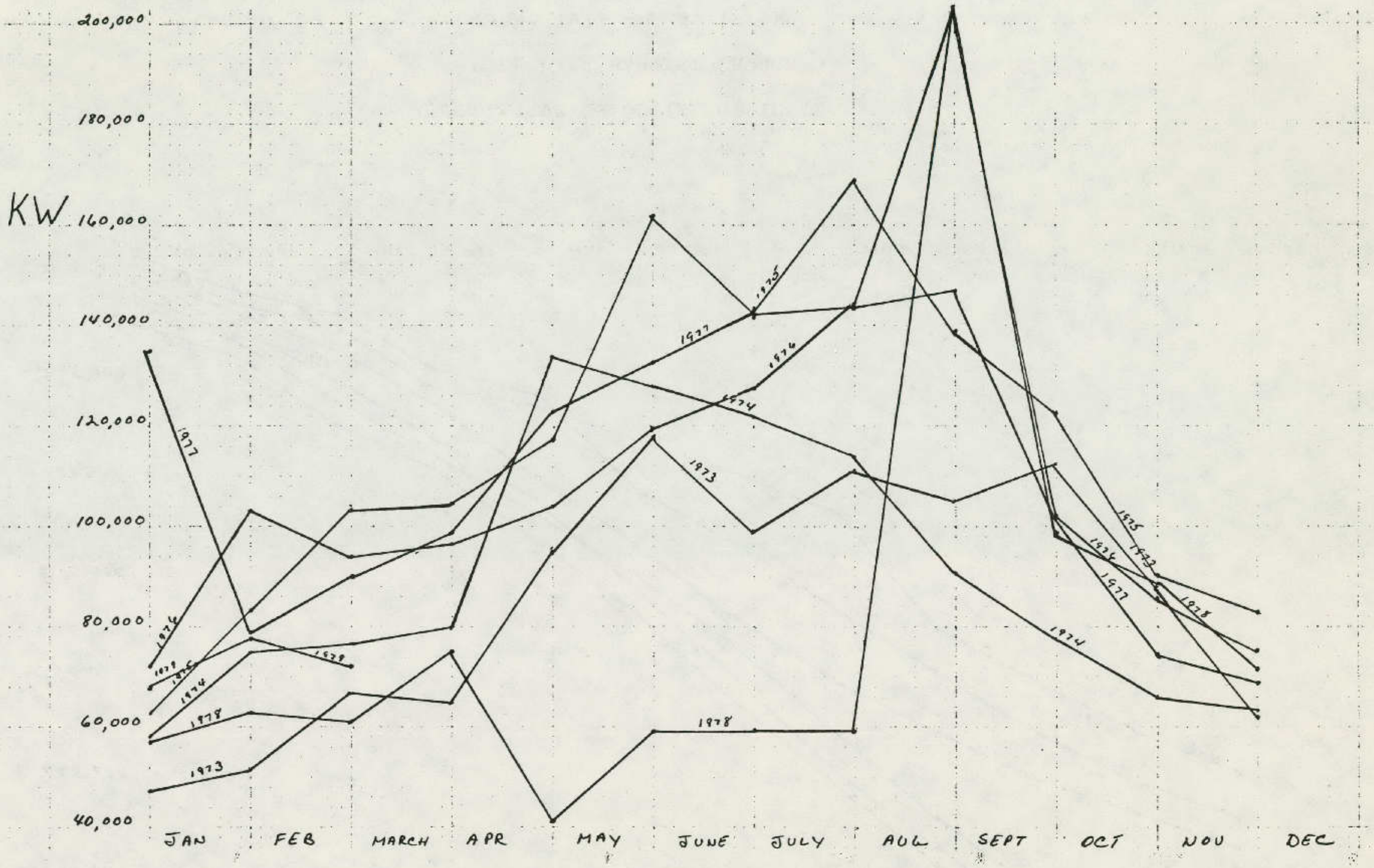
B - Electricity Bill Computation
Including Rate Structure

