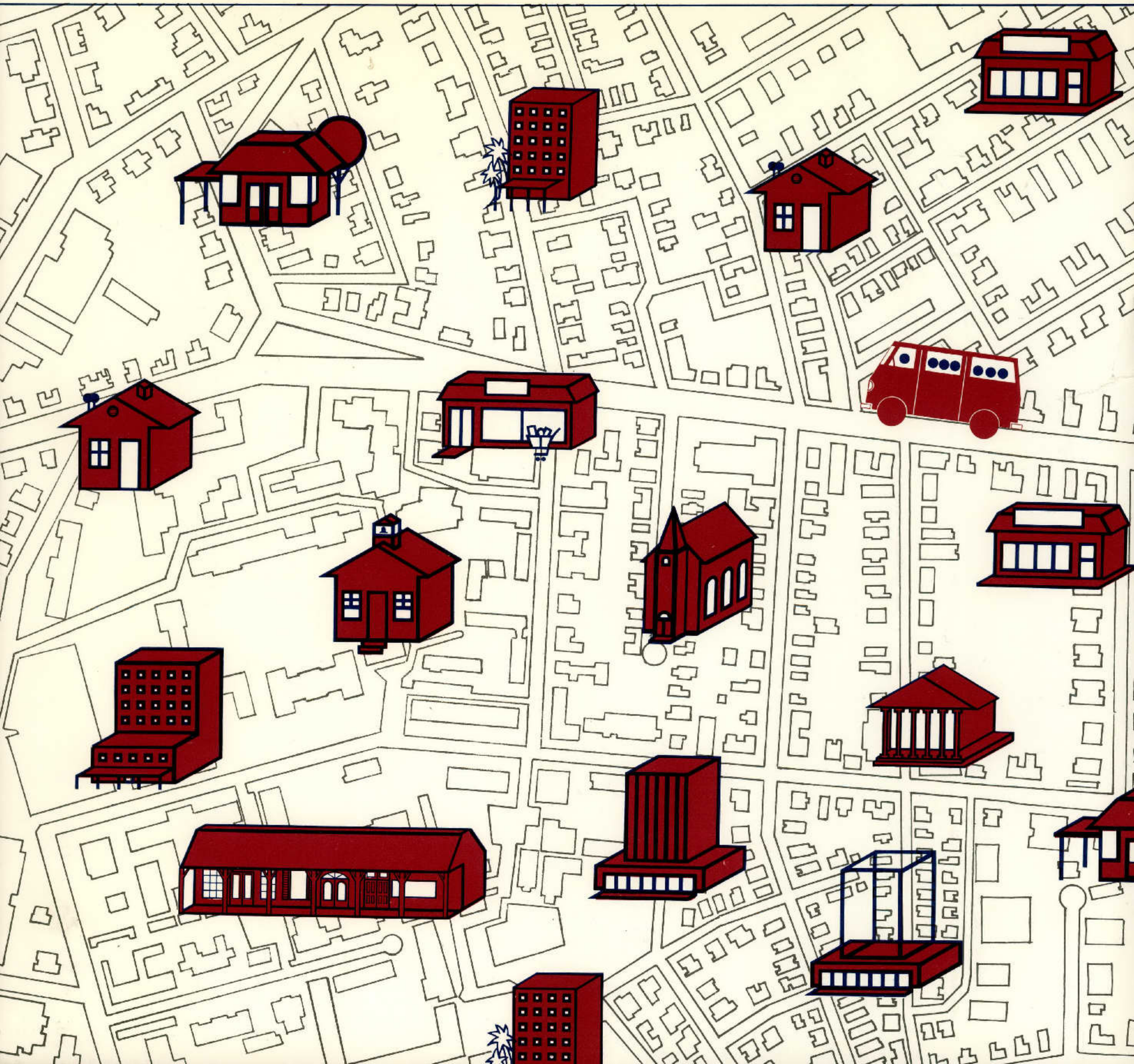
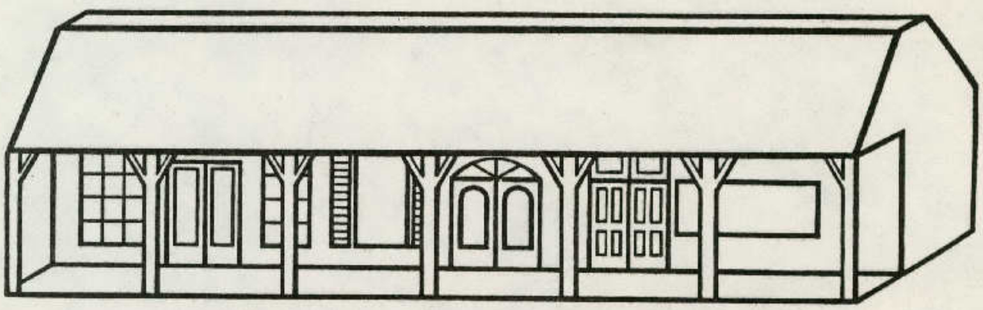
TEXAS ENERGY MANAGEMENT



TEXAS ENERGY MANAGEMENT



SHOPPING CENTERS

WILLIAM P. CLEMENTS JR.
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Energy Management in Shopping Centers

A Workshop Sponsored by
The Governor's Office of Energy Resources

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grant from the Department of Energy.

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ENERGY FACTS

ENERGY FACTS

TABLE OF CONTENTS

ENERGY FACTS

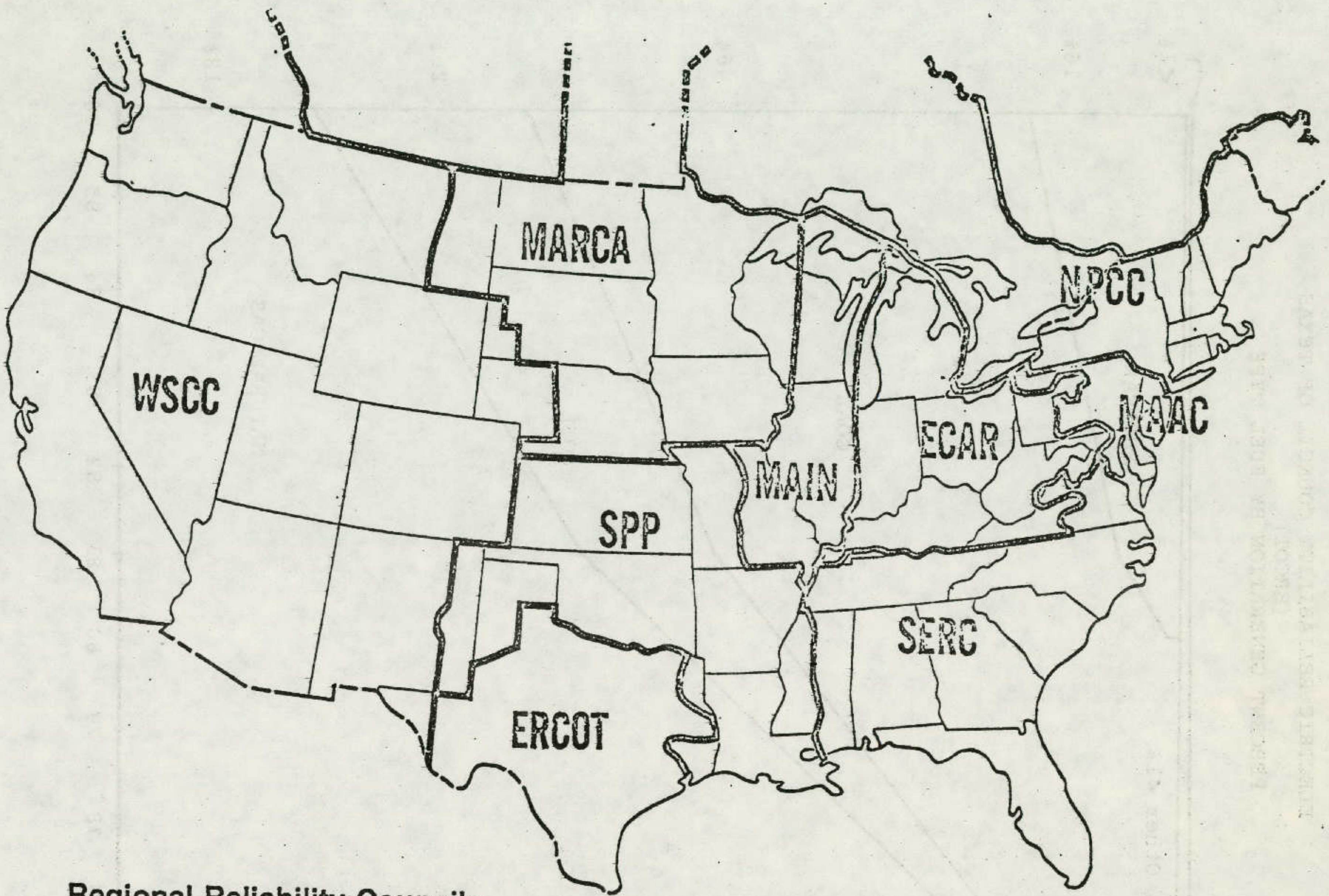
The subject of this workshop is energy conservation, or energy management as it is being referred to more frequently today; in this workshop then we will discuss how you may reduce your demand for energy.

But we know all too well from the days of late 1973 and early 1974 and from the current situation in the United States today, that the other side of any economic equation is supply. And as residents of Texas you are all very aware of the supply side of things since Texas produces about 35% of the nation's crude oil and about 35% of the nation's natural gas.

So in this section on energy facts the most important aspects of both supply and demand or use in Texas are presented. We believe you will want to update these facts in your workbook as you read or find articles and information which have an impact on your business and which you will want to retain.

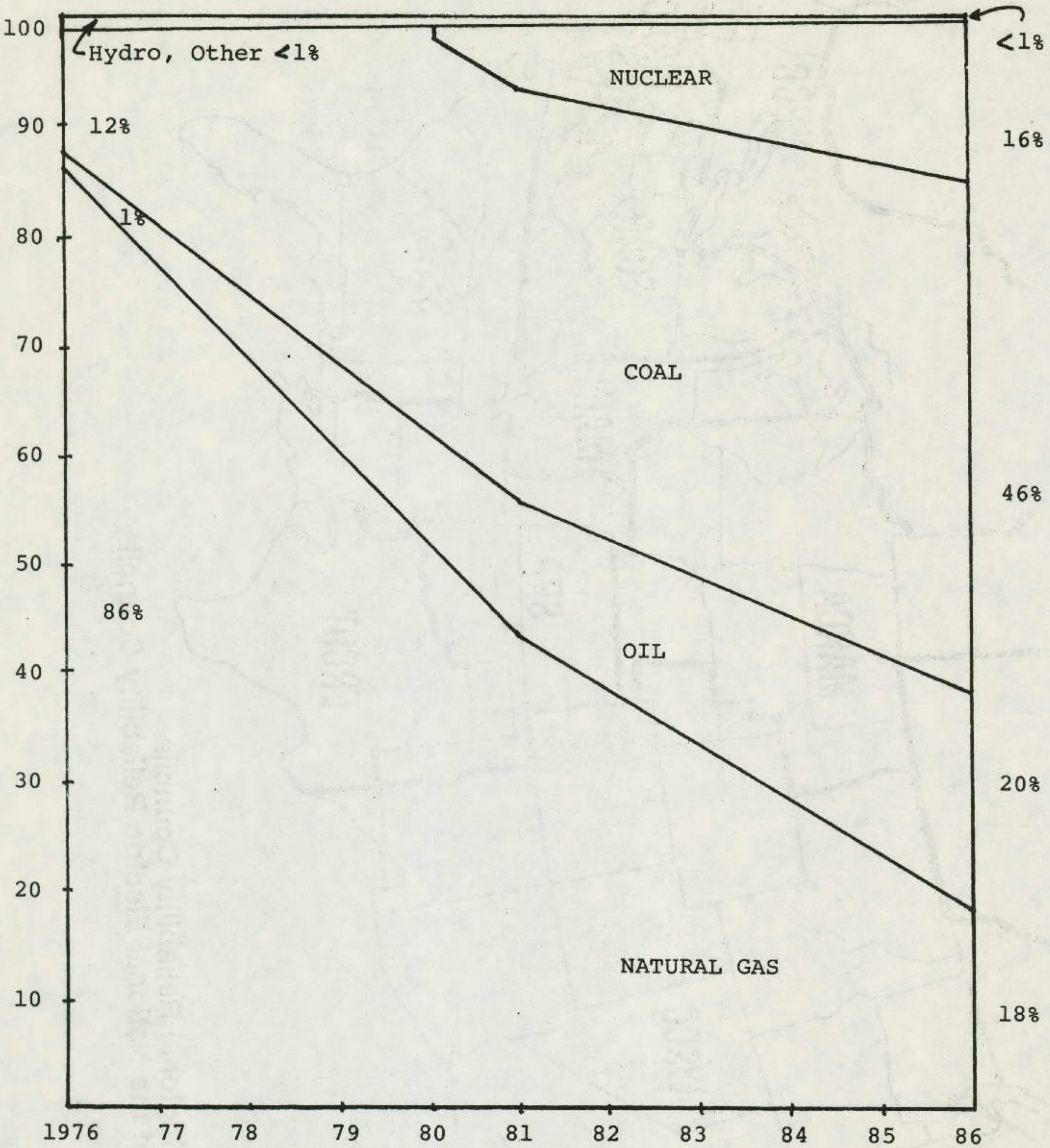
1978 WORLD OIL PRODUCTION

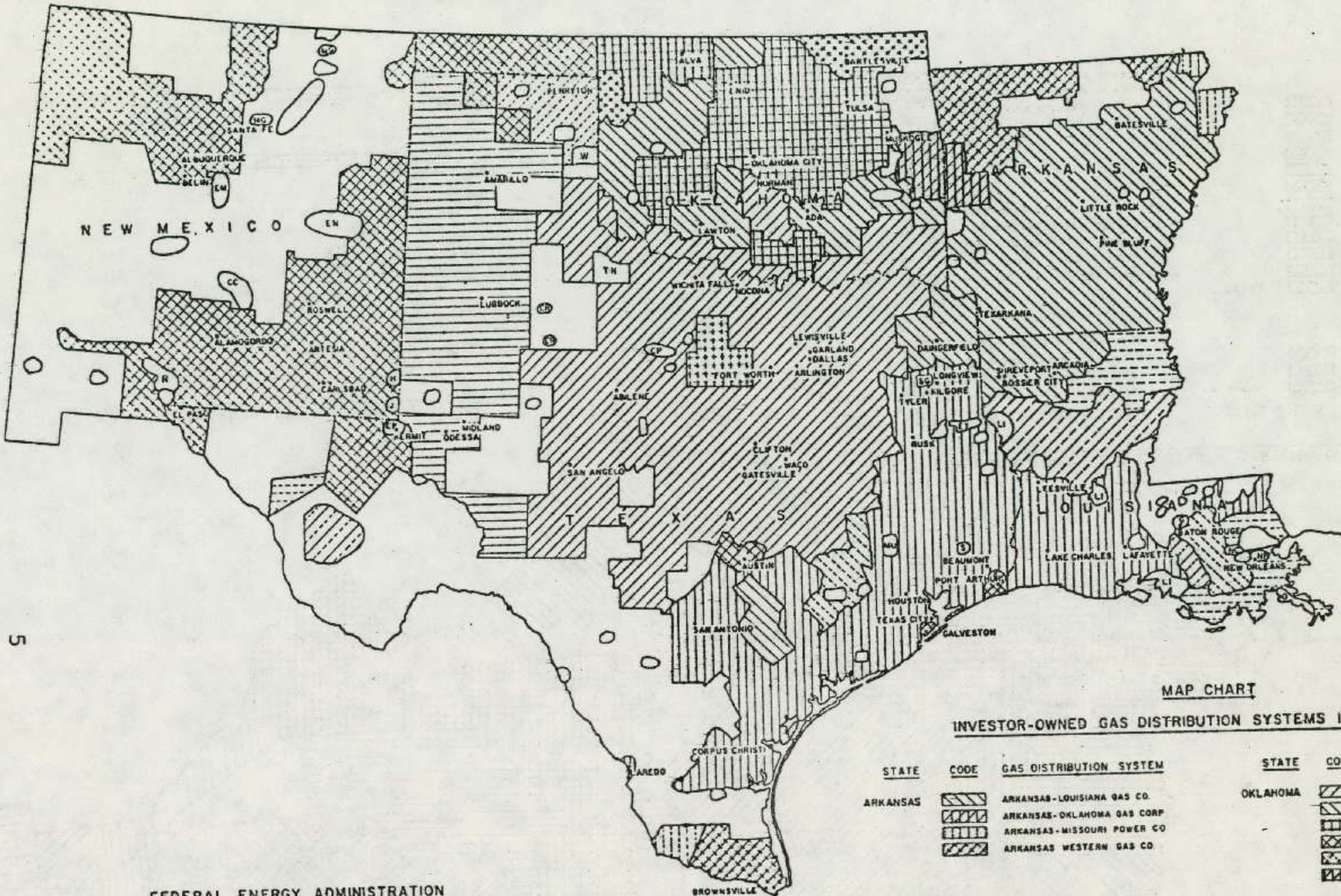
	MILLION BARRELS PER DAY
U.S.S.R.	11.40
UNITED STATES	8.66
SAUDI ARABIA	7.80
IRAN	5.25
IRAQ	2.50
VENEZUELA	2.15
LIBYA	2.05
CHINA	2.00
KUWAIT	1.90
NIGERIA	1.80
INDONESIA	1.65
ABU DHABI	1.45
CANADA	1.30
MEXICO	1.27
ALGERIA	1.26
UNITED KINGDOM	1.10

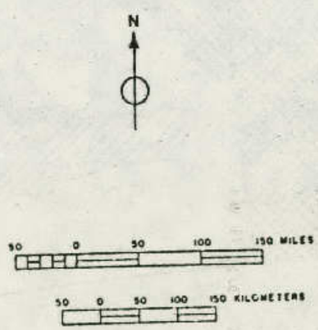


Regional Reliability Councils of the National Electric Reliability Council

ELECTRIC RELIABILITY COUNCIL OF TEXAS
(ERCOT)
PERCENT GENERATION BY FUEL TYPE







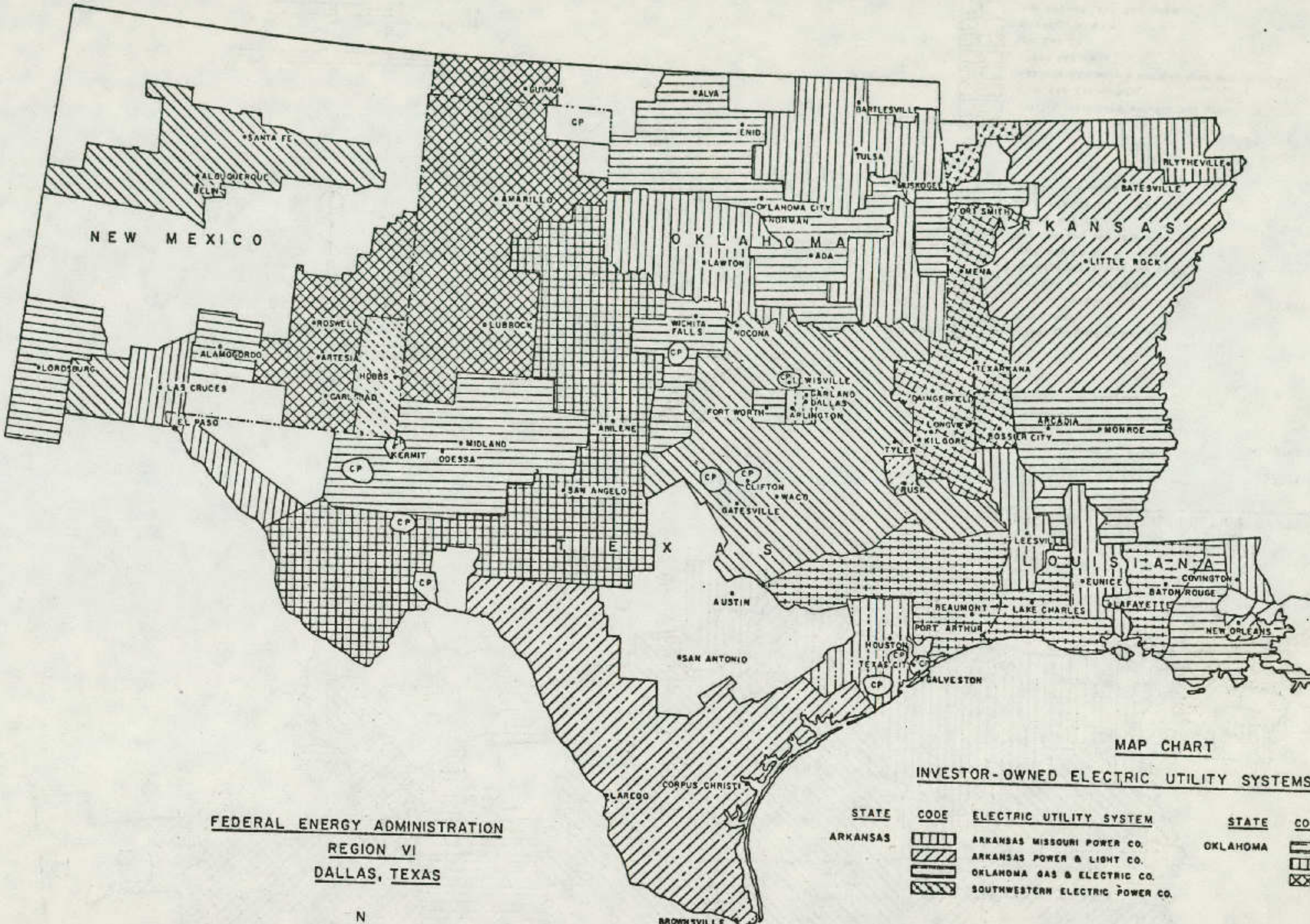
FEDERAL ENERGY ADMINISTRATION
REGION VI
DALLAS, TEXAS

MAP CHART

INVESTOR-OWNED GAS DISTRIBUTION SYSTEMS IN REGION VI (39)

STATE	CODE	GAS DISTRIBUTION SYSTEM
ARKANSAS		ARKANSAS-LOUISIANA GAS CO.
		ARKANSAS-OKLAHOMA GAS CORP
		ARKANSAS-MISSOURI POWER CO
		ARKANSAS WESTERN GAS CO
LOUISIANA		ARKANSAS-LOUISIANA GAS CO.
		ENTEX, INC.
		CENTRAL LOUISIANA ELECTRIC CO
		LOUISIANA GAS SERVICE CO.
	LI	LOUISIANA INTRASTATE GAS CORP
		DIXIE GAS CO.
	NP	NEW ORLEANS PUBLIC SERVICE INC.
	D	DELTA GAS CO.
	G	GULF STATES UTILITIES
	NC	NORCO GAS & FUEL CO
NEW MEXICO		SOUTHERN UNION GAS CO.
	CC	CAPITAN-CARRIZOZO NATURAL GAS ASSN.
	EM	EMW GAS ASSOCIATION
	EN	EASTERN NEW MEXICO NAT. GAS ASSN. INC.
	H	HOBBS GAS CO.
	J	JAL GAS CO.
	MG	MAXWELL GAS CO.
	R	RIO GRANDE NAT. GAS ASSN.

STATE	CODE	GAS DISTRIBUTION SYSTEM
OKLAHOMA		LONE STAR GAS CO.
		ARKANSAS-LOUISIANA GAS CO
		OKLAHOMA NATURAL GAS CO.
		SOUTHERN UNION GAS CO
		GAS SERVICE CO
		ARKANSAS-OKLAHOMA GAS CORP.
TEXAS		LONE STAR GAS CO.
		ARKANSAS-LOUISIANA GAS CO.
		ENTEX, INC
		PIONEER NATURAL GAS CO.
		SOUTHERN UNION GAS CO.
		BRAZOS RIVER GAS CO
	CA	CAP ROCK GAS CO.
		HIGH PLAINS NATURAL GAS CO.
	MU	MORAN UTILITIES
		GULF ENERGY & DEVELOPMENT CORP.
	ET	EAST TEXAS MUNICIPAL GAS CORP.
	SG	SOUTHERN GAS CO.
		RIO GRANDE VALLEY GAS CO.
	CP	COMMUNITY PUBLIC SERVICE
	S	SOUTHWEST GAS DISTRIBUTORS INC.
	TN	TEXAS NATURAL GAS CO
		TEXAS SOUTHEAST GAS CO.
		SOUTHWEST TEXAS MUNICIPAL GAS CO
		TEXAS WESTERN MUNICIPAL GAS CO
	W	WHEELER GAS CO.



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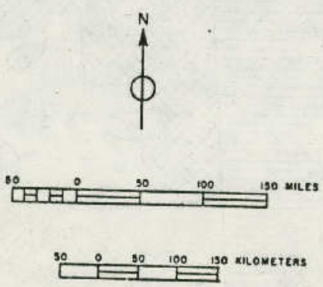
FEDERAL ENERGY ADMINISTRATION
REGION VI
DALLAS, TEXAS

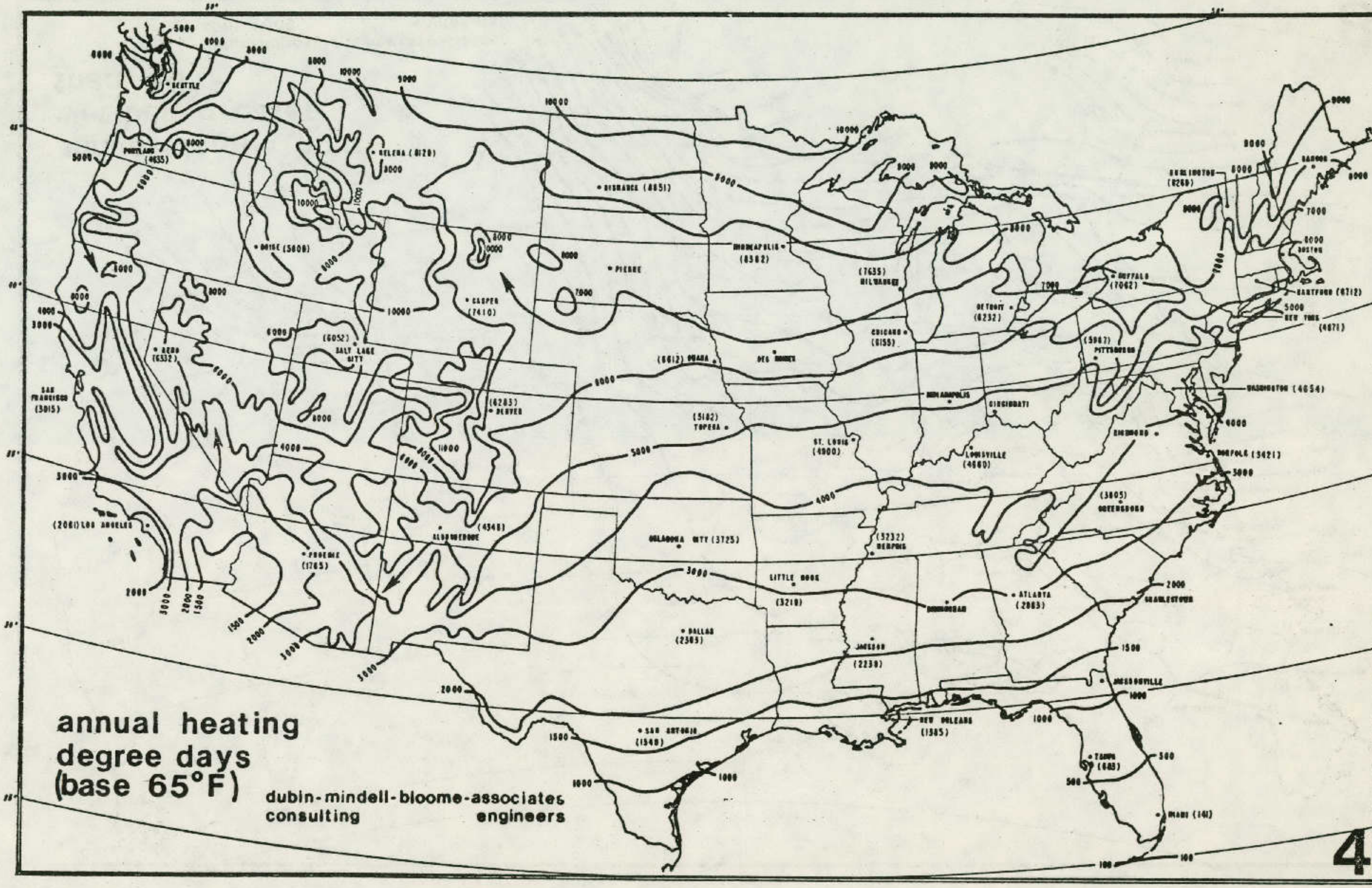


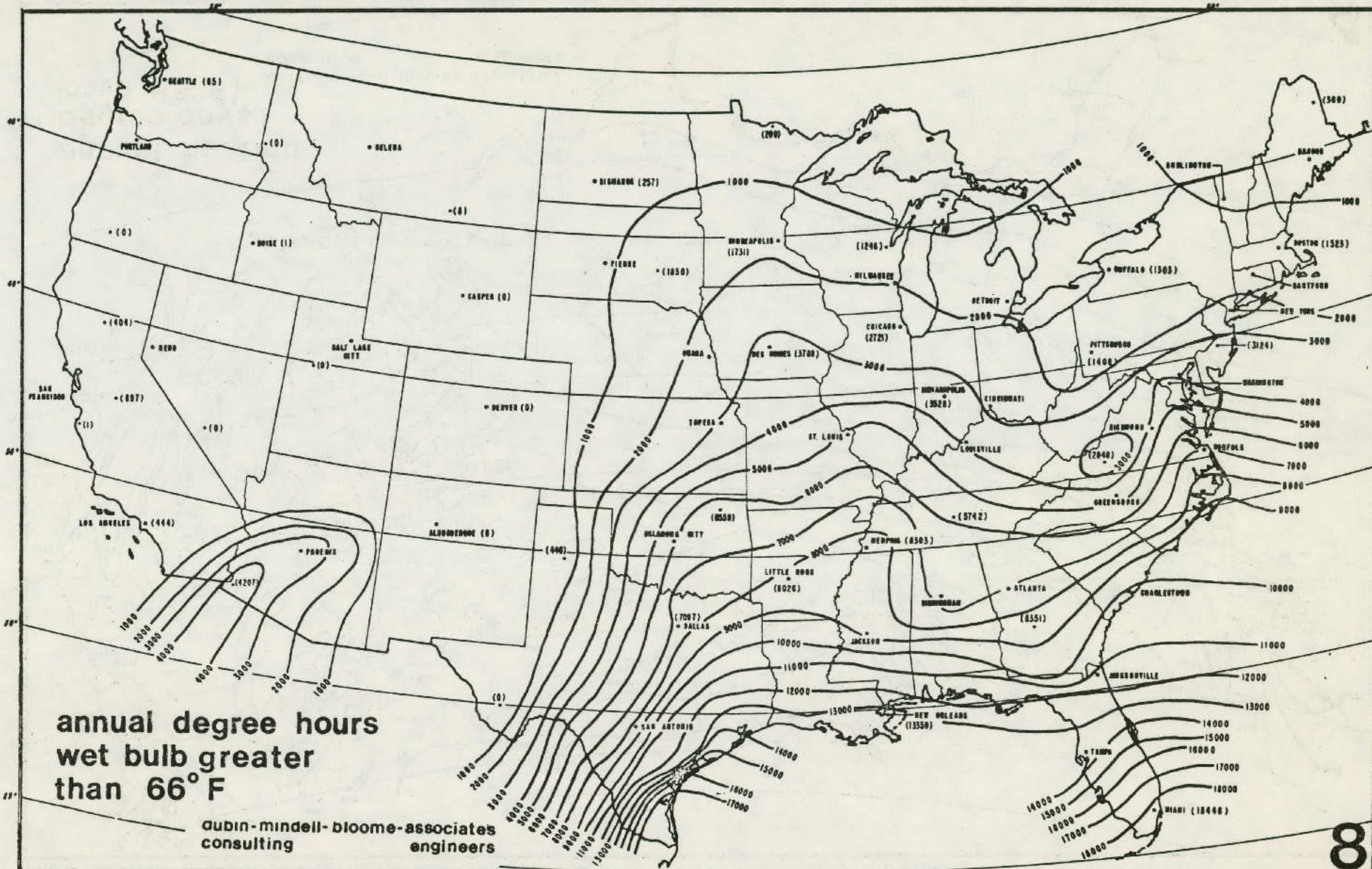
MAP CHART

INVESTOR-OWNED ELECTRIC UTILITY SYSTEMS IN REGION VI (22)

STATE	ELECTRIC UTILITY SYSTEM
ARKANSAS	ARKANSAS MISSOURI POWER CO.
	ARKANSAS POWER & LIGHT CO.
	OKLAHOMA GAS & ELECTRIC CO.
	SOUTHWESTERN ELECTRIC POWER CO.
LOUISIANA	CENTRAL LOUISIANA ELECTRIC CO INC
	GULF STATES UTILITIES CO.
	LOUISIANA POWER & LIGHT CO.
	NEW ORLEANS PUBLIC SERVICE, INC
	SOUTHWESTERN ELECTRIC POWER CO.
NEW MEXICO	COMMUNITY PUBLIC SERVICE CO
	EL PASO ELECTRIC CO.
	NEW MEXICO ELECTRIC CO
	PUBLIC SERVICE CO OF NEW MEXICO
	SOUTHWESTERN PUBLIC SERVICE CO.
OKLAHOMA	OKLAHOMA GAS & ELECTRIC CO
	PUBLIC SERVICE CO OF OKLAHOMA
	SOUTHWESTERN PUBLIC SERVICE CO
TEXAS	CENTRAL POWER & LIGHT CO
	COMMUNITY PUBLIC SERVICE CO (CP)
	DALLAS POWER & LIGHT CO
	EL PASO ELECTRIC CO
	GULF STATES UTILITIES CO
	HOUSTON LIGHTING & POWER CO
	SOUTHWESTERN ELECTRIC POWER CO
	SOUTHWESTERN ELECTRIC SERVICE CO
	SOUTHWESTERN PUBLIC SERVICE CO
	TEXAS ELECTRIC SERVICE CO
	TEXAS POWER & LIGHT CO
	WEST TEXAS UTILITIES CO

Extracted from: Guidelines for Saving Energy in Existing Buildings. Building Owners and Operators Manual: ECM 1 Vol.





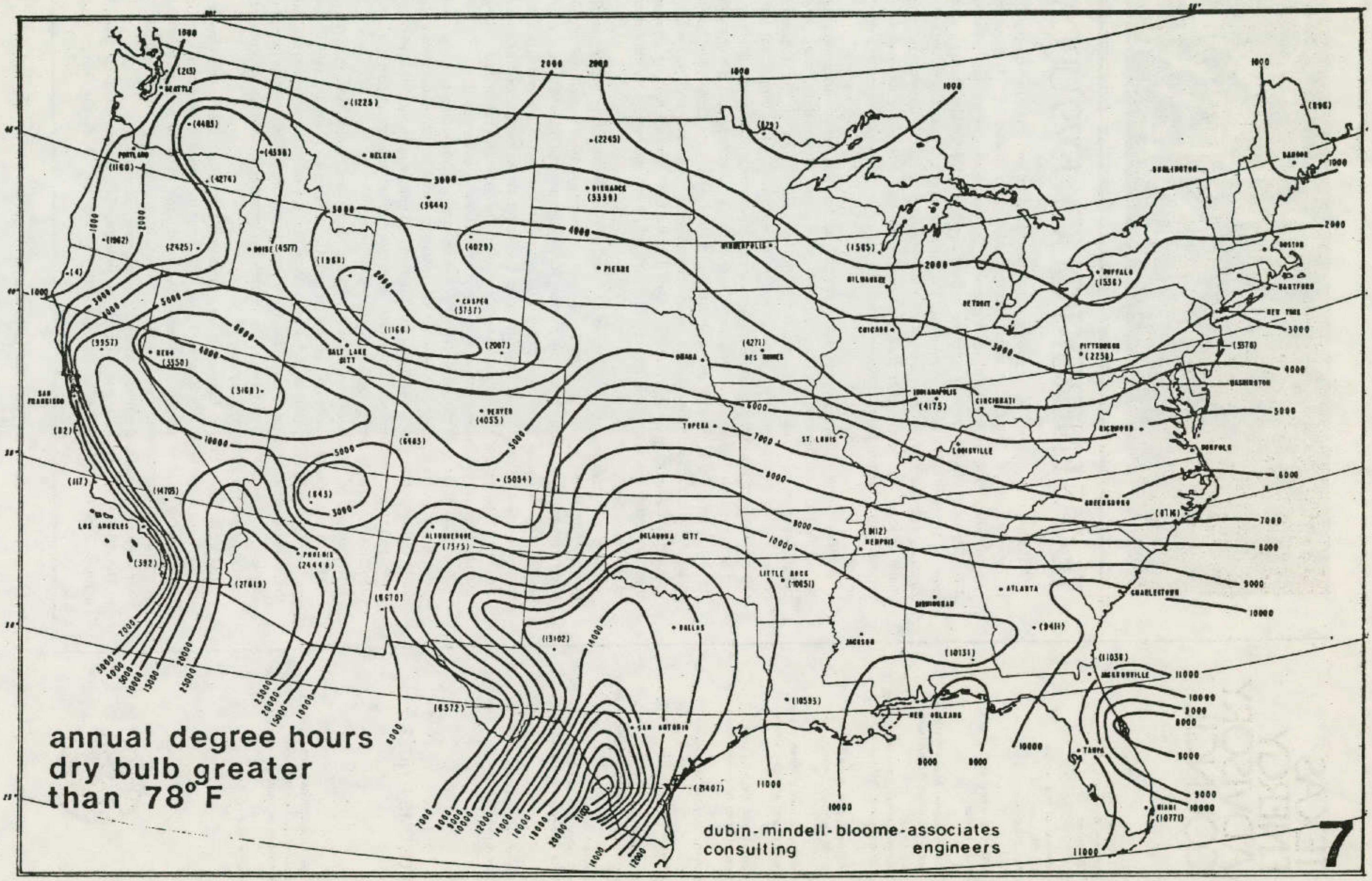
annual degree hours wet bulb greater than 66°F

dubin-mindell-bloome-associates consulting engineers

8

8

-65-


annual degree hours
dry bulb greater
than 78°F
dubin-mindell-bloome-associates
consulting engineers
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TEXAS ENERGY ADVISORY COUNCIL

VOLUME I, NO. 2

The TEAC NEWS is published quarterly; subscriptions available on request

Sheila Moritz, Editor

TEAC NEWS

TEXAS ENERGY POLICY: 1979 UPDATE

A major statement on Texas energy policy was adopted and published by the Council in February, 1977. Since then major changes in world, national and state events have occurred, requiring an update of the statement. During September through December of 1978 the staff, the Advisory Committee to the Council and the Council worked through a process of revising the policy statement. The new statement, *Texas Energy Policy: 1978 Update*, was adopted by the Council at the December 15, 1978 Council meeting. The major changes and additions contained in the more recent version are summarized in this article. Copies of the policy statement may be obtained by writing or calling the TEAC office.

A "State Role in Energy Policy Formulation" section was added concerning the need for explicit state input to national energy policy decision. National decisions on energy policy have major and disproportionate impacts on sectors of the economy and geographic regions of the country, particularly Texas. It is, therefore, important for states to have access to information and to participate in the national debate over energy policy.

The section on "Agriculture" was partially rewritten emphasizing that the energy needs for Texas agriculture are season oriented and require a reasonably certain fuel supply for successful production. The section recognizes that the State provided for relief from agriculture curtailment in legislation enacted by the 65th Legislature and recommends that agriculture maintain a high priority in demand policy and regulatory considerations of the legislature.

Two major additions to the section on "Boiler Fuel Restrictions" recognizes Texas' pivotal role with regard to a national boiler conversion policy and the potentially significant economic impact of rapid mandatory boiler conversion from the use of oil and gas to other fuel sources. The statement recommends the use of tax incentives for any conversion rates above that already occurring, balancing the economic costs of conversion and the economic benefits of natural gas and oil conservation in boiler fuel policy, and consideration of the environmental effects from mandatory conversion.