C - Equipment Summary

D - Lighting Summary

E - Building Sketch

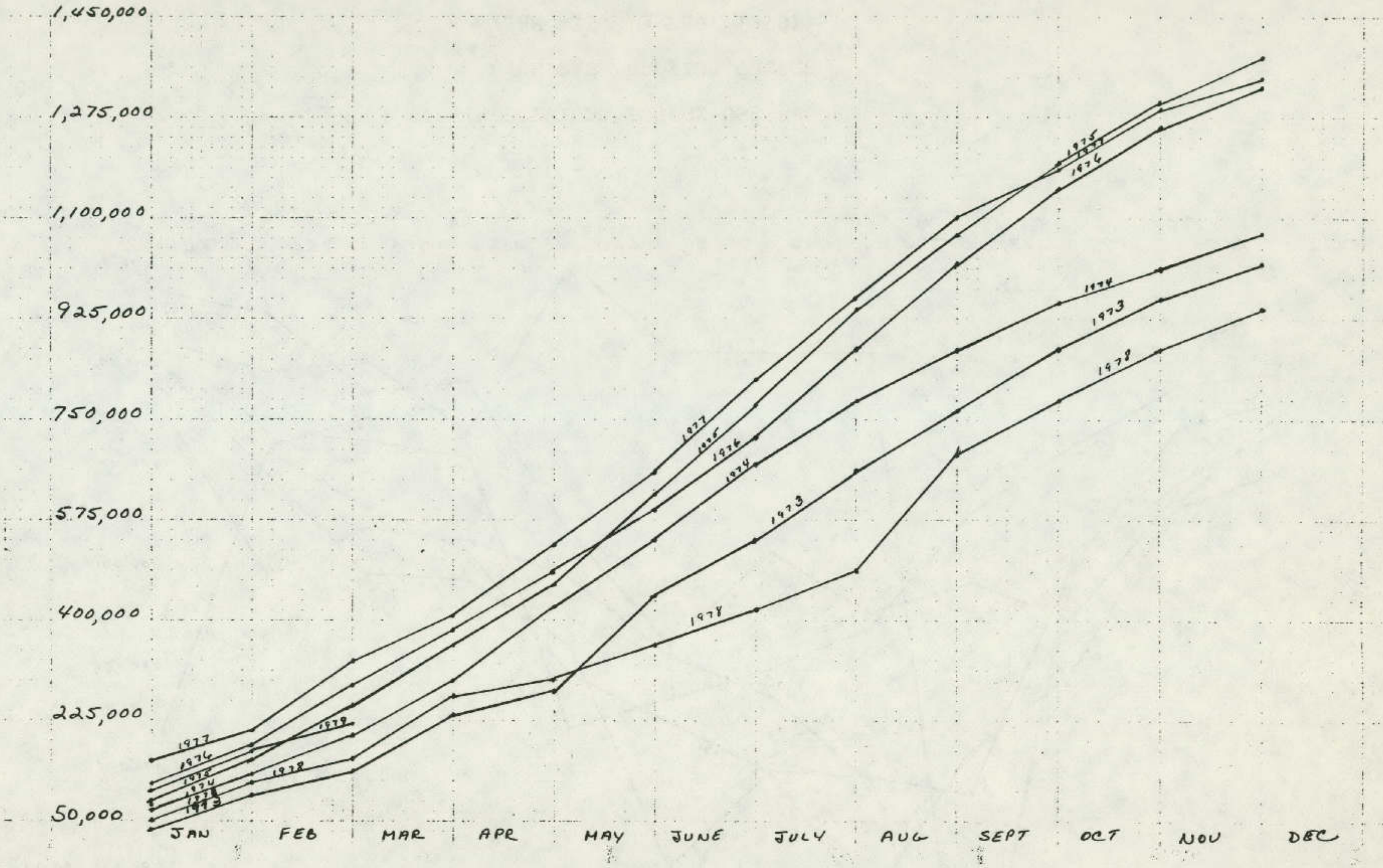
APPENDIX A



ELECTRICAL ENERGY USE RECORD

HYDE PARK BAPTIST CHURCH

(JAN. 1973 - FEB. 1979)



CUMMULATIVE USAGE (ELECTRICITY)

HYDE PARK BAPTIST CHURCH

(JAN. 1973 - FEB. 1979)

APPENDIX B

Electricity Bill
Computations
for
Hyde Park Baptist Church
3901 Speedway
Austin, Texas

1.	Outdoor Overhead Lighting (nightwatchman)		
	3 poles @ $1.50	$ 4.50	
	5 lights @ $3.30	16.50	
	60 KWH/light = 300 KWH @ $.0048	1.44	
			$ 22.44
2.	Fuel Charge for Outdoor Lights		
	300 KWH @ $.02411		7.23
3.	Customer Charge	4.50	
	use over 10,000 KWH	15.00	
			19.50
4.	Energy Charge		
	68,800 KWH @ $.012		825.60
5.	Fuel Charge		
	68,800 KWH @ $.02411		1,658.77
			$2,503.87

Character of Service:

Alternating current, 60 cycles, single phase, (or three phase) service in accordance with the Installation Rules and Standards for Electric Service prescribed by the City of Austin from time to time.

Rate:

	Billing Months of November through April	Billing Months of May through October
Customer Charge	$3.50	$3.50
Energy Charge	*.66¢ per KWH all KWH	*.66¢ per KWH all KWH
Capacity Charge	NONE	2.5¢ per KWH first 500 KWH 1.275¢ per KWH all additional KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

GENERAL SERVICE
Multiple Fuels

Application:

This rate is applicable to all electric service required by any customer to whom no other specific rate applies and when the electricity provided by the City of Austin is used in conjunction with other forms of energy.

Electric service of one standard character will be delivered to one point of service on the customer's premises and is measured through one meter.

Character of Service:

Alternating current, 60 cycles, single phase or three phase in accordance with the Installation Rules and Standards for Electric Service prescribed by the City of Austin from time to time.

Rate:

Applicable to a customer whose electric service meets or exceeds 30 kilowatts per month for any two months within the most recent six summer billing months or as determined by the City of Austin. This rate shall be applied for a term of not less than one year (twelve months).

OTHER CITY

Application:

This rate is applicable to all electric service required for municipal buildings, parks and other municipally owned and operated establishments within the City of Austin.

Character of Service:

Alternating current, 60 cycles, single phase or three phase in accordance with Installation Rules and Standards for Electric Service prescribed by the City of Austin from time to time.

Rate:

	Billing Months of November through April	Billing Months of May through October
Customer Charge	$10.00 per meter	$10.00 per meter
Energy Charge	* .60¢ per KWH all KWH	* .60¢ per KWH all KWH
Capacity Charge	NONE	1.16¢ per KWH all KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

NIGHTWATCHMAN:

Application:

Applicable to private outdoor overhead lighting installed, owned, operated, and maintained by the City of Austin.

Rate:

	Billing Months of November through April	Billing Months of May through October
Customer Charge	** $3.30 per Light	** $3.30 per Light
Energy Charge	* .48¢ per KWH all KWH	* .48¢ per KWH all KWH
Demand Charge	NONE	.62¢ per KWH all KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

** Plus $1.50 per month, per pole, for all poles.

SERVICE ADDR 3901 SPEEDWAY A

ACCT # 2015-625902-1 | SAN. UNITS 0 | WTR MTR SIZE 2.0 | KWH CONSTANT 400

SERVICE	02/02 READ	01/04 READ	CONSUMPTION	CHARGE	SERVICE	CHARGE
ENW	3 POLES	5 175W	0 400W	2244		
ENF	.024110		300	723		
ELC				1950		
E05	2732	2560	68800	82560		
ELF	.024110		68800	165877		
SUB-TOTAL ELECTRIC - - - - - -				250387		
W08	157399	155942	1457	9836		
WW8			1428	8059		

TOTAL $2712.49 ← OR A PENALTY IS CHARGED.

PENALTY $134.14

$2846.63 ← PAY THIS AMOUNT AFTER DUE DATE

03/07/79 DUE DATE

FOR ASSISTANCE CALL → 476-2173

CITY OF AUSTIN
UTILITY STATEMENT

THIS OFFICE IS OPEN MONDAY THRU FRIDAY 7:45 AM – 4:45 PM. SEE RETURN ENVELOPE FOR SUBSTATIONS. PLEASE BRING BOTH PARTS OF FORM WHEN PAYING IN PERSON