The "Conservation Through Government Programs" section discusses the need for government entities to employ energy conservation measures, thereby demonstrating conservation potential and providing information and encouragement for conservation in other sectors; it recommends that state government continue to support conservation programs aimed at reducing fossil energy consumption.

The section on "Conservation Through Public Awareness" emphasizes that the public needs to be made aware of conservation practices and methods which can be implemented with significant energy savings for either the retrofit of existing buildings or the construction of new ones. The statement recommends that Texas continue to encourage dissemination of energy information designed to provide energy conservation assistance and technical information.

The section on "Energy Emergency Preparedness" recognizes that energy emergencies can have debilitating effects if government and industry are not prepared for such an event and discusses cooperation between government and industry and the coordination of energy emergency measures by state agencies. It recommends that a long-term state energy emergency preparedness plan be formulated and adopted.

The "Gas Purchase Contracts" section was rewritten and discusses federal government actions and regulations under the Natural Gas Act of 1978, the Texas Railroad

Commission's work on setting realistic allowables, the benefits and adverse effects of "take-or-pay" provisions of gas purchase contracts, and the declaration of surplus natural gas. It recommends that the State of Texas continue its strong resistance to federal encroachment in the intrastate natural gas market; that the Railroad Commission continue its effort to balance statewide production with demand; and that provision be made for further study of the effects of "take-or-pay" provisions of gas purchase contracts on the natural gas market.

The section on "Industrial Energy Efficiency and Cogeneration" discusses the production of electricity from steam, and institutional and technical changes which are needed for better use of energy resources. This section's recommendations concern encouragement of the cogeneration of process steam and electricity, and the amendment of the Public Utility Regulatory Act to facilitate cogeneration.

The section on "Utility Rate Reform" was revised and discusses, among other matters, recent regulatory policy by the Public Utility Commission which established "flat" rates within user classes and the practical application of marginal cost pricing concepts to electric utility rate structures. Major recommendations suggest that utility rate structures should be used to accurately reflect costs to all consumer classes and should not be used for income transfer purposes, rate reform should be done equally for all energy utilities, and rate structures should encourage efficient allocation of scarce energy resources.

The "Community Impacts of Energy Development" section discusses the community impacts of energy development and facility construction. The section recommends that the State study alternative means of helping communities provide front-end financing for dealing with community service requirements associated with energy development.

A new section on "Energy Production from Agricultural Products" pertains to agriculture's role as a potential producer of energy and recommends that the state expand its support and encouragement of the rapid development of this alternate source of renewable energy.

The section on "Federal Coal Leasing" recommends that the national program called for by the Coal Leasing Act Amendments of 1977 be expedited so as to insure the timely and efficient development of federally owned coal.

The section entitled "Interconnection of Utility Systems" concerns intrusion of the federal government into Texas intrastate utility systems for purposes of interstate interconnections. The section encourages the PUC to continue to allow separate intrastate systems and to resist federal intrusion.

The "Interstate Utilities and System Reliability" section recommends that study be given to the creation of interstate compact commissions to resolve the problems of unequal regulation affecting the operation and reliability of Texas systems.

The primary focus in the "Nuclear Power" section is on encouragement of breeder technology and reprocessing and the streamlining of the licensing process to facilitate decision-making.

The section entitled "Production and Pricing of Crude Oil and Refined Products" discusses the problems of crude oil price controls and the entitlements program and recommends their orderly elimination.

The section on "Production and Pricing of Natural Gas" emphasizes support of a federal policy of phased deregulation and the use of all available means of preventing further federal intrusion into the intrastate market.

A new section was added entitled "Uranium Processing" recommending that state legislation be developed to satisfy certain federal conditions to allow state agencies to retain regulatory control of the licensing process for uranium mining and milling in Texas.

The section on "Technology Development Policy" recommends state support of RD&D for developing energy sources through direct funding, coordination and encouragement of federally funded Texas projects. The section recommends that market forces and the removal of institutional and regulatory barriers should provide the basis for commercialization of new technologies.

A new section, "Energy Taxation Policy", deals with the objectives and uses of energy taxation. The section recommends that federal energy taxation in the form of a crude oil equalization tax is inappropriate and that the objective of increasing domestic oil prices to world market levels should be accomplished through decontrol. The section recognizes the important role of energy taxes in supporting public services in Texas, the instability of this tax source because of changing energy markets and the need for study of the long-term implications of maintaining the current energy tax structure compared to available alternatives.

The new section on "Environmental Policy" deals with energy-related environmental policies of interest to Texas and seeks to address the major areas where the development, production and use of energy resources have significant implications for the integrity of the human and natural environment.

An "Energy Facility Siting" section recommends, among other things, that the present state government approach of regulating the impacts of energy activities rather than the activities themselves be continued.

The "Air Quality" section recognizes the critically limiting importance of existing state and federal air pollution policies to the use of coal and new energy facility siting and construction. The statement recommends the State Implementation Plan be revised to allow Texas assumption of permitting authority regarding prevention of significant deterioration policies.

The section on "Water Quality and Supply" recommends that revised national standards for thermal discharges from electric power plants continue to allow for maximum engineering flexibility in designing cooling systems and that requirements for documenting the effects of thermal discharges take into account regional climatic and environmental variation. It recommends that primary responsibility in addressing energy related water quality issues rest with the state.

The section on "Surface Mining Regulation" recommends continued state regulation of surface mining operations in Texas through the rewriting or amendment of the Texas surface mining law to meet the requirements of the Federal Surface Mining Control and Reclamation Act of 1977.

A "Nuclear Waste Disposal" section recommends that Texas continue to work with the federal government to determine the suitability of Texas geologic formulations for long-term storage, that Texas seek the powers of approval over the location in Texas of any waste disposal site and that the State support reprocessing of spent nuclear fuel.

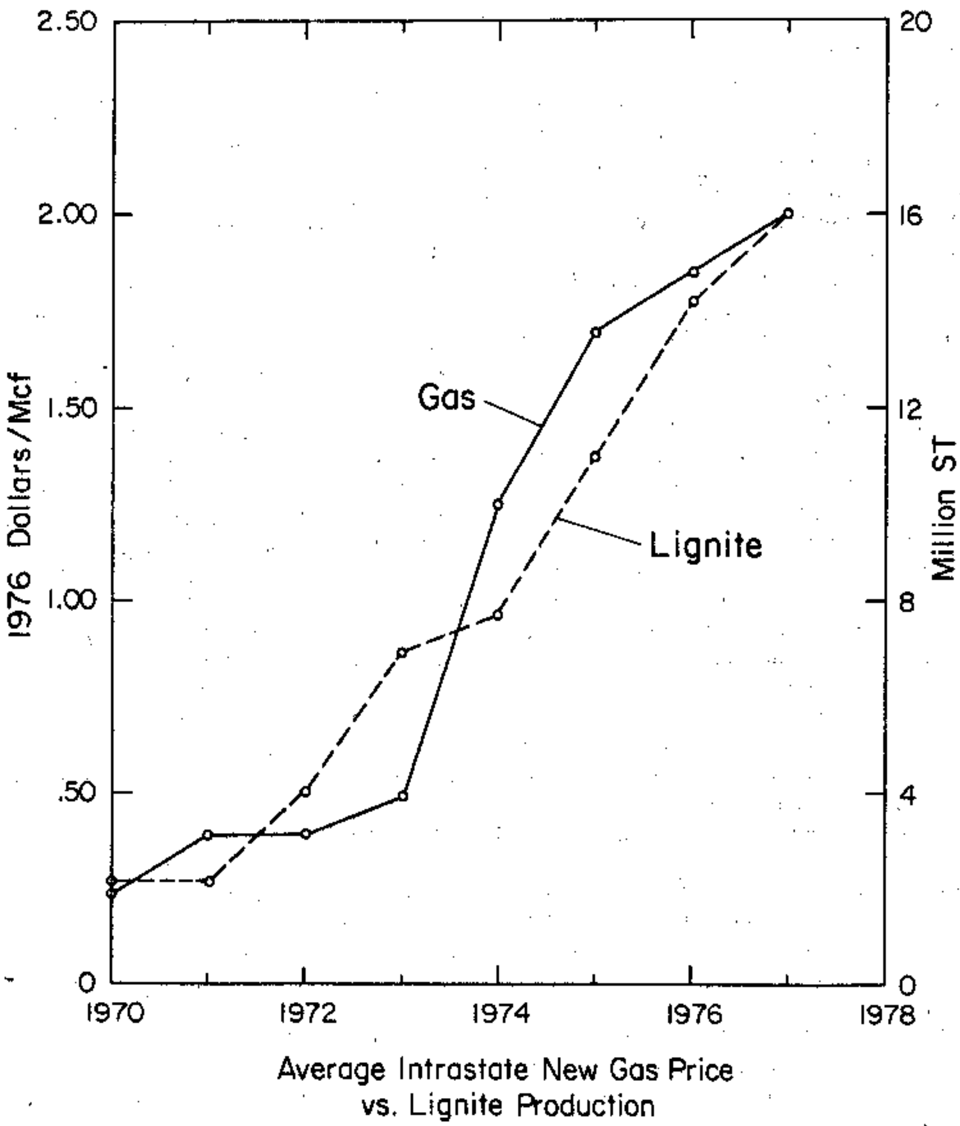


Figure 2. Correlation of rising intrastate gas price and increasing lignite production in Texas.

TABLE 3. TEXAS LIGNITE STEAM-ELECTRIC STATIONS

STATION	LOCATION	OWNER	SIZE MW	START UP	ANN PROD 10^6 ST[1]
Sandow	Alcoa Milam Co.	Alcoa	3(120)	1954	2.1
		Alcoa and Tx. Power & Light Co.	575	1981	2.7
Big Brown	Fairfield Freestone Co.	Texas Utilities Co.	575 575	1971 1972	2.7 2.7
Monticello	Monticello Titus Co.	Texas Utilities Co.	575 575 750	1974 1975 1978	2.9 2.9 3.8
Martin Lake	Tatum Rusk Co.	Texas Utilities Co.	750 750 750 750	1977 1978 1979 1983	3.5 3.5 3.5 3.5
Forest Grove	Athens Henderson Co.	Texas Utilities Co.	750	1982	3.8
San Miguel	Christine Atascosa Co.	So.Tx.& Medina Elec. Coops and Brazos Elec. Power Coop	400 400	1980 1985	2.7 2.7
Gibbons Creek	Carlos Grimes Co.	Texas Municipal Power Agency	400 400	1981 1984	2.7 2.0+
Twin Oak	Bald Prairie Robertson Co.	Tx. Power & Light Co. and Alcoa	750 750	1984 1985	3.5 3.5
Mill Creek	Oak Hill Rusk Co.	Texas Utilities Co.	750 750	1986	3.5
Undetermined	Harrison Co.	Southwestern Elec. Power Co.	640 640	mid-1980's	3.0
Oak Knoll	Oletha Limestone Co.	Texas Utilities Co.	750 750		
Undetermined	Unsited	Lower Colo. River Authority & Partners	600-750	1984	3.0

[1]Estimated from unit size, 80 percent capacity factor, 9,750 Btu/kwh, and lignite appropriate to each unit of 7,300, 6,700, or 5,000 Btu/lb.

TABLE 4. WESTERN COAL STEAM-ELECTRIC STATIONS

STATION	LOCATION	OWNER	SIZE MW	START UP	ANN. CONSUM 10^6 ST[1]
Harrington	Amarillo Potter Co.	Southwestern Public Service Co.	360 360 360	1976 1978 1980	1.45 1.45 1.45
Welsh	Cason Morris Co.	Southwestern Elec. Power Co.	528 528 528	1977 1980 1982	2.25 2.25 2.25
J. T. Deely	Elmendorf Bexar Co.	Public Service Board of San Antonio	418 418 375[2]	1977 1977 1986	1.75 1.75
W. A. Parish	Booth Fort Bend Co.	Houston Lighting & Power Co.	660 660 550	1978 1979 1980	2.65 2.65 2.20
Undetermined	Unsited		750	1984	2.85
Fayette	Fayetteville Fayette Co.	Lower Colo. R. Auth. and City of Austin	550 550	1979 1980	2.05 2.20
Coleto Creek	Fannin Goliad Co.	Central Power & Light	550 550	1979 1986	1.75
Plant X	Sudan Lamb Co.	Southwestern Public Service Co.	475 475	1982 1984	1.80 1.80
Morgan Creek	Colorado City Mitchell Co.	Tx. Elec. Service Co.	460[3]	1983	1.75
Tradinghouse Cr.	Waco McLennan Co.	Tx. Power & Light Co.	713[4]		
Permian Basin	Monahans Ward Co.	Tx. Elec. Service Co.	497[4]		
De Cordova	Granbury Hood Co.	Tx. Power & Light Co.	713[3]	1985	2.70
Undetermined	Unsited	West Texas Utilities	250 250	1982 1985	0.95 0.95

[1] Estimated from unit size, 80 percent capacity factor, 9,750 Btu/kwh, and coal appropriate to each unit of 10,700, 9,200, 9,000, 8,500, 8,200, & 8,000 Btu/lb.

[2] Bituminous coal or lignite.

[3] Conversion of gas-fired unit to coal firing.

[4] Possible conversion of gas-fired unit to coal firing between 1983 & 1985.

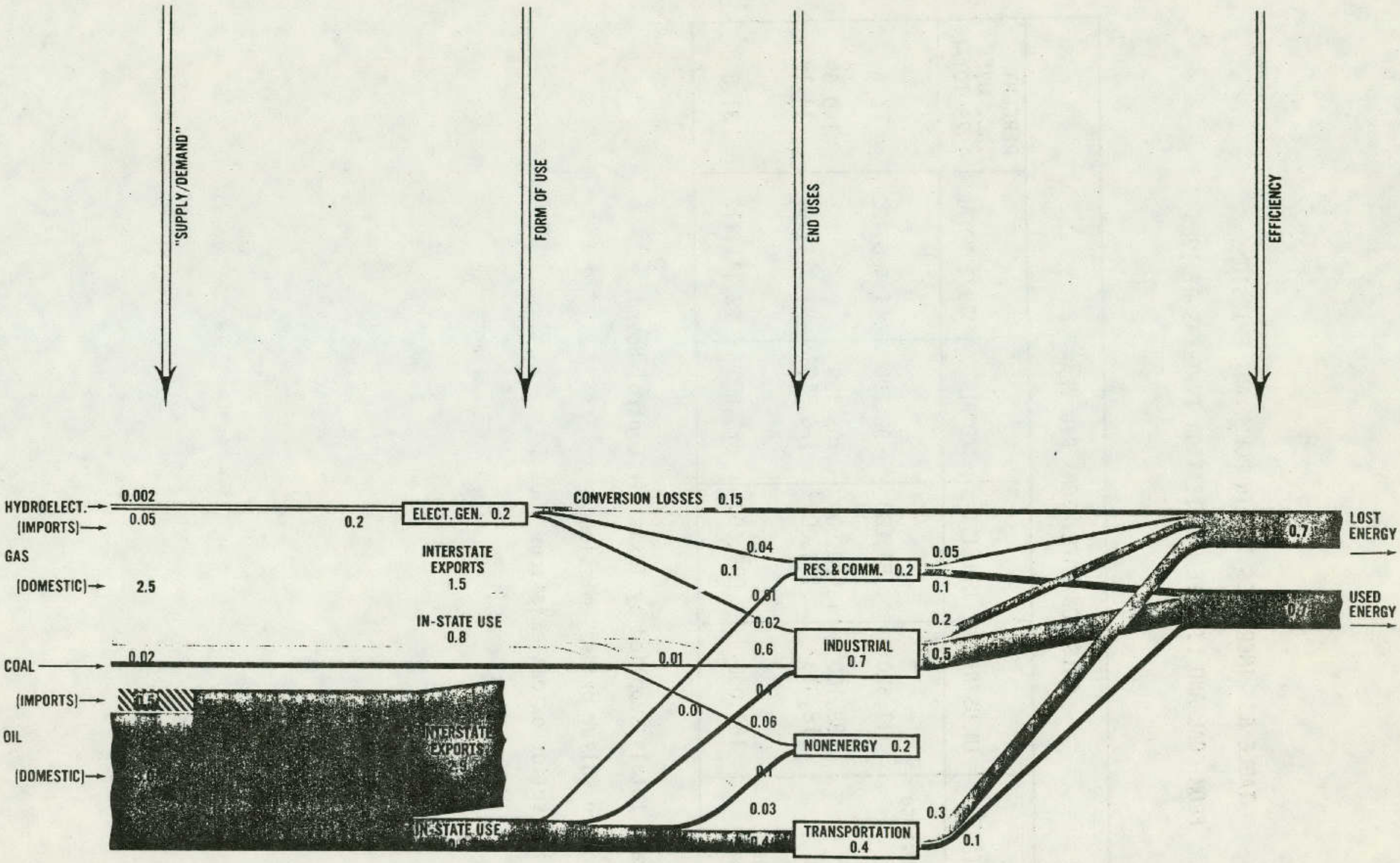
TABLE 6. INCREASES IN AIR POLLUTANT EMISSIONS FROM COAL AND LIGNITE UTILIZATION IN TEXAS BY 1985

EMISSION RATE--TONS PER YEAR					
AIR POLLUTANT	INDUSTRIAL	UTILITY	TOTAL	1973 TOTAL[1]	PERCENT INC. OVER 1973 TOTAL
Particulate Matter	11,520	81,280	92,800	1,406,132	6.6
Sulfur Oxides	188,100[2] 18,810[3]	1,520,000[2] 152,000[3]	1,708,100[2] 170,810[3]	1,214,909	140.6[2] 14.1[3]
Nitrogen Oxides	162,000	509,600	671,600	2,111,113	31.8

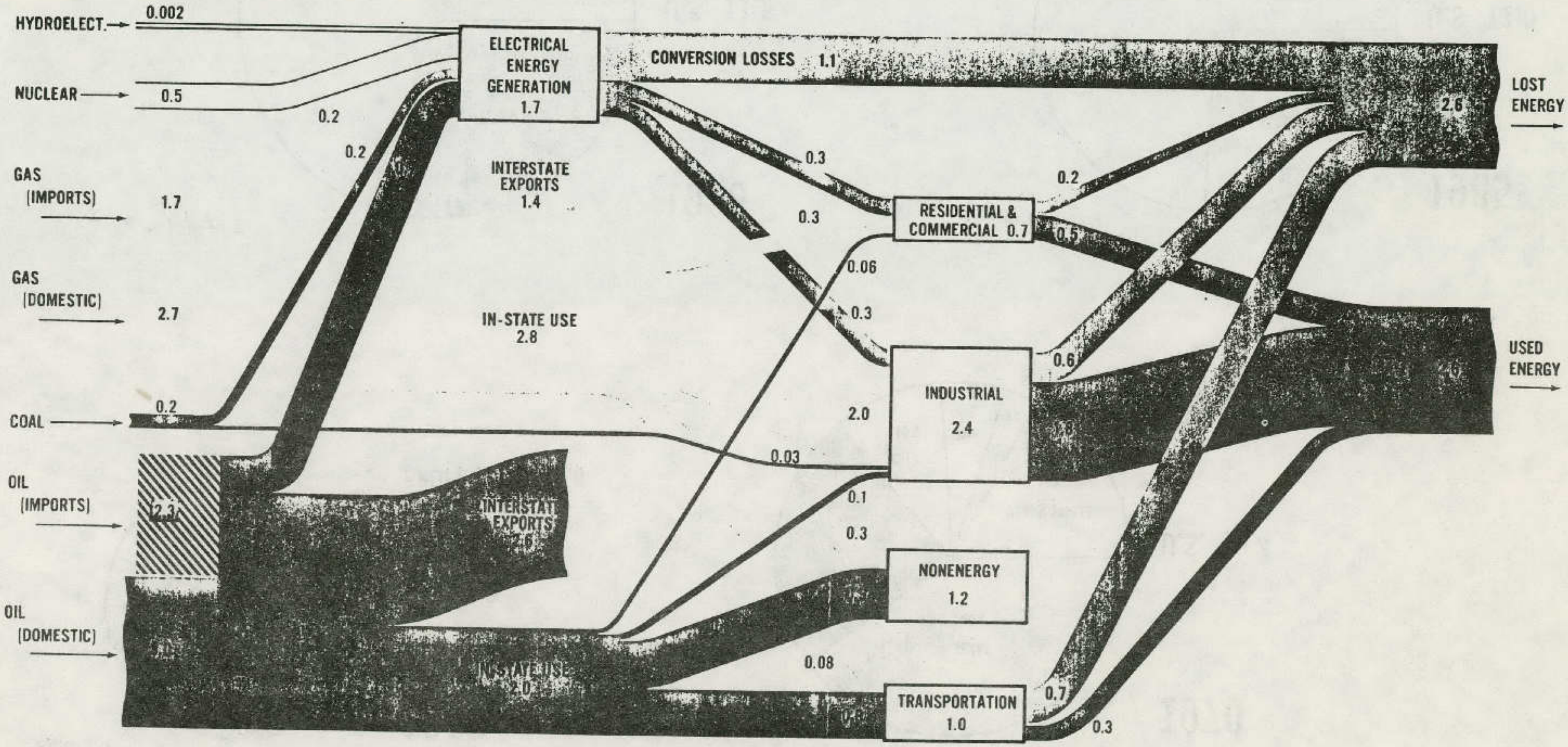
[1] 1973 State totals supplied by Texas Air Control Board.

[2] Uncontrolled sulfur oxides emissions.

[3] Controlled sulfur oxides emissions (90%).



(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

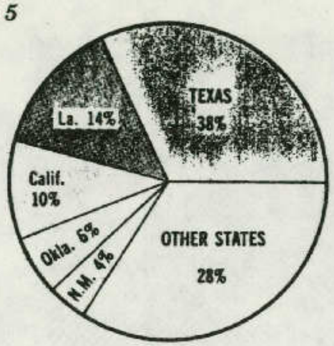


(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

D

Texas Proportion of U.S. Crude Oil Production, 1960-1985

Figure 5

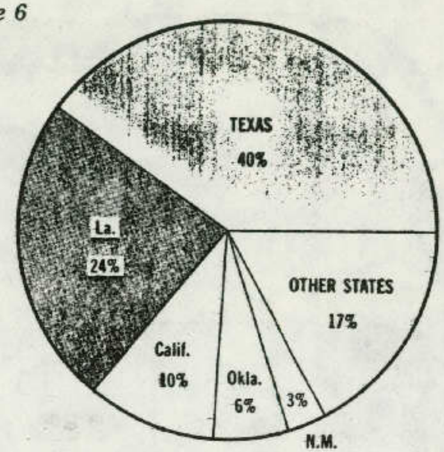


1960

U.S. 7.8*

TEXAS PROPORTION 3.0

Figure 6

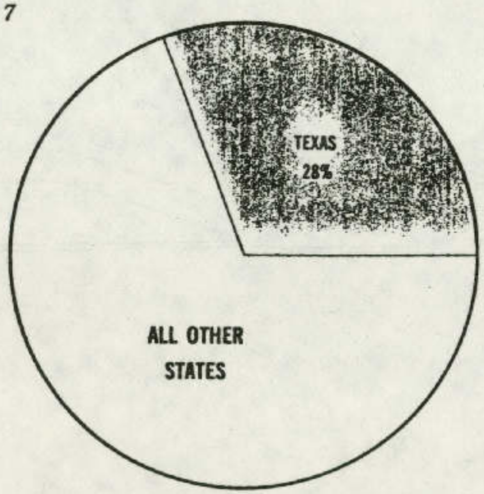


1970

U.S. 10.4

TEXAS PROPORTION 4.2

Figure 7

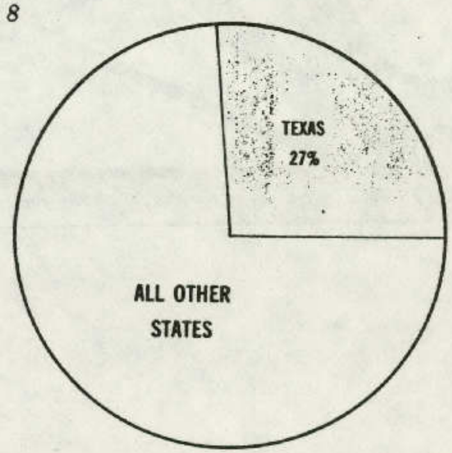


1980

U.S. 11.5

TEXAS PROPORTION 3.2

Figure 8



1985

U.S. 11.0

TEXAS PROPORTION 3.0

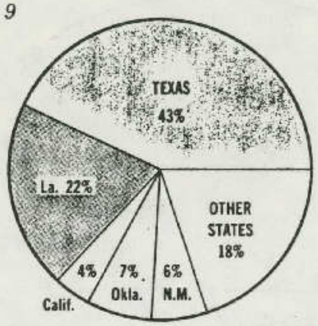
H

* All figures are Millions of Barrels per Day of Oil.
Size of the four graphs gives volumetric proportion.

FOLD-OUT "H"

Texas Proportion of U.S. Natural Gas Production, 1960 - 1985

Figure 9

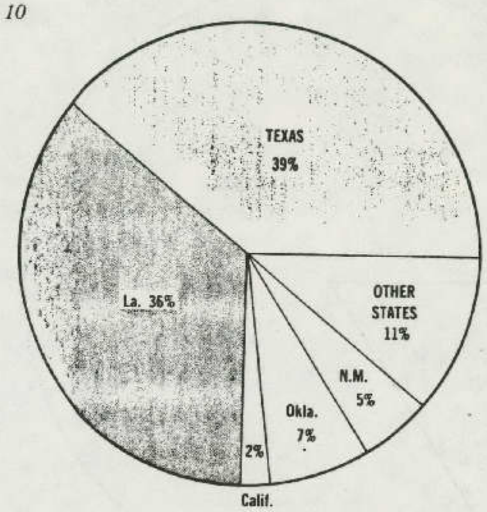


1960

U.S. 5.8*

TEXAS PROPORTION 2.5

Figure 10

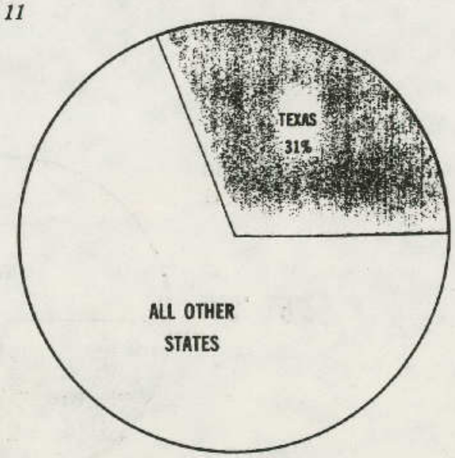


1970

U.S. 10.3

TEXAS PROPORTION 4.0

Figure 11

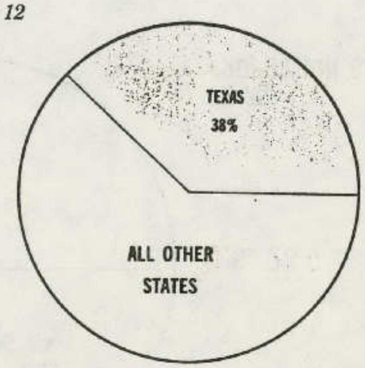


1980

U.S. 10.0

TEXAS PROPORTION 3.1

Figure 12



1985

U.S. 7.1

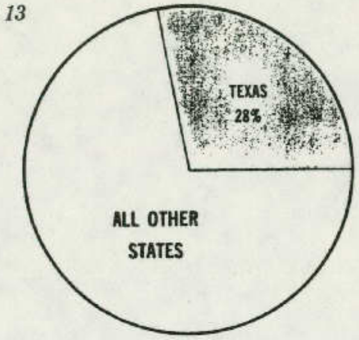
TEXAS PROPORTION 2.7

I

* All figures for Natural Gas are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

Texas Proportion of U.S. Total Energy Production, 1960 - 1985

Figure 13

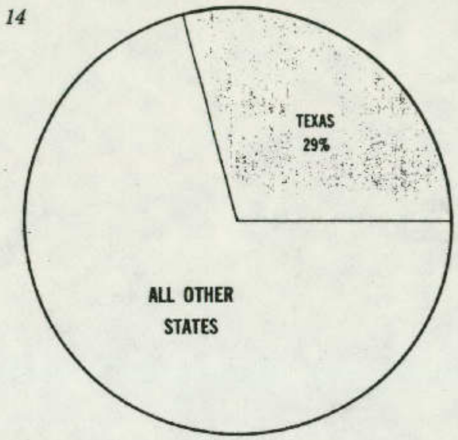


1960

U.S. 19.2*

TEXAS PROPORTION 5.4

Figure 14

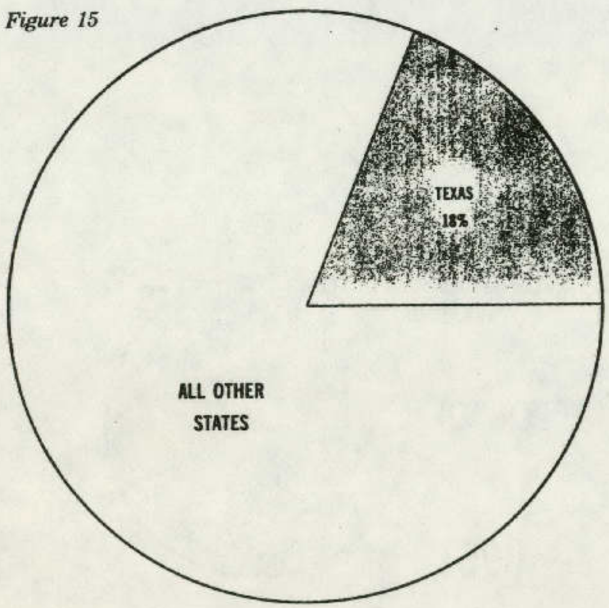


1970

U.S. 28.6

TEXAS PROPORTION 8.3

Figure 15

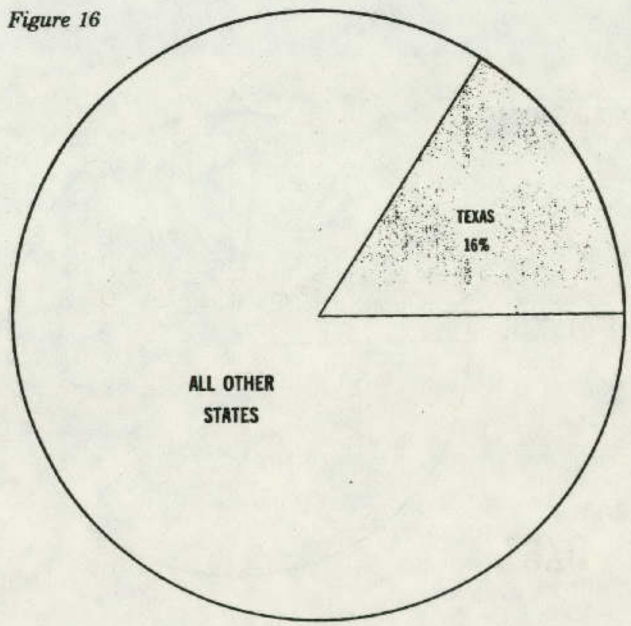


1980

U.S. 36.4

TEXAS PROPORTION 6.5

Figure 16



1985

U.S. 40.1

TEXAS PROPORTION 5.7

* All figures are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

FOLD-OUT "J"

Texas Total Energy Production/Consumption, 1960-1985

Figure 17

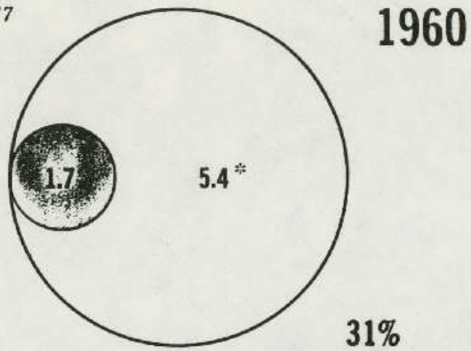


Figure 18

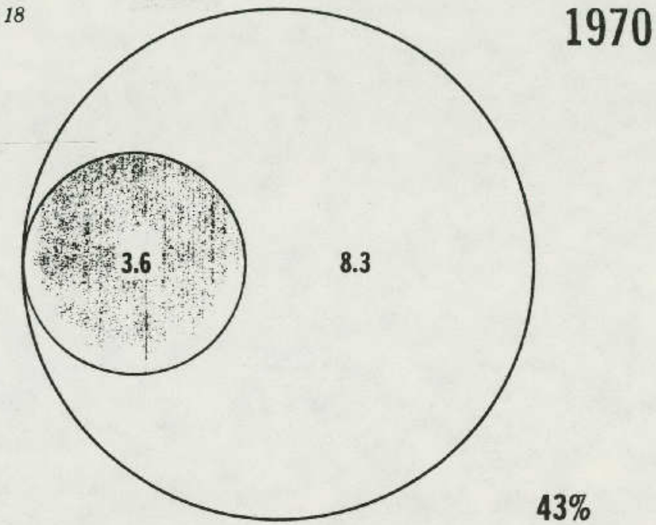


Figure 19

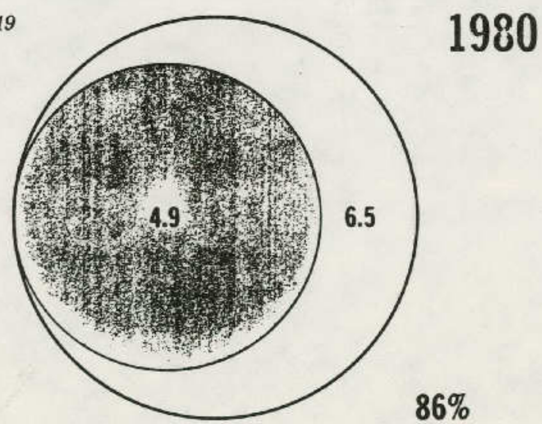
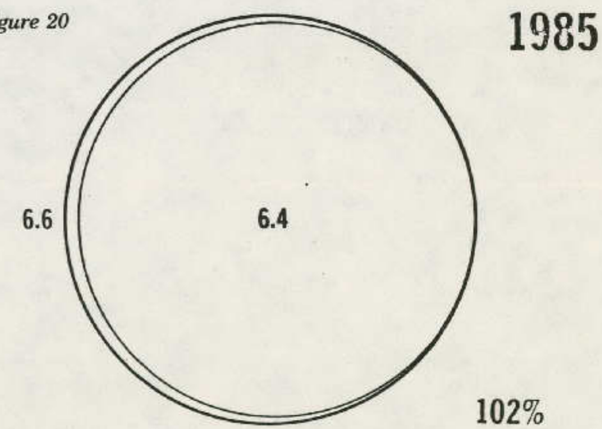


Figure 20



◯ Production ◯ Consumption

* All figures are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

FOLD-OUT "K"

2

ENERGY MANAGEMENT/CONTROL SYSTEMS

Energy Management/Control Systems

Table of Contents

ENERGY MANAGEMENT

Energy Supply

Energy consumption per capita in the United States is 2.3 times that of the western European nations and 2.6 times that of Japan. These figures clearly illustrate that we have major opportunities for more efficient energy use without impairment of our standard of living. The United States is very fortunate in having extensive resources of petroleum, natural gas, coal, uranium, and other fuels.

But as we know only too well from the early weeks of 1979, no source of imports can be considered truly reliable. Production in Iran, interrupted in November 1978, was not resumed for 3-4 months thereafter, and even then not at the pre-revolution level. For a few weeks, Iran did not produce enough oil for its own consumption, and the world had to do without that part of the 5.25 million barrels per day which Iran had normally exported. Western European nations, Japan, and Israel were harder hit by this sudden end of exports than was the United States, since the U.S. was only importing 500,000 barrels a day from Iran. But by May the United States was feeling the result of the disruption in the form of gasoline lines across the nation. The impact of the Iran shortage would have been felt much more, and sooner, but for the increase in production by Saudi Arabia from 7.8 million barrels per day in 1978 to a near capacity production of 11.5 million barrels per day.

It might be well to keep in mind who produced oil in what quantities in the world in 1978. The United States, just three years ago was still the number one producer of oil and natural gas liquids in the world. In 1978, the Soviet Union was number one in oil production, and exceeded the number two producer Saudi Arabia by nearly three million barrels per day. The United States regained the number two position from Saudi Arabia in the full flow from the Alaskan North Slope.

	Million Barrels Per Day
U.S.S.R.	11.40
United States	8.66
Saudi Arabia	7.80
Iran	5.25
Iraq	2.50
Venezuela	2.15
Libya	2.05
China	2.00
Kuwait	1.90
Nigeria	1.80
Indonesia	1.65
Abu Dhabi	1.45
Canada	1.30
Mexico	1.27
Algeria	1.26
United Kingdom	1.10

To put this in perspective, United States imports of crude oil in December of 1978 were on the order of 6.8 million barrels per day, up 11% from 1977, 15% since 1976, and 114% since 1973, the year of the Arab embargo. As long as the United States must rely on imports for such a high percentage of its energy supply, the ever-changing social and economic order in the supplying nations will make that supply uncertain. Thus, supply as well as cost is a consideration in wise and farsighted energy management. The talk in early 1979 of rationing of gasoline and forced closing of gasoline stations on Sunday is not without justification.

Energy Cost

Beginning in the 1950's, energy prices in the United States and the free world had declined in real value. The cost of production was considered to be the major variable, not the real worth of the oil, gas, or coal in the ground. In the fall of 1973 that suddenly changed, and that change continues unabated today. We have laws on the books in the United States that will gradually phase out price controls on both crude oil and natural gas. So it seems reasonable to assume that oil and gas prices, on the average will increase by the average rate of inflation plus a gradual, but increasing, price increment to bring domestic oil and gas prices to the "free market" or world price. And then we should expect these prices to rise by at least the average rate of inflation in the free world. Long-term contracts now held by some electric and gas utilities will ameliorate the increase and slow its total impact, but they will not change the eventual result.

The cost of energy has in the past been so relatively inexpensive that the majority of businesses made little effort to limit their energy consumption. Whether it was something as simple as shutting down an air conditioning unit at night and on week-ends or turning off unnecessary lights, standard practice was to ignore the potential savings in energy costs since the energy bill seemed insignificant when compared to other plant operating costs.

But with energy costs rising 400 to 800% in many places over the last few years, we have all been forced to re-evaluate our attitudes. When energy bills approach and exceed 5% of total expenses, most owners, managers, and operators begin to realize the potential profit to be realized by using energy more wisely.

Total Energy Management

A need for energy management has quite obviously replaced the earlier cry for energy conservation; so energy management is the subject for the remainder of this workbook.

All buildings have three fundamental systems which affect energy use. These are energized systems, non-energized systems, and human systems.

Energized systems are those which consume energy directly. Typical energized systems include, among others, those used to provide heating, ventilation, cooling, humidification, dehumidification, lighting, hot water heating, interior conveyance, food cooking, dishwashing, and waste handling as well as various pieces of equipment such as typewriters, computers, copying machines, and specialized process equipment unique to the process conducted in the building.

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

Human systems comprise those persons who affect when and in what quantity energy is consumed. These persons include building owners and managers; operating and maintenance personnel; as well as occupants or users of the building. Were it not for this third category of systems, energy management conducted solely by operating and maintenance personnel might suffice. But since there are so many ways the tenant or occupant can influence the amount of energy used, there is a need for total energy management. Accordingly, this manual is intended for management, technical personnel, and occupants. The word total thus implies actions on the part of every person who in any way is connected with the use of the building.

Viewed in the total context, total or overall energy management becomes not a series of disconnected unrelated actions, but rather a logical progression of management and planning actions. The necessary and desirable actions are listed here:

1. Decide to implement overall energy management system
   - -- assign responsibility
   - -- sell idea
2. Set up system to track energy use in BTU/SQ. FT./MONTH and BTU/?/MONTH where "?" is any other unit of measure you desire.
   - -- past year(s)
   - -- future
3. Develop Overall Energy Management Program with involvement at all levels.
   - -- orientation, education, program for all employees or occupants
   - -- operations and maintenance
   - -- plant modifications, mechanical and lighting systems, building shell

4. Conduct an energy audit
   - -- preliminary energy audit, walk-through survey or mini-audit
   - -- computerized analysis
   - -- detailed energy analysis or maxi-audit
5. Establish tough and measurable energy use goal, using energy tracking system for measurement
   - -- implement all no-cost actions
   - -- implement selected capital improvement retrofit projects and measure energy savings
6. Report the results in both energy and dollar terms.