SEE REVERSE SIDE FOR SERVICE CODES AND CUSTOMER RIGHTS

WATER IS BILLED IN HUNDREDS OF GALLONS

PLEASE WRITE ACCT # ON CHECK

YOUR PAYMENT FOR THE TOTAL MUST BE RECEIVED IN THIS OFFICE ON/BEFORE DUE DATE

SERVICE ADDR 3901 SPEEDWAY A			WTR MTR SIZE	2.0
ACCT # 2015-625902-1		SAN. UNITS	0 KWH CONSTANT	400
SERVICE 02/02 READ	01/04 READ	CONSUMPTION	CHARGE	SERVICE / CHARGE
ENW 3 POLES	5 175W	0 400W	2244	
ENF .024110		300	723	
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WATER IS BILLED IN HUNDREDS OF GALLONS

PLEASE WRITE ACCT # ON CHECK

YOUR PAYMENT FOR THE TOTAL MUST BE RECEIVED IN THIS OFFICE ON BEFORE DUE DATE

	Billing Months of November through April	Billing Months of May through October
Customer Charge	** $4.50	** $4.50
Energy Charge	* 1.2¢ per KWH all KWH	* 1.2¢ per KWH all KWH
Capacity Charge	$3.22 per KW all KW	$5.78 per KW first 30 KW $3.95 per KW all additional KW

The kilowatt (KW) for the current billing month shall be the maximum indicated or recorded by metering equipment installed by the City of Austin. When the power factor is less than 85%, kilowatt (KW) shall be determined by multiplying the indicated KW by 85% and dividing by such lower peak power factor.

Rate:

Applicable to a customer whose electric service does not meet or exceed 30 kilowatts per month for any two months within the most recent six summer billing months or as determined by the City of Austin.

	Billing Months of November through April	Billing Months of May through October
Customer Charge	** $4.50	** $4.50
Energy Charge	* 1.2¢ per KWH all KWH	* 1.2¢ per KWH all KWH
Capacity Charge	NONE	2.5¢ per KWH first 1,000 KWH 1.85¢ per KWH all additional KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

** Plus an additional $15.00 per month for customers whose KWH billed in any month within the last 12 months exceeded 10,000 KWH.

GENERAL SERVICE
Single Fuel

Application:

This rate is applicable to all electric service required by any customer to whom no other specific rate applies and where the electricity provided by the City of Austin is the only source of energy used on the premises. The primary use of this energy must be for space comfort conditioning.

APPENDIX C

Equipment Summary

HVAC

Pumps

HP	Volts	Amps	RPM	Phase	KW Rating
5	208	15.2	1740	3	5.47595
5	208	15.2	1740	3	5.47595
5	220/440	21/10.5	3640	3	8.00184
7.5	230/460	21/10.5	1750	3	8.36556
7.5	230/460	21/10.5	1750	3	8.36556
5	208	15.2	1750	3	5.47595
3	200	9.3	1735	3	3.22152
3	200	9.3	1735	3	3.22152
5	200	9.3	1750	3	3.22152
3	230/460	9.4	1745	3	2.85384
Fan Motors					
6	200	16.6	1720	3	5.75024
15	200	47	1755	3	16.28080
15	200	47	1755	3	16.28080
10	208	28.6	1750	3	10.30344
10	208	28.6	1750	3	10.30344
2	208	6.2	1750	3	2.23361
2	208	6.2	1750	3	2.23361
3	208	8.7	1735	3	3.13426
7.5	208	23		3	8.28598
5	220/440	14.4/7.2	1735	3	5.48698
Compressor Motors					
40	220/440	97.3/48.7	1760	3	37.07519
	208	109.2	1760	3	39.34039
	208	76.5	1750	3	27.55989
	208	109.2	1760	3	39.34039
	208	102	1755	3	36.74652
	208	102	1755	3	36.74652
	208	102	1755		36.74652
					387.52779

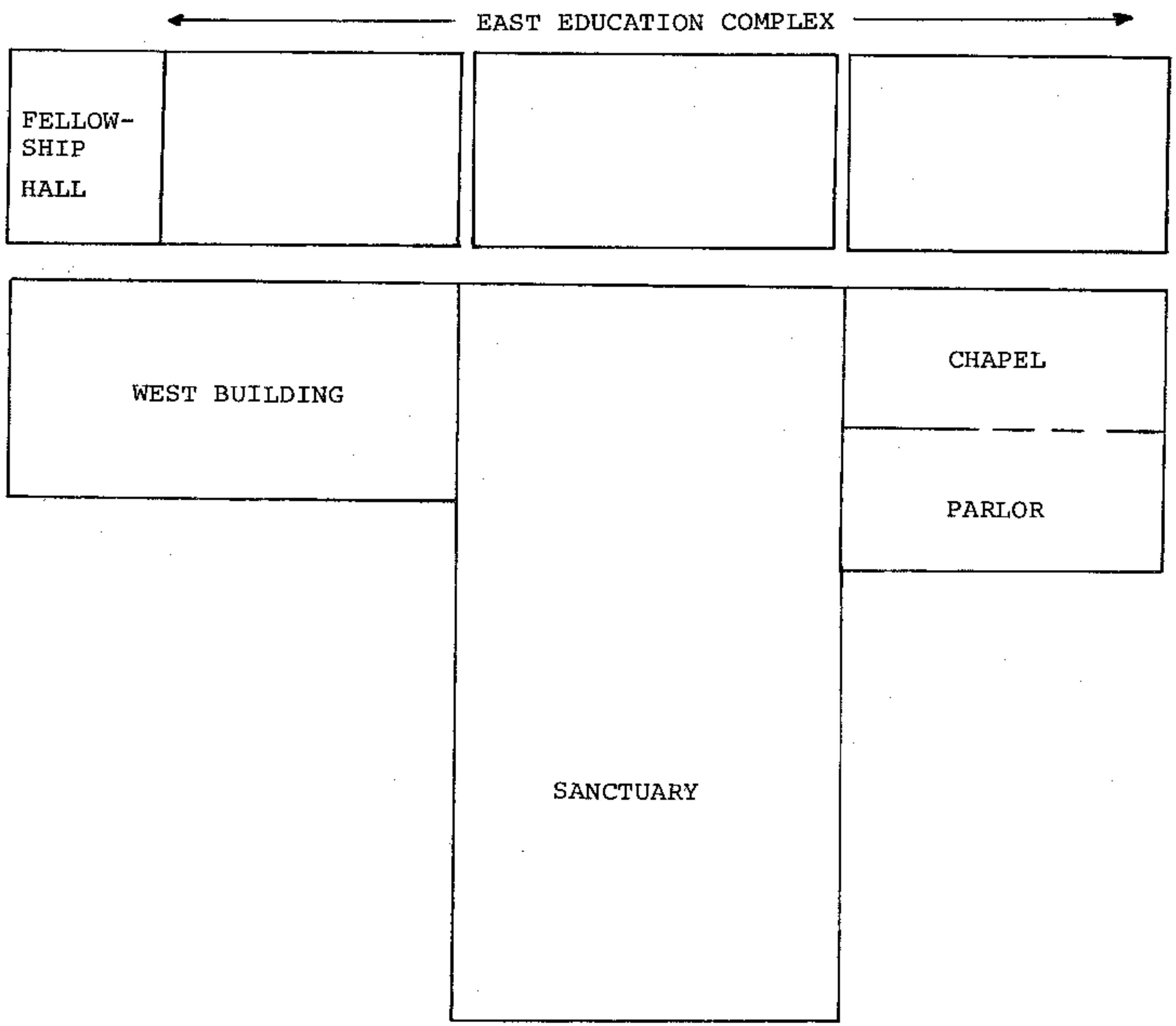
APPENDIX D

Lighting Summary

Building	Area	Number	Total Watts	Total KW
Sanctuary Incandescent	9,246	130	9,750	9.75
Parlor & Chapel	7,304			
Incandescent		62)	12,800	13.86
Fluorescent		120)		
West Building	29,904			
Incandescent		34)	12,950	15.54
Fluorescent		259)		
*East Education Complex	82,028			
Incandescent		314)	141,540	166.06
Fluorescent		2,392)		
Mercury		2		
TOTAL	128,482		187,040	205.21

*Includes Area of Fellowship Hall.

APPENDIX E



BUILDING SKETCH
HYDE PARK BAPTIST CHURCH

10

SPECIAL PROBLEMS

Kitchens *

Since many places of worship have fully equipped kitchens, managing energy use in them is also desirable. Kitchens, in places of worship, range from the fairly simple (kitchenette style) to very sophisticated (restaurant style).

Energy savings could be realized through the efficient use of the religious complex's kitchen equipment.