Accomplishment of total energy management goals requires that top management be committed to the concept. Based on this commitment, managers and operators can set in motion the necessary management actions. The first of these involves the assignment of responsibility and the initiation of actions to convince all personnel of the need for such a program.

The first substantive management effort should be a review of the building's past energy consumption. This review will be discussed in detail later in this section. It should include the development of an energy use index in BTU's (British Thermal Units) of energy used per square foot of heated and cooled space -- computed monthly and added for all twelve months for the year for an annual use index. Such computations will permit energy use in the building to be compared with similar sized energy efficient buildings and with other buildings of a similar size and similar use.

Concurrently with this use analysis for each building, a program of actions and a schedule should be established. These actions should and must involve all employees or occupants, and all operating and maintenance personnel. All of these personnel must be trained in the recognition of inefficient situations and in the proper actions to be taken.

An energy audit is next. An energy audit is a comprehensive building survey, the purpose of which is to determine where opportunities for energy conservation exist. In many cases significant waste can be eliminated through repair of faulty equipment and improved maintenance and operating practices. Numerous other options are available, some requiring little change from current procedures, others involving modifications much broader in scope. The energy audit may vary in detail and complexity, usually with final results proportional to the initial invested effort, from a walk-through survey to a computerized analysis and to a detailed energy analysis.

Following a review of the audit results, it is management's responsibility to turn opportunities into actual savings and to establish priorities. Many of these will require little or no cost, others will require more study, detailed cost analysis, and major expenditures of funds.

Finally, the results of the program should be reported to all those involved from time to time to insure continued maximum effectiveness of the programs.

OFFICE BUILDING ENERGY MULTIPLYING FACTORS

	MULTIPLIERS COOL	HEAT	ELECTRIC
1. Hours of Operation			
One Shift Only	1.00		1.40
More than one but less than three	1.24		1.40
Three Shifts	1.49		1.90
2. Controls			
Heating and Cooling			
Heating only			0.95
Simultaneous heat and cool	1.74	1.74	1.54
3. HVAC System Type			
Thru wall units	1.41	0.62	0.84
Central chilled water			
Rooftop or packaged units	1.41		
4. Glass Area			
Less than 25% single glass or any quantity of double glass	0.82	0.73	0.94
25% to 75% single glass			
More than 75% single glass	1.21	1.31	1.04
5. Ventilation			
Less than 0.25 CFM/SF			
More than 0.25 CFM/SF	1.05	1.25	1.05
6. Energy Type For Cooling			
Electric			
Steam or Hot Water	5.00		
7. Lighting			
Less than 50 FC or 2 W/SF	0.81		0.71
50 to 100 FC or 2 to 4 W/SF			
More than 100 FC or 4 W/SF	1.14	1.00	1.31
8. Other Uses in Building			
None			
Computer (less than 5% SF)	2.05		2.04
Parking (less than 20% SF)			1.11
Commercial or Food Service (up to 10% SF)	1.11		1.11
More than any of above (Not Considered)			
9. Climate			
Less than 3,000 DD	1.24	0.79	
3,000 to 6,000 DD			
More than 6,000 DD	0.91	1.29	
10. Energy Type For Heating			
Purchased steam, hot water or electric			
Gas or Oil Boilers	1.61	1.49	

Product of Multipliers (By Category)

ENERGY (BTU/SF/YR) = Product of Heating Multipliers x 29000 =
Product of Cooling Multipliers x 11000 =
Product of Electric Multipliers x 44000 =

EXAMPLE:

An office building in Atlanta in which hours of operation are from 7 a.m. to 8 p.m. each day, that has over 75% glass single pane, that brings in over .25 CFM per sq. ft., uses approximately 5 watts per sq. ft. 120 FC at the 3½ ft. level, has a gas fired boiler, and a terminal reheat system.

HEATING

1.0 x 1.74 x 1.31 x 1.25 x .79 x 1.49 = 3.35 x 29,000 + 97,150 BTU/Sq.Ft.

COOLING

1.24 x 1.74 x 1.21 x 1.05 x 1.14 x 1.24 = 3.87 x 11,000 + 42,570 BTU/Sq.Ft.

ELECTRIC

1.4 x 1.54 x 1.04 x 1 05 x 1.31 = 3;04 x 44,000 + 133,760 BTU/Sq.Ft.

273,480 BTU/Sq.Ft.

ENERGY USE IN COMMERCIAL BUILDINGS

As part of its effort to develop building performance standards, the Department of Energy had AIA Research Corp. survey 6,254 recently completed buildings to estimate how much annual energy use the structures require per gross square foot per year. The nonresidential results are summarized below.

One way to view the results is to see how much more efficient than the median were the top 20 percent of the category's buildings. Regulators could argue that a level reached 20 percent of the buildings might eventually by reached by 50 percent, particularly if the differences among survey results from different climatic zones are modest. Using this approach, the greatest room for improvement lies in warehouses, secondary schools and hospitals.

Another way to view the results is to compare them with the nationwide median for high-rise apartment buildings, which is 49,000 British thermal units per year per square foot, and which would be 49 in the table below. The statistics are based on design characteristics, not actual energy consumption. The estimates exclude energy needs for hot water, office equipment, commercial equipment and the like.

DEFINITION OF CLIMATIC ZONES: The Minneapolis zone, with maximum heating and little cooling, also includes Binghamton, Madison (Wis.), and Milwaukee. The Chicago zone, with heavy heating and little cooling, also includes Akron, Allentown, Boston, Columbus, Denver, Detroit, Hartford, Johnstown (Pa.), Omaha, and Spokane. The Newark zone, with substantial heating and little cooling, also includes Albuquerque, Charleston (West Va.), Kansas City (Mo.), Louisville, Portland (Ore.), and Washington (D.C.). The Dallas zone, with moderate heating and much cooling, also includes Bakersfield and Las Vegas. The San Francisco zone, with moderate heating and little cooling, also includes Atlanta, Birmingham (Ala.), Raleigh, and Sacramento. The Miami zone, with little heating and much cooling, also includes Baton Rouge, Mobile, Phoenix, and San Antonio. The Los Angeles zone, with little heating and little cooling, also includes San Diego. The two levels of climatic air-conditioning needs are divided at 2,000 cooling degree-days per year. The five levels of climatic heating needs are divided at 2,000 heating degree-days per year and then at 4,000, 5,500 and 7,000. Degree days are a measure of how much and how often the outside temperature differs from 65 degrees.

In thousands of British thermal units of heat needed annually per gross square foot:

	Required By Median Bldg. In Category	Category's Extreme Cases	Mid-Range After Excluding Top 20% And Bottom 20%	Percent Saving In Energy Over Median Achieved By Worst Bldg. In Top 20%
OFFICE BULDINGS:				
Nationwide	61	26-199	48-80	21
Minneapolis zone	61	38-109	55-75	10
Chicago zone	71	28-199	63-76	11
Newark zone	59	30-140	49-82	17
Dallas zone	65	26-128	52-68	20
San Francisco zone	57	34-132	45-68	21
Miami zone	48	31-92	39-58	19
Los Angeles zone	51	29-92	34-54	33
RESTAURANTS:				
Nationwide	140	49-392	105-210	25
Minneapolis zone	138	89-390	114-184	17
Chicago zone	150	84-392	111-221	26
Newark zone	160	82-352	106-232	34
Dallas zone	125	54-279	104-157	17
San Francisco zone	137	49-379	102-153	28
Miami zone	120	76-280	104-154	13
Los Angeles zone	113	71-193	89-155	21
STORES:				
Nationwide	84	25-230	62-99	26
Minneapolis zone	88	56-190	72-120	18
Chicago zone	93	25-230	67-134	28
Newark zone	87	46-150	69-97	21
Dallas zone	80*	44-114	—	—
San Francisco zone	80	55-98	72-91	10
Miami zone	83	44-120	55-100	34
Los Angeles zone	62	31-141	40-86	35
THEATERS:				
Nationwide	53	20-166	40-69	25
Minneapolis zone	58*	35-83	—	—
Chicago zone	62	39-163	46-103	26
Newark zone	61	33-166	53-75	13
Dallas zone	57*	24-99	—	—
San Francisco zone	47	21-117	42-58	11
Miami zone	57	20-153	33-102	42
Los Angeles zone	34	27-142	30-45	12
ELEMENTARY SCHOOLS:				
Nationwide	50	23-165	47-79	6
Minneapolis zone	114*	80-135	—	—
Chicago zone	67	29-149	54-84	19
Newark zone	61	44-95	51-86	16
Dallas zone	57*	23-82	—	—
San Francisco zone	61	29-165	53-80	13
Miami zone	48	23-71	38-55	21
Los Angeles zone	49	30-91	39-65	20
SECONDARY SCHOOLS:				
Nationwide	49	16-242	35-66	29
Minneapolis zone	77*	52-100	—	—
Chicago zone	64	33-242	45-78	30
Newark zone	48	32-98	37-75	23
Dallas zone	34*	27-61	—	—
San Francisco zone	47	19-141	39-55	17
Miami zone	36	16-68	29-54	19
Los Angeles zone	34	22-66	24-49	29
WAREHOUSES:				
Nationwide	61	20-179	38-83	38
Minneapolis zone	75*	40-122	—	—
Chicago zone	72	33-179	61-99	15
Newark zone	69	22-93	48-80	30
Dallas zone	39*	20-56	—	—
San Francisco zone	50*	38-61	—	—
Miami zone	37*	22-44	—	—
Los Angeles zone	36*	31-45	—	—
CLINICS:				
Nationwide	60	33-162	52-79	13
Minneapolis zone	84*	42-162	—	—
Chicago zone	70	43-151	49-90	30
Newark zone	71*	46-127	—	—
Dallas zone	59*	45-76	—	—
San Francisco zone	65*	43-103	—	—
Miami zone	59*	33-104	—	—
Los Angeles zone	61*	38-104	—	—
HOSPITALS:				
Nationwide	160	85-493	113-231	29
Minneapolis zone	—	—	—	—
Chicago zone	209*	106-493	—	—
Newark zone	171*	91-301	—	—
Dallas zone	197*	91-442	—	—
San Francisco zone	227*	152-489	—	—
Miami zone	230*	200-238	—	—
Los Angeles zone	207*	85-380	—	—
COLLEGE BUILDINGS:				
Nationwide	56	31-168	41-88	27
Minneapolis zone	67*	39-103	—	—
Chicago zone	70*	51-124	—	—
Newark zone	46*	31-125	—	—
Dallas zone	83*	36-168	—	—
San Francisco zone	59*	38-134	—	—
Miami zone	73*	70-123	—	—
Los Angeles zone	87*	83- 89	—	—

* Asterisk means average is used rather than the median because too few buildings were surveyed to use distribution percentages. The average of the numbers one, three and eight is four, the sum divided by three. The median, the case ranked in the middle, is three.

Source: AIA Research Corp., "Phase One Base Data for the Development of Energy Performance Standards for New Buildings."

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.

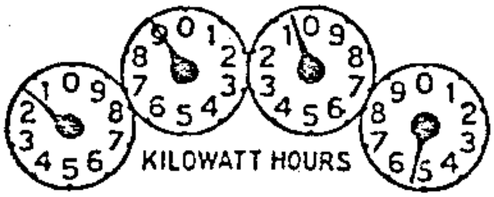
The kilowatthour demand meter may be separate from or be a component of the kilowatthour meter. Due to the many variations in demand meters and methods of reading each, you should consult with your utility company for instructions in reading your specific demand meter.

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.

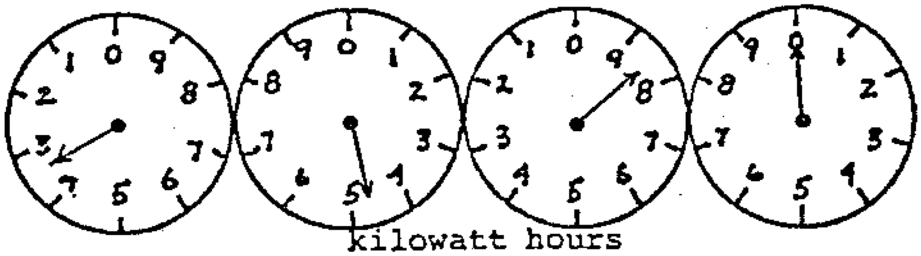
The sweep dial face meter records the maximum demand during the billing period. The pointers will indicate directly and hold the maximum KW demand during any period of the billing month. This indicated demand must be multiplied by the indicated dial face multipliers, if there is one, to obtain the correct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

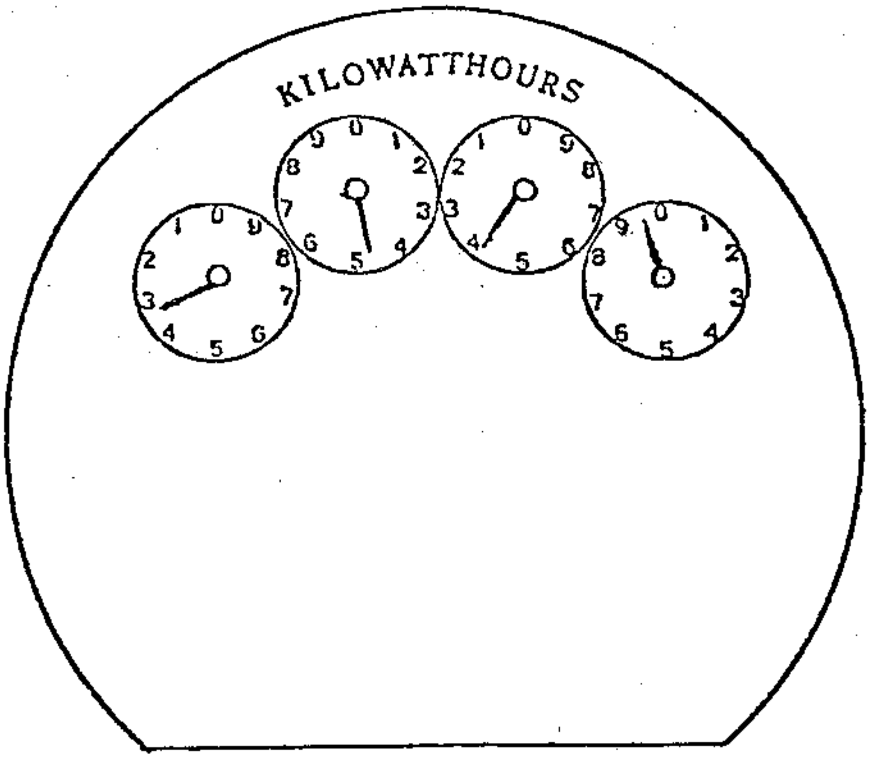
KILOWATTHOUR METERS



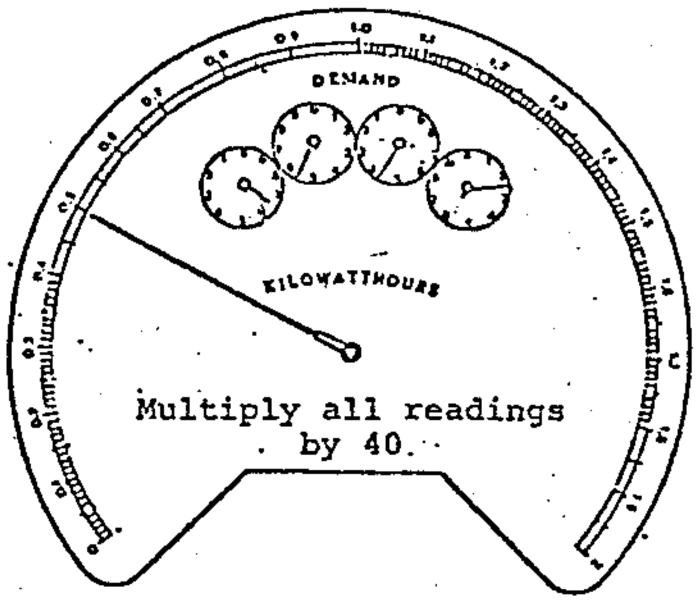
Reading = 1905 KWH



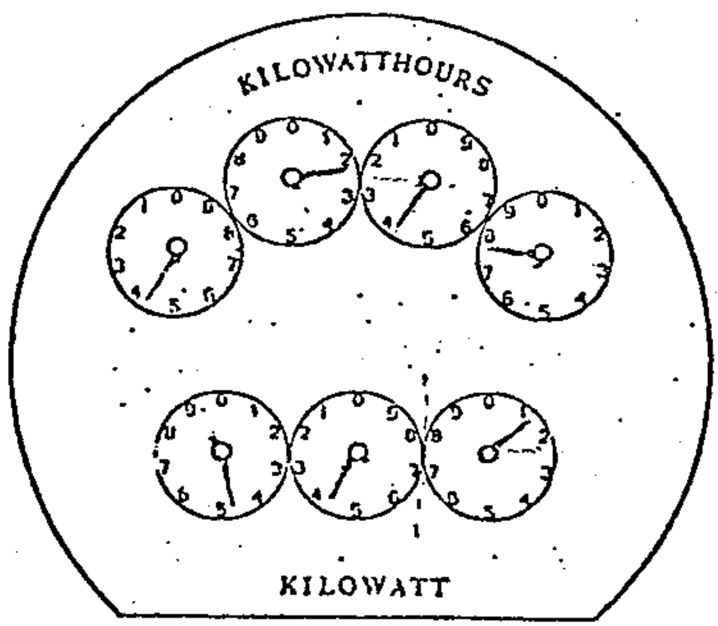
Reading = 3480 KWH



Reading = 3449 KWH

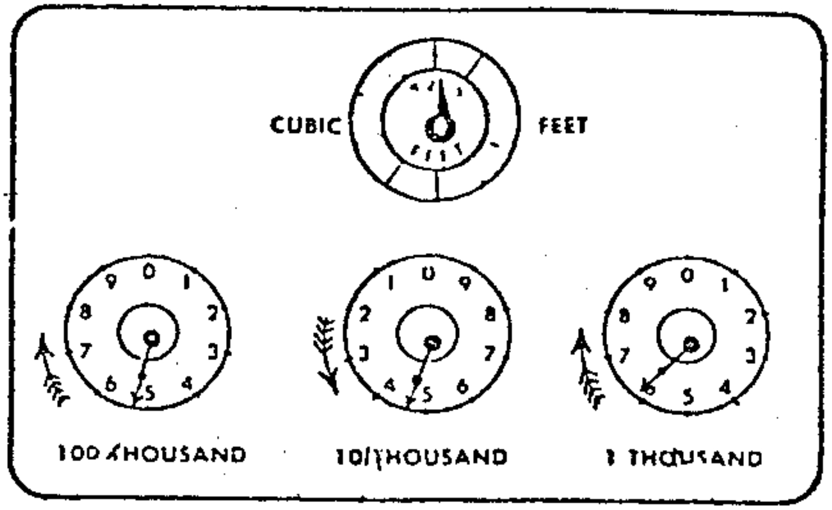


Reading 6542 KWH
.5 x 40 = 20 KW demand

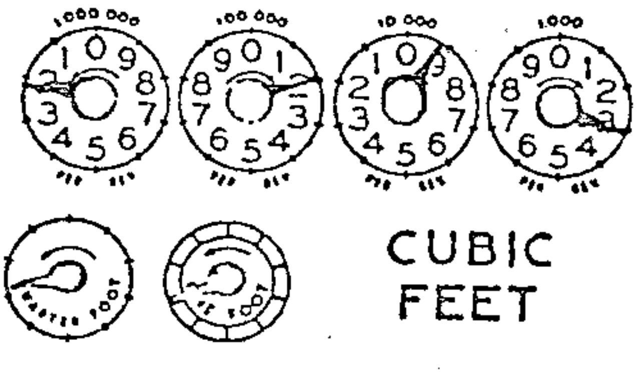


Reading 4247 KWHR
44.1 KW demand

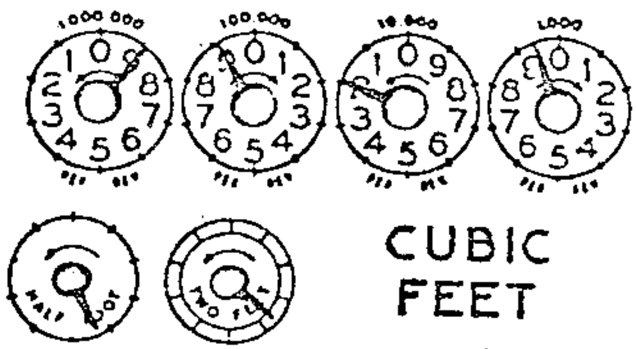
Gas Meters



Reading = 546,000 ft 3



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



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

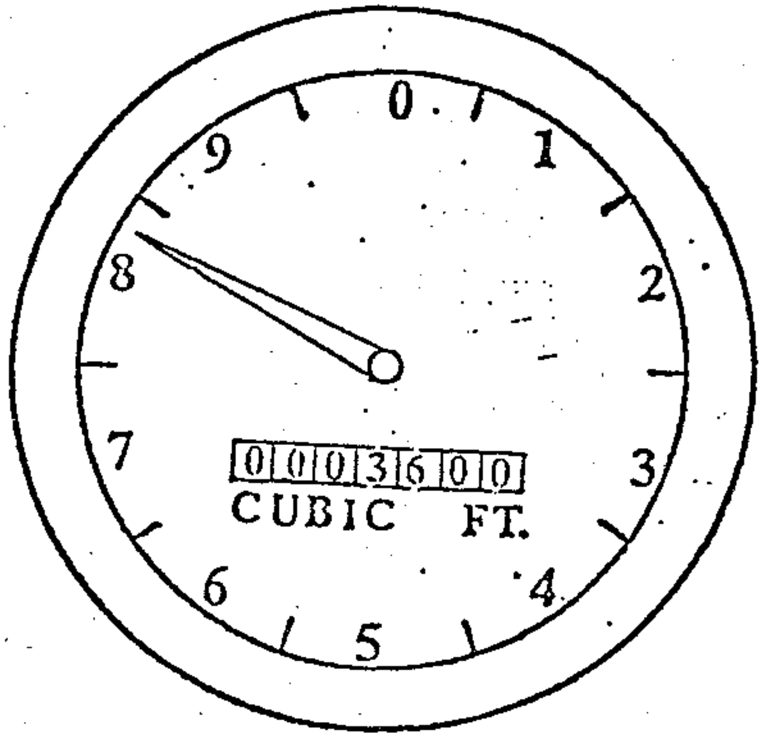
The above indicates different arrangements of gas meter faces. Others exist, however, are similar.

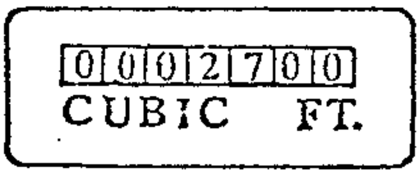
The low capacity, 1/4, 1/2, and 2 cubic feet dials are used to test the meter, as well as check gas consumption in the building under controlled gas usage.

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

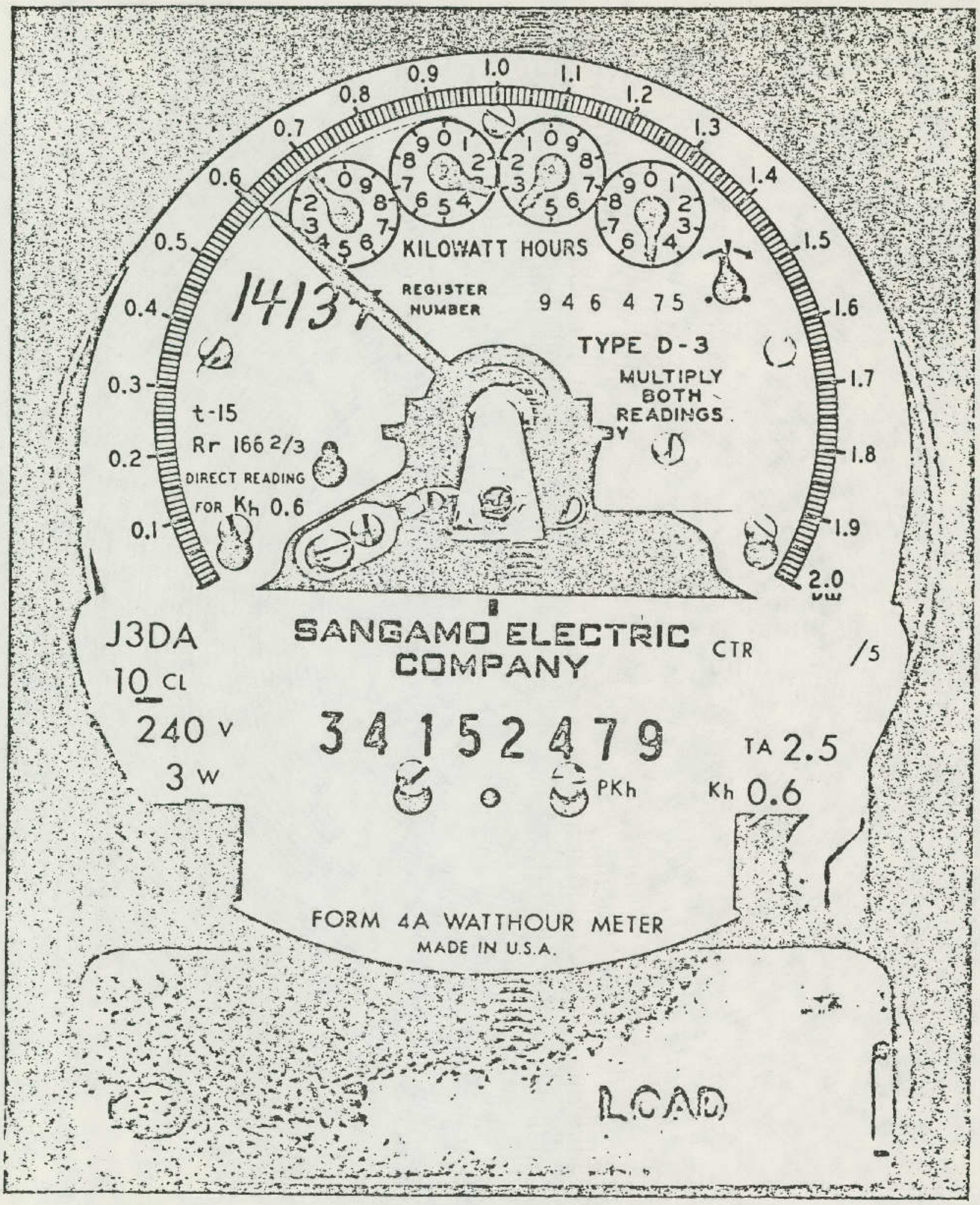




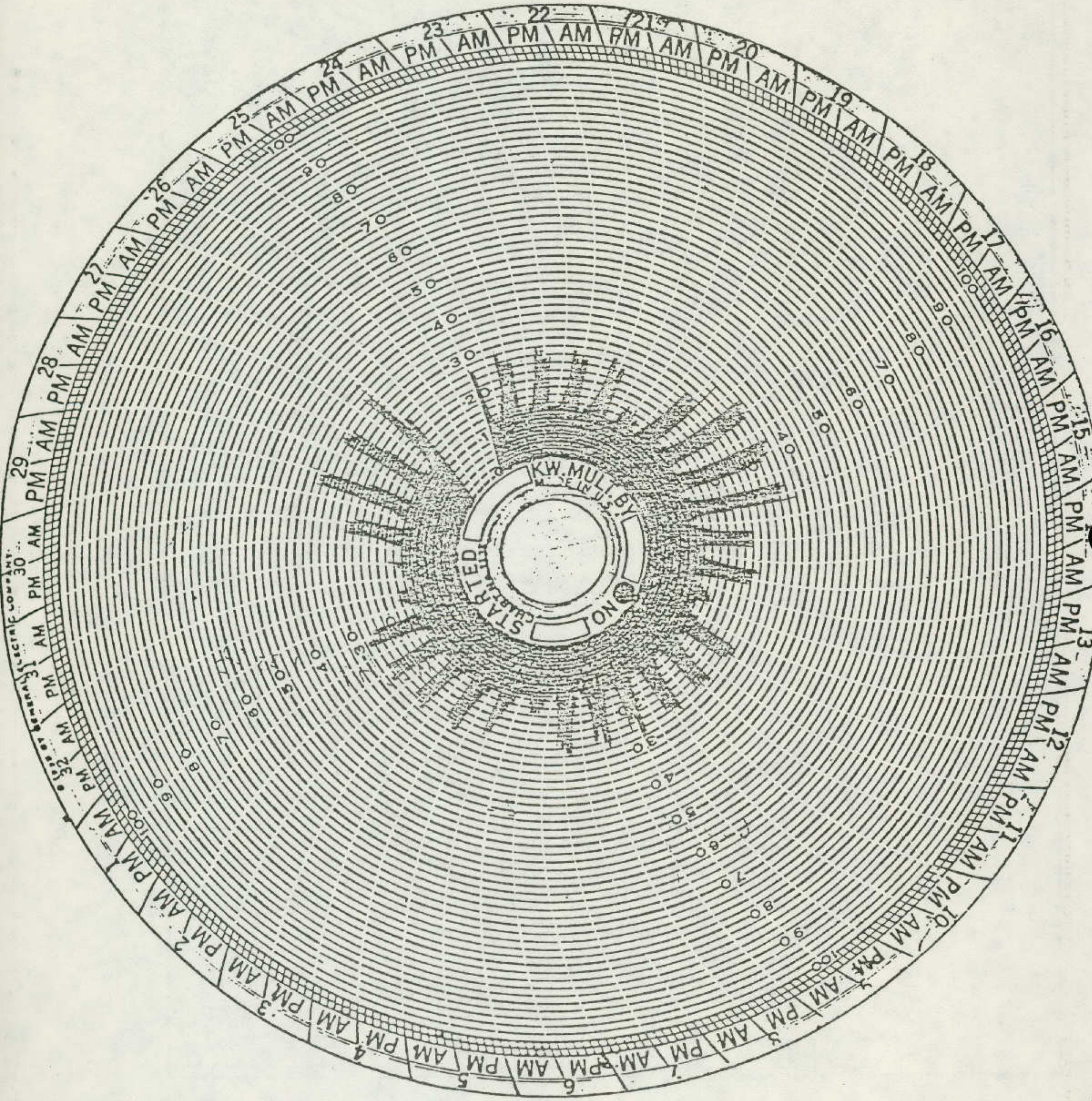
Water meter quantities are read directly as recorded on the meters as shown above. Meters may read in cubic feet, as shown, or in gallons. The type of measure will be shown on the meter face.

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.



0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
KILOWATT HOURS
14137
REGISTER NUMBER
9 4 6 4 7 5
TYPE D-3
MULTIPLY BOTH READINGS BY
t-15
Rr 166 2/3
DIRECT READING FOR Kh 0.6
J3DA
10 CL
240 V
3 W
SANGAMO ELECTRIC COMPANY
CTR /5
34152479
TA 2.5
PKh
Kh 0.6
FORM 4A WATTHOUR METER
MADE IN U.S.A.
LOAD


KW. MULT. BY
STARTED
ON

Meter Readings Previous	Present	MULT	Kilowatt Hours Used	Description	Sales Tax	AMOUNT Incl. Sales Tax
51746	63333	60	695220	BASE RATE	628.51	13198.68
				FUEL	315.14	6618.00

KILOWATTS - 1968
BILLING KW IS 2088

ELECTRIC AMOUNT 19816.68 *
EXCESS FACILITIES 293.23

*3% LATE PAYMENT CHG ADDED
IF PAID AFTER MAR 15 1979.

AMOUNT DUE 20109.91

ELECTRIC SERVICE	Fuel Cost Per Kilowatt Hour	Service Period	Past Due After
100 W ABRAM ST P O BOX 887 ARLINGTON TX 76010 PHONE 336-9454	$0.0090660	DEC 27 To JAN 26	FEB 15 1979
	Service Address		Your Account Number
			RATE G

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.

F. Demand "Ratchet" Analyses

1977 Rate -- Texas Electric Service Company

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 50 KW.

1978 Rate (effective October 26, 1978)

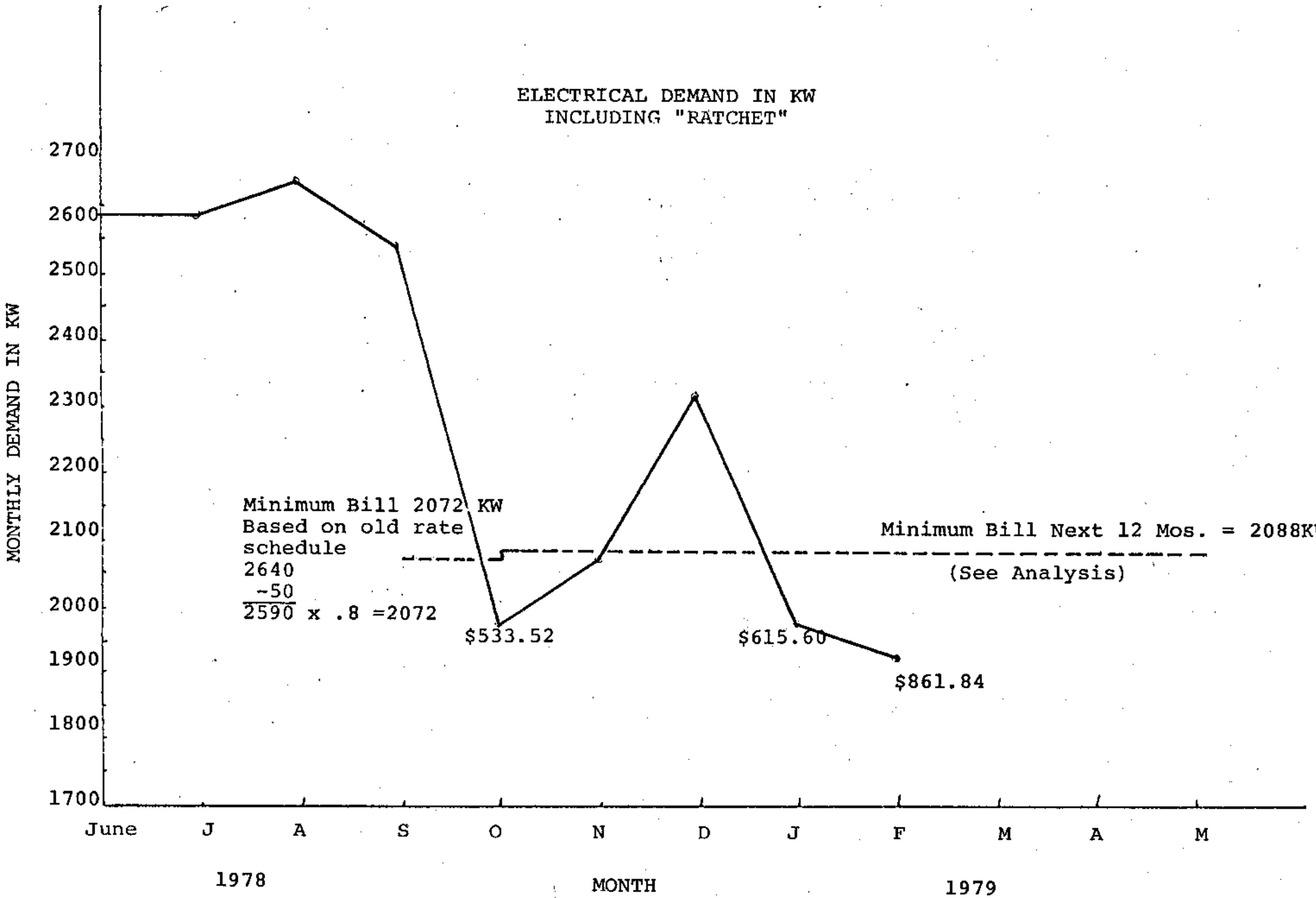
Identical to 1977 except "exceeds 50 KW" is changed to "exceeds 30 KW".

	1977 Demand	1978 Demand
June	2,592	2,592
July	2,400	2,592
August	2,256	2,640
September	2,352	2,544
October	2,304	1,968
Highest	2,592	2,640
Less	50	30
	2,542	2,610
	.8	.8
"Ratchet" =	2,034	2,088

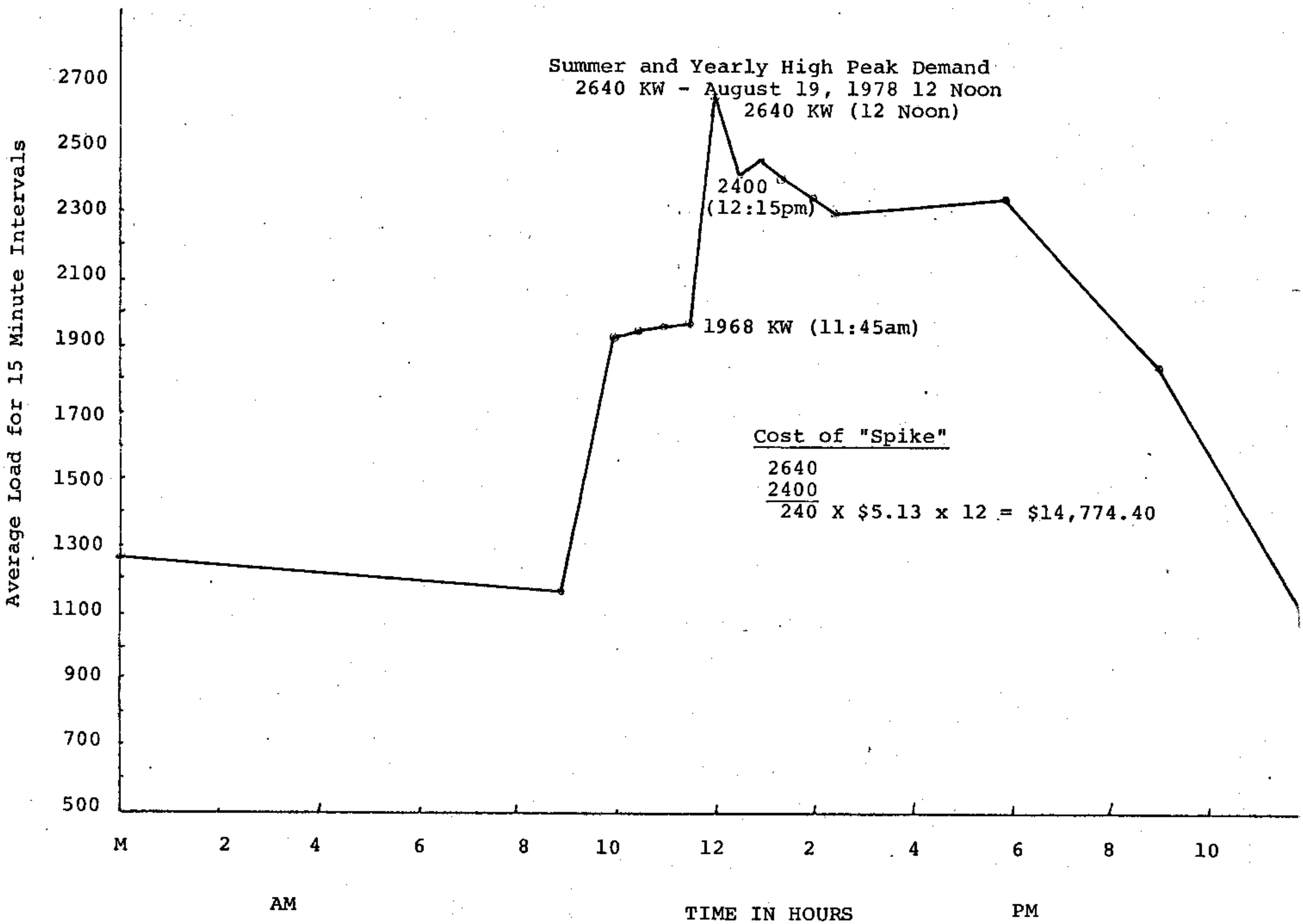
Lowest in winter of 1978 was 1,824 KW in February

All winter months of 1979 will be billed for minimum of 2,088 KW

This minimum bill has to date cost $533.52 in October, a small amount in November, $615.60 in January, and $861.84 in February for a peak demand set in August of 1978; these added costs were not for energy used, but for demand capacity which the utility must provide.


ELECTRICAL DEMAND IN KW
INCLUDING "RATCHET"
MONTHLY DEMAND IN KW
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
Minimum Bill 2072 KW
Based on old rate
schedule
2640
-50
2590 x .8 =2072
Minimum Bill Next 12 Mos. = 2088KW
(See Analysis)
$533.52
$615.60
$861.84
June
J
A
S
O
N
D
J
F
M
A
M
1978
MONTH
1979

24 HOUR LOAD PROFILE



Extracted from: Texas Industrial Commission Energy Conservation Workbook on Meat Products

APPENDIX A-13

FORM C-1 - ELECTRIC KW DEMAND SCHEDULE INSTRUCTIONS

1.0 GENERAL. This form may be used to gain an insight to the existing electricity usage patterns of the plant, and to determine whether a single or combination of several proposed electrical ECO's will affect the plant monthly KW demand. To determine the existing electrical usage patterns, fill out a sufficient number of these Forms until all electrical items of equipment in the plant have been profiled for each day type of each month. Subtotal the KW's for each hour of the day type on each FORM C-1. After all items of equipment have been profiled for each month's day type, total the hourly KW's to obtain a total KW for each hour of each month's day type. Each month's plant KW demand is the greatest hourly KW total observed when examining the total hourly KW's for all day types of each month. To determine the effects of one or a combination of several proposed ECO's, the auditor may examine the profiles for the plant and revise them according to the proposed ECO's requirements.

2.0 EXPLANATION.

a. Equipment I.D.#. Use same I.D.# for each item of equipment as used on other FORMS in this workbook.

b. Day Type. A group of one or more days which are distinguished by such characteristics as # of operating hours, # of personnel working, # of processes taking place, etc.

Example 1. The H.M. Smith Packing Company has a January schedule as follows:

DAY	OPERATING HOURS	OPERATIONS	
Mon. through Thurs.	7AM to 4PM	All	(1)
Friday	7AM to 2PM	All	(2)
Sat. & Sun.	Closed	None	(3)
Holiday on Jan. 1	Closed	None	(3)

Determine the number of day types.

Solution: There are 3 day types as numbered in right hand column above.

c. Peak KW Demand. Enter highest value of KW that each item of equipment can have during each hour of the day. Enter zero for hours "off" and enter highest value for hours "on". If item does not run continuously (e.g., a fan cycled by a thermostat), enter its highest KW value.

3.0 EXAMPLES. Samples of Form C-1 are shown on the following two pages.

#1 → 4: COMPRESSORS 12 → 15 LIGHTS
#5 → 11: MOTORS

Month July
Day Type Mon - Fri.

Equip. ID	HOUR OF DAY (1=midnight to 1 am, 2= 1 am to 2 am, etc.)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	PEAK KW DEMAND																							
1	216	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
2	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
3	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
4	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
5	0	0	0	0	0	0	0	23	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	5	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	19	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	6	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	18	---	---	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0
10	0	0	0	0	0	0	18	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	12	---	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	124	---	---	---	---	---	---	---	---	---	---	---	---	---	---→	0	0	0
13	0	0	0	0	0	0	0	9	---	---	---	---	---	---	---→	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	76	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
15	7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---→
TOTAL	724	717	717	717	717	717	972	1034	1034	1034	1034	1034	1034	1034	1034	995	868	848	848	848	848	724	724	724

#1 → 4 COMPRESSORS
#15: LIGHTS

Month JULY

Day Type SAT&SUN & JUL. 4

Equip. ID	HOUR OF DAY (1=midnight to 1 am, 2=1 am to 2 am, etc.)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	PEAK KW DEMAND																							
1	216	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->
2	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->
3	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->
4	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->
15	7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->
TOTAL	724	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-->

Month________

Day Type________

HOUR OF DAY (1=midnight to 1 am, 2=1 am to 2 am, etc.)

PEAK KW DEMAND

Equip. ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

ENERGY MANAGEMENT CONTROLS

KWH CONTROL

PEOPLE

TIME CLOCKS

KW OR DEMAND CONTROL

1. SOLID STATE-LOW VOLTAGE (15-20%)(COST $2500 TO $8000)
   BUILT IN PROGRAM PERMITS
   PROGRAMMING THE ON/OFF OF LOADS
   - KWH CONTROL - ON/OFF
   - KW CONTROL - DUTY CYCLING

2. MINICOMPUTERS/MICROPROCESSORS ($10,000 UP)
   MORE MEMORY
   PROGRAMMING FLEXIBILITY
   BINARY PLUS ANALOG

ENERGY MANAGEMENT SYSTEMS

COMMAND SYSTEM

1. TIME CLOCKS -- EXISTING POWER LINES

2. SOLID-STATE DEVICES AND MINICOMPUTERS/MICROPROCESSORS

   A. EXISTING POWER LINES AND JUNCTION BOXES
   B. LOW VOLTAGE LINES
   C. EXISTING A.C. POWER LINES - CODED SIGNAL
   D. F.M. RADIO
   E. COAXIAL CABLE

MINICOMPUTERS/MICROPROCESSORS

1. SCHEDULING (ON/OFF)
   OPTIMIZED START-UP AND SET BACK

2. DUTY CYCLING

3. LOAD SHEDDING

4. CHILLER CONTROL
   START/STOP/CHILLED WATER RESET

5. OUTSIDE AIR ECONOMIZER

6. SUPPLY AIR RESET

7. TERMINAL REHEAT
   SUPPLY AIR RESET

8. DUAL DUCT
   HOT AND COLD DUCT RESET

OBSERVATIONS OF AN ENERGY AUDITOR

DOLLAR SAVINGS OPPORTUNITIES IN PRIORITY

1. Air-Conditioning Not Turned Off During Periods Not Needed.

2. Use Of Excessive Outside Air

   *Design
   *Disrepair of Systems, Dampers, Controls
   *Operators w/o Basic Knowledge or Written Instructions

3. Use Of Terminal Reheat Or Double Duct Systems.

4. Heating Systems Not Operated On Night Set-Back.

5. All Buildings Lack Proper Insulation.

6. Lighting Loads Which Can Be Reduced.

   *Reduced Lighting Levels
   *Use Energy Efficient Bulbs and Ballasts
   *Replace Incandescent Where Possible

7. Hot Water Systems Which Are Part Of Heating System

Data Sheet: PDS001-03/78
Date: 1 March 1978

product data from Texas Controls, Inc.

Power Management Master

General Description

The need for reducing the level of energy consumption, together with the problems of coping with ever-increasing energy costs, enhance the value of the Model 416 Power Management Master (PMM).

The PMM is a microprocessor-based master load controller pre-programmed for demand monitoring and load controlling, load scheduling and load cycling of electrical devices such as fans, compressors, heaters, lighting and etc.. The activation or deactivation of associated relays, contactors or motor starters by the PMM is the means of reducing energy consumption.

Unlike systems which continually meter pulses, the PMM utilizes the more sophisticated Predictive Demand Control (PDC) logic method. PDC employs a "sample and hold" technique, with the "hold" being the period between control points at which forecasts are made. The PDC system can accommodate a wide variety of load profiles and is highly accurate.

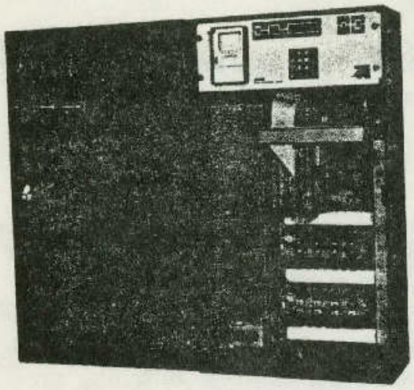
The PMM is available in two models; the wall-mounted, and a designer desk configuration. Each includes all required software, operator/display panel, relay outputs, battery back-up and options including a printer, strip chart recorder, output expansion and etc..

Advantages

- U. L. Approved
- Eliminates telephone line installation and the related recurring costs.
- Low cost — Fast payout
- Minimal maintenance through self-testing and diagnosis

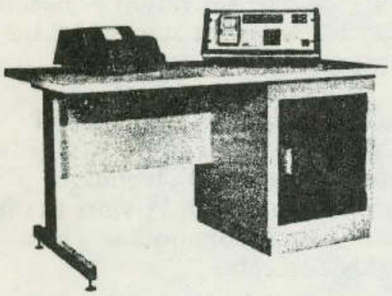
SALES & SERVICE CENTERS

Configurations



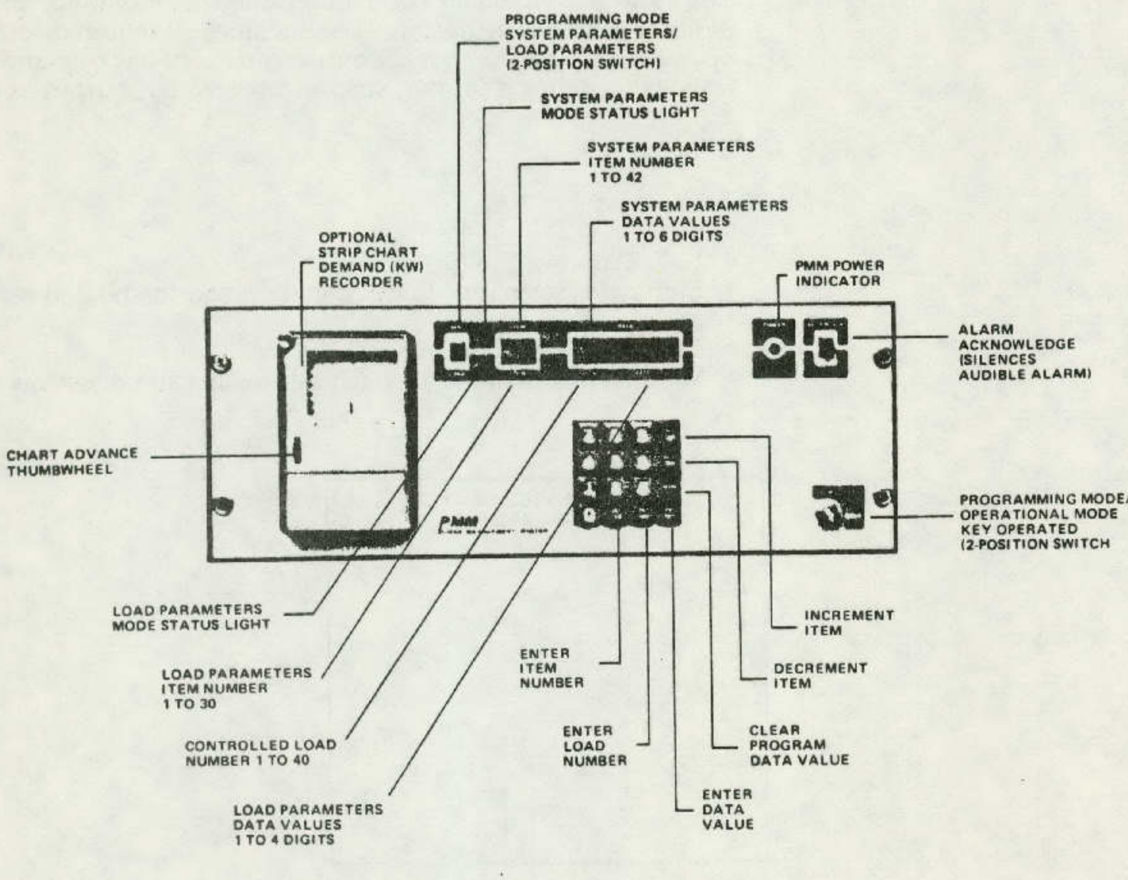
Model 416W

The Model 416W is a self-contained, indoor, wall-mountable, firmware driven master controller for energy management application. The base unit contains a power supply, battery back-up (for memory retention), watchdog timer, audio alarm and relay, 16 relay outputs, four digital status inputs, four demand meter contact inputs, 16-key keypad and operator/ display panel. Options include up to 24 control relays and 40 override switch assemblies (both available in groups of eight (8) only), one analog output, KW demand strip chart recorder and a 40 column impact printer. A unique feature in the power management industry is the self-test and diagnostic abilities of the PMM.



Model 416D

The Model 416D base unit contains the same electronics as the Model 416W except they are housed in the designer desk pedestal. Pedestal space includes provisions for 24 additional relay outputs and up to 40 override switch assemblies (each in groups of eight). The keypad and operator/display is housed in an attractive and functional desk-top console.



System Description

The Power Management Master (PMM) is designed to optimize power consumption and limit demand in commercial and industrial buildings. Significant energy savings are made by:

- Monitoring demand, predicting future demand and controlling electrical loads to minimize demand peaks.
- Scheduling loads on an individual basis for any two periods of time during the day.
- Cycling any load on an individual on/off cycle schedule.

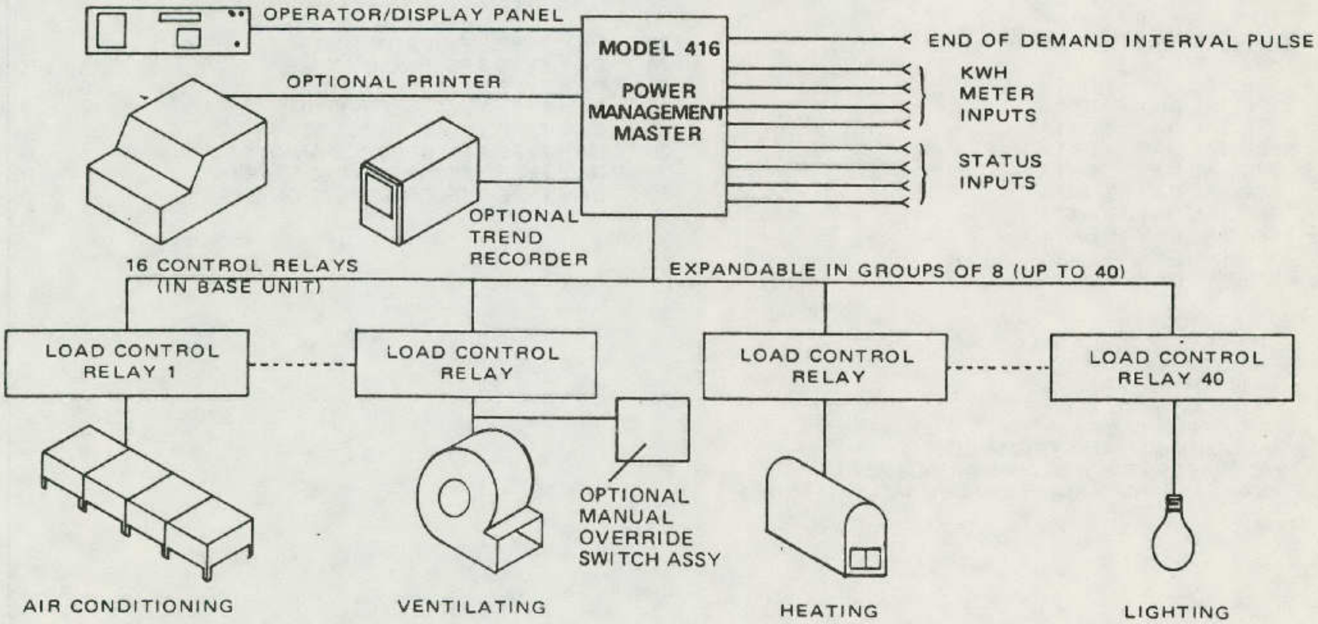
Inputs from four KWH meters and four status inputs, which can be used with thermostats and/or humidistats, are provided for truly adaptive control. The status inputs can be used to modify cycling strategy as a result of changing environmental conditions and etc..

Convenience and adapability of the PMM are considerably enhanced by the Operator/Display panel. It provides for the individual entry and display of all 42 system and 30 load parameters via a 16-key keypad.

Entry of this data is simplified with the 'fill in the blanks' approach. The input data is divided into two categories: system parameters and load parameters. Input data sheets are supplied to the user to aid in preparation of the data and provide a record of the data. A sample of the parameter items is shown on the following page. Initial variable entry on a typical 24 output system can easily be made in approximately 30 minutes.

The PMM refreshes the display values twice per second thereby insuring all values are current. Ten parameters are automatically updated by the PMM; date, time, most recent demand, maximum demand this month, most recent power company demand, power company maximum demand this month, resettable KWH totalizer, perpetual KWH totalizer, daily KWH totalizer and current day type.

The unique self-test and diagnostic abilities of the PMM require no user action unless there is a problem. Each morning at 9:00AM, the PMM automatically performs a self-test of its memory. Problem notification is given on the operator/display panel by displaying an item number of 99 and flashing an error code (1-14) in the data field. In addition to the displayed error code, the alarm relay is energized to announce an error. All load control action ceases when a self-test error occurs.



Parameters

Input data is divided into two categories which are: system parameters and load parameters. Input data sheets are supplied with the equipment to aid the user in preparation of input data and to provide a record of the data. Parameters can only be changed when PMM is in the program mode.

Up to 36 system parameters may be input to the PMM. These parameters plus six (6) other information parameters may be displayed on the operator/display panel when the equipment is in System mode. Also, up to 30 load parameters may be input to the PMM for each load. These parameters may be displayed on the operator/display panel when the load/system switch is in the load position.

There is a range of valid values defined for each system or load parameter. The system will not accept a parameter outside that range. A pre-programmed value is also specified for each system and load parameter. The PMM will use the pre-programmed value for any parameter not given another value by operator/display panel input.

SYSTEM PARAMETERS

01 DATE
02 TIME
03 CURRENT DAY OF WEEK
04 DEMAND INTERVAL
05 TARGET DEMAND
06 CONTROL BAND%
07 ALARM SETPOINT DEMAND
08 EMERGENCY SHED DEMAND

09 METER 1 METER FACTOR
10 METER 2 METER FACTOR
11 METER 3 METER FACTOR
12 METER 4 METER FACTOR

13 STATUS INPUT 1 OFF CYCLE MULTIPLIER
14 STATUS INPUT 2 OFF CYCLE MULTIPLIER
15 STATUS INPUT 3 OFF CYCLE MULTIPLIER
16 STATUS INPUT 4 OFF CYCLE MULTIPLIER

17 DAY TYPE OF SUNDAY
18 DAY TYPE OF MONDAY
19 DAY TYPE OF TUESDAY
20 DAY TYPE OF WEDNESDAY
21 DAY TYPE OF THURSDAY
22 DAY TYPE OF FRIDAY
23 DAY TYPE OF SATURDAY

24 SPECIAL DAY 1 DATA
25 SPECIAL DAY 2 DATA
26 SPECIAL DAY 3 DATA
27 SPECIAL DAY 4 DATA
28 SPECIAL DAY 5 DATA
29 SPECIAL DAY 6 DATA
30 SPECIAL DAY 7 DATA
31 SPECIAL DAY 8 DATA
32 SPECIAL DAY 9 DATA
33 SPECIAL DAY 10 DATA

34 PRINT MODE
35 CHART RECORDER FULL SCALE
36 RESETTABLE KWH TOTALIZER
37 KWH TOTALIZER
38 DAILY KWH TOTALIZER
39 MOST RECENT DEMAND
40 MAXIMUM DEMAND THIS MONTH
41 MOST RECENT POWER COMPANY DEMAND
42 POWER COMPANY MAXIMUM DEMAND THIS MONTH

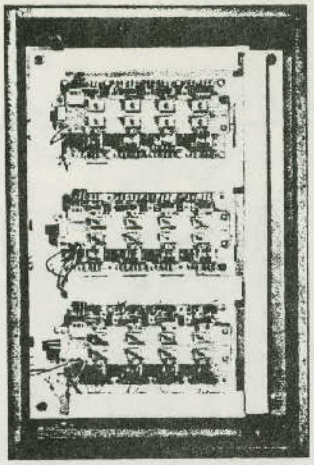
LOAD PARAMETERS

01 LOAD SIZE
02 PRIORITY LEVEL
03 MINIMUM ON/OFF TIMES
04 SHED/CYCLE OFF CONDITION STATEMENT NUMBER
05 SHED/CYCLE OFF CONDITION LOAD NUMBER(S)
06 OFF-CYCLE ASSOCIATED STATUS INPUT(S)

07 DAY TYPE 1 FIRST ON TIME
08 DAY TYPE 1 SECOND ON TIME
09 DAY TYPE 1 FIRST OFF TIME
10 DAY TYPE 1 SECOND OFF TIME
11 DAY TYPE 1 FIRST CYCLE START
12 DAY TYPE 1 FIRST CYCLE ON/OFF
13 DAY TYPE 1 SECOND CYCLE START
14 DAY TYPE 1 SECOND CYCLE ON/OFF

15 DAY TYPE 2 FIRST ON TIME
16 DAY TYPE 2 SECOND ON TIME
17 DAY TYPE 2 FIRST OFF TIME
18 DAY TYPE 2 SECOND OFF TIME
19 DAY TYPE 2 FIRST CYCLE START
20 DAY TYPE 2 FIRST CYCLE ON/OFF
21 DAY TYPE 2 SECOND CYCLE START
22 DAY TYPE 2 SECOND CYCLE ON/OFF

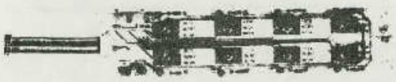
23 DAY TYPE 3 FIRST ON TIME
24 DAY TYPE 3 SECOND ON TIME
25 DAY TYPE 3 FIRST OFF TIME
26 DAY TYPE 3 SECOND OFF TIME
27 DAY TYPE 3 FIRST CYCLE START
28 DAY TYPE 3 FIRST CYCLE ON/OFF
29 DAY TYPE 3 SECOND CYCLE START
30 DAY TYPE 3 SECOND CYCLE ON/OFF



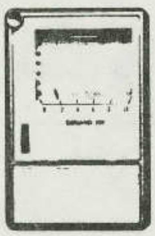
Expansion Unit

This unit contains eight to 24 output relays (in groups of eight) housed in a 35 pound indoor, wall mountable and lockable enclosure (24" X 16" X 7"D). It is available only with the Model 416W as no additional enclosure is required for expansion of the Model 416D.

Override Switch Assembly

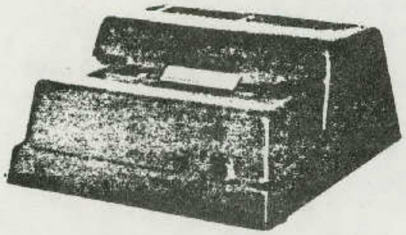


Eight to 40 switch assemblies are available (in groups of eight). Each includes one 3-position (on-off-automatic) switch and one status LED indicator for each output relay.



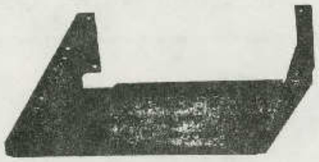
Trend Recorder

This is a 30-day, 1"/hour strip chart recorder mountable in the operator/display panel. It requires 115V AC ± 10% supplied by the base unit. 0—10V DC input option is required.



Printer

The 40 column, 64 character, 50 cps, six lines/inch recorder requires 115V AC ± 10%, 50-60 Hz at 1.5 amp. Overall dimensions are: 6.5" H X 13" W X 13" D. Weight is 10 pounds and estimated head life is 10 X 10^6 lines. Ribbon life: 4 X 10^6 characters and cable length: 72"



Printer Wall Mount Bracket

The wall mount bracket is included when printer is used with the Model 416W. The bracket is not required for Model 416D. 4.5" X 14.19" X 14.19"D

Specifications Summary

	416W BASE UNIT	416D BASE UNIT
OPERATING CHARACTERISTICS		
ENCLOSURE	SELF CONTAINED, INDOOR WALL MOUNTABLE WITH LOCK	DESK
KWH MOTOR INPUTS	1 to 4 DRY CONTACTS SELECTABLE NORMALLY OPEN OR NORMALLY CLOSED (FORM 'C'). EXCITATION VOLTAGE 5V DC @ .5 mA SUPPLIED BY BASE UNIT. PULSE RATE UP TO 10 PPS. METER FACTOR RANGE .00 - 99.99	
STATUS INPUTS	1 to 4 DRY CONTACTS SELECTABLE NORMALLY OPEN OR NORMALLY CLOSED (FORM 'C'). EXCITATION VOLTAGE 12V DC @ .5 mA SUPPLIED BY BASE UNIT.	
END OF DEMAND INTERVAL (IF DESIRED)	1 AT EITHER 5, 15, 30 OR 60 MINUTE INTERVALS. SELECTABLE EITHER NORMALLY OPEN OR NORMALLY CLOSED DRY CONTACT. EXCITATION VOLTAGE 5V DC @ .5 mA SUPPLIED BY BASE UNIT.	
DIGITAL OUTPUT RELAYS		
COIL VOLTAGE	12V DC @ 1.2 WATTS	
COIL IMPEDANCE	120 OHMS	
CONTACT RATING	ONE SET OF FORM 'C' CONTACTS RATED @ 10 AMPS @ 28V DC OR 240V AC	
POWER REQUIRED	115V AC (± 10%), 60 HZ, 5 AMP	
CUSTOMER CONNECTIONS	POWER & I/O FIELD CONNECTIONS	
PHYSICAL CHARACTERISTICS		
DIMENSIONS	36" X 21" X 9" DEEP (91.44 cm X 53.34 cm X 22.96 cm)	60" X 31" X 30" DEEP (152.40 cm X 78.74 cm X 76.20 cm)
NET WEIGHT (APPROX)	70 LBS (31.78 KG)	160 LBS (73.64 KG)
POWER CABLE	CUSTOMER FURNISHED 14 AWG, 3 CONDUCTOR CABLE OR LARGER	
PAINT COLOR	NITRO BLUE	DECORATOR WHITE TOP & PEDESTAL WITH NITRO BLUE PEDESTAL DOOR
ENVIRONMENTAL CHARACTERISTICS		
OPERATING TEMPERATURE RANGE	0° TO 50° C	
RELATIVE HUMIDITY	0 TO 95% NONCONDENSING	

Q. How many times can a load be shed within a given demand interval?

A. Depends on the length of demand interval, minimum on/off times specified and availability for shedding based on demand, priority and scheduling.

Q. Describe the electrical energy management control strategy.

A. The PMM employs demand control, load scheduling and cycling strategies to attain its energy management goal.

Q. Can the 24-hour day be divided into contiguous time segments?

A. A 24-hour day can be divided into two contiguous or non-contiguous time segments (user selectable).

Q. Can startup and shutdown times be designated for each controlled load?

A. Each load can be independently programmed to two different cycle plans which can be started or stopped at two different sets of time of day.

Q. How many meters and loads can be connected to the system?

A. Up to four KWH pulse sources can be accommodated by the PMM and up to 40 load control relays are available.

Q. Does the PMM require constant attention after system and load parameters have been programmed by the user?

A. No, the PMM is designed to function unattended.

Q. Does the system produce a scheduled or operator requested hard copy data log?

A. The printer option records all system events as they occur. A daily summary is printed at midnight.

Q. Are there inputs other than KWH meter and end of demand interval? If so, how do they affect control strategy?

A. Yes, there are four (4) status inputs. The set state of these inputs are used, if selectd, to affect the off time (multiply by .0-99.99) set for each load/cycle period.

Q. Are there any provisions for facility load coordination within the system?

A. Yes, each load can be programmed so that its capability for shedding or cycling is a function of the state of up to two other loads. There are eight (8) facility coordination statements that can be selected for performing this function.

Q. In what sequence are loads shed and restored?

A. Priority one (1) loads are shed first, restored last and priority six (6) loads are shed last, restored first.

Q. What type of monitor/control device is incorporated in the energy management system.

A. A microprocessor programmable controller.

Q. Since the device is programmable, does the system include all requisite system and application software for energy management, i.e., must the user write any software?

A. User does not write any software. Equipment comes completely programmed. User inputs system and load parameter data via the 16-key keypad.

Q. Is 'brown out' and power failure detection and protection included?

A. Yes, a separate solid state adjustable AC voltage sensor for 'brown out' detection is included along with a battery backup in the base unit.

Q. What is the frequency of execution of the control algorithm?

A. Every 1/20th of the PMM demand interval. Demand interval is operator selectable at 5, 15, 30 or 60 minutes.

Q. Is synchronization with the power utility's demand interval required?

A. Not required, but may be used for synchronization with supplying utility if desired.

Q. When shedding action is initiated, are loads shed singly or in multiples?

A. Loads are shed singly or in multiples depending on load size and rate of consumption.

Q. Are loads shed by cumulative KW load depending upon either the magnitude of the computed excess demand or the time elapsed in the demand interval?

A. Loads available for shedding are checked for size, among several things, and actual shedding is then done on basis of loads required to change the slope of 'Demand Trend' to stay within deadband.

Q. Are all shed loads restored at the end of a demand interval and what are the criteria for load restoration?

A. Loads may and will be restored singly at any time during the demand interval. Restoration is based on the continuous predictive demand.

Q. How is short cycling of loads inhibited?

A. By use of minimum on/off times.

Q. Explain how loads are sequenced for shedding.

A. A combined priority/rotational method is used. There are actually eight (8) priority levels any load may be assigned to. Six (6) of these are used for establishing shedding priority. A priority zero (0) assigned load will remain off and a priority seven (7) load is not available for shedding, only scheduling and cycling.

Commitment to Industry

General

The main business of Texas Controls, Inc. is the design and production of data acquisition and control equipment. Because of this the company has made the large and necessary investment not only in extensive manufacturing facilities, but also in developing the necessary hardware and software products which inherently assure quality, performance and on-going support. It is this investment in facilities, products and people that provides our customers with the hard dollar "plus factors" that aren't available from job shops or rack-and-stack suppliers.

Because of the company's commitment to, and dependence upon, data acquisition and control business, you can rely on us to be around year after year and in the forefront of technological development.

Training

Texas Controls, Inc. maintains a complete, professionally staffed training center at its headquarters in Dallas, Texas. Comprehensive hardware courses are conducted at a level customers find interesting, informative and challenging. All training courses are conducted by instructors who have had extensive experience. Classroom instruction and practical equipment demonstrations are presented in a balanced curriculum for a maximum learning environment. Manuals and equipment documentation are made available to each student for his retention. A thirty (30) day advance notice for attendance is required and classes are on a 'first come-first serve' basis.

Test Equipment

The company's philosophy towards field test equipment is to keep all specialized test equipment requirements to a minimum and build those desired test features into the prime product. With this in mind we recommend each customer have access to general test equipment standard to the industry.

Sales and Service

Texas Controls, Inc., provides sales, service and applications assistance from its National Sales and Service Centers or headquarters in Dallas, Texas.

TEXAS CONTROLS, INC.

13735 Omega Road / P. O. Box 59469
Dallas, Texas 75229
(214) 386-5000

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MASTER METERING/LEASE ENERGY AGREEMENTS

MASTER METERING/LEASE ENERGY ARRANGEMENTS

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Section 12 of UCAN Manual of Conservation
Measures, FEA Conservation Paper No. 35,
1975 (FEA/D-75/628)

12.0 INDIVIDUAL VERSUS MASTER-METERING

12.1 Summary

This section of the manual discusses the energy conservation and economic aspects of individual versus master-metering. It is shown that individual metering can conserve a significant quantity of electric energy consumption. Actions that can be taken by utilities and state regulatory commissions to promote increased use of individual metering are discussed and cost benefit analyses presented.

12.2 Introduction

Master-metering of residential apartments is practiced widely throughout the U.S. Exhibit 12-1 shows the number of master-metered dwelling units in eight cities throughout the U.S. As shown, a significant portion of multi-family dwelling units are master-metered.

According to HUD and many private experts in the housing field, dwelling units which are master-metered consume significantly more electricity than those which are individually metered. This follows from the fact that individually metered customers are aware of the cost of their electricity usage and have an economic incentive to reduce consumption. Surveys have indicated that electricity consumption can be reduced by the order of 25% if the concept of master-metering is discouraged.

Lower installation costs and favorable utility rate structures have served to encourage master-metering by apartment house owners. Some localities, however, have provided construction subsidies favoring individual metering (e.g. Los Angeles) and some utilities have adopted policies which prohibit master-metering in new residential buildings (e.g. Commonwealth Edison-Chicago).

12.3 Underlying Principles

The practice of master-metering electric service to apartments and offices allows the sale of electricity to a building or complex at wholesale rates which are usually justified by the utility by the requirement for only one meter, one reading, and one bill for the sale of a large quantity of electricity. Furthermore, the electric utility company need not supply an electrical distribution system for the buildings. Alternate metering practices are individual metering--where each user such as an office or apartment receives electricity through a meter which serves only that user--and sub-metering--where an entire building receives electricity through a master-meter but the users within the building have their service monitored by a secondary meter. In the latter case the secondary meter may be used as a basis for charging a fee for service or merely to identify heavy users. The use of submeters is regulated or prohibited by some states or utility companies.

Master-metering has, on the surface, elements of economic attraction for all participants. For the landlord or building owner, the block rate structure for utility services appears to offer the opportunity to purchase the same amount of electricity as would be consumed by all his tenants for less cost by acting as a single customer. This offers the landlord the opportunity to resell the electricity (in some states) and make a profit or to provide electrical service "free" as part of the rental package. This latter alternative has apparent attraction for the tenant as well, since landlords frequently pass on some or all of the planned savings in electricity costs as reduced (and thus more competitive) rent. For the utility, a master-meter installation reduces installation costs as well as monthly meter reading costs. It seems like a situation in which everyone benefits. However, when individual tenants no longer have monthly feedback and an economic incentive for conservation of electricity usage, their consumption usually increases. There is strong evidence to indicate that this indeed is the case. Exhibit 12-2 shows the relative electric energy consumed in master-metered and individually metered dwelling units.

When utility company tariffs permit a choice of metering in an office or apartment building, the choice is usually made on the basis of a balance between several economic factors. Among these are electrical wiring costs and utility rate structures, which are discussed below.

Initial electrical wiring costs for an office or apartment building depend on the choice of metering used as well as on local building codes. Individual metering requires separate electrical feeders to each apartment from a central distribution point and separate meter sockets and meters. Master-metering would allow elimination of the apartment panels and many of the separate feeders required by individual meters. Hence, the cost of labor and materials would be reduced.

The share of the cost of internal distribution which must be borne by the builder, and whether this cost will be in favor of master or individual metering, depends on utility company policies, which vary widely. For example, the Los Angeles Department of Water & Power will provide both inside and outside transformers to large buildings if individually metered, but will require the builder to provide such equipment if master-metered. Therefore, there is a wide range across the U.S. for the difference between the cost of wiring for individual metering and that of master-metering. The wiring cost differences between individual and master-metering range from no difference in Los Angeles, $125-175 difference per dwelling unit in Kansas City, $250 difference per dwelling unit in Washington, D.C., to $400 difference per dwelling unit in New York City. This data shows that while the initial wiring cost is not the major factor it serves as an important incentive for selecting master-metering.

A factor which does not apply to the initial choice of metering practice in a building, but which can influence an owner's decision to convert to other metering styles, is the cost of retrofitting. The costs of conversion from master to individual metering are influenced by several factors. First, those buildings which have been wired at minimum cost during construction usually have apartments and building services sharing feeder lines and are more complicated to rewire for individual service. Second, older styles of buildings in which the electrical wiring is buried behind plaster or other permanent wall construction are expensive to convert because of consequent structural work and refinishing. Costs of up to $1200 per dwelling unit have been quoted for retrofitting. The highest conversion costs prevail in those apartments where the initial wiring was originally installed at minimum cost. In such situations it is generally necessary to install new feeders to each apartment and to provide a separate set of circuits for the public areas of the building. It is also necessary to install meter sockets and load centers for each unit. Part of the high cost of these conversions is for consequent construction and decorating work. High conversion cost is the reason most often expressed by apartment owners for delaying conversion to individual metering (for those who wished to convert their service). It is, therefore, concluded that the cost of conversion is the major factor preventing a decrease in existing master-metering.

A second way of individualizing electricity cost is to submeter. The costs of submetering could be substantially less than individual metering since the metering would no longer have to meet utility regulatory standards, although it would still provide an accurate picture of individual consumption. Utilities usually require a grouping of meters at a point of easy access and a separate meter for a public area, requiring a separate circuit. A building owner, on the other hand, would most likely install meters in each individual apartment. In mid-1974, the Department of Housing & Urban Development (HUD) estimated a cost of about $400 per apartment unit to install rewiring, meter bases, and meters for "check-metering" (a form of submetering) in public housing projects. However, check-metering or other forms of submetering is prohibited by several state Public Service Commissions because it has the potential for allowing building owners to adjust electricity costs for tenants (and in effect reset rates) without commission approval. Several cases have reached the courts on this very issue.

Another important factor affecting the owners choice of metering is the local utility rate schedule. Many utility companies offering service to groups of offices or apartments under general service rates make the group service much less expensive than the total cost of individual services (a large portion of this difference is due to extra customer cost borne by the utility for individual services). The greater this difference, the more master-metering is encouraged. An example of the comparison of individual and master-metered rates for residential service is shown in Exhibit 12-3. The graph shows the cost per kilowatt-hour of electricity for a single dwelling unit if it is served by an individual meter (residential) or if it is in a group of 5, 50, or 100 units served by a master-meter. Clearly, if it is one of 50 units in a building, the electricity is cheap enough that the owner might afford to provide it as a business attraction and thus might select master-metered service.

The factors of wiring costs and utility rate structures continue to be deciding factors in the election of master-metering service or individual metering service by apartment builders and owners. However, the relative importance of these various factors has been undergoing rapid changes during the past year. Utility costs have been rising rapidly with commercial rates leading residential rates. The gap between residential and commercial rates is thus closing. Furthermore, the increased resistance to rent increases often provided by rigid rent controls has placed the owner or operator of apartments in a severe profit squeeze by not allowing electric rate increases to be passed along to the tenants. Finally, the growing social pressure for energy conservation has begun to work against master-metering.

12.4 Potential for Energy Conservation through Avoiding Master-Metering

There is a definite tendency for the electricity customer to use more electricity when the feedback effect of a periodic utility bill is not present. This extra consumption is held to be common knowledge by some utility marketing personnel and reported ratios of consumption by master-metered versus individually metered customers range from 1.88 to 1.33. Utility company load planners use ratios of from 1.15 to 1.35 for planning load requirements for master-metered apartment buildings.

A recent study for the FEA surveyed consumption in adjacent master-metered and individually metered apartments for eight cities in the U.S. Exhibit 12-2 contains the results of this survey which show that the master-metered customer consumed 8% to 169% more electricity than his individually metered counterpart. The average overall increase in consumption was 34%. HUD has recently published estimates of energy savings which range from 15 to 25% for check-metering and from 25 to 35% for individual metering when compared to the alternative of master-metering. It is therefore clear that encouragement should be given to individual or submetering as a means of energy conservation.

The emphasis in this section has been placed on the metering of residential buildings. While commercial buildings may also be master-metered there is no data available with which to accurately measure the impact of master-metering vs. individual metering in a commercial building. The requirements for office space flexibility for new tenants and the need for the building owner to use office lighting services during maintenance hours make individual metering of offices undesirable. Also, the difference in energy consumption due to having the office tenant pay his own bill would be small because most factors such as lighting level, occupancy, thermostat settings and hours of operation are determined by company policies which are based on factors other than the receipt of a utility bill. It can therefore be stated that the individual metering of commercial buildings will be harder to promote and the impact on energy conservation will be smaller than individual metering of residential buildings.

12.4.1 Specific Implementation Strategies

a. Utility changes to rate structures to eliminate rate differentials between individually and master-metered residential buildings with the same overall pattern of consumption.

From an incremental cost point of view, utility rate structures which differentiate between individually and master-metered residential dwellings should be based on the following factors:

- Lower meter reading and billing and accounting costs for master-metering.

- Lower costs for metering and distribution equipment for master-metering.

- The higher cost of providing increased electricity demand and consumption for master-metered customers. Since master-metered consumers have been shown to consume about 25% more electricity than their individually metered counterparts, and since residential consumers are generally characterized by a lower load factor than the utility system average, this factor could well outweigh the above factors which favor master-metering in setting rates.

The following is a hypothetical example of a cost-benefit analysis of a change to individual from master-metering where the rate structures do not afford a discount for master-metering:

(1) Operational change: Replace master-metering system with individually metered system (with no change in overall rates paid).

(2) Assumptions:
Residential Building-Washington, D.C.
Tenant Energy Consumption: 800 KWH/Mo. master-metered
600 KWH/Mo. individual meters
Electricity Cost for increment from 600 to 800 KWH-3.5¢/KWH

(3) Savings: 2400 KWH/yr./apt.
$84.00/yr./apt.

(4) Implementation cost - $250/apt. for additional wiring. It is assumed that the additional costs of metering, billing and accounting are offset by system savings due to reduced demand at peak.

(5) Payback for conversion to individual metering is less than three years.

b. Utilities or local government agencies to subsidize the additional expense of individual metering or conversely to increase owner costs for master-metering.

Individual apartment metering is more costly to install than a single metering system. Therefore owners who are solely interested in low first (construction) cost may install a master-metering system rather than individual metering. However, if a utility or local government agency bears a larger share of the implementation costs of individual versus master-metering, there would no longer be a first cost advantage to the builder favoring master-metering. Los Angeles provides just such an example, where the Department of Water & Power furnishes both inside and outside transformers for large building electrical distribution systems if the owner elects individual metering, whereas otherwise such costs would have to be borne by the owner. Therefore, if the builder elects individual metering, the extra wiring costs are offset. This policy is a major reason that construction cost data shows no additional cost to the building owner for installing individual metering in the City of Los Angeles. The increased cost to the utility for this distribution system will be offset by decreased capital charges for meeting peak demand.

c. <u>Utilities and State Regulatory Commissions to ban the installation of master-metering in new residential buildings</u>

Since master-metering has been shown to cause the consumption of significantly greater amounts of electricity, a ban on master-metered service for new residential buildings by utilities and state regulatory commissions should be considered. The feasibility of such a plan is demonstrated by the Commonwealth Edison Company of Chicago:

> Commonwealth Edison provides <u>no master-metering</u> of electrical service for residential customers except for a few older buildings which have continued their master-metered service under "grandfather" clauses. This company has established workable practices for the maintenance and servicing of their portion of distribution systems within large buildings. Their policy of refusal to serve residential customers through master-meters has been defended successfully in the Illinois courts and the policy has been in effect for 20 years. This example clearly supports a conclusion that the elimination of master-metering from residential service is indeed practical.

d. <u>State regulatory commissions to allow the submetering of existing master-metered apartments</u>

Because of the high cost of conversion from a master-metered building to individual metering it may be highly uneconomical to force existing building owners to convert for the purpose of energy conservation. However, state regulatory commissions should allow submetering of existing master-metered apartments in order to permit the owner to identify heavy users of electricity so that he can adjust his rent accordingly. The Department of Housing and Urban Development estimates that a 15 to 25% reduction in electricity would be accomplished by checkmetering the federally financed housing projects under its jurisdiction.

An example of the savings accomplished by checkmetering is:

(1) Operational change: Institution of checkmetering to identify and charge heavy electrical energy consumers.

(2) Assumptions:
Electricity used for all tenants in a 500 unit family project is 8,755,700 KWH/yr.
Installation of checkmeter reduces electric consumption to 7,442,345 KWH/yr.

(3) Savings: 1,313,355 KWH/yr.
$39,400/yr @ 3.0¢/KWH.

(4) Implementation cost - $200,000

(5) Payback of 5 years for installation of submetering.

EXHIBIT 12-1

EXTENT AND TRENDS IN MASTER-METERING IN 10 SELECTED CITIES

City	Year	(1) Total Number of Dwelling Units	(2) Number of Dwelling Units in M/F Structures	(3) % of Total Dwelling Units in M/F Structures (2)/(1)	(4) No. of Units in M/M, M/F Structures	(5) % of Units (M/F) Which are M/M (4)/(2)	(6) % of Dwelling Units Which are M/M (4)/(1)
New York	1970	3,856,000	2,260,792	59%	804,000	36%	21%
	1974	3,982,298	2,331,815	59%	837,500	36%	21%
Los Angeles	1974	2,583,354	942,426	36%	166,880	18%	6%
Philadelphia	1974	1,592,667	338,130	21%	169,065	50%	12%
Detroit	1960	1,152,941	142,901	12%	70,610	49%	6%
	1970	1,267,000	224,693	18%	57,275	25%	5%
	1974	1,360,097	273,255	20%	54,651	20%	4%
San Francisco	1970	1,086,000	355,571	33%	28,300*	8%	3%
	1974	1,203,324	421,543	35%	33,550*	8%	3%
Washington, D.C.	1960	618,152	215,986	35%	166,310	77%	27%
	1970	937,518	383,252	41%	295,100	77%	32%
	1974	1,072,696	439,421	41%	342,750	78%	31%
Boston	1960	814,035	263,445	32%	27,587	11%	4%
	1970	850,000	285,547	33%	41,751	15%	5%
	1974	914,747	326,994	36%	63,671	19%	7%
Houston	1974	713,933	177,940	25%	140,573	79%	20%

* San Francisco data were developed using Pacific Gas and Electric Co. figures for only the number of master-metered multi-family units on their DM rate schedule.

M/M = Master-Metered
M/F = Multi-Family

Sources: Data from 1970 Census of Housing: 1974 values are adjusted from 1970 by demolition and construction records.

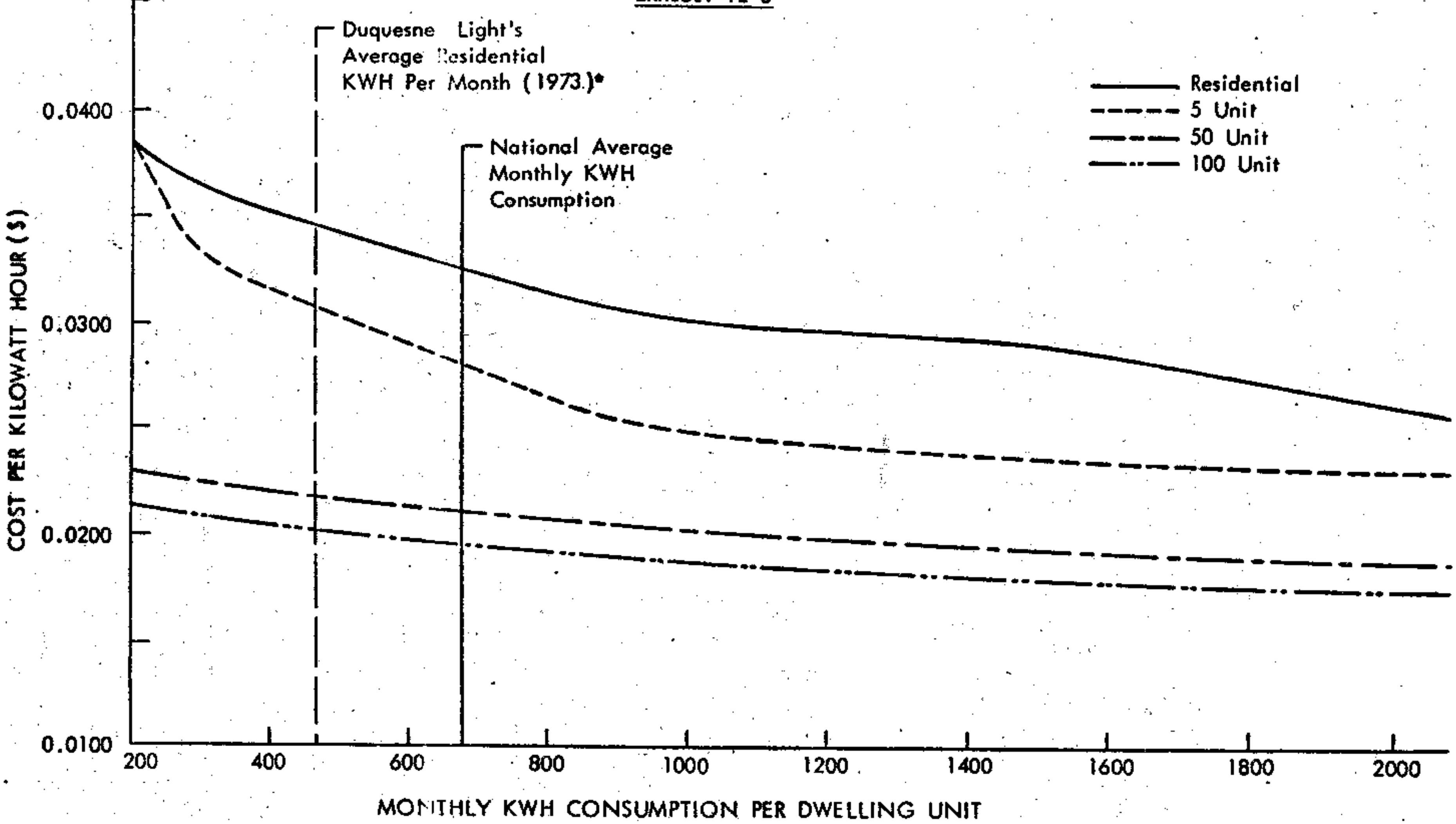
EXHIBIT 12-2

RELATIVE ELECTRICITY CONSUMPTION OF MASTER-METERED AND INDIVIDUALLY METERED MULTI-FAMILY DWELLING UNITS

	Master-Metered Units			Individually Metered Units			
City	No. of Units	Consumption/Apt/Year, kwh	Dates of Metering	No. of Units	Consumption/Apt/Year, kwh	Dates of Metering	% 2:5
Los Angeles	20*	3,456	Jan 73 - Dec 73	20	1,284	Jan 74 - Dec 74	269
	20*	1,968	Jan 74 - Dec 74	20	984	Jan 72 - Dec 72	200
	9*	2,868	Jan 74 - Dec 74	9	2,664	Jan 72 - Dec 72	108
Philadelphia	279	9,096	Nov 73 - Oct 74	31 of 250	5,676	Apr 74 - May 75	160
Detroit	44	2,904	Jan 74 - Dec 74	44	1,748	Jan 74 - Dec 74	166
	194	9,745	Jan 74 - Dec 74	140	6,338	Jan 74 - Dec 74	154
San Francisco	1,683*	3,105	Nov 72 - Oct 73	1,683	2,298	Nov 69 - Oct 70	135
Washington, D.C.	172 of 296	3,684	Jan 74 - Dec 74	24 of 264	2,880	Jan 74 - Dec 74	128
	76*	4,176	Jan 73 - Dec 73	76	2,736	Jan 74 - Dec 74	152
Boston	208	13,032	Jan 72 - Dec 72	37	11,196	Jan 72 - Dec 72	116
Pittsburg	216	17,316	Jan 72 - Dec 72	92	13,368	Jan 72 - Dec 72	129.5
	144	16,788	Jan 72 - Dec 72	207	14,376	Jan 72 - Dec 72	117
	21*	4,438	Jan 71 - Dec 71	21	2,658	May 73 - May 74	165
	20*	4,440	Jan 72 - Dec 72	20	2,733	May 73 - May 74	163
Kansas City	155	10,168	Jan 74 - Dec 74	135	5,412	Jan 74 - Dec 74	186

* Metering service conversion.

EXHIBIT 12-3



* Electrical World, Directory of Electric Utilities (1974-75), McGraw Hill

Figure 1 - Cost per Kilowatt-Hour as a Function of Monthly Consumption (kwh) per Apartment Under Residential and General Service Rate. General Service Rates are Shown for 5, 50, and 100 Apartments per Master-Meter.

Attached to and made a part of
the Lease by and between
, Landlord and

____

As Tenant, Dated______________

ELECTRIC ENERGY

Sec. 1: Landlord shall furnish the electric energy that Tenant shall require in the Demised Premises for $_________per month, which Tenant agrees to pay commencing on the 1st day of the month following delivery of the premises to Tenant. Landlord shall not be liable in any way to Tenant for any failure or defect in the supply or character of electric energy furnished in the Demised Premises by reason of any requirement, act or omission of the public utility serving the building with electricity or for any other reason not attributable to Landlord, Tenant shall furnish and install and replace lighting tubes, lamps, bulbs and ballasts required in the Demised Premises.

Sec. 2: Tenant's use of electric energy in the Demised Premises shall not at any time exceed the capacity of any of the electrical conductors and equipment in or otherwise serving the Demised Premises. In order to insure that such capacity is not exceeded and to avert possible adverse effect upon the building electric service, Tenant shall not, without Landlord's prior written consent in each instance (which shall not be unreasonably withheld), connect any heating or cooking equipment or any additional fixtures, appliances or equipment (other than lamps, typewriters and similar small office machines) to the building electric distribution system or make any alteration or addition to the electric system of the Demised Premises as compared to the circumstances existing on the Commencement Date. Should Landlord grant such consent, all additional risers or other equipment required therefore shall be provided by Landlord and the reasonable cost thereof shall be paid by Tenant upon Landlord's demand. As a condition to granting such consent, Landlord may require Tenant to agree to an increase in the fixed rent by an amount which will reflect the value to Tenant of the additional service to be furnished by Landlord, that is, the potential additional electrical energy to be made available to Tenant based upon the estimated additional capacity of such additional risers or other equipment. If Landlord and Tenant cannot agree thereon, such amount shall be determined by a reputable, independent electrical engineer, to be selected by Landlord and paid equally by both parties.

Sec. 3: If the public utility rate schedule for the supply of electric current to the building shall be increased or decreased during the term of this lease, the fixed charges herein reserved shall be equitably adjusted to reflect the resulting increase or decrease in Landlord's cost of furnishing electric service to the Demised Premises, and the amount set forth in Section 1 shall also be adjusted accordingly. If Landlord and Tenant cannot agree thereon, the amount of such adjustments shall be determined by a reputable, independent electrical engineer, to be selected by Landlord and paid equally by both parties. When the amount of such adjustment is so determined, the parties shall execute an agreement supplementary hereto to reflect such adjustments in the amount of the fixed charges stated in this Exhibit and in the amount set forth in Section 1, effective from the effective date of such increase or decrease in the public utility rate schedule; but such adjustments shall be effective from such date whether or not a supplementary agreement is executed.

Sec. 4: Landlord reserves the right to discontinue furnishing electric energy to Tenant in the Demised Premises at any time upon not less than thirty (30) days notice to Tenant. If Landlord exercises such right of termination, this lease shall continue in full force and effect and shall be unaffected thereby, except only that, from and after the effective date of such termination, Landlord shall not be obligated to furnish electric energy to Tenant and the Tenant shall be relieved of its obligation to pay the charges set forth in Section 1. If Landlord so discontinues furnishing electric energy to Tenant, Tenant shall arrange to obtain electric energy directly from the public utility company furnishing electric service to the building. Such electric energy may be furnished to Tenant by means of the then existing building system feeders, risers and wiring to the extent that the same are available, suitable and safe for such purposes. All meters and additional panel boards, feeders, risers, wiring and other conductors and equipment which may be required to obtain electric energy directly from such public utility company shall be installed by Landlord at its expense before discontinuance of service.

Sec. 5: The Landlord shall have the right to install a check meter on Tenant's electrical service at the point of entry into the Demised Premises or at any other mutually agreeable location for the purpose of determining the Tenant's maximum demand for electric current. If the demand load exceeds _______ KW for any thirty (30) minute period, then the Tenant will pay to Landlord an additional $_________ per month for each KW of such excess demand. If Tenant requires the use of a substantial amount of power for more than _________ hours per week, then the Tenant will pay to Landlord an additional amount equal to _________ times the amount stated in Section 1 for each hour of such excess per week. Five per cent or more of normal operating requirements shall be deemed to be substantial.

EXHIBIT C

4

AUDITS, COSTS/TAX INCENTIVES

Audits, Costs, Tax Incentives

Table of Contents

WHAT IS AN ENERGY AUDIT

QUANTIFICATION OF ENERGY USE BY:

TYPE	-	ELECTRIC, OIL, GAS, L.P.
AREA	-	OFFICE, PLANT, PROCESS
SYSTEM	-	HEATING, VENTILATING, AIR CONDITIONING, LIGHTING, PROCESS
TIME	-	DUTY CYCLES, OCCUPIED/UNOCCUPIED, HOURS/YEAR

LIGHTING AUDIT

1. COUNT INCANDESCENT BULBS AND NOTE WATTAGE

2. COUNT FLUORESCENT BULBS, NOTE WATTAGE, MULTIPLY WATTAGE BY 120% (FOR BALLAST)

3. MULTIPLY BY OPERATING HOURS PER MONTH

EXAMPLE

$$\frac{200 \times 75 \times 1.20 \times 310}{1000} = 5580 \text{ KWH/MONTH}$$

ELECTRIC MOTOR AUDIT

1. CHECK NAMEPLATE FOR VOLTS AND FULL LOAD CURRENT (FLA)

2. ESTIMATE LOAD FACTOR (70%)

3. MULTIPLY BY OPERATING HOURS PER MONTH

EXAMPLE

$$\frac{115V \times 5.5A \times .7 \times 200 \text{ Hours}}{1000} = 88 \text{ KWH}$$

APPENDIX A-2

MOTORS - GENERAL FORMULAE AND SIZING

1.0 GENERAL FORMULAE.

		A. C. MOTORS		D. C. MOTORS
		Single Phase	Three Phase	
		(a)	(b)	(c)
(1)	$P_{KW} =$	$\frac{V \times I \times PF}{1000}$	$\frac{V \times I \times 1.73 \times PF}{1000}$	$\frac{V \times I}{1000}$
(2)	$P_{IHP} =$	$\frac{V \times I \times PF}{746}$	$\frac{V \times I \times 1.73 \times PF}{746}$	$\frac{V \times I}{746}$
(3)	$P_{OHP} =$	$\frac{V \times I \times PF \times Eff}{746}$	$\frac{V \times I \times 1.73 \times PF \times Eff}{746}$	$\frac{V \times I \times Eff}{746}$
(4)	$I =$	$\frac{P_{OHP} \times 746}{V \times Eff \times PF}$	$\frac{P_{OHP} \times 746}{1.73 \times V \times Eff \times PF}$	$\frac{P_{OHP} \times 746}{V \times Eff}$

(5) $P_{KW} = P_{IHP} \times .746$

(6) $P_{KW} = \frac{P_{OHP}}{Eff} \times .746$

(7) $P_{OHP} = Eff \times P_{IHP}$

SYMBOLS:

P = Power

P_{KW} = input power in KW

P_{IHP} = input power in HP

P_{OHP} = output power in HP

V = line voltage, e.g., 120, 208, 240, 480v.

I = amperage input to motor

PF = Power Factor (varies with I); obtained from mfgr.'s data.

Eff = Efficiency (varies with I); obtained from mfgr.'s data.

1 HP = 746w = 0.746 KW (by definition)

1 KW = 1000w (by definition)

2.0 SIZING. Motors should be sized to handle the horsepower requirement of the application, but should not be excessively oversized. An excessively oversized motor wastes energy because its efficiency is relatively low at low load. In general, the common A.C. induction motor will operate with only minor efficiency loss from 100% to 50% of its full load output horsepower. If the measured amperage input to the motor is approximately 25% or less of the full load amperage rating, then substitution of a smaller motor may save sufficient energy to pay back in a reasonable time. Use the following procedure to evaluate this ECO:

a. Obtain mfgr.'s literature for both the existing motor and the proposed motor. Data should include ratings of I, PF, and Eff for various percentages of full-load output.

b. Measure I for the existing motor at all ranges of capacity of the equipment that the motor serves; e.g., a pump will require a higher P_{OHP} from its motor when pumping against a lower head than usual. The highest I determined is I_M.

c. Calculate the percentage of full-load (%FL) that the existing motor is operating:

$$\%FL = (P_{KW}) \div (P_{KW} \text{ nameplate})$$

$$= \frac{I_M \times (PF)_M}{I_N \times (PF)_N} \times 100$$

where

I_M = measured amperage

$(PF)_M$ = PF @ I_M (mfgr.'s data)

I_N = nameplate amperage

$(PF)_N$ = nameplate PF (mfgr.'s data)

d. Calculate P_{OHP} of existing motor:

$$P_{OHP} = (\%FL) \times (\text{nameplate } P_{OHP})$$

e. From mfgr.'s data for the existing motor, interpolate as necessary and determine Eff at the %FL calculated in c. above. Use Equation (6) above to calculate P_{KW}.

f. Since the proposed motor will have to provide the same P_{OHP} to the machine served as the existing motor does, then

$$(P_{OHP} \text{ of proposed motor}) = P_{OHP} \text{ of existing motor})$$

g. Calculate %FL for proposed motor = $\frac{P_{OHP}}{\text{nameplate HP}}$.

From mfgr.'s data for proposed motor interpolate as necessary and determine Eff for the proposed motor.

h. Calculate P_{KW} for the proposed motor using Equation (6) above.

i. Is P_{KW} of proposed motor less than P_{KW} of existing? If so, its installation may pay back; proceed to j. below.

j. Payback Time: Calculate the annual \$ savings from reducing the KWH consumption and the KW demand. Estimate the installed cost of the proposed motor.

$$\text{Payback Time} = \frac{\text{Installed cost of motor}}{\text{Annual \$ Savings}}$$

2.1 Example.

Given A 460v. 20 HP, three-phase motor with FLA = 26 amps and PF = 80%. Its measured amperage I_M = 5.2 amps. PF = 45% and Eff = 50% at this 5.2 amps.

Required: Examine benefits of installing a smaller motor. Last block KWH cost is \$.02/KWH. Motor runs 2000 hrs./year.

Solution: Follow procedure of paragraph 2.0 above.

c. $\% \text{ FL} = \frac{5.2 \text{ amps} \times .45}{26 \text{ amps} \times .80} \times 100 = 11\%$

d. $P_{OHP} = (\%FL) \times (\text{nameplate } P_{OHP})$

$= .11 \times 20$ HP

$= 2.2$ HP

e. Eff = .50

$$P_{KW} = \frac{P_{OHP}}{Eff} \times .746$$

$$= \frac{2.2}{.50} \times .746$$

$= 3.28$ KW

f. P_{OHP} of

proposed motor = 2.2 HP

Thus, a 3 HP motor is proposed.

g. % FL of
proposed motor $= \frac{2.2 \text{ HP}}{3 \text{ HP}} \times 100 = 73\%$

Eff @ 73% FL = 78% (from mfgr.'s data)

h. P_{KW} of
proposed motor $= \frac{P_{OHP}}{Eff} \times .746$

$$= \frac{2.2 \text{ HP}}{.78} \times .746$$

$= 2.10$ KW

i. $\Delta P_{KW} = 3.28$ KW $- 2.10$ KW

$= 1.18$ KW (reduction)

j. Annual KWH = 1.18 KW x 2000 hrs. = 2360 KWH

Annual KWH cost $= 2360 \text{ KWH} \times \frac{\$.02}{\text{KWH}} = \$47.20$

cost of 3 HP motor = $150.

Payback Time $= \frac{\$150}{\$47.20} = 3.2$ years

(NOTE: 3.2 yr. payback time is for KWH $ savings only and does not include any $ savings for reducing KW demand.)

MONTHLY DETAILED ENERGY AUDIT-ELECTRICAL

DATE________________________

USAGE (EXCEPT MOTORS	RATED WATTS (1)	H	KWH	BTU
OFFICE LIGHTING				
OUTSIDE LIGHTING				
SPACE HEATING				
SOLDERING IRONS				
TANK HEATERS				
ETC.				

MOTORS	RATED WATTS (1)	WATTS (2)	H	KWH	BTU
VENTILATING FANS					
EXHAUST FANS					
AIR CONDITIONERS					
HAND TOOLS					
BIG MOTOR #1					
BIG MOTOR #2					
ETC.					
		TOTALS		________	________

DEMAND________KW POWER FACTORS________________

NOTES: (1) NAME-PLATE DATA, WATTS EQUALS VOLTS TIME AMPERES. FOR FLUORESCENT TUBES, ADD 20 PERCENT FOR THE BALLAST; I.E., MULTIPLY THE RATING BY 1.20. FOR THREE-PHASE MOTORS, WATTS EQUALS VOLTS TIMES AMPERES TIMES 1.732.

(2) RATED WATTS TIMES THE FRACTION OF FULL LOAD, USUALLY ABOUT 70 PERCENT. IF THE OPERATING CURRENT HAS BEEN MEASURED, USE VOLTAGE TIMES THE MEASURED CURRENT (TIMES 1.732 IF IT IS A THREE-PHASE MOTOR.)

ELECTRICAL REQUIREMENT

Gross sq ft
of area ____________ ______________________________ Floor______
(Area Identification)

Electrical Equipment	1	2	3	4*	5	6	7
	No.	Watts	Tot. Watts (Col. 1 x Col.2)	Tot. Kw: See below	Number Hours per day	Number Days per year	Kwh Annual Requirements
Lights:							
Incandescent							
Fluorescent							
Other							
MOTORS							
Kw H.P. Use							
TOTAL							

*Lighting Multiplier: Incandescent = .001 Motors: Column 3 + 1,000
Fluorescent: = .0012

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft
of area ____________ ______________________________ Floor______

(Area Identification)

Electrical Equipment	1 No.	2 Watts	3 Tot. Watts (Col. 1 x Col.2)	4* Tot. Kw: See below	5 Number Hours per day	6 Number Days per year	7 Kwh Annual Requirements
TOTAL							

*Lighting Multiplier: Incandescent = .001
Fluorescent: = .0012

Motors: Column 3 ÷ 1,000

THERMAL REQUIREMENTS

Location:________________

ITEMS	NO.	BTU	TOTAL BTU	NO. HRS/DAY	NO. DAYS/YR	ANNUAL REQMTS. BTU
TOTAL						

ENERGY INVENTORY
COMBINED RE-CAP

FACILITY	ELEC-TRICITY KWH	FUEL OIL GALLONS	NATURAL GAS THERMS	STEAM 1,000lbs.	OTHER	TOTAL BTU
GUEST ROOMS						
LOBBY						
OFFICE & COMM. SPACE						
BALLROOMS & MEETING ROOMS						
KITCHENS						
EQUIPMENT ROOMS						
BARS						
DINING ROOM-RESTAURANT						
HALLWAYS						
ELEVATORS-ESCALATORS						
HOUSEKEEPING ROOMS						
PUBLIC REST ROOMS						
LAUNDRY						
BUILDING EXTERIOR						
SWIMMING POOLS						
RECREATION FACILITIES						
OTHER						
TOTAL						

TEN MOST SIGNIFICANT FEATURES
OF
ENERGY CONSUMPTION IN BUILDINGS

1. HOURS OF OPERATION
2. HVAC SYSTEM TYPE
3. HVAC CONTROLS
4. VENTILATION
5. GLASS AREA
6. HEATING ENERGY TYPE
7. COOLING ENERGY TYPE
8. CLIMATE
9. LIGHTING
10. OTHER USES IN BUILDING

LIFE-CYCLE ANALYSIS FOR ENERGY MANAGEMENT DECISIONS

Del Fowler, P.E., Planergy, Inc.

For those who are serious about energy managment, energy use computations from past bills for a given building or facility are usually followed by a detailed energy audit of that building or facility. Observations during the audit and computations and analysis following the audit will provide a "shopping list" of energy conservation opportunities, or as I prefer to call them, Dollar Saving Opportunities (DSOs). To compile a list of such potential retrofit projects is not enough, however; we will need other information if we are to make good decisions based on sound economics. For example, we might want to know:

- should this project be done at all
- which of the many potential projects should be done first
- for my yearly budget of "X" dollars for such projects, which of those on the "shopping list" will provide me the greatest return on investment

This section discusses how to go about this analysis.

Simple Pay-back

Most of us would probably think of this analysis even if we had never heard of it. It is simply the first cost (estimated cost of labor and materials required for the retrofit project) divided by the net annual savings; in other words how many months or years will it take to recover the cost of the project.

$$\text{Payback Period} = \frac{\text{First Cost}}{\text{Net Annual Savings}}$$

In this case net annual savings would, in the simplest form, be the annual fuel or energy saving (computed using projected fuel or energy prices) less any additional operating cost which might be required for the energy-saving equipment installed.

$$\text{Payback Period} = \frac{FC}{(AFS \times PFP) - AAOC}, \text{ where}$$

FC = First Cost
AFS = Annual Fuel Saving
PFP = Projected Fuel Price
AAOC = Additional Annual Operating Cost

The payback period is then compared to the expected lifetime of the investment in order to make some rough judgement as to its potential for cost recovery. A payback period of less than one-half the life time of an investment would generally be considered profitable where the lifetime is ten years or less.

Return on Investment

Return on Investment (ROI) is somewhat superior to the above because it takes into account the depletion of the investment over its economic life by providing for renewal through a depreciation charge. Using a straight line depreciation charge (DC) where

$$DC = \frac{FC \text{ (First Cost)}}{EL \text{ (Estimated Lifetime)}}$$

the percent return on investment can be calculated using

$$ROI, \%/yr = \frac{S-DC}{FC} \times 100\%$$

S = Net Annual Savings

ROI has the advantage of putting investments with different life expectancies on a comparable basis. It is frequently used in the financial analysis of potential investments because of its simplicity of calculation.

These measures, payback period and return on investment, as measures of performance, give rise to problems, however. For instance, they do not consider debt service, price escalations, or energy cost increases. One cannot say, for example, that an initial capital investment of $100,000 which results in annual energy savings of $20,000 has a payback period of five years. To do so ignores the fact that interest must be paid on the loan of $100,000, or that -- if no loan is involved -- the $100,000 would otherwise be earning interest. So for the larger projects in particular, we need measures of performance which will incorporate the time value of money.

Life-Cycle Costing

Once we have taken the mental step of deciding to include the price of money from year to year, we have entered the world of life-cycle costing. To examine what we mean by life-cycle costing, we might look at how you might buy an automobile. If you decide you want a specific model of automobile, say based on style and appearance, then you are really going to base your decision to buy based only on first cost. You will most likely buy from a dealer which offers the lowest sales price, even though a second dealer with a slightly higher price might have a cheaper source of money which would finance your loan for the car purchase with a lower monthly payment. Buying without checking on the cost of money for the car loan is certainly buying on first cost alone, and without considering the principles of life-cycle costing.

Additionally, if you ignore gasoline mileage, other operating costs, maintenance costs, and "salvage value" or trade-in cost at the end of a certain period of time, you are ignoring the principles of life-cycle costing.

> DEFINITION -- The term "life-cycle cost" means the total costs of owning, operating, and maintaining a building or a piece of equipment over its useful life.

In the National Energy Conservation Policy Act of 1978, the Federal Government has directed that all federal agencies develop and establish methods for applying life-cycle costing for all federal buildings. This same act, to give you a picture of what the federal government is in the process of doing, requires that:

1. The Secretary of Energy and others shall establish and publish energy performance targets for all federal buildings.

2. Each federal agency must conduct a preliminary energy audit of all federal buildings with more that 30,000 square feet as soon as possible and report to Congress in 1979 on the accomplishments.

3. Similarly, they are to next conduct preliminary energy audits of all federal buildings with 1,000 or more but less that 30,000 square feet of floor space, and report to Congress in 1980 on the accomplishment.

4. In the first year, all federal agencies should retrofit 1% of the total gross square footage of floor space as recommended in the preliminary energy audits.

5. By 1990, all federal building will be retrofitted so as to assure their minimum life-cycle costs.

Because there are always alternative investment opportunities available for funds, a dollar held today is worth more than a dollar held at some future time. This is true even without continuing inflation, which promises to reduce the value of that future dollar even more. To bring into the analysis this cost of money we will use standard interest tables and present worth factors. In life-cycle costing, the most commonly included costs are first cost (in place), operating costs, maintenance costs, and interest on the investment. To use interest tables we must know the life of the system. This is one judgement we must make --that is, the useful life.

In addition we must make judgements on interest rates (i.e., the cost of money or capital), on inflation rates, and on rate increases in costs of energy and of maintenance.

Cost of Money

Let us examine this question, since it is probably the most important judgement or decision management will have to make.

Financial managers in any company will usually know what return in percent they want to realize on cash or capital which they spend from earned income. They arrive at their decision by looking at the various earning alternatives available for that same cash, to include investment in savings instruments of some kind, as well as the reinvestment of that cash in their own business. These alternate investment decisions can be based on the rate of return before taxes, but sound financial decisions must take into account corporate income and other taxes. We can take income taxes into account by setting the "before income tax rate" of return at a higher value than the "after income tax rate". If a 12% return is the minimum desired after taxes, the rate before taxes can be determined by

$$i_b = \frac{i_a}{1-I} = \frac{.12}{1-.48} = 23.1\%$$

where

i_b = before tax rate of return

i_a = after tax rate of return

I = income tax bracket (48% in above example)

At the 48% corporate tax level, it can be seen that the before tax rate of return must be about twice that of the desired after tax rate.

THE INCOME TAX CREDIT

Regular Investment Tax Credit

Investment tax credits encourage capital investments by reducing the income tax paid. Income tax to be paid may be reduced by 10% of the cost of equipment which qualifies up to a limit which is defined in IRS regulations:

1. If the tax due is $25,000 or less, an investment tax credit is permitted up to the total tax due.
2. If the total tax due is more than $25,000, then an investment tax credit is permitted which equals $25,000 plus 60% (1979 tax year) of the difference between the total tax due and $25,000.
3. In addition, any part of an investment tax credit you cannot use because it exceeds the tax due, may be carried back 3 years and forward 7 and may be used to the extent permissable with the limitations applicable in those years.

1978 TAX LAW CHANGES

In 1978 significant changes were made in the tax system which provide new tax incentives to commercial businesses for certain energy management measures. Both incentives take the form of an investment tax credit:

- The Revenue Act of 1978 extends the regular 10% investment tax credit to building rehabilitation expenditures for buildings which qualify.
- The Energy Tax Act of 1978 provides a new 10% investment tax credit for certain energy conservation equipment classified as "energy property." This credit is in addition to the regular investment tax credit of 10%, to the extent that the "energy property" also qualifies as regular investment credit property under existing law. As discussed in greater detail below, "energy property" includes, among other things, automatic energy control systems and economizers, two items of particular interest to the commercial sector.
- The Energy Tax Act of 1978 also provides for a 10% refundable energy tax credit for solar or wind energy property; all other tax credits are non-refundable. Refundable means that the credit can exceed the tax due, and the limits on investment tax credits discussed earlier do not apply. In fact if this tax credit exceeds the tax due, the government pays the taxpayer the difference.

BUSINESS ENERGY TAX CREDITS

The Energy Tax Act of 1978 contains changes in the tax system to create incentives for energy conservation by businesses and to penalize certain business investments that would increase usage of oil or gas. For the most part these take the form of tax credits. A new 10% investment tax credit may be claimed on property classified as "energy property" acquired or constructed and placed in service after September 30, 1978, and before December 31, 1982. The business energy tax credit is determined separately from the regular investment tax credit. It may be claimed in addition to the regular investment tax credit if the property meets the qualifications for both. The business energy tax credit rate drops to 5%, however, when the eligible property is financed with tax exempt industrial development bonds.

Eligible Property

Energy property, as defined in the law, is any of the following:

1. Alternative energy property -- includes equipment for producing synthetic fuel and geothermal energy; does not include hydroelectric and nuclear equipment and structures

2. Solar or wind energy property -- includes equipment using such energy to heat, cool, or provide hot water in a structure, or to generate electricity; "passive" solar equipment is not included

3. Specially defined energy property -- includes:

   *recuperators
   *heat wheels
   *regenerators
   *heat exchangers
   *waste heat boilers
   *heat pipes
   *automatic energy control systems
   *turbulators
   *preheaters
   *combustible gas recovery systems
   *economizers
   Other items specified by the Secretary of Energy that reduce the amount of heat wasted or energy consumed in existing commercial or industrial processes and facilities will also be eligible. In March of 1979 no list of "other items" was yet available.

4. Recycling equipment

5. Shale oil equipment

6. Equipment for producing natural gas from geopressured brine

Equipment must be new, depreciable property with a useful life of at least 3 years. Equipment can be a structural component or used in connection with lodging (unlike eligible equipment under the regular investment tax credit). All property must meet quality and performance standards, if any, prescribed by the Treasury which are in effect when the property is acquired. At present there are no such regulations and some Treasury sources indicate it may be this summer before they are issued.

The final legislation omitted from the business energy property tax credit two types of expenditures included in both the House and Senate versions of the bill: cogeneration equipment and business insulation expenditures for items like storm doors, weatherstripping, structural insulation, etc. Therefore, businesses cannot obtain tax credits for insulation of offices, apartment buildings, shopping centers and other buildings under this section of the Act. However, it does appear that most equipment in a coal-fired cogeneration system, except the turbines generating electricity, may qualify for the credit.

Limitation

The business energy tax credit is limited to 100% of tax liability except for solar or wind energy property on which the tax credit is refundable (i.e., the credit can exceed the taxpayer's tax liability).

IRS Forms and Publications

1. The non-refundable energy tax credit for investment in energy property (other than solar and wind energy property) is computed in Part I of Schedule B (Form 3468) and is then entered on Form 3468 (Computation of Investment Credit) to determine the allowable credit for the year.

2. The refundable energy tax credit for investment in solar or wind energy property is computed in Part II of Schedule B (Form 3468) and is then entered on the specified line of Form 1040, Form 1120, or the appropriate line on other returns.

Samples of these forms are shown on the following pages. For more information concerning the business energy credit, see IRS Publication 572, Tax Information on Investment Credit (not available in March 1979).

1978 Department of the Treasury
Internal Revenue Service

Instructions for Form 3468

Computation of Investment Credit

(References are to the Internal Revenue Code)

New Tax Law Provisions

1. The Energy Act of 1978 provides a refundable energy investment credit of 10% for solar and wind energy property and a nonrefundable energy investment credit of 10% for other energy property. The credits are in addition to the regular 10% investment credit if the energy property also qualifies as regular investment credit property under existing law without considering the energy credit provisions. New Schedule B (Form 3468) will be made available to provide for the computation of the energy credits.

2. For tax years ending in 1979, the tax liability limitation as figured on line 12(b) was increased to 60%. Public utilities, railroads and airlines, see section 46(a)(7) and (8) concerning revised limitations.

3. The 10% credit rate and the $100,000 limitation on used property are made permanent.

4. See new section 48(a)(1)(D) concerning certain single purpose agricultural or horticultural structures which qualify for the investment credit.

5. For tax years ending after 10/31/78, cooperative organizations described in section 1381(a) may claim the investment credit to the same extent it is available for taxpayers in general. In addition, new section 46(h) provides that any credit the cooperative cannot use because of the tax liability limitation (section 46(a)(3)) shall be allocated to the patrons of the cooperative.

6. Generally, pollution control facilities are eligible for 100% investment credit for tax years ending after 1978. See section 46(c)(5).

7. New section 48(a)(1)(E) extends the investment credit to rehabilitation expenditures for all types of business and productive buildings, except those, such as apartments, which are used for residential purposes. This provision is effective for qualified expenditures paid or incurred after 10/31/78 for buildings which have been in use for at least 20 years.

8. The investment credit is denied for certain air conditioning or heating units as well as certain boilers fueled by oil or gas which are placed in service after September 30, 1978. See sections 48(a)(1)(A) and 48(a)(10) for details.

9. Commuter highway vehicles having a useful life of 3 years or more are eligible for 100% investment credit. See section 46(c)(6).

General Instructions

A. Who Must File.—Any individual, estate, trust, or corporation claiming an investment credit must attach this form to its income tax return.

Partnerships and small business corporations are not required to file this form because the credit is claimed by the partners and shareholders. They, however, must complete Schedule K on their returns showing the amount of investment credit property and qualified progress expenditures that is to be divided among the partners or shareholders.

This credit does not apply to a Domestic International Sales Corporation (DISC) and is not divided among DISC shareholders.

An estate or trust is allowed a credit for its share of the investment in depreciable property with an estimated useful life of 3 or more years. An estate or a trust that divides the qualified investment among itself and its beneficiaries must attach to this form a statement showing the allocation of the investment among its beneficiaries. The statement must show each beneficiary's allocable share of the basis of the new property, the cost of used property, and the life years assigned to the property. If the estate or trust has made an election under section 46(d)(6), the statement must show each beneficiary's portion of the qualified progress expenditures.

B. When Allowed.—The credit is allowed for the first year in which the qualified property is placed in service or for the year in which progress expenditures are taken into account (see section 46(d)(4)(F) for exceptions).

C. Property Defined.—(See New Tax Law Provisions above which add and delete certain properties from the listing below depending on when the item is acquired, constructed, or placed in service.) You are allowed a credit against your tax for investment in depreciable property with an estimated useful life of 3 years or more. For qualifying progress expenditures, you are allowed this credit for property with a useful life of 7 years or more. The credit is applicable to:

(1) Tangible personal property,

(2) Elevators and escalators,

(3) Other tangible property, including certain real property (except buildings and their structural components and land) if used as an integral part of manufacturing, production, or extraction, etc., or used as a research facility or bulk storage facility for fungible commodities for these activities, and

(4) Livestock (other than horses) if substantially identical livestock (not subject to recapture tax) is not disposed of or sold during the one-year period beginning 6 months before the acquisition date. Reduce the cost of the acquired livestock by the amount realized on the disposition of the substantially identical livestock.

This credit does not apply to property:

(1) Used mainly outside the U.S.;

(2) Owned by or leased to a tax-exempt organization, unless the unrelated business income tax applies;

(3) Owned by or leased to governmental units;

(4) Used for lodging or for furnishing the lodging unless—

(a) The property, such as a restaurant, is used and located in commercial facilities,

(b) The property is used by a hotel or motel, or

(c) The property is a coin-operated vending machine, washing machine, or dryer; and

(5) Amortized over a 5-year period such as railroad rolling stock, rehabilitation of low income rental housing, or child-care facilities (see sections 184, 167(k), or 188 respectively).

D. Election for Leased Property.—A lessor may elect to treat all or part of an investment in new property as if it were made by the lessee. (See section 48(d).) For limitation on availability of the credit to certain lessors, see section 46(e)(3).

E. Recomputed Tax on Early Disposition of Property.—If you dispose of property prior to the life-years category used in figuring investment credit, recompute the credit. You may use Form 4255 to compute the tax increase.

F. Carryback and Carryover of Unused Credits.—Any part of an investment credit you cannot use because it exceeds the amount allowable (including any unused credit created by the carryback of a net capital loss or a net operating loss) may be carried back 3 years and forward 7 and may be used to the extent permissible within the limitations applicable in those years.

Special Rule for Carryover of Unused Credits from Tax Years Ending Before 1971.—Any unused credit which originated before 1971 which can be carried over to any year after 1970 may be carried forward 10 years. Also, any credit unused because of the 20% limitation on carryover and carryback for any year after 1968 but before 1971 may be carried forward 10 years.

You may make a claim for refund based upon the carryback of an unused investment credit by filing Form 1040X (individuals) or Form 1120X (corporations) for the year to which the unused credit is carried. For a tentative (quick) refund, file Form 1045 (individuals) or Form 1139 (corporations).

Priority of Application of Credits.—The limitation is first absorbed by:

(1) Investment credit carryovers to current year, then by

(2) Investment credit earned in current year, and then by

(3) Investment credit carrybacks.

G. Basis and Cost.—The credit for new property applies to the basis of the property. The credit for used property applies to the cost of the property. The cost of used property does not include the basis of any property traded in unless the trade-in resulted in the recapture of all or any portion of an investment credit previously allowed or resulted in a reduction of an investment credit carryback or carryover.

No adjustment for additional first-year depreciation or salvage value is required.

For purposes of the investment credit, the useful life of the qualifying property must be the same as the useful life used for depreciation or amortization.

H. Qualified Progress Expenditures.—You may elect under section 46(d) to increase your qualified investment for a year by the allowable qualified investment in progress expenditures property as defined in section 46(d)(2) and (3). This election is made by attaching a statement to this form and shall apply to the tax year for which it is made and to all subsequent tax years.

The amount of qualified progress expenditures which may be taken into account in a tax year beginning in 1978 is the sum of (a) 80% of the qualified progress expenditure made in a tax year beginning in 1978 plus (b) 20% of the qualified progress expenditures made after January 21, 1975, in tax years beginning in 1974, 1975, 1976, and 1977, providing a proper election as prescribed in section 46(d)(6) was in effect for such years.

I. 11%–11.5% Investment Credit (Corporations Only).—A corporation may elect an 11% (or 11.5%) investment credit for qualified investment in property that is otherwise eligible for the 10% credit providing it meets the requirements of section 46(a)(2)(B) and section 301(d) of the Tax Reduction Act of 1975 (as amended).

A corporation may elect the additional credit by attaching a statement to this form.

J. Public Utilities, Railroads, or Airlines.—The alternative limitation under section 46(a) will apply to a public utility, a railroad or an airline, if the amount of qualified investment attributed to public utility property (or railroad property) (or airline property) is 25% or more of the total of its qualified investment for the year. For public utilities this applies to any year ending before 1981; for railroad and airlines this applies to any year ending after 1976 and before 1983. See section 46(a)(7) for public utilities and 46(a)(8) for railroads, airlines, and manufacturers who lease railroad property.

K. Ships.—An investment credit equal to 50% of the normal investment credit is allowed for certain vessels. See section 46 (g)(1) through (6) for additional details.

Note: *If you claim 100% instead of 50%, you are required to check the block in the instruction for line 1 on the front of this form.*

L. Movies and Television Films.—See section 48(k) for special rules on the computation of investment credit for movies and television films.

M. Mutual Savings Institutions, Regulated Investment Companies, Real Estate Investment Trusts, and Cooperatives.—The qualified investment for investment credit property and the $25,000 amount in line 12(a) are limited for the above organizations. See section 1.46–4 of the regulations to determine these limits.

N. 7% Property (4% for Public Utilities).—Property acquired or constructed prior to January 22, 1975, and placed in service during the taxable year must be reported on line 4 of Form 3468. The investment credit rate for this property is 7% (4% for public utilities).

Specific Instructions

Lines 1(a)–(c). New Property.—Enter on the appropriate line the basis of new property placed in service during the year. (See instructions C and G.)

Lines 1(d)–(e). Qualified Progress Expenditures.—Enter on line 1(d) column (2), the amount of qualified progress expenditures made in 1974, 1975, 1976, and 1977. Enter on line 1(e), column (2), the amount of qualified progress expenditures made in 1978. (See instruction H and section 46(d)(7).)

Do not take any qualified progress expenditures for the year in which the progress expenditure property is placed in service or for the year for which recapture is required for the property. The investment credit allowed for the year in which the property is placed in service is based on the entire qualified investment in the property reduced by the progress expenditures that were included as qualified investment in previous years.

Lines 1(f)–(h). Used Property.—Enter on the appropriate line the cost (subject to the dollar limitation) of used property placed in service during the year. (See instruction G.) Property inherited, received as a gift, or acquired from certain related parties does not qualify for the investment credit.

Dollar Limitation on Used Property.—In general, the amount of used property that you may take into account may not exceed $100,000. This amount is determined without regard to the applicable percentages based on useful life.

If a husband and wife file separate returns, each may claim up to $50,000. If one of them has no qualifying used property, the other may claim up to $100,000.

The amount of used property placed in service by a partnership, small business corporation, estate, or trust that may be taken into account cannot exceed $100,000. The $100,000 limitation also applies to each partner, shareholder, and beneficiary.

A controlled group of corporations (see section 48(c)(3)(C)) must apportion the $100,000 limitation among the component members of the group. The apportionment is based on the total cost of used property that each member placed in service. The $100,000 limitation and the applicable percentages based on useful life are not considered in making the apportionment.

Estates and Trusts.—For an estate or trust the amount of qualified investment is apportioned among the estate or trust and the beneficiaries. The apportionment is based on the income of the estate or trust allocable to each.

Line 5(a).—The additional 1% credit on line 5(a) is allowable to the extent the corporation makes the required contribution of stock or cash to a qualified employee stock ownership plan (ESOP). This required contribution must equal 1% of the qualified investment (line 2) less any portion of the additional credit carried over to a later year.

Line 5(b).—The credit to be entered on line 5(b) is limited to a maximum of .5% multiplied by the qualified investment for investment credit property acquired, constructed, or erected after 1976. To determine the qualified investment to be used in the above computation, reduce line 2 by the qualified investment for property acquired, constructed, or erected before 1977. (For example, if any part of the qualified investment on line 2 is attributable to 1974, 1975 or 1976 progress expenditure property (line 1(d)), then line 2 would have to be reduced by such qualified investment.) The resulting figure is multiplied by the appropriate percentage (see instruction I) and that figure is entered on line 5(b). Do this computation on a separate sheet of paper and attach to this form. (See section 46(a)(2)(B) and (D).)

Line 9(c). Tax on Lump-sum Distributions.—Individuals, estates, or trusts which are recipients of lump-sum distributions from qualified employees' trusts or annuity plans are to enter the amount of partial tax included in line 8. This partial tax is computed on Form 4972 and Form 5544.

Line 12. Limitation.—If the tax liability (line 11) is $25,000 or less, the investment credit may not exceed the amount of the tax liability.

If the tax liability exceeds $25,000, the credit may not exceed $25,000 plus 50% (60% for tax years ending in 1979) of the excess for calendar year taxpayers.

If you and your spouse file separate returns and both are entitled to an investment credit, compute the limitation by substituting $12,500 for the $25,000 shown in line 12(a).

Controlled corporate groups (see section 46(a)(6)) must divide the $25,000 among all component members.

An estate or trust must reduce the $25,000 amount to (a) $25,000 multiplied by (b) the qualified investment apportioned to the estate or trust, divided by (c) the total qualified investment apportioned among the estate or trust and its beneficiaries.

☆ U.S.GPO:1978-0/263-150 E.I.#430814328

Form **3468**

Department of the Treasury
Internal Revenue Service

Computation of Investment Credit

▶ Attach to your tax return.

1978

Name	Identifying number as shown on page 1 of your tax return

1 Use the format below to list qualified investment in new and used property acquired or constructed and placed in service during the tax year. Also list qualified progress expenditures made during the 1978 tax year and qualified progress expenditures made in 1974, 1975, 1976, and 1977 if you made the proper election prescribed in section 46(d)(6) for those tax years. If progress expenditure property is placed in service during the tax year, do not list qualified progress expenditures for this property. See instruction for line 1.

If you are claiming 100% investment credit on certain ships, check this block ▶ ☐. See instruction K for details.

Note: *Include your share of investment in property made by a partnership, estate, trust, small business corporation, or lessor.*

Type of property		Line	(1) Life years	(2) Cost or basis (See instruction G)	(3) Applicable percentage	(4) Qualified investment (Column 2 x column 3)
New property		(a)	3 or more but less than 5		33⅓	
		(b)	5 or more but less than 7		66⅔	
		(c)	7 or more		100	
Qualified progress expenditures	1974, 1975, 1976 and 1977	(d)	7 or more		20	
	1978	(e)	7 or more		80	
Used property (See instructions for dollar limits)		(f)	3 or more but less than 5		33⅓	
		(g)	5 or more but less than 7		66⅔	
		(h)	7 or more		100	

2 Qualified investment—Add lines 1(a) through (h) (see instruction M for special limits)

3 10% of line 2

4 7% (4% for public utility property) of certain property (see instructions M and N)

5 Corporations electing the additional investment credit for contributions to Employee Stock Ownership Plans—Attach election statement (see instruction I and instruction for line 5)

(a) Additional 1% credit—Enter 1% of line 2

(b) Additional credit (not more than .5%)—Enter allowable percentage times adjusted line 2 (attach schedule)

6 Carryback and carryover of unused credit(s)—Attach computation (see instruction F)

7 Tentative investment credit—Add lines 3 through 6

Limitation

8 (a) Individuals—Enter amount from Form 1040, line 37, page 2

(b) Estates and trusts—Enter amount from Form 1041, line 27 or 28, page 1

(c) Corporations—Enter amount from Schedule J (Form 1120), line 9, page 3

9 (a) Credit for the elderly (individuals only)

(b) Foreign tax credit

(c) Tax on lump-sum distributions (see instruction for line 9(c))

(d) Possession tax credit (corporations only)

(e) Section 72(m)(5) penalty tax (individuals only)

10 Total—Add lines 9(a) through (e)

11 Subtract line 10 from line 8

12 (a) Enter smaller of line 11 or $25,000. See instruction M for special limits. (Married persons filing separately, controlled corporate groups, estates, and trusts, see instruction for line 12.)

(b) If line 11 is more than line 12(a) and your tax year ends in 1978, enter 50% of the excess (if your tax year ends in 1979, enter 60% of the excess). (Public utilities, railroads, and airlines, see instruction J.)

13 Total—Add lines 12(a) and (b)

14 Enter smaller of line 7 or line 13

15 Subtract line 14 from line 11

16 Enter energy property credit from line 3 of Schedule B (Form 3468)

17 Enter smaller of line 15 or line 16 (if there is no entry on line 16, enter zero)

18 Total Investment Credit—Add lines 14 and 17. Enter here and on Form 1040, line 41; Schedule J (Form 1120), line 10(b), page 3; or the appropriate line on other returns

Schedule A If any part of your investment in line 1 or 4 above was made by a partnership, estate, trust, small business corporation, or lessor, complete the following statement and identify property qualifying for the 7% or 10% investment credit.

Name (Partnership, estate, trust, etc.)	Address	Property: Progress expenditures	Property: New	Property: Used	Life years
		$	$	$	

If property is disposed of prior to the life years used in figuring the investment credit, see instruction E.

Form **3468** (1978)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—O-263-356 58-040-1110

SCHEDULE B (Form 3468) (November 1978) Department of the Treasury Internal Revenue Service

Computation of Business Energy Investment Credit

▶ Attach to your tax return.

To be Used ONLY for Tax Years Ending After 9/30/78

Name	Identifying number

Note: *All filers are to attach a schedule showing the computation of total basis and total qualified investment for each category (lines 1(a) through 1(e) and line 4) of energy property. See instructions.*

Part I Nonrefundable Energy Credit

	(a) Basis	(b) Qualified investment
1 Enter total amounts from attached schedule(s) for each category of energy property below:		
(a) Alternative energy property		
(b) Specially defined energy property		
(c) Recycling equipment		
(d) Shale oil equipment		
(e) Equipment for producing natural gas from geopressured brine		
2 Add lines 1(a) through 1(e), columns (a) and (b)		
3 Nonrefundable energy credit—Enter 10% of line 2, column (b), here and on Form 3468 (see instructions)		

Part II Refundable Energy Credit

	(a) Basis	(b) Qualified investment
4 Enter total amounts for solar and wind energy property from attached schedule		
5 Refundable energy credit—Enter 10% of line 4, column (b), here and on the appropriate line of Form 1040, Form 1120, and other returns as explained in the instruction for line 5		

Part III If Any Part of Your Investment in Parts I and II Above was Made by a Partnership, Estate, Trust, Small Business Corporation, or Lessor, Complete the Following Statement: (Under "Category," indicate which line applies—1(a), (b), (c), (d), (e) or line 4.)

Name (Partnership, estate, trust, etc.)	Address	Property			
		Category	Life years	Progress expenditures	Basis
				$	$

Highlights of the Energy Act of 1978

(References are to the Internal Revenue Code)

Refundable Energy Credit

(a) The Act provides for a refundable energy credit (i.e. the credit can exceed the taxpayer's tax liability) for investment in solar and wind energy property acquired or constructed after September 30, 1978.

(b) The credit is equal to 10% of the qualified investment in solar or wind energy property as defined in section 48(l)(4). The credit is computed in Part II of Schedule B (Form 3468) and is then entered on the appropriate line of Form 1040, Form 1120, etc., as indicated in the instruction for line 5.

Nonrefundable Energy Credit

(a) The Act provides for a nonrefundable energy credit for investment in energy property (other than solar and wind energy property) acquired or constructed after September 30, 1978.

(b) The credit is equal to 10% of the qualified investment in energy property as defined in sections 48(l)(3) and 48(l)(5) through (8).

(c) The credit is limited to 100% of tax liability as defined in section 46(a)(4) reduced by the allowable credit for regular investment credit property. The credit is computed in Part I of Schedule B (Form 3468) and is then entered on Form 3468 to determine the allowable credit for the year (see instruction for line 3).

Energy Credit is in Addition to Regular Investment Credit

(a) Generally, the refundable or nonrefundable energy credit is in addition to, and not instead of, the regular 10% investment credit to the extent that the energy property also qualifies as regular investment credit property under existing law. The property must qualify as regular investment credit property without regard to the special energy credit provision contained in section 48(l)(1). For example, solar and wind energy property which is considered under existing law to be a structural component of a building would not qualify as regular investment credit property because of the structural component rule of section 48(a)(1)(B). Accordingly, such solar or wind energy property would qualify for the refundable energy credit, but not for the regular investment credit.

(b) If energy property qualifies for the energy credit and the regular investment credit, such property would be listed on line 1, Form 3468, and also on the appropriate line of Schedule B (Form 3468). If the property qualifies only as energy property, it would be listed only on Schedule B (Form 3468).

General Instructions

A. Who Must File.—Any individual, estate, trust, corporation, or organization (including exempt organizations if the energy property is used predominantly in an unrelated trade or business the income of which is subject to tax under section 511) claiming the refundable or nonrefundable energy credit must attach Schedule B (Form 3468) to its income tax return.

B. Energy Property Defined.—Energy property means property which is:

(1) alternative energy property,
(2) solar or wind energy property,
(3) specially defined energy property,

(Continued on page 2)

235-320-1

(4) recycling equipment,
(5) shale oil equipment, or
(6) equipment for producing natural gas from geopressured brine.

To qualify for the energy investment credit, energy property must:

(1) Meet the requirements of regular investment credit property except that the provisions of sections 48(a)(1) and 48(a)(3) do not apply to energy property,

(2) Be constructed after September 30, 1978, or acquired after September 30, 1978, if the original use commences with the taxpayer,

(3) Meet certain performance and quality standards which are in effect at time of acquisition (section 48(l)(9)), and

(4) Have a useful life of three years or more at the time the property is placed in service.

See sections 48(l)(1) through (12) for details.

C. Special Rules.—The following special rules apply:

(1) Alternative energy property, solar or wind energy property, and recycling equipment do not include property which is public utility property. In addition, specially defined energy property does not include property which is public utility property because specially defined energy property must be installed in connection with an existing industrial or commercial facility,

(2) The energy credit is limited to 5% in the case of property which is financed in whole or part by the proceeds of an industrial development bond (section 48 (l)(11)),

(3) Solar equipment does not include "passive solar" equipment,

(4) Specially defined energy property must be installed in connection with an existing industrial or commercial facility. See section 48(l)(10) for a definition of the term "existing," and

(5) If property qualifies under more than one category of energy property, the taxpayer is limited to a single 10 percent energy credit for that property.

Specific Instructions

Lines 1(a) through 1(e) and Line 4.—Enter the total basis and total qualified investment for each category of energy property on lines 1(a) through 1(e) and line 4. See sections 46(c) and 48(b). Basis and qualified investment are computed for energy property acquired or constructed after September 30, 1978, and placed in service in the tax year. Basis and qualified investment are computed for qualified progress expenditures incurred after September 30, 1978.

A separate schedule showing the computation of basis and qualified investment for each category of property must be attached. The schedule must contain all items of information as shown in the Sample Computation Schedule located at the end of these instructions. See sections 48(l)(1) through (12) for details about items within each category of property.

If any part of your investment was made by a partnership, estate, trust, small business corporation, or lessor, be sure to complete Part III of Schedule B (Form 3468).

If qualified progress expenditures are involved, see section 46(d)(1) through (7) and the Instructions for Form 3468 for details concerning qualified progress expenditures.

Line 3.—

1978 Calendar and Fiscal Year Taxpayers (1978 Form 3468).—These taxpayers may claim the nonrefundable energy credit by entering the amount from line 3 of Schedule B (Form 3468) on line 16 of the 1978 Form 3468 and completing Form 3468 as applicable.

1977 Fiscal Year Taxpayers With Tax Years Ending After September 30, 1978 (1977 Form 3468).—These taxpayers should determine and claim the nonrefundable energy credit as follows:

(1) Computation to determine the credit—

(a) Enter the amount from line 11 of the 1977 Form 3468	
(b) Enter the smaller of line 7 or line 13 of the 1977 Form 3468	
(c) Tax liability limitation—Subtract line (b) from line (a)	
(d) Allowable credit—Enter the smaller of line (c) or line 3 of Schedule B (Form 3468)	

(2) Enter the amount from (d) above in the margin to the right of line 14 of the 1977 Form 3468 and identify it as "Energy Credit."

(3) Combine the energy credit with the regular investment credit (the lesser of line 7 or line 13 of the 1977 Form 3468) and enter the combined total on line 14 of the 1977 Form 3468.

Line 5.—Individuals, estates, trusts, corporations, and other organizations (including exempt organizations if the energy property is used predominantly in an unrelated trade or business the income of which is subject to tax under section 511) are to claim the refundable energy credit (refundable if this credit is in excess of the tax liability or if there is no tax liability) on their respective returns.

The refundable energy credit is allowable only for tax years ending after September 30, 1978. If your tax year ends after this date and you have not filed your income tax return by the time you read these instructions, include the refundable credit in the total amount to be entered on the line referenced below and write in the margin next to the total amount the amount of the energy credit and the words "refundable energy credit."

(1) 1977 Form 1040, line 62, page 2; 1978 Form 1040, line 62, page 2.

(2) 1977 Form 1041, line 41, page 1; 1978 Form 1041, line 37, page 1.

(3) 1977 Form 1120, line 32, page 1; 1978 Form 1120, line 32, page 1.

(4) 1977 Form 1120F, line 6, page 1; 1978 Form 1120F, line 6, page 1.

(5) 1977 Form 990–C, line 34, page 1; 1978 Form 990–C, line 32, page 1.

(6) 1977 Form 990–T, line 21, page 1; 1978 Form 990–T, line 21, page 1.

(7) 1978 Form 1120L, line 22, page 1.

(8) 1978 Form 1120M, line 20, page 1.

If you have filed your income tax return without claiming a refundable or nonrefundable energy credit that you're entitled to, you should file Form 1040X or Form 1120X, or an amended income tax return, whichever applies.

As this schedule is printed, business energy property regulations are being prepared by the Internal Revenue Service. When these regulations are final, they will be printed in the Internal Revenue Bulletin and the Federal Register. The Service is also revising **Publication 572**, Tax Information on Investment Credit, to reflect the new business energy investment credit. You may want to obtain the regulations or **Publication 572** when they are published for more detailed information on the business energy investment credit.

Sample Computation Schedule

Line (1)	Description Of Asset Within Each Category of Properties (2)	Life years (3)	Basis (4)	Applicable percentage (5)	Qualified investment (column 4 × column 5) (6)
(a)		3 or more but less than 5		33⅓	
(b)		5 or more but less than 7		66⅔	
(c)		7 or more		100	
(d)		1978 qualified progress expenditures		80	
(e)		1977 qualified progress expenditures*		60	
Total—Add lines (a) through (e), columns 4 and 6					

*Applies only to years ending 10–31–78 and 11–30–78.

U.S. GOVERNMENT PRINTING OFFICE : 1978—235-320

235–320–2

INVESTMENT TAX CREDITS FOR BUILDING REHABILITATION

Most types of buildings have not been eligible for investment tax credit since the credit was first enacted. Investment tax credit will now be available to partially offset rehabilitation expenditures for certain existing structures. The Revenue Act of 1978 extends the 10% investment tax credit to rehabilitation expenditures for all kinds of commercial buildings, including hotels. However, renovation costs for apartments and other residential structures are not eligible.

Rehabilitation expenditures are defined as capital expenditures incurred after October 31, 1978, effective for taxable years ending after that date. Such expenditures may qualify for the credit if:

1. The building was placed in service before the rehabilitation began;

2. The building previously has been in service for at least 20 years and has not been the object of a rehabilitation project within the prior 20 years;

3. At least 75% of the existing external walls are retained in place as external walls, although they can be reinforced or receive a new cover; and

4. The property or the additions or improvements to the property have a useful life of 5 years or more.

Additions with a 5 or 6-year life will be eligible only for two-thirds of the 10% investment credit rate. The cost of acquiring a building or enlarging a building will not qualify for the credit. Rehabilitation expenditures will be considered new property and thus not subject to the $100,000 used property limitation of the investment tax credit.

It appears that capital expenditures such as those for the replacement of heating or air conditioning systems (including temperature control systems), insulation, plumbing, electrical wiring, flooring, and permanent interior partitions and walls would qualify as rehabilitation expenditures when incurred in connection with a rehabilitation.

IRS Forms and Publications

The investment tax credit is computed on Form 3468 (Computation of Investment Credit) to determine the allowable credit for the year.

For more information on the investment credit for building rehabilitation, see IRS Publication 572, Tax Information on Investment Credit (not available in March 1979 at this printing).

INVESTMENT TAX CREDITS NON-REFUNDABLE

PROBLEM: You install "an automatic energy control system" costing $50,000 with an expected life of 10 years. What is your investment tax credit?

SOLUTION:

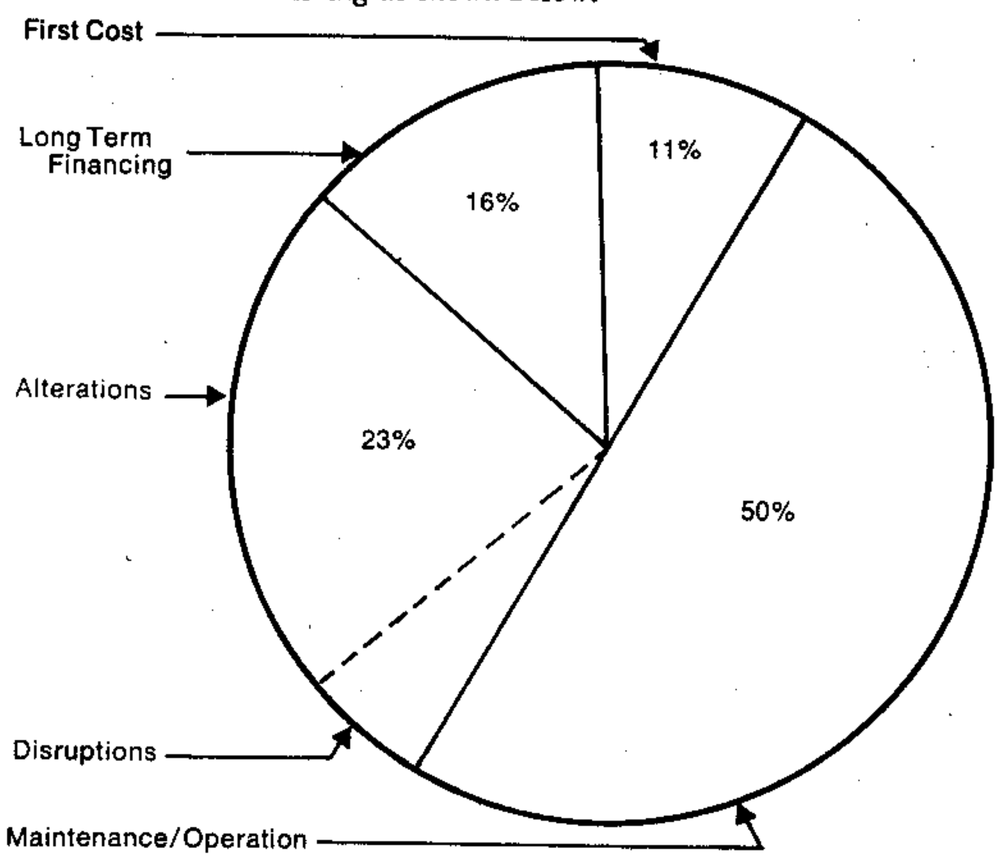
1. Consult your tax specialist to find out if this system qualifies for the regular investment tax credit of 10%. If it does, enter $50,000 on line 1(c) of Form 3468

2. It does qualify as "specially defined energy property" and is therefore also eligible for the 10% business energy tax credit. So also enter $50,000 on line 1(b) of Schedule B to Form 3468. Enter 10% of $50,000 on line 3 and on line 16 of Form 3468

3. Line 18 will be sum of the $5,000 regular tax credit, if the system qualifies, and the $5,000 business energy tax credit.

WHY LIFE CYCLE COSTING?

The Educational Facilities Laboratories, Inc., of Menlo Park, California, portrays the lifetime cost of a building as shown below.



With the first cost representing only 11% of the total, the reason for considering all costs seems obvious. And since maintenance and operations are 50% of the total, again the logic in designing a facility to minimize energy use and operating costs is obvious.

Present Value Analysis

If all the factors involved in life-cycle costing did not change with time from year to year and if every energy investment were for the same number of years, there would be no need to reduce what happens from year to year to a common base. But as we know only too well, things do change, and the useful life of various energy projects are quite different. The rate of inflation as measured by the cost of living index or the wholesale price index, or any other such index, has varied in the past few years from month to month from 6 or 7 percent for year to as much as 14 percent. This rate obviously affects maintenance costs where the provision of supplies and services is involved.

We also know that energy prices are going to escalate for several years at a rate greater than those in the rest of our economy, primarily since price controls on energy are to be removed gradually, so as to bring our domestic energy supplies up to free world prices. So we need some analytical method of comparing these different investment opportunities.

Life-cycle costing in terms of present worth or present values provides us such a tool. Life-cycle costing extends our decision-making time frame from one year and first costs to a time frame of future years and all costs. Present worth or present value analysis does for the future of an analysis what a telescopic lens does to distance. It brings the future up to the present, allowing future costs to be reflected in their true value today, considering that all money will be invested in some area every year. Just as first costs have been compared and decisions made according to the lowest or first-cost bid, now we will begin using life-cycle costing and present worth or present value concepts to compare pieces of equipment or hardware, or in our case, alternative energy saving and dollar saving opportunities.

The concept of present worth or present value in life-cycle costing is based on the assumption that funds that are borrowed always carry interest charges for their use; in similar manner, if cash on hand is to be used, that cash, if not used, could be invested in some manner and earn interest. Present value analysis provides us a tool to reduce future annual savings to a common, or equilvalent, basis with current savings or current costs. Such a reduction is necessary because a dollar saved today is worth considerably more than a dollar saved some years from now, because a dollar available today can be invested and earn interest whereas the future dollar cannot so earn interest in any year prior to its receipt. What we are able to do is answer this type of question:

> "I want to invest $10,000, which I either have in cash, or will borrow. Should I reinvest it in my business in added inventory, in added sales space, in the stock market, or in an energy and dollar saving opportunity? In other words, will my energy saving investment provide me with the highest equivalent interest rate of all the investment opportunities available?"

We are all accustomed to thinking in interest terms; for example, we readily understand and can compute or find in interest tables what $1.00 invested today at 10% will be worth ten years from now. This so-called future value would be

$$\$1.00\,(2.57) = \$2.57$$

The future value factor of 2.57 is shown below under column A opposite year 10.

PRESENT VALUE ANALYSIS

A Future Value of $1.00 at 10%	Years (n)	B Present Value of $1.00 at 10%	C Present Value of $1.00 Received Annually for each of "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 or present value analysis just "turns this upside down" or reverses the process. In other words the $2.57 ten years from now has a present value of $1.00 if invested at 10%. We could actually do most of our present value analysis from interest tables like that in column A, but it could be awkward and we would constantly be interpolating between figures in the table. So we have constructed tables which are based on the same interest principles, but which give us a quickly read present value factor instead of the future value factor we got from interest tables. For example, we can look in column B at 10 years and get the present value factor of .38; that factor used with the earlier $2.57 will give us the original $1.00.

$$\$2.57\ (.38) = \$1.00$$

What this says is that $2.57 received 10 years from now has a present value of $1.00 if it were invested at 10%.

But with some energy-saving investments, we will be saving an amount each year, in contrast to the previous example when the saving was only in year 10. Referring to column B we can see that if $1.00 were saved in year 1, it's present value is .91, and another $1.00 in year 2 has a present value of .83. Note now that column C is the sum of these two. In other words the figure 1.74 opposite year 2 in column C reflects the present value of $1.00 saved in year 1 and another $1.00 saved in year 2. And in similar manner the 8.51 in column C opposite year 20 reflects the present value of $1.00 saved each of the 20 years, and is the collective sum of all the present values in column B between year 1 and year 20, both inclusive. Another way of looking at this same set of numbers is that if $8.51 were invested now at 10%, the return or yield would be $1.00 for the next 20 years.

The very simple table above covers only an interest rate of 10%. We will obviously use a range of possible interest rates in our life-cycle cost computations. Such a range is provided in Table I; note that the figures in column C of the illustrative example are identical to those in the 10% column of Table I.

Benefit/Cost or Savings/Investment Ratio

At this point, we need to look at a simple illustrative problem. And in doing so we are now returning to the energy audit and the "shopping list" of energy saving or dollar saving opportunities (DSOs) we mentioned in the introduction to this section. In this illustrative problem, we want to compare two alternatives.

	Alternative A	Alternative B
First Cost	$100,000	$100,000
Annual Energy Savings	3.0 billion BTUs	2.7 billion BTUs
Energy Cost	$11.72/million BTUs	$14.65/million BTUs
Useful life	15 years	15 years
Cost of money (or desired return on investment before taxes)*	20%	20%

*In general, a 20% return before taxes is necessary for a 10% return after taxes.

The best analysis of such alternatives will be one which provides for each alternative or option a single number which reflects both benefits and costs. Public or governmental agencies normally use these two and produce a benefit/cost ratio. The same principle is used in the business world with what is called a savings/investment ratio. Keeping in mind all the earlier discussion on life-cycle costs and present value, what we need to do for both System A and System B is to determine the present value of the savings for both alternatives A and B, and the present value of the necessary investment for both.

	Alternative A	Alternative B
Investment cost (present value)	$100,000	$100,000
Energy Savings (present value)		
Millions BTUs saved/year	3000	2700
Cost per million BTU	x 11.72	x 14.65
	$35,160	$39,555
Cumulative Present Value Factor	x 4.67	x 4.67
	$164,197	$184,722
Savings/Investment Ratio	$\frac{164,197}{100,000} = 1.64$	$\frac{184,722}{100,000} = 1.85$

The cumulative present value factor of 4.67 used was obtained from the 20% column (opposite 15 years) of Table I.

As can be seen, both alternatives A and B have Saving/Investment ratios greater than 1.0, indicating that both will return all funds invested at a rate greater than the desired rate of return of 10%. The greater the savings/investment ratio (SIR), the higher the rate of return and the more effective the investment. Thus Alternative B with a SIR of 1.85 is a better investment than Alternative B, a fact which was not obvious even in this rather simple illustration.

Energy and Maintenance Differential Cost Escalation

As was mentioned earlier it is quite possible that maintenance costs may increase at a higher rate from year to year than other costs, and it is a certainty that energy prices will rise at a more rapid rate than other elements of our economy. Actual rates of increase in costs of energy are being projected as high as 15 or 20%. Any differential increase, even 2%, materially affects normal present value computations. For example, in the illustrative situation just discussed, the present value factor for energy saving would have been 10.86 instead of the 4.67 if an annual energy price increase of 15% had been factored in. Because of the need to include these annual increases in our computations, Tables II and III have been included, for desired returns of 10% and 20%. Respectively, the 10.86 figure just quoted is obtained from the 15% column of Table III opposite 15 years.

To illustrate the effects of these factors, let us go back to the illustrative problem and add an annual energy price increase of 15% and an annual price increase in maintenance costs of 4%. In this illustration the maintenance cost is that which is required on the new energy-saving devices being installed. Hence the present value of the added maintenance cost must be subtracted from the present value of the energy savings to obtain the overall net saving.

	Alternative A	Altermative B
First Cost	$100,000	$100,000
Annual Energy Savings	3.0 billion BTUs	2.7 billion BTUs
Energy Cost	$11.72/million BTUs	$14.65/million BTUs
Added Annual Maintenance Cost	$1500/year	$2000/year
Useful Life	15 years	15 years
Desired Return on Investment	20%	20%
Annual Energy Price Increase	15%	15%
Annual Maintenance Price Increase	4%	4%

Our savings/investment ratio previously looked like this:

$$\frac{\text{present value of energy savings}}{\text{present value of investment}}$$

With maintenance costs added to the equation, the SIR will now be:

$$\frac{\text{(present value of energy savings) - (present value of added maintenance)}}{\text{present value of investment}}$$

In addition, we will need to refer to Table III for present value factors for both energy and maintenance, rather than Table I.

		Alternative A	Alternative B
Investment Cost (present value)		$100,000	$100,000
A.	Energy Savings (present value)	$35,160	$39,555
	Cumulative Present Value Factor	10.86	10.86
		$381,838	$429,567
B.	Added Maintenance Costs	$1500	$2000
	Cumulative Present Value Factor	5.74	5.74
		$8,610	$11,480
	A - B	$373,228	$418,087
Savings/Investment Ratio		$\frac{373,228}{100,000} = 3.73$	$\frac{418,087}{100,000} = 4.18$
Earlier SIR (w/o energy & maintenance cost escalation)		1.64	1.85

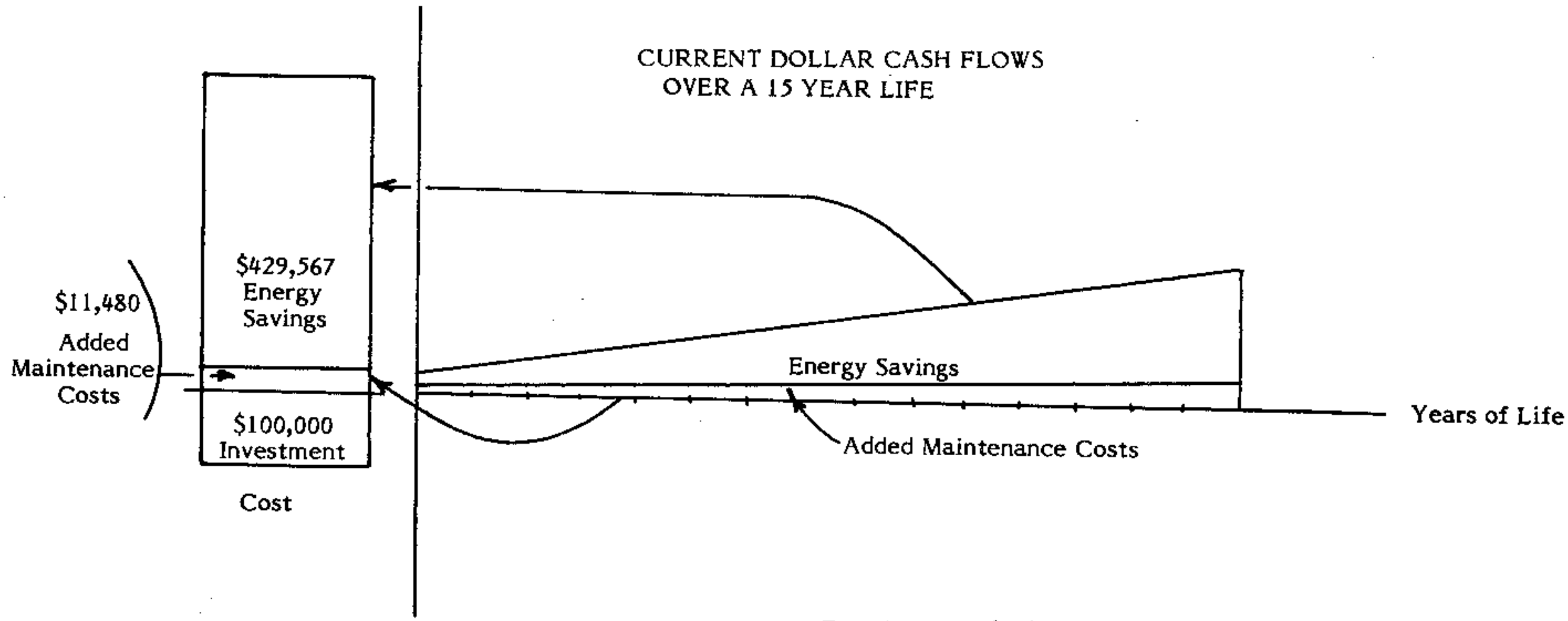
The effect of escalating energy prices on this analysis is unmistakable, and points out that this factor should be included in all computations for all such energy decisions.

This type of problem can be shown graphically as an aid in visualizing the time and relationships involved; such a graphical portrayal of Alternative B alone is at Figure 1.

Energy Audits

The only requirement which remains is how to pack all this knowledge into something more compact for an energy audit report. For each of the energy conserving Dollar Saving Opportunities (DSOs) we fill out a one page form like the one shown at the end of this section, and secondly we set priorities, based on the SIRs for each DSO, on a second one page form, a copy of which is also included at the end of this section.

FIGURE 1



$$\text{Savings/Investment Ratio} = \frac{\text{Energy Saving (PV) - Added Maintenance Costs (PV)}}{\text{Investment Costs (PV)}}$$

$$= \frac{\$418{,}087}{100{,}000}$$

$$= 4.18$$

TABLE I

CUMULATIVE 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

$$\text{Present value} = \frac{(1 + i)^n - 1}{i(1 + i)^n} \quad \text{where}$$

n = number of years

i = interest rate, 6%, 8%, 10%, etc.

TABLE II

CUMULATIVE PRESENT VALUE OF $1.00 SAVED EACH YEAR WHEN THE COST OF MONEY IS 10% (C) AND ENERGY COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

OR

CUMULATIVE PRESENT VALUE OF $1.00 SAVED (OR SPENT) EACH YEAR WHEN THE COST OF MONEY IS 10% (C) AND MAINTENANCE COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

	ANNUAL INCREASE (AI)								
Year (n)	0%	2%	4%	6%	8%	10%	12%	15%	20%
1	.91	.93	.94	.96	.98	1.00	1.01	1.05	1.09
2	1.74	1.79	1.84	1.89	1.94	2.00	2.07	2.14	2.28
3	2.49	2.58	2.68	2.79	2.89	3.00	3.14	3.29	3.58
4	3.17	3.32	3.48	3.65	3.82	4.00	4.20	4.49	4.99
5	3.79	4.01	4.24	4.48	4.73	5.00	5.28	5.73	6.54
6	4.35	4.64	4.95	5.28	5.63	6.00	6.38	7.04	8.23
7	4.87	5.24	5.63	6.05	6.51	7.00	7.50	8.40	10.07
8	5.33	5.78	6.27	6.80	7.37	8.00	8.68	9.82	12.07
9	5.76	6.29	6.87	7.51	8.22	9.00	9.86	11.32	14.26
10	6.14	6.76	7.44	8.20	9.05	10.00	11.06	12.88	16.64
15	7.60	8.64	9.86	11.30	12.99	15.00	17.38	21.80	32.26
20	8.51	9.93	11.69	13.87	16.59	20.00	24.30	32.96	56.39
25	9.08	10.82	13.07	16.00	19.87	25.00	31.87	46.87	93.66
30	9.43	11.43	14.11	17.78	22.86	30.00	40.15	64.29	151.25
40	9.78	12.13	15.49	20.48	28.08	40.00	59.14	113.11	377.64

$$\text{Present Value} = \frac{1 + AI}{C - AI}\left[1 - \left[\frac{1 + AI}{1 + C}\right]^n\right] \quad \text{where}$$

C = Cost of money (10% for this table)

AI = Annual Increase in Energy Costs or Maintenance Costs

n = Number of years (life of energy-saving item)

TABLE III

CUMULATIVE PRESENT VALUE OF $1.00 SAVED EACH YEAR WHEN THE COST OF MONEY IS 20% (C) AND ENERGY COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

OR

CUMULATIVE PRESENT VALUE OF $1.00 SAVED (OR SPENT) EACH YEAR WHEN THE COST OF MONEY IS 20% (C) AND MAINTENANCE COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

	ANNUAL INCREASE (AI)								
Year (n)	0%	2%	4%	6%	8%	10%	12%	15%	20%
1	.83	.85	.86	.89	.90	.91	.94	.97	1.00
2	1.53	1.57	1.62	1.67	1.71	1.76	1.81	1.89	2.00
3	2.11	2.19	2.27	2.35	2.44	2.53	2.62	2.76	3.00
4	2.59	2.71	2.83	2.96	3.10	3.23	3.37	3.61	4.00
5	2.99	3.15	3.32	3.50	3.69	3.88	4.09	4.42	5.00
6	3.33	3.53	3.74	3.98	4.22	4.48	4.75	5.18	6.00
7	3.60	3.85	4.11	4.39	4.77	5.02	5.36	5.93	7.00
8	3.84	4.13	4.43	4.76	5.13	5.51	5.94	6.65	8.00
9	4.03	4.35	4.71	5.10	5.52	5.97	6.48	7.31	9.00
10	4.19	4.55	4.95	5.38	5.86	6.39	6.97	7.98	10.00
15	4.67	5.17	5.74	6.39	7.15	8.02	9.03	10.86	15.00
20	4.87	5.45	6.13	6.94	7.90	9.08	10.47	13.41	20.00
25	4.95	5.57	6.32	7.23	8.35	9.75	11.51	15.07	25.00
30	4.98	5.62	6.41	7.39	8.62	10.19	12.24	16.58	30.00
40	5.00	5.66	6.48	7.55	8.87	10.66	13.12	18.81	40.00

$$\text{Present Value} = \frac{1 + AI}{C - AI} \left[1 - \left(\frac{1 + AI}{1 + C} \right)^n \right] \quad \text{where}$$

C = Cost of money (20% for this table)

AI = Annual Increase in Energy or Maintenance Costs

n = Number of years (life of energy-saving item)

Planergy, Inc.
901 W. M.L.K. Blvd.
Austin, Texas 78701
512/477-8012

ENERGY AUDIT

FIRM/BUSINESS: ____________

TYPE OF FIRM/BUSINESS: ____________

FACILITY: ____________

LOCATION: ____________

ADDRESS: ____________

DATE OF AUDIT: ____________

AUDITORS: ____________

____

____

DOLLAR SAVINGS OPPORTUNITY (DSO) NO. ______

DESCRIPTION:

SPECIFIC ASSUMPTIONS:

USEFUL LIFE ________ yrs.

ADDED (OR REDUCED) MAINTENANCE $________

COST OF MONEY ______%

ANNUAL ENERGY COST INCREASE ______%

ANNUAL MAINTENANCE INCREASE ______%

COST SAVINGS:

INVESTMENT COST NEEDED TO REALIZE COST SAVINGS:

$$\text{SAVINGS/INVESTMENT RATIO} = \frac{\text{(PRESENT VALUE OF ENERGY SAVINGS)} \pm \text{(PRESENT VALUE }^{\text{ADDED}}_{\text{REDUCED}}\text{ MAINTENANCE COST)}}{\text{PRESENT INVESTMENT COST}}$$

SAVINGS/INVESTMENT RATIO ____________ SIR =

SIMPLE PAYBACK PERIOD ____________ SPB =

Planergy, Inc.
901 W. M.L.K. Blvd.
Austin, Texas 78701
512/477-8012

ENERGY AUDIT

DOLLAR SAVINGS OPPORTUNITIES (DSOs) PRIORITIES

FIRM/BUSINESS: ____________

TYPE OF FIRM/BUSINESS: ____________

FACILITY: ____________

LOCATION: ____________

ADDRESS: ____________

DATE OF AUDIT: ____________

AUDITORS: ____________

ASSUMPTIONS FOR ESTABLISHING PRIORITIES:

COST OF MONEY ______ %

ANNUAL ENERGY COST INCREASE ______ %

ANNUAL MAINTENANCE INCREASE ______ %

PRIORITY	DSO NO.	DESCRIPTION	USEFUL LIFE (Yrs.)	COSTS SAVED (PRESENT VALUE)		PRESENT INVESTMENT COST	SAVINGS / INVESTMENT RATIO	SIMPLE PAYBACK
				ENERGY	ADDED OR REDUCED MAINTENANCE (±)			

REMARKS:

5

LIGHTING

Lighting

Table of Contents

Energy

- A Watt Is Not *A Unit Of Light,* But *A Unit Of Work,* Which Releases 3.4 BTU Of Heat/Hour
  - 100 Watts = 341 BTU
  - 1000 Watts = 3,413 BTU
- A 100 Watt Light Bulb, . . . A 100 Watt TV And A 100 Watt Heating Pad, . . . All Produce 341 BTU Of Heat

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 Energy Compared To Total Energy 1976

Total Fuel Consumed *All Types*	100%
Total Fuel Consumed *Electrical* 1525 10^9 KWH	25%
Total Fuel Consumed *Lighting* 313 10^9 KWH	5%

	TOTAL LIGHTING KWH 10^9	LIGHTING % of TOTAL
Industrial	63.95	1.05%
Street Lighting	12.20	.20%
Residential	92.05	1.53%
Commercial	144.72	2.40%
TOTAL	312.92	5

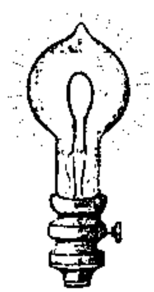
Total Lighting Represents About 5% Of The Total Fuels Consumed

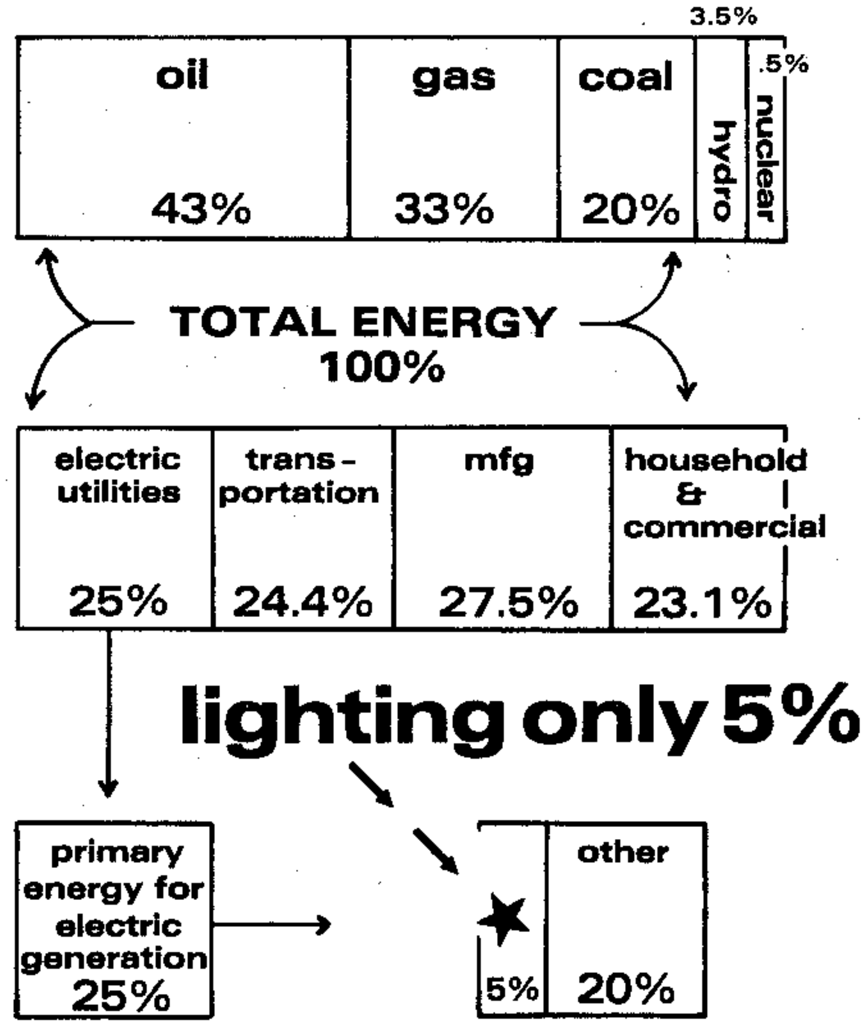
U.S.A. Heat Energy Consumption

1. Transportation	25%	6. Refrigeration	6%
2. Process Heat	24%	7. Water Heating	5%
3. Space Heat	19%	8. Lighting	5%
4. Electric Drive	8%	9. Others	3%
5. Air Conditioning	6%		

Industry Estimates Of Fuel Input To The NEAREST %

electric energy uses





ENERGY FOR LIGHTING

RETAIL FACILITIES	60%
HOTELS & MOTELS	11%
SUPERMARKETS/GROCERIES	20%
OFFICE BUILDINGS	25%
RESTAURANTS	8.2%

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

ILLUMINATION LEVELS

FOOTCANDLES

	IES	FEA
MERCHANDISE, REQUIRING CLOSE INSPECTION		30 - 100
GENERAL MERCHANDISE AREAS		30 - 50
MERCHANDISING AREAS		
SERVICE	100	
SELF-SERVICE	200	
SHOWCASES AND WALL CASES		
SERVICE	200	
SELF-SERVICE	500	
FEATURE DISPLAYS		
SERVICE	500	
SELF-SERVICE	1000	

RETAIL STORES

ILLUMINATION LEVELS

WATTS/SQUARE FOOT

CALIFORNIA (OPTIONAL)

(2.5 WATTS/SQ.FT.)(A_1) + (1 WATT/SQ.FT.)(A_2) + SHOWCASE AND DISPLAY WATTS

A_1 = PRIME SALES AREAS (DO NOT INCLUDE SHOWCASE AND DISPLAY AREAS) IN SQUARE FEET

A_2 = CIRCULATION AREAS IN SQUARE FEET

MASSACHUSETTS (MANDATORY)

3 WATTS/SQ.FT. OF SALES AREA
1 WATT/SW. FT. OF STORAGE AREA

THERE IS MORE TO LIGHTING THAN

FOOTCANDLES!

<u>DEFINITION</u>

1 LUMEN PER SQUARE FOOT = 1 FOOTCANDLE

DESIGN

NUMBER OF FIXTURES REQUIRED =

$$\frac{\text{(SQUARE FEET TO BE LIGHTED) (FOOTCANDLES)}}{\text{(LAMPS/FIXTURE) (LUMENS/LAMP)(C.U.)(M.F.)}}$$

WHERE C.U. = COEFFICIENT OF UTILIZATION

M.F. = (L.L.D.)(L.D.D.)

L.L.D. = LAMP LUMEN DEPRECIATION

L.D.D. = LUMINAIRE DIRT DEPRECIATION

DESIGN EXAMPLE

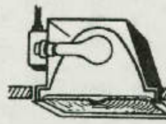
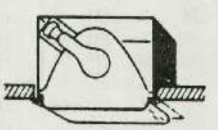
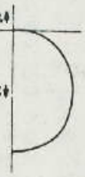
LIGHT REQUIRED: 100 FOOTCANDLES OVER 50,000 SQUARE FEET

LAMP TO BE USED: 50,000 LUMENS PER LAMP
90% LAMP LUMEN DEPRECIATION (L.L.D.)

LUMENS TO BE USED: 1 LAMP PER LUMINAIRE
.74 COEFFICIENT OF UTILIZATION (C.U.)
.85 LUMINAIRE DIRT DEPRECIATION (L.D.D.)

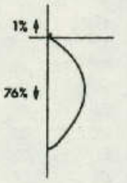
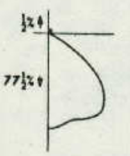
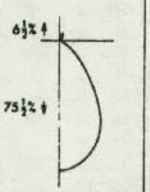
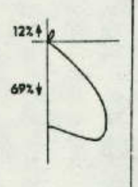
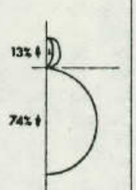
$$\text{NUMBER FIXTURES} = \frac{(50{,}000)\ (100)}{1 \times 50{,}000 \times .74 \times .90 \times .85} = 177$$

TABLES OF COEFFICIENTS OF UTILIZATION

Typical Luminaire	Typical Distribution and Per Cent Lamp Lumens: Maint. Cat.	Maximum S/MH Guide[d]	ρcc[a] → / ρw[b] → / RCR[c] ↓	80: 50	80: 30	80: 10	70: 50	70: 30	70: 10	50: 50	50: 30	50: 10	30: 50	30: 30	30: 10	10: 50	10: 30	10: 10	0: 0	WDRC[e] ↓
				Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (ρ_{FC} = 20)																
10	V	1.4	0	.63	.63	.63	.62	.62	.62	.59	.59	.59	.56	.56	.56	.54	.54	.54	.53	
			1	.58	.56	.54	.57	.55	.54	.54	.53	.52	.52	.51	.50	.50	.50	.49	.48	.14
	0% ↑		2	.53	.50	.48	.52	.49	.47	.50	.48	.46	.48	.47	.45	.47	.45	.44	.43	.13
			3	.48	.45	.42	.47	.44	.42	.46	.43	.41	.44	.42	.40	.43	.41	.40	.39	.12
			4	.44	.40	.37	.43	.40	.37	.42	.39	.37	.41	.38	.36	.40	.38	.36	.35	.12
	53½% ↓		5	.40	.36	.33	.39	.36	.33	.38	.35	.33	.37	.35	.32	.36	.34	.32	.31	.11
			6	.36	.32	.30	.36	.32	.29	.35	.32	.29	.34	.31	.29	.33	.31	.29	.28	.11
			7	.33	.29	.26	.33	.29	.26	.32	.28	.26	.31	.28	.26	.30	.28	.26	.25	.10
Wide distribution unit with			8	.30	.26	.23	.30	.26	.23	.29	.26	.23	.28	.25	.23	.28	.25	.23	.22	.10
lens plate and inside frost			9	.27	.23	.21	.27	.23	.21	.26	.23	.21	.26	.23	.20	.25	.22	.20	.19	.09
lamp			10	.25	.21	.18	.25	.21	.18	.24	.21	.18	.24	.20	.18	.23	.20	.18	.17	.09
11	V	1.3	0	.61	.61	.61	.60	.60	.60	.57	.57	.57	.54	.54	.54	.51	.51	.51	.50	
			1	.53	.51	.48	.52	.50	.47	.49	.47	.46	.47	.45	.44	.45	.44	.42	.41	.23
	1½% ↑		2	.46	.42	.39	.45	.42	.39	.43	.40	.38	.41	.39	.37	.39	.37	.35	.34	.20
			3	.40	.36	.33	.40	.35	.32	.38	.34	.31	.36	.33	.31	.35	.32	.30	.29	.18
			4	.36	.31	.28	.35	.31	.28	.34	.30	.27	.32	.29	.26	.31	.28	.26	.25	.16
	50½% ↓		5	.32	.27	.24	.31	.27	.24	.30	.26	.23	.29	.25	.23	.28	.25	.22	.21	.15
			6	.29	.24	.20	.28	.24	.20	.27	.23	.20	.26	.22	.20	.25	.22	.19	.18	.13
			7	.26	.21	.18	.25	.21	.18	.24	.20	.17	.23	.20	.17	.22	.19	.17	.16	.12
			8	.23	.19	.16	.23	.18	.15	.22	.18	.15	.21	.18	.15	.20	.17	.15	.14	.11
Recessed unit with dropped			9	.21	.17	.14	.21	.16	.14	.20	.16	.13	.19	.16	.13	.19	.15	.13	.12	.11
diffusing glass			10	.19	.15	.12	.19	.15	.12	.18	.14	.12	.18	.14	.12	.17	.14	.12	.11	.10
12	V	1.3	0	.78	.78	.78	.76	.76	.76	.73	.73	.73	.70	.70	.70	.67	.67	.67	.65	
			1	.71	.69	.68	.70	.68	.66	.67	.66	.64	.65	.64	.62	.62	.62	.61	.59	.17
	0% ↑		2	.65	.62	.59	.64	.61	.58	.62	.59	.57	.60	.58	.56	.58	.56	.55	.54	.16
			3	.59	.55	.52	.58	.55	.52	.57	.53	.51	.55	.52	.50	.53	.51	.49	.48	.15
			4	.54	.50	.47	.54	.50	.46	.52	.49	.46	.51	.48	.45	.49	.47	.45	.43	.14
	66% ↓		5	.50	.45	.42	.49	.45	.41	.48	.44	.41	.47	.43	.41	.46	.43	.40	.39	.13
			6	.46	.41	.37	.45	.40	.37	.44	.40	.37	.43	.39	.37	.42	.39	.36	.35	.13
			7	.41	.37	.33	.41	.36	.33	.40	.36	.33	.39	.35	.33	.38	.35	.32	.31	.12
Clear HID lamp and glass re-			8	.38	.33	.30	.38	.33	.30	.37	.33	.30	.36	.32	.29	.35	.32	.29	.28	.12
fractor above plastic lens			9	.35	.30	.27	.34	.30	.27	.34	.29	.26	.33	.29	.26	.32	.29	.26	.25	.11
panel			10	.32	.27	.24	.31	.27	.24	.31	.27	.24	.30	.26	.24	.30	.26	.23	.22	.11
13	V	1.4	0	.85	.85	.85	.83	.83	.83	.79	.79	.79	.76	.76	.76	.73	.73	.73	.71	
			1	.78	.76	.74	.76	.74	.73	.73	.72	.70	.71	.69	.68	.68	.67	.66	.65	.17
	0% ↑		2	.71	.68	.65	.70	.67	.64	.68	.65	.63	.65	.63	.61	.63	.62	.60	.59	.16
			3	.65	.61	.57	.64	.60	.57	.62	.59	.56	.60	.57	.55	.59	.56	.54	.53	.16
			4	.60	.55	.51	.59	.54	.51	.57	.53	.50	.55	.52	.50	.54	.51	.49	.48	.15
	71½% ↓		5	.54	.49	.45	.54	.49	.45	.52	.48	.45	.51	.47	.44	.50	.46	.44	.43	.14
			6	.49	.44	.40	.49	.44	.40	.47	.43	.40	.46	.42	.40	.45	.42	.39	.38	.14
			7	.44	.39	.35	.44	.39	.35	.43	.38	.35	.42	.38	.35	.41	.37	.35	.33	.14
			8	.40	.35	.31	.40	.35	.31	.39	.35	.31	.38	.34	.31	.38	.34	.31	.30	.13
Enclosed reflector with an in-			9	.37	.31	.28	.36	.31	.28	.36	.31	.28	.35	.31	.28	.34	.30	.27	.26	.13
candescent lamp			10	.33	.28	.25	.33	.28	.25	.32	.28	.25	.32	.28	.25	.31	.27	.24	.23	.12
14	III	0.7	0	.92	.92	.92	.90	.90	.90	.86	.86	.86	.82	.82	.82	.78	.78	.78	.76	
			1	.87	.85	.83	.85	.83	.82	.81	.80	.79	.78	.77	.76	.75	.75	.74	.72	.11
	1½% ↑		2	.81	.79	.76	.80	.77	.75	.77	.75	.73	.75	.73	.72	.72	.71	.70	.69	.10
			3	.77	.73	.71	.76	.72	.70	.73	.71	.69	.71	.69	.67	.70	.68	.66	.65	.10
			4	.73	.69	.66	.72	.68	.65	.70	.67	.64	.68	.66	.64	.67	.65	.63	.62	.09
			5	.69	.65	.62	.68	.64	.61	.66	.63	.61	.65	.62	.60	.64	.61	.59	.58	.09
	77% ↓		6	.65	.61	.58	.64	.61	.58	.63	.60	.57	.62	.59	.57	.61	.58	.56	.55	.09
			7	.62	.57	.54	.61	.57	.54	.60	.56	.54	.59	.56	.53	.58	.55	.53	.52	.09
Narrow distribution venti-			8	.58	.54	.51	.58	.54	.51	.57	.53	.51	.56	.53	.51	.55	.52	.50	.49	.09
lated reflector with clear			9	.55	.51	.48	.55	.51	.48	.54	.50	.48	.53	.50	.48	.53	.50	.48	.47	.08
HID lamp			10	.53	.49	.46	.52	.48	.46	.52	.48	.46	.51	.48	.45	.50	.47	.45	.44	.08

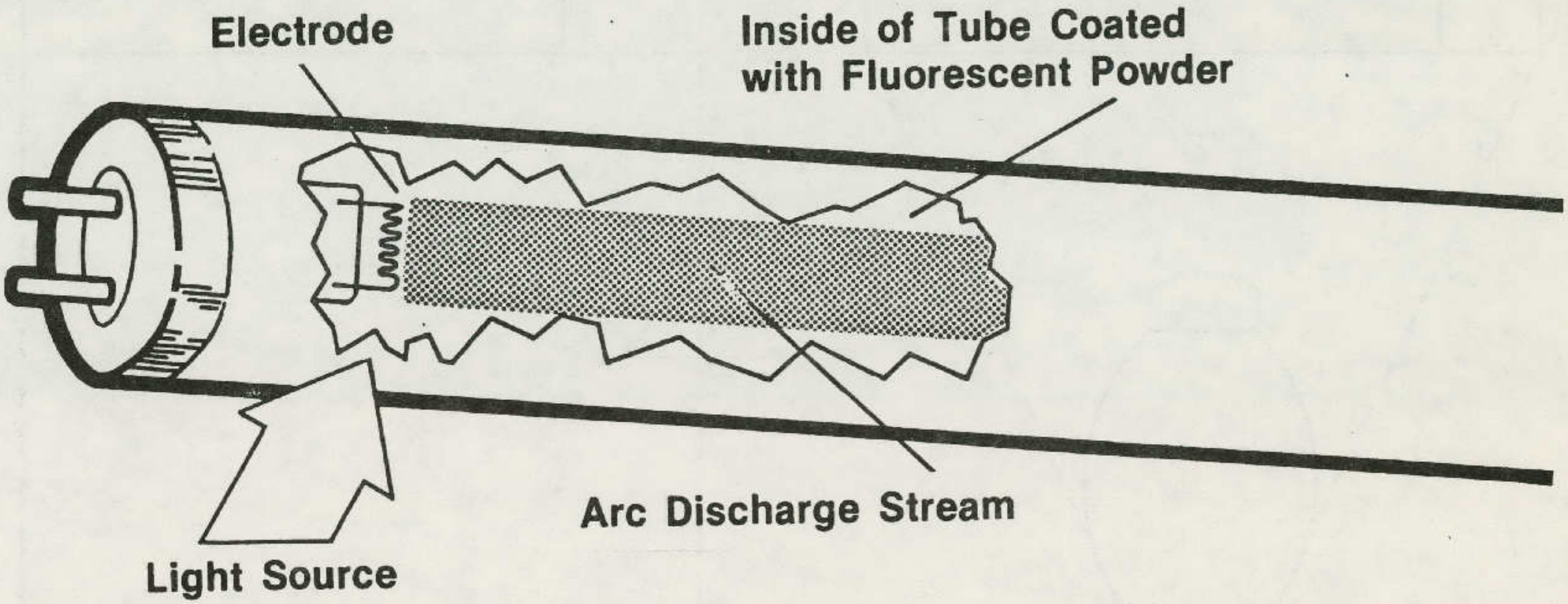
[a] ρcc = per cent effective ceiling cavity reflectance.
[b] ρw = per cent wall reflectance.
[c] RCR = Room Cavity Ratio.
[d] Maximum *S/MH* guide—ratio of maximum luminaire spacing to mounting or ceiling height above work-plane.

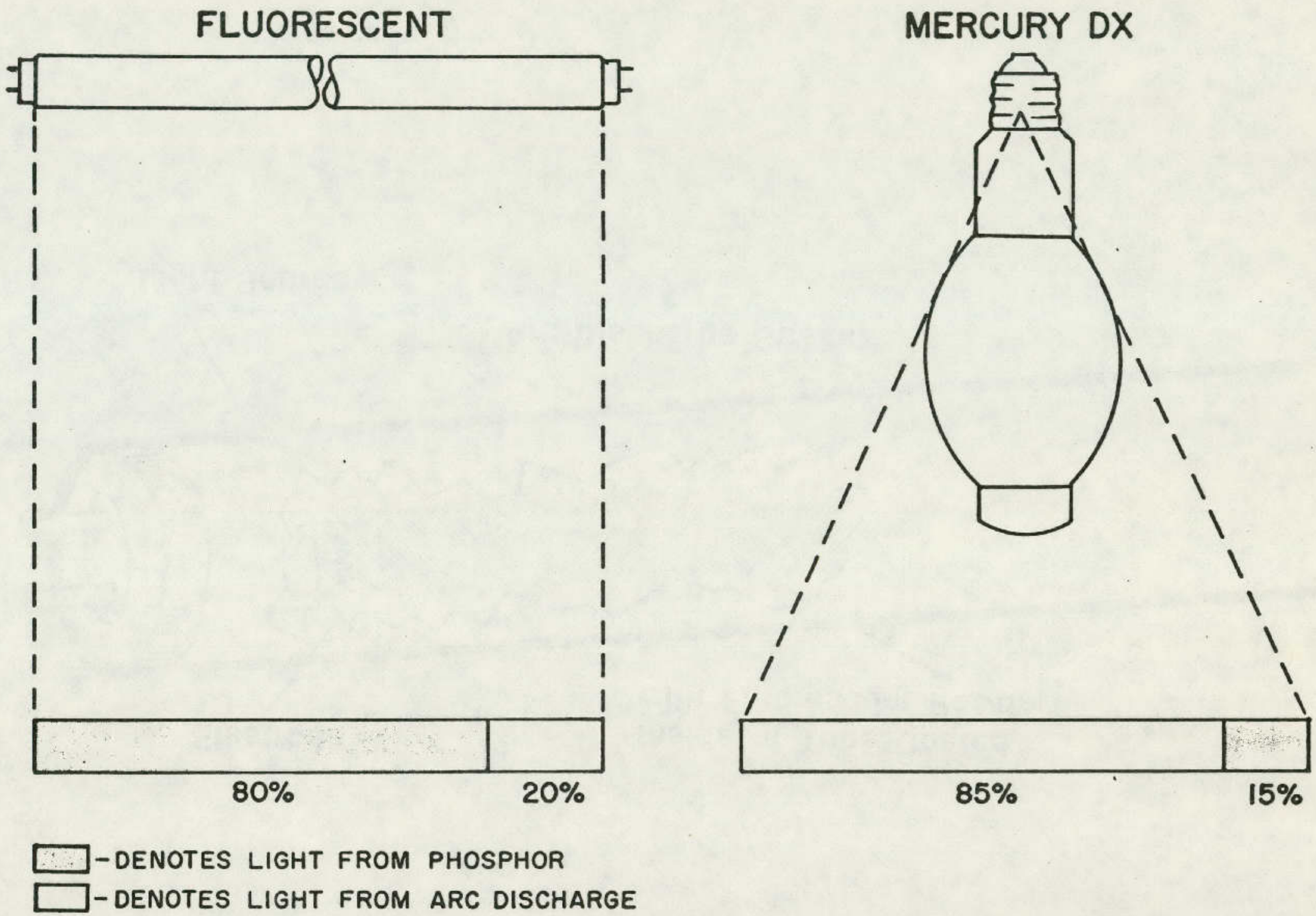
TABLES OF COEFFICIENCY OF UTILIZATION

Typical Luminaire	Typical Distribution and Per Cent Lamp Lumens		ρ_{CC}[a] →	80			70			50			30			10			0	WDRC[e] ↓
			ρ_W[b] →	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0	
	Maint. Cat.	Maximum S/MH Guide[d]	RCR[c] ↓	Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (ρ_{FC} = 20)																
15	III	1.0	0	.91	.91	.91	.89	.89	.89	.84	.84	.84	.81	.81	.81	.77	.77	.77	.75	
			1	.84	.81	.79	.82	.80	.78	.79	.77	.76	.76	.74	.73	.73	.72	.71	.69	.16
			2	.77	.73	.70	.76	.72	.70	.73	.70	.68	.70	.68	.66	.68	.66	.65	.63	.16
			3	.71	.66	.63	.69	.65	.62	.67	.64	.61	.65	.62	.60	.63	.61	.59	.57	.15
			4	.65	.60	.56	.64	.59	.56	.62	.58	.55	.60	.57	.54	.59	.56	.54	.52	.15
			5	.59	.54	.50	.59	.54	.50	.57	.53	.50	.56	.52	.49	.54	.51	.48	.47	.14
			6	.54	.49	.45	.54	.49	.45	.52	.48	.45	.51	.47	.44	.50	.47	.44	.42	.14
			7	.50	.44	.40	.49	.44	.40	.48	.43	.40	.47	.43	.39	.46	.42	.39	.38	.14
Intermediate distribution			8	.45	.40	.36	.45	.40	.36	.44	.39	.36	.43	.39	.35	.42	.38	.35	.34	.13
ventilated reflector with			9	.41	.36	.32	.41	.36	.32	.40	.35	.32	.39	.35	.32	.38	.35	.32	.30	.13
clear HID lamp			10	.38	.33	.29	.37	.32	.29	.37	.32	.29	.36	.32	.29	.35	.31	.28	.27	.12
16	III	1.5	0	.92	.92	.92	.90	.90	.90	.86	.86	.86	.82	.82	.82	.79	.79	.79	.77	
			1	.85	.82	.80	.83	.81	.79	.79	.78	.76	.76	.75	.74	.74	.72	.71	.70	.19
			2	.77	.73	.70	.75	.72	.69	.73	.70	.67	.70	.68	.66	.68	.66	.64	.63	.19
			3	.70	.65	.61	.68	.64	.60	.66	.62	.59	.64	.61	.58	.62	.59	.57	.56	.18
			4	.63	.58	.53	.62	.57	.53	.60	.56	.52	.58	.55	.52	.57	.54	.51	.49	.18
			5	.57	.51	.47	.56	.51	.47	.55	.50	.46	.53	.49	.46	.52	.48	.45	.44	.17
			6	.51	.45	.41	.51	.45	.41	.49	.44	.40	.48	.43	.40	.47	.43	.40	.38	.16
			7	.46	.40	.35	.45	.39	.35	.44	.39	.35	.43	.38	.35	.42	.38	.34	.33	.16
Wide distribution ventilated			8	.41	.35	.31	.41	.35	.31	.40	.34	.31	.39	.34	.30	.38	.33	.30	.29	.15
reflector with clear HID			9	.37	.31	.27	.37	.31	.27	.36	.30	.27	.35	.30	.27	.34	.30	.26	.25	.15
lamp			10	.33	.27	.24	.33	.27	.23	.32	.27	.23	.31	.27	.23	.31	.26	.23	.22	.14
17	III	1.0	0	.96	.96	.96	.93	.93	.93	.87	.87	.87	.82	.82	.82	.77	.77	.77	.75	
			1	.89	.87	.84	.86	.84	.83	.82	.80	.79	.78	.76	.75	.74	.73	.72	.70	.14
			2	.82	.79	.76	.80	.77	.74	.76	.74	.72	.73	.71	.69	.70	.68	.67	.65	.13
			3	.76	.72	.68	.74	.70	.67	.71	.68	.65	.68	.66	.63	.66	.63	.61	.60	.13
			4	.70	.66	.62	.69	.65	.61	.66	.63	.60	.64	.61	.58	.62	.59	.57	.55	.13
			5	.65	.60	.56	.64	.59	.56	.62	.58	.54	.60	.56	.53	.58	.55	.52	.51	.12
			6	.60	.55	.51	.59	.55	.51	.57	.53	.50	.56	.52	.49	.54	.51	.48	.47	.12
			7	.56	.51	.47	.55	.50	.46	.53	.49	.46	.52	.48	.45	.50	.47	.44	.43	.12
Intermediate distribution			8	.52	.47	.43	.51	.46	.43	.50	.45	.42	.48	.44	.41	.47	.43	.41	.40	.11
ventilated reflector with			9	.48	.43	.39	.47	.42	.39	.46	.42	.39	.45	.41	.38	.44	.40	.38	.36	.11
phosphor coated HID lamp			10	.45	.40	.36	.44	.39	.36	.43	.39	.36	.42	.38	.35	.41	.37	.35	.34	.10
18	III	1.5	0	.93	.93	.93	.89	.89	.89	.83	.83	.83	.77	.77	.77	.71	.71	.71	.68	
			1	.85	.83	.81	.82	.80	.78	.77	.75	.74	.72	.71	.69	.67	.66	.65	.63	.15
			2	.78	.74	.71	.76	.72	.69	.71	.68	.66	.67	.65	.63	.63	.61	.60	.58	.14
			3	71	.67	.63	.69	.65	.62	.65	.62	.59	.62	.59	.57	.58	.56	.54	.53	.14
			4	.65	.60	.56	.64	.59	.55	.60	.56	.53	.57	.54	.51	.54	.52	.50	.48	.13
			5	.60	.54	.50	.58	.53	.49	.55	.51	.48	.53	.49	.46	.50	.47	.45	.43	.13
			6	.54	.49	.45	.53	.48	.44	.51	.46	.43	.48	.45	.42	.46	.43	.40	.39	.13
			7	.49	.44	.40	.48	.43	.39	.46	.41	.38	.44	.40	.37	.42	.39	.36	.34	.12
Wide distribution ventilated			8	.45	.39	.35	.44	.38	.35	.42	.37	.34	.40	.36	.33	.38	.35	.32	.31	.12
reflector with phosphor			9	.41	.35	.31	.40	.34	.31	.38	.33	.30	.36	.32	.29	.35	.31	.28	.27	.12
coated HID lamp			10	.37	.31	.27	.36	.31	.27	.34	.30	.26	.33	.29	.26	.32	.28	.25	.24	.11
19	III	1.3	0	1.00	1.00	1.00	.96	.96	.96	.89	.89	.89	.82	.82	.82	.76	.76	.76	.73	
			1	.88	.85	.82	.85	.82	.79	.79	.77	.74	.73	.72	.70	.68	.67	.66	.63	.27
			2	.78	.72	.67	.75	.70	.66	.70	.66	.62	.65	.62	.59	.61	.58	.56	.53	.26
			3	.69	.62	.57	.66	.60	.56	.62	.57	.53	.58	.54	.51	.54	.51	.48	.46	.23
			4	.61	.54	.48	.59	.52	.47	.55	.50	.45	.52	.47	.43	.49	.45	.42	.39	.22
			5	.54	.46	.41	.52	.45	.40	.49	.43	.39	.46	.41	.37	.43	.39	.36	.33	.20
			6	.48	.41	.35	.47	.40	.35	.44	.38	.34	.44	.36	.32	.39	.34	.31	.29	.19
			7	.43	.36	.31	.42	.35	.30	.40	.34	.29	.37	.32	.28	.35	.31	.27	.25	.17
			8	.39	.32	.27	.38	.31	.26	.36	.30	.25	.34	.28	.24	.32	.27	.24	.22	.16
Porcelain-enameled reflector			9	.35	.28	.23	.34	.27	.23	.32	.26	.22	.30	.25	.21	.28	.24	.20	.19	.15
with 14°CW shielding			10	.32	.25	.20	.31	.24	.20	.29	.23	.19	.28	.22	.19	.26	.21	.18	.17	.14

[a] ρ_{CC} = per cent effective ceiling cavity reflectance.
[b] ρ_W = per cent wall reflectance.
[c] RCR = Room Cavity Ratio.
[d] Maximum S/MH guide—ratio of maximum luminaire spacing to mounting or ceiling height above work-plane.

Courtesy IES Handbook


Electrode
Inside of Tube Coated with Fluorescent Powder
Arc Discharge Stream
Light Source


FLUORESCENT
MERCURY DX
80%
20%
85%
15%
- DENOTES LIGHT FROM PHOSPHOR
- DENOTES LIGHT FROM ARC DISCHARGE

(Rev. 1/79)

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

COLOR RENDERING INDEX
(CRI)

Lamp Type	CRI
Natural Light	100
Incandescent	97
Fluorescent	
Cool White	67
Deluxe Cool White	86-89
Warm White	56
Warm White Deluxe	71
Daylite	75
Vita-Lite	91
Ultralume	85
Energy Efficient	
Lite-white	48
Econo-O-White	51
Mercury	22-52
Metal Halide	65-70
High Pressure Sodium	20
Low Pressure Sodium	0

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
	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
	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
	DELUXE WHITE	H33GL-400/DX	400	23,000	57	51	4,000	45	24,000
	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
	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
	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

Sylvania Product Information Bulletin

FLUORESCENT

SuperSaver II "Lite White" Fluorescent Lamps reduce energy use while maintaining high levels of lighting efficiency.

FL-22

SUPERSAVER II FLUORESCENT LAMPS

A blend of new phosphors provides the principle means by which Sylvania is able to introduce two new SuperSaver lamps with significant increases in efficacy. The phosphor which makes this possible, provides a lamp color slightly different from Cool White which will be identified as "Lite White". In order to minimize confusion in the industry, lamps with the Lite White phosphor will be known as SuperSaver II. The lamps in which this new phosphor will be used initially are the F40/LW/RS/SS and the F96T12/LW/SS, the two most commonly used sizes. .

The Lite White phosphor provides a color with more energy in the green/yellow portions of the spectrum than Cool White. For those applications where color rendition is not critical, standard F40 or F96T12 lamps can be replaced with reduced energy use of 15% or 20% respectively and lumen reductions of 5% or less. It is estimated that Lite White SuperSaver II lamps will provide satisfactory color rendition for most applications where Cool White is currently being used. Size for size, SuperSaver II lamps provide the same wattage reduction characteristics as the standard SuperSaver lamps.

SuperSaver II lamps can be used indoors where temperatures are 60°F or higher. They should not be used where exposed to direct drafts from air diffusers sufficient to cause flickering or striations. The F40/LW/RS/SS should be used only in luminaires equipped with high power factor single lamp or two-lamp series, rapid start ballasts meeting ANSI specifications. The F96T12/LW/SS is recommended for use only with two-lamp, instant start ballasts meeting ANSI specifications.

Lamp performance specifications are as follows:

Ordering Abbreviation	Rated Watts	Color	Approx. Lumens	Avg. Life Hours*	NAED Code No.
F40/LW/RS/SS	35	Lite White	3050	20,000+	24520
F96T12/LW/SS	60	Lite White	6000	12,000	29850

Lite White —	Color Temperature	4150°K
	Color Rendering Index	48

Engineering estimates indicate lumen maintenance equal to Cool White phosphor.

*Engineering estimates based on three hour burning cycle.

GTE SYLVANIA

LIGHTING CENTER, DANVERS, MASS. 01923

TABLE III

REFERENCE DATA ON SYLVANIA FLUORESCENT LAMPS

Lamp[2] Designation	Nominal Watts	Nominal Length (inches)[3]	Base	Lamp Operating Amps.	Lamp Operating Volts
Preheat					
F4T5	4	6	Min. Bipin	0.170	29
F6T5	6	9	Min. Bipin	0.160	42
F8T5	8	12	Min. Bipin	0.145	57
F13T5	13	21	Min. Bipin	0.165	95
F14T12	14	15	Med. Bipin	0.380	39
F15T8	15	18	Med. Bipin	0.304	56
F15T12	15	18	Med. Bipin	0.330	46
F20T12	20	24	Med. Bipin	0.380	56
F25T12	25	33	Med. Bipin	0.445	64
F30T8	30	36	Med. Bipin	0.350	100
F90T17	90	60	Mog. Bipin	1.500	62
Rapid Start – Preheat[4]					
F40T12	40	48	Med Bipin	0.430	102
Rapid Start					
F30T12	30	36	Med. Bipin	0.430	78
High Output					
F24T12/HO	32	24	Rec. D.C.	0.800	42
F36T12/HO	44	36	Rec. D.C.	0.800	
F48T12/HO	60	48	Rec. D.C.	0.800	79
F72T12/HO	85	72	Rec. D.C.	0.800	116
F72T12/HO	100	72	Rec. D.C.	1.000	105
F96T12/HO	110	96	Rec. D.C.	0.800	152
Very High Output					
F48T12/VHO	115	48	Rec. D.C.	1.500	83
F72T12/VHO	165	72	Rec. D.C.	1.500	124
F96T12/VHO	215	96	Rec. D.C.	1.500	161
Circline					
FC8T9	22	8" Diam.	4 – Pin	0.380	60
FC12T10	32	12" Diam.	4 – Pin	0.430	82
FC16T10	40	16" Diam.	4 – Pin	0.415	108
Curvalume					
FB40/6"	40	24	Med. Bipin	0.430	100
Instant Start[5]					
F40T12/IS	40	48	Med. Bipin	0.420	104
F40T17/IS	40	48	Mog. Bipin	0.420	107
Slimline[6]					
F42T6	25	42	Single Pin	0.200	145
F64T6	38	64	Single Pin	0.200	225
F72T8	38	72	Single Pin	0.200	218
F96T8	51	96	Single Pin	0.200	290
F48T12	39	48	Single Pin	0.425	100
F72T12	55	72	Single Pin	0.425	149
F96T12	75	96	Single Pin	0.425	197

Reference Notes

[1] Rated initial lumens, mean lumens and rated life are not included in this bulletin because frequent improvements in lamp performance continuously obsoletes published data. Refer to other engineering bulletins for current ratings.

[2] "T" stands for tubular bulb; number indicates diameter of tube in eighths of an inch.

[3] Indicates length of lamp plus two standard lampholders.

[4] Electrical values are slightly different for preheat operation.

[5] Base pins shorted inside base.

[6] T-6 and T-8 Slimline lamps are also operated at 0.100 amp. and 0.300 amp.

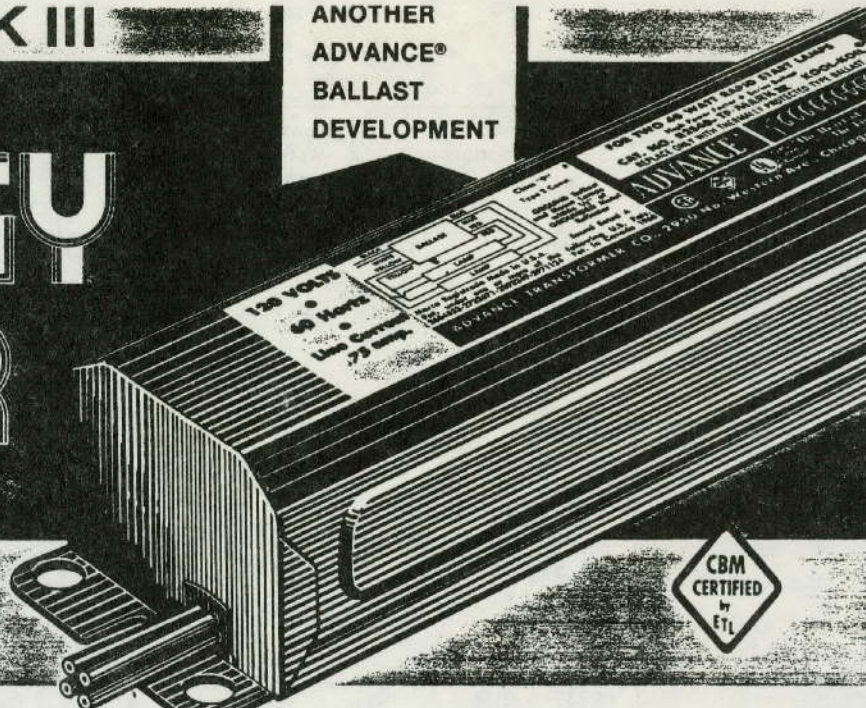
New, Improved MARK III

ANOTHER ADVANCE® BALLAST DEVELOPMENT

ENERGY SAVER

(2) F40 RAPID START LAMPS

FULL LIGHT OUTPUT



CBM CERTIFIED by ETL

ADVANCE® Mark III Rapid Start Ballasts . . .

• Reduce Energy Costs • Operate 25°C Cooler than Standard • Provide Longer Life
• Maintain Full Light Output • Also Compatible with Energy-Saving Lamps

- ADVANCE® Full Light Output, Energy Saving Ballasts are available for both 120V and 277V operation of two (2) F40T12/RS (430 MA.) fluorescent lamps.
- Full light output is provided. Ballasts are CBM Certified.
- Input *at full light output* is reduced by approximately 10 watts compared to standard ballasts used in the same application. This energy savings translates directly into significant savings in operating costs. These ballasts truly pay for themselves many times over during normal life.
- Unique ADVANCE Mark III ballast design operates approximately 25°C cooler in fixture than standard ballasts. Result: should easily provide up to four times longer ballast life; reduced maintenance because of less change-out cost for replacement ballasts and labor; and lower air conditioning load.
- Physically interchangeable with standard ballasts. Ideal for both new and existing installations.
- ADVAN-guard® automatic resetting thermostat is included to afford Class P ballast protection.
- High power factor and sound rated "A" for widest possible use.
- Listed by Underwriters' Laboratories, Inc.

Energy Savings Become More Important Every Year

Energy costs have increased substantially in recent years, and industry forecasts call for continued increases—perhaps *three times today's rates* in the next 15 years. These higher power costs make the ADVANCE Full Light Energy Saving Ballasts a wise choice now—and an even wiser choice for every year they operate at reduced watts input.

Compute Your Savings

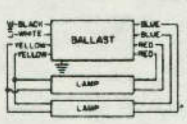
See tables on the reverse side of this bulletin to compute the savings you will gain with ADVANCE Mark III ballasts. You'll save with reduced energy, longer ballast life and reduced maintenance.

Depending on energy costs, total life savings up to $89.00 per ballast can be expected.

Full Light Energy Saving Ballasts 60Hz

Lamp Data: Description	Lamp Data: Watts	Circuit (Volts)	Min. Starting Temp. (°F.)	Catalog Number (Class P)	Electrical Data: Line Current (Amps.)	Electrical Data: Input* (Watts)	Sound Rating	Dimensions (Inches): Length	Width	Height	Mounting	Shipping Data: No. of Units Per Std. Ctn.	Wt. Std. Ctn. (Lbs.)
(2) F40T12/RS	40	120 277	50°	R2S40-1-TP V2S40-1-TP	.73 .32	86/82	A	9½	2⅜	1½	8 29/32	10	40

Wiring Diagram



*Higher figure for Bare Lamp Fixture
Lower figure for Enclosed Fixture.

Specify ADVANCE® Mark III Ballasts For Full Light Energy Savings

ADVANCE® TRANSFORMER CO.
2950 N. Western Avenue, Chicago, Ill. 60618
A NORTH AMERICAN PHILIPS COMPANY

Form No. 1286 Rev. 10/77 Printed in U.S.A.

Specifications and data in this bulletin are subject to change without notice.

How ADVANCE® Mark III Ballasts Save You $$$ 3 Ways
while Maintaining Full Light Output

The three factors which contribute to substantial savings with ADVANCE Mark III Full Light Output Ballasts are: 1) Reduced energy consumption; 2) Longer ballast life; and 3) Reduced maintenance costs. The modest list price premium of a Mark III ballast is far outweighed by the savings tabulated below.

1. Significant Savings in Energy Costs

Input has been reduced by10watts compared to standard ballasts used in the same application. Compute your *annual* cost savings in energy alone by referring to the power rate for your area in the following table.

Power Rate	Annual Energy Savings Per Ballast (Based on 3000 Hr. Operation @ 10 Watt Reduction or 30 KWHr)
2¢/KWHr	$ .60
3¢/KWHr	.90
5¢/KWHr	1.50
8¢/KWHr	2.40
10¢/KWHr	3.00

The annual savings computed above add up to substantial savings when considered over the life of a standard ballast. Using an average standard ballast life of 10 to 12 years the savings will be:

Power Rate	Full-Life Energy Savings Per Mark III Ballast (Over average life of standard ballast—10 to 12 years)
2¢/KWHr	$6.00 to $7.20
3¢/KWHr	$9.00 to $10.80
5¢/KWHr	$15.00 to $18.00
8¢/KWHr	$24.00 to $28.80
10¢/KWHr	$30.00 to $36.00

Keep in mind that energy costs are likely to increase in the future so savings over the life of the ballast would be even greater.

2. Longer Ballast Life Multiplies Energy Savings

Ballast life is a function of ballast operating temperature. Standard ballast operating temperature of 90°C results in an expected ballast life of 10 to 12 years according to accepted industry standards.

Mark III ballasts are designed to operate at a much cooler temperature-easily resulting in an average life of at least 25 years.

The following table shows the energy savings based on a conservative 25-year life with Mark III ballasts. Again, there is the strong probability of future rate increases which would make the savings even greater.

Power Rate	Full-Life Energy Savings Per Mark III Ballast (based on conservative ballast life of 25 years)
2¢/KWHr	$15.00
3¢KWHr	22.50
5¢/KWHr	37.50
8¢/KWHr	60.00
10¢/KWHr	75.00

3. Additional Savings from Reduced Maintenance

This table shows the savings you will gain when Mark III ballasts are used in a lighting unit over a 25-year period. The longer life provided by Mark III ballasts will reduce the number of change-outs required.

Ballast Type	No. of Change-Outs	Cost Each (Ballast plus Labor)	Total Cost
Standard	2*	$17.00	$34.00
Mark III	1	$20.00	$20.00
Mark III Ballast Maintenance Savings =			$14.00*

*Conservative—actual is 2.5 change-outs.

Mark III Energy & Maintenance Savings Add Up To Significant Extended Life Savings

Using an example of a power rate of 5¢/KWHr over a 25-year life, the following table shows how each Mark III ballast will return tremendous savings to you. The savings in energy costs, plus longer life and reduced maintenance, make Mark III ballasts today's most logical choice. And the continually increasing power rates will mean even greater savings for you in the future.

TOTAL SAVINGS (over 25-year period)	
Energy Savings (based on 5¢/KWHr rate)	$37.50
Maintenance Savings	14.00
Total per Ballast	$51.50

For various power rates, refer to this table for total savings

Total Savings per MARK III Ballast (over 25-year period)	
Power Rate	**Total Savings**
2¢/KWHr	$29.00
3¢/KWHr	36.50
5¢/KWHr	51.50
8¢/KWHr	74.00
10¢/KWHr	89.00

To Compute Your Savings . . .

You can readily compute the savings you will gain with Mark III ballasts. Simply multiply the number of ballasts in your installation by the total savings shown for each unit in the above table, using the power rate in your area.

Example: If you have a lighting installation requiring 320 ballasts and your power rate is 5¢/KWHr, your total savings would be:

320 × $51.50 = $16,480 Total Savings

Mark III ballasts are compatible with energy-saving lamps, permitting additional cost savings.

Typical Specifications for Full Light Output Energy Saving Rapid Start Ballasts

The Advance Transformer Co. Mark III Full Light Output Energy Saving Ballast catalog number ________. The ballast shall be CBM certified for full light output and have an average input wattage of 86 watts when operating two (2) non-enclosed F40T12 Rapid Start Fluorescent Lamps in ambients of 77°F. It shall not exceed 90°C operating temperature in a 73°C heat box. Tests shall be conducted at a minimum of 33°C over CBM and U/L testing procedures. Ballast shall be guaranteed not to overheat capacitor insulating oil beyond manufacturer's warranty limits.

LAMP PERFORMANCE WHEN 40-WATT BIPIN FLUORESCENT LAMPS ARE INTERCHANGED WITH TYPICAL BALLASTS

Ballast Type	Bipin-Lamp Type		Lamp Performance
Preheat	Preheat	OK	Normal rated life.
	Instant-Start	NG	Won't start. Filament is short-circuited inside lamp base Starter will keep trying to strike an arc until failure occurs or the lamp is disconnected.
	Rapid-Start	OK	Normal rated life.
Instant-Start	Preheat	NG	May start Very short life because primary current flows through one filament, causing early darkening and early failure.
	Instant-Start	OK	Normal rated life.
	Rapid-Start	NG	May start. Very short life because *high* primary current flows through one filament designed for *low* heating current.
Rapid-Start	Preheat, only	NG	Not recommended. Might start with best grounding and high line voltage, but starting is doubtful and unreliable under usual field conditions.
	Instant-Start	NG	Will not start. Short-circuited filament across heater winding will overheat ballast and could cause burnout.
	Rapid-Start	OK	Normal rated life.

TABLE IV

APPROXIMATE WATTS LOSS IN TYPICAL
FLUORESCENT LAMP BALLASTS

Lamp Designation	Nominal Watts	118 Volts[1]			277 Volts[2]		
		Single Lamp	Two – Lamp Series	Two – Lamp Lead-Lag	Single Lamp	Two – Lamp Series	Two – Lamp Lead-Lag
Preheat							
F4T5	4	2	–	–	–	–	–
F6T5	6	2	–	–	–	–	–
F8T5	8	2	–	–	–	–	–
F13T5	13	6	–	–	–	–	–
F14T12	14	6	–	–	–	–	–
F15T8	15	5	–	8	–	–	–
F15T12	15	5	–	8	–	–	–
F20T12	20	6	–	10	–	–	–
F25T12	25	6	–	–	–	–	–
F30T8	30	10	–	17	–	–	–
F40T12	40	10	–	16	10	–	16
F90T17	90	20	–	33	–	–	33
Rapid Start							
F30T12	30	52[3]	75[3]	–	52[3]	–	76[3]
F40T12	40	52[3]	94[3]	–	52[3]	–	94[3]
High Output							
F24T12	32	70[3]	100[3]	–	65[3]	100[3]	–
F48T12	60	85[3]	154[3]	–	85[3]	150[3]	–
F72T12	85	135[3]	210[3]	–	135[3]	210[3]	–
F96T12	110	140[3]	246[3]	–	140[3]	246[3]	–
Very High Output							
F48T12/VHO	115	138[3]	247[3]	–	140[3]	247[3]	–
F72T12/VHO	165	200[3]	360[3]	–	200[3]	360[3]	–
F96T12/VHO	215	235[3]	450[3]	–	230[3]	450[3]	–
Circline							
FC8T9	22	29[3]	–	–	–	–	–
FC12T10	32	45[3]	–	–	43[3]	–	–
FC16T10	40	56[3]	–	–	56[3]	–	–
Instant Start							
F40T12/IS	40	20	20	25	23	21	24
F40T17/IS	40	20	20	25	23	21	24
Slimline							
F42T6[4]	25	16	–	16	16	–	16
F64T6[4]	38	17	–	30	–	–	–
F72T8[4]	38	17	–	30	12	–	25
F96T8[4]	51	19	–	30	18	–	30
F48T12[5]	39	20	20	25	23	21	24
F72T12[5]	55	26	27	33	25	26	27
F96T12[5]	75	26	27	33	25	26	27

Reference Notes

[1] Ballast range, 110-125 volts.

[2] Ballast range, 255-290 volts.

[3] Total input watts to ballast, including lamp and ballast watts.

[4] Operating lamp at 200 ma.

[5] Operating lamp at 425 ma.

Comparison Of Typical Discharge Lamp Performance

Lamp Type	Initial			End of Life**		Rated Average Life
	Lumens	Lumens Per Watt: Lamp	Lumens Per Watt: 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.

ENERGY EVALUATION OF SYLVANIA HID LIGHT SOURCES
September 1978

Light Source	Average (000) Life*	Color Temp. In Degrees Kelvin (Coated)		Color Rendering Index (Coated)		Initial Lumens (LPW)**
Incandescent (REF)	1.0	3000-K		97		(20)
F40CW (REF)	25.0	4300-K		67		(79)
MERCURY — 40-50-75-100-175-250-400-700-1000 Watts				**Good**		**Fair**
175 DX	24.0	4,000		45		8,500 (49)
400 DX Deluxe	24.0	4,000		45		23,000 (58)
400/N Warm Tone	24.0	3,300		52		19,500 (49)
Self-Ballasted (By Others)	16.0	4,000		45		POOR (10-26)
METALARC LEAD PEAK BALLAST				**Excellent**		**Good/Excellent**
M-175 BU/BD	7.5	4,400	(4,000)	65	(70)	14,000 (80)
M-250 BU/BD	10.0	4,500	(3,900)	65	(70)	20,500 (82)
M-400 BU/BD (15,000 Hrs/Horiz)	20.0	4,000	(3,700)	65	(70)	34,000 (85)
M-1000 BU/BD	10.0	3,900	(3,400)	65	(70)	100,000 (100)
M-1500 BU/BD	3.0	3,700		70		155,000 (103)
MM-400 (Mercury CWA Ballast)	12.0	4,000	(3,700)	65	(70)	34,000 (85)
SUPER METALARC LEAD PEAK BALLAST				**Excellent**		**Excellent**
MS-175 Horizontal Only	10.0	4,700	(4,200)	65	(70)	15,000 (86)
MS-400 Horizontal Only	20.0	4,500	(3,800)	65	(70)	40,000 (100)
MS-400 BU or BD Only	15.0	3,700		65	(70)	40,000 (100)
MS-1000 BU or BD Only	10.0	3,500	(3,100)	65	(70)	125,000 (125)
LUMALUX HPS "BURN ANY POSITION"				**Fair**		**Excellent**
LU-70	24.0	2,100		20		5,800 (83)
LU-70/D (Coated)	24.0	2,100		20		5,400 (77)
LU-100	24.0	2,100		20		9,500 (95)
LU-100/D (Coated)	24.0	2,100		20		8,800 (88)
LU-150/100	24.0	2,100		20		16,000 (107)
LU-150/55	24.0	2,100		20		16,000 (107)
LU-150/55/D (Coated)	24.0	2,100		20		15,000 (100)
LU-200	24.0	2,100		20		22,000 (110)
LU-250	24.0	2,100		20		27,500 (110)
LU-250/D (Coated)	24.0	2,100		20		26,000 (104)
LU-250/S	24.0	2,100		20		30,000 (120)
LU-310	24.0	2,100		20		37,000 (119)
LU-400	24.0	2,100		20		50,000 (125)
LU-400/D (Coated)	24.0	2,100		20		47,500 (119)
LU-1000	24.0	2,100		20		140,000 (140)
UNALUX HPS "RETROFIT" LAG BALLAST				**Fair**		**Excellent**
ULX-150 (175W Merc. Ballast)	12.0	1,800		20		13,000 (87)
ULX-150/D (Coated)	12.0	1,800		20		12,000 (80)
ULX-215 (250W Merc. Ballast)	12.0	2,000		20		20,000 (93)
ULX-360 (400W Merc. Ballast)	16.0	2,060		20		38,000 (106)
ULX-360-D (Coated)	16.0	2,060		20		36,000 (100)
ULX-880 (1000W Merc. Ballast 480 Volt Reactor)	12.0	2,100		20		102,000 (116)

* Average life based on 10 hours per start. Values are approximate, consult your Sylvania Representative or IES Handbook.

** (LPW) stands for LUMENS PER WATT, a common denominator for comparing energy efficiency. Ballast loss not included.

CHARACTERISTICS OF SYLVANIA LAMPS (1)

	TUNGSTEN HALOGEN INCANDESCENT	FLUORESCENT	MERCURY	METALARC	LUMALUX	LOW PRESSURE SODIUM
LUMENS PER WATT	6-23	25-84	30-63	68-125	77-140	137-183
LUMENS	40-33,600	96-15,000	1,200-63,000	12,000-155,000	5,400-140,000	4,800-33,000
MAINTENANCE %	75-97	75-91	70-86	73-83	90-92	75-90*
WATTAGE RANGE	6-1,500	4-215	40-1,000	175-1,500	70-1,000	35-180
LIFE	750-8,000	9,000-20,000	16,000-24,000+	1,500-15,000	20,000-24,000	18,000
COLOR TEMPERATURE	2,400-3,100	2,700-6,500	3,300-5,900	3,200-4,700	2,100	1,780
COLOR RENDITION	95-99	55-95	22-52	65-70	21	0
COLOR BREADTH OF APPLICATION	Good	Good	Fair	Good	Fair	Poor
CONTROL	Excellent	Poor	Fair	Fair to Good	Good	Poor
INITIAL COST (PER LAMP)	Low	Moderate	Moderate	High	High	Moderate
OPERATIONAL COST (POWER)	High	Moderate	Moderate	Low	Low	Low
BREADTH OF APPLICATION	Wide	Wide	Medium	Medium to Wide	Narrow	Narrow

(1) General Lighting Types

*Lumen per watt maintenance

APPLICATIONS
LIGHT SOURCE SELECTOR GUIDE

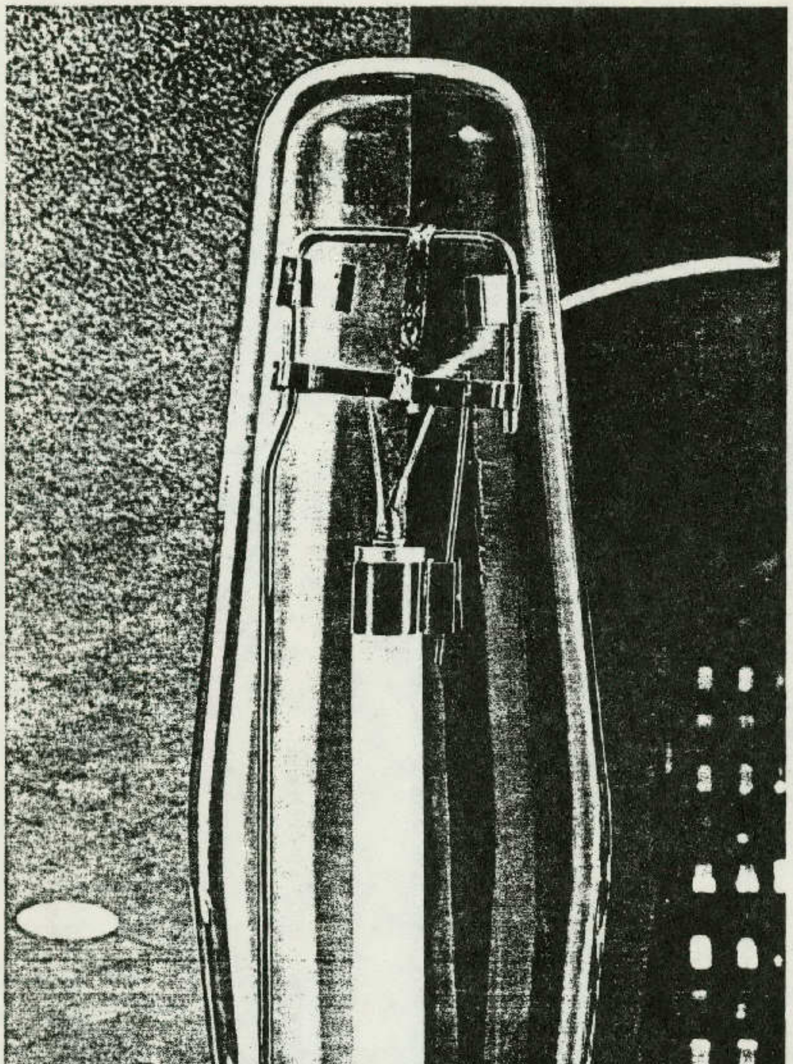
CHARACTERISTICS OF SOURCES ➡	HIGH COLOR FIDELITY (color rendering)			EFFICIENCY (lumens per watt) (initial)			LUMEN MAINTENANCE (mean lumens)			RATED AVG. LIFE (hours)			DEGREE OF LIGHT CONTROL			INPUT POWER REQ'D. (for equal light)				SYSTEM OPERATING COST (for equal light)			INITIAL EQUIPMENT COST (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.



Westinghouse Lamp Information Bulletin

CERAMALUX 4 Lamp™

The indoor light with outdoor economy. The outdoor light with indoor colors

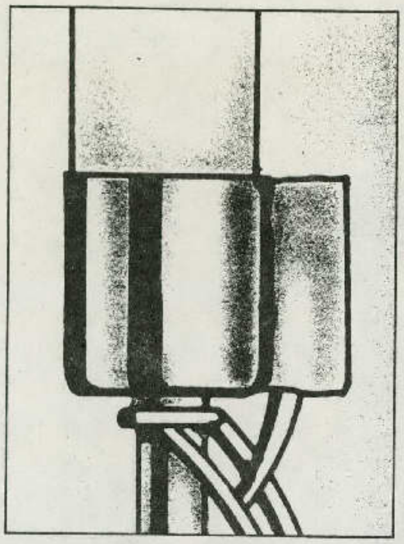
The Ceramalux-4™ high pressure sodium lamp features good color rendition in addition to the high efficacy normally associated with Ceramalux™ lamps, making it a highly desirable new light source for a wide variety of applications both indoors and outdoors.

The HPS lamp that breaks the "color barrier."

The C250S50/DX4 lamp, the first of a line of Ceramalux-4 lamps, exhibits superior color rendering properties. Its color rendering index (CRI) is 65, compared to 25 for standard Ceramalux lamps. The CRI is about equivalent to the value of the Cool White fluorescent lamp with CRI of 67, and superior to the Warm White fluorescent lamp with a CRI 53. It surpasses other HID type lamps. For example, the deluxe mercury lamp has a CRI about 50 and the metal halide lamp about 55.

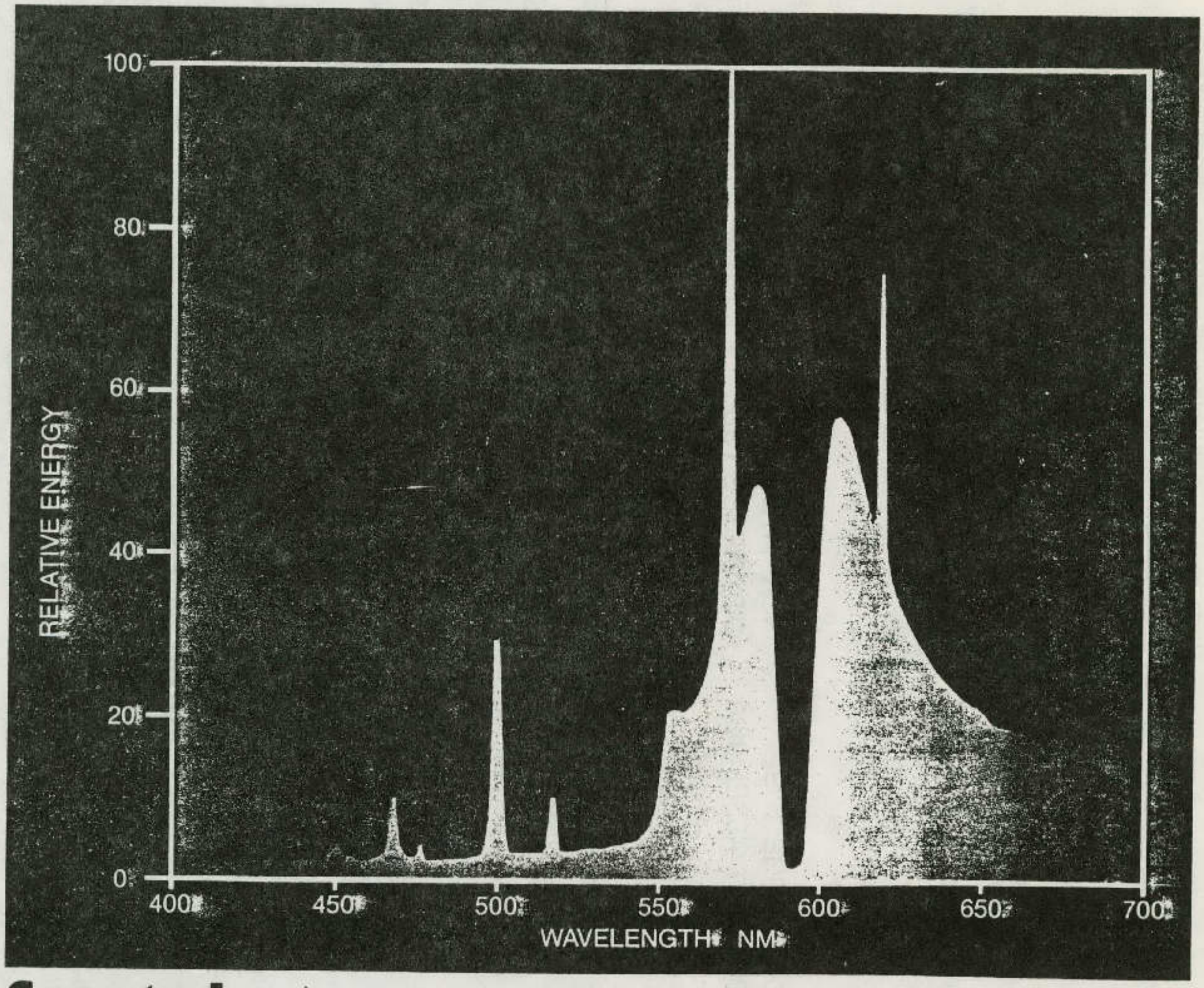
This very favorable CRI, coupled with an initial rated output of 25,000 lumens, or 100 LPW, and an initial rated average life of 7,500 hrs. are what make the new Ceramalux-4 lamp such an ideal and versatile light source.

Ideal for interior *and* exterior use in a wide variety of applications: industrial operations, schools, commercial buildings, institutions, public buildings, merchandising, sports fields, arenas, parking lots, floodlighting, streets and highways, and security.



Improved Color Rendition: The Secret's in the Seal.

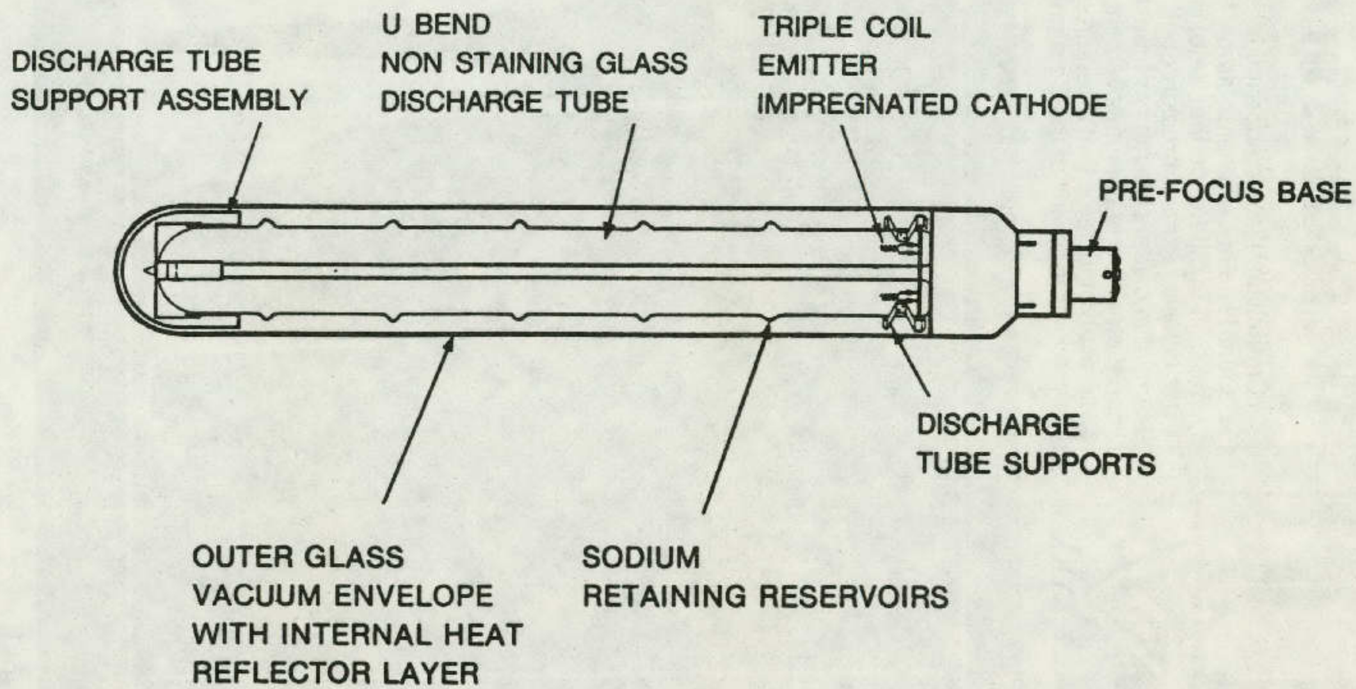
Ceramalux-4 lamps appear very similar in construction to the standard line of Ceramalux lamps. However, there is one very significant built-in difference that is not immediately apparent to the eye. This involves a major breakthrough in the seal joint between the aluminum oxide, ceramic arc tube material and the niobium metal conductor. This major improvement permits the higher temperature operation of the seal that is required to achieve the improved color rendering properties of the Ceramulux-4 lamp without seal failure.



Spectral Power Distribution

This chart graphically illustrates the improved color rendering properties of the Ceramalux-4 high pressure sodium lamp. The increased energy content in the violet, blue, green and particularly the orange and red portions of the spectrum relative to the yellows, materially improves the CRI of the Ceramalux-4 lamp.

Low Pressure Sodium



HIGH PRESSURE SODIUM LAMPS—SON

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
70 WATTS							
09350	LU70°	24	9.5	Clear—Burn any Position	24,000	5,800	5,250
09349	LU70D/D°	24	9.5	Diffuse Coated—Burns any Position	24,000	5,450	4,930
100 WATTS							
09319	LU100	24	9.5	Clear—Burn any Position	24,000	9,500	8,550
09314	LU100/D	24	9.5	Diffuse Coated—Burn any Position	24,000	8,700	8,040
150 WATTS							
09320	LU150/55	24	9.5	Clear—Burn any Position	24,000	15,800	14,850
09313	LU150/55/D	24	9.5	Diffuse Coated—Burn any Position	24,000	14,850	13,960
09321	LU150/100	12	7.0	Clear—Burn any Position	24,000	15,400	14,000
200 WATTS							
09307	LU200°	12	7.0	Clear—Burn any Position	24,000	22,000	19,800
250 WATTS							
09305	LU250	12	7.0	Clear—Burn any Position	24,000	27,500	25,500
09309	LU250/D	12	7.0	Diffuse Coated—Burn any Position	24,000	25,500	23,500
310 WATTS							
09360	LU310°	12	7.0	Clear—Burn any Position	24,000	37,000	33,300
400 WATTS							
09306	LU400	12	7.0	Clear—Burn any Position	24,000	50,000	46,500
09310	LU400/D	6	6.0	Diffuse Coated—Burn any Position	24,000	47,500	43,500

RETROFIT HIGH PRESSURE SODIUM LAMPS—SON-H

These lamps are designed for direct replacement of existing mercury vapor lamps in installations employing lag type autotransformer ballasts or 240V-277V reactor ballasts.

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
150 WATTS (for 175 watt mercury circuits)							
09372	LU150-H	12	7.0	Clear—Burn any Position	12,000	12,000	10,400
09365	LU150-H/D	12	7.0	Diffuse Coated—Burn any Position	12,000	11,000	9,400
215 WATTS (for 250 watt mercury circuits)							
09366	LU215-H°	12	7.0	Clear—Burn any Position	12,000	20,000	18,000
09367	LU215-H/D°	12	7.0	Diffuse Coated—Burn any Position	12,000	18,500	16,500
360 WATTS (for 400 watt mercury circuits)							
09368	LU360-H°	6	6.0	Clear—Burn any Position	16,000	38,000	35,000
09369	LU360-H/D°	6	6.0	Diffuse Coated—Burn any Position	16,000	36,000	32,600

°Available after March 1, 1979

LOW PRESSURE SODIUM LAMPS—SOX

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
18 WATTS							
09299	SOX 18	20	8.0	Clear	10,000	1,800	1,800
35 WATTS							
09300	SOX 35	12	10.0	Clear	18,000	4,800	4,800
55 WATTS							
09301	SOX 55	9	10.75	Clear	18,000	8,000	8,000
90 WATTS							
09302	SOX 90	9	15.00	Clear	18,000	13,500	13,500
135 WATTS							
09303	SOX 135	9	24.00	Clear	18,000	22,500	22,500
180 WATTS							
09304	SOX 180	9	39.75	Clear	18,000	33,000	33,000

Printed in U.S.A.

CS-222

North American Phillips Lighting Corporation
Bank Street, Hightstown, N.J. 08520 (609) 448-4000

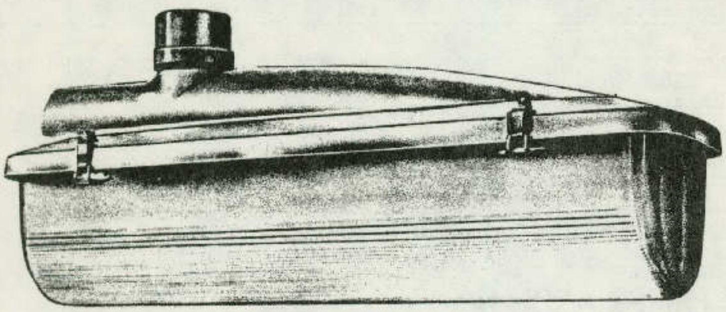
Norelco®

SPECIFICATION SHEET

NORTH AMERICAN PHILIPS LIGHTING CORPORATION

Type: Low Pressure Sodium Roadway Luminaire (SRX-114)

35/55 WATT SOX   4800/8000 LUMENS



Made in U.S.A.

Norelco Low Pressure Sodium SRX-114 luminaire combines attractive appearance with outstanding optical performance. Fixtures are cast aluminum construction with prismatic polycarbonate refractors.

HOW TO ORDER

Wattage	Ordering Code [a]	Lamp Lumens	Volts [b]	Ballast Type	Fixture [c] Wt. Lbs.
35/55	33155	4800/8000	120/240	HX-HPF	16
35 [d] 55	09300 09301	4800 8000	SOX-35 LOW PRESSURE SODIUM LAMP SOX-55 LOW PRESSURE SODIUM LAMP		

(a) Jumper cap is included for continuous operation of fixture.
(b) 120/240 volt units are factory wired 120 volts; fixtures can be reconnected easily in field for 240 volts. Other voltages available on request.
(c) including ballast assembly, less lamp.
(d) Sox 35W and Sox 55W lamps are electrically interchangeable.

Note: Lamps must be ordered separately.

HOW TO SPECIFY

LUMINAIRE HOUSING shall be of high quality, corrosion resistant die cast aluminum providing mounting for all electrical components as well as Tenon (mounting arm) securing.

LUMINAIRE FINISH shall be aluminum gray.

HARDWARE shall be stainless steel or cadmium plated.

REFLECTOR shall be high gloss white enamel internal surface of housing.

REFRACTOR shall be moulded prismatic polycarbonate, hinged and secured with spring clips for rainwater water tightness.

LAMP SOCKET shall have spring-loaded nickel plated contacts.

GASKET shall be of high temperature neoprene rubber providing continuous interface between housing and refractor.

BALLAST shall be H.P.F. type, suitable for high ambient temperature operation and mounted on luminaire housing for maximum heat dissipation and ease of field maintenance.

SLIPFITTER shall allow leveling adjustment and provide two position securing by means of locking screws. Suitable for minimum 5" straight Tenon of 1-5/8" O.D. to 2-3/8" O.D.

MAXIMUM PROJECTED SQUARE AREA shall