The following energy management check list provides practical, helpful hints that can produce conservation results in the kitchens of your place of worship.

While this list is not an exhaustive list of all energy savings tips, it should get you started in the energy management process.

See if you can add to this list.

General

1. Set thermostats on all cooking equipment to lowest temperature that will still give satisfactory results, consistent with safe food-handling practices.
2. Limit the number of electrical appliances that can be used at one time.
3. Cook in the largest volume possible.
4. Select the correct equipment for each job.
5. Turn off all equipment not actually in use.
6. Establish a regular schedule for maintenance checks of all equipment.

---

*If you have electric cooking equipment, you can now take advantage of the new ventilation design criteria that has been approved by The National Fire Protection Association. NFPA regulations now allow you to reduce your kitchen exhaust by 45% or more, based upon the heating load of the equipment, thus reducing exhaust motor requirements and the amount of conditioned air removed.

7. Keep records of all breakdowns and parts replacement
8. Have serviceman check gas pressure to applicances, adjust gas/air mixture on all gas burners, and check adjustment of pilot lights.

Ovens

9. Ovens are essential for most food service operations, but they are heavy energy users. In some cases, only 40% of the heat produced by an oven is actually used to cook food. The rest escapes into the air, and is wasted. Here are some things you can do to improve your oven efficiency.
10. Plan ahead, so you can load ovens to capacity. Heating empty space wastes energy. (But allow at 2" clearance for air to circulate around pans.)
11. Set thermostat at desired temperature when preheating oven. Dialing higher will not speed things up, but you'll waste energy.
12. Begin the day's baking or roasting with foods that require lowest oven temperature. If you start out at a higher temperature, then let oven cool down, you'll waste energy.
13. Begin cooking while oven is warming up. (Select foods that will not dry out or overcook.)
14. Cook meat slowly, at lower temperature. Less heat loss to surrounding air will more than make up for longer cooking time
15. Load and unload ovens quickly, and don't open oven door during operation. Every second oven door is open, temperature drops 10^{o}.
16. Aluminum foil retards the baking of a potato. Wrap potatoes in aluminum foil after baking.
17. If electric oven is used, bake during off-peak hours.

Microwave Ovens

18. Follow manufacturer's instructions carefully. Use only recommended utensils.
19. Keep microwave oven interior clean of spills and food particles. Never clean with abrasives, which may damage oven surface and reduce efficiency.
20. Keep lower edge of door free of food particles so door will seal properly.
21. Keep interior walls and heating elements clean for maximum efficiency.
22. Check self-cleaning or continuous-cleaning oven for dents in surface that may impede performance.
23. Have qualified service representative calibrate thermostats every few months, inspect burners, door closings, insulation, and adjust air/gas mixture at least once a year.
24. Have service representative check for radiation leaks regularly. Have safety interlock, magnetron and timer checked once a year.

Ranges

Of all cooking equipment, rangetops griddles and broilers have the greatest potential for wasting energy through heat loss to the surrounding air. Because they often form the center of activity in a kitchen, good conservation practices for these equipment items are extremely important.

1. Use foil under burners to improve efficiency, but guard against blocking air inlets.
2. Covering pots and pans will reduce cooking time.
3. Lower heat to simmer as soon as liquids begin to boil.
4. Group cooking utensils on range to reduce heat loss. Heat only section of closed-top range being used.

5. Make sure only tips of flames touch utensil bottoms. Flame should just cover bottom of pot.
6. Electric coils should be about 1 inch smaller than diameter of pot.
7. Use pots and pans with flat bottoms on electric or closed-top ranges.
8. Cook at lowest temperature that will still give satisfactory results.
9. Turn off units when not in use.
10. Check gas burners periodically. If flame is yellow or uneven, clean burner with wire brush and make sure holes are clear. If trouble persists, have service representative adjust gas/air mixture.
11. Check pre-heating times for electric units routinely. Contact utility representative if unit is not functioning properly.

<u>Broilers</u>

1. Pre-heat no longer than manufacturer's instructions recommend
2. Turn char-broilers to medium as soon as briquets are hot.
3. Use surface areas of heated broilers to capacity whenever possible. Heat only sections needed.
4. Infrared boilers should be used when possible. They can be turned off when not in use, and reheated quickly.
5. Schedule regular checks of gas burners by service representative.
6. Empty grease pan, and wash pan, drip shields and grids with a mild solvent to remove residue. Scrape grid surface as needed.
7. Clean burners and check air shutters to make sure air/gas mixture is correct.
8. Rearrange ceramic chips in under-fired broilers once a month to assure even heat. Replace blackened or cracked chips.

9. Check ceramic burners on infrared broilers for cracks, popping sounds, blackening or crumbling - signs of efficiency-reducing deterioration.

Domestic Hot Water

1. Use cold water whenever it will do the job.
2. Use hot tap water for cooking whenever possible, and if water does not contain concentrations of heavy metals.
3. Don't leave faucets running.
4. Fill sinks for pot washing. Don't use running water.
5. Schedule regular checks on insulation on hot water pipes.
6. Limit hot water for general use to 110° (43°C).
7. Mop from buckets to conserve hot water.
8. Install flow restrictors in faucets.
9. Install spring-operated valves on faucets, with foot treadles for kitchen sinks.
10. Install separate water heaters near hot water-using equipment, to minimize heat loss from pipes.
11. Replace washers in dripping faucets immediately.
12. Drain and flush hot water tanks every six months.
13. Check steam trap on steam water heater regularly.
14. Feel for hot spots on water heater to check insulation.
15. Have burner adjusted if exhaust is smokey, high in CO_2, or stack is excessively hot.
16. Use cold water <u>only</u> in bathrooms
17. Insulate hot water lines.

Dishwashing

1. Fill dishwasher to capacity for each use.
2. Adjust power drier to deliver heated air just long enough to barely dry dishes.
3. Consider using a setting agent instead of a power dryer.
4. Locate hot water boosters within five feet of dishwashers, to minimize heat loss from pipes.

5. Turn boosters off when not needed.
6. Make sure power rinse turns off automatically.
7. Set flow controls for proper amount of rinse water.
8. Check rinse water regularly for excessive temperatures.

Refrigeration

Energy consumption by refrigerators and freezers can be needlessly high with insufficient use and poor maintenance.

1. Use refrigerator to thaw frozen food. Allow 1½ hours per pound.
2. Cool hot food for several minutes before placing in refrigerator, but observe safe food handling practices.
3. All items in refrigerator and freezer should be labeled clearly.
4. Store frequently used items near the front.
5. Tape diagram showing location of items to door of refrigerator or freezer.
6. Keep door clear to allow tight closing.
7. Plan ahead to minimize frequency and length of time door is opened.
8. Use light switches with pilot lights on walk-in coolers.
9. Consolidate foods and turn off unneeded refrigerators and freezers.
10. Maintain at least 4 feet of space around compressor.
11. Compressors should be located in cool areas, not near heating units, to help dissipate heat removed from refrigeration unit.
12. Replace worn or damaged compressor belts.
13. Check refrigerant level if short cycling or loss of temperature control is observed.
14. Set up a regular schedule for cleaning of fan, condenser fins and plates, and blower coils.
15. Keep door gaskets and seals in good condition. Make sure unit is level so that doors close automatically and fit tightly.

16. Defrost freezers periodically.
17. Have automatic defrosters adjusted periodically by a trained technicians.
18. Make sure thermostats are properly calibrated.
19. Lubricate hinges and latches monthly. Use food grade oil.
20. Feel outside walls for cold spots that indicate insulation failure.

Pipe Organs

1. Pipe organs without trumpet pipes (reeds) are generally not affected by temperature and humidity fluctuations.
2. In order for pipe organs with trumpet pipes (reeds) to remain in tune, temperature and humidity conditions should be maintained at human comfort levels.
3. Extreme dryness adversely affects pipe organ with trumpet pipes.
4. Contact your organ builder if extremely high or low temperatures or humidity conditions occur.

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Presented by the
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512/475-5407

WILLIAM P. CLEMENTS, Jr., Governor

David B. Marks, Director

RETAIL BUSINESS

OFFICE BUILDINGS

HOTEL/MOTEL/ RESTAURANTS

CHURCHES

FAST FOOD RESTAURANTS

LOCAL GOVERNMENTS

NEW RESIDENTIAL

SCHOOLS

HOSPITALS

SUPERMARKETS

SHOPPING CENTERS

RIDE SHARING

APPRAISERS AND REALTORS

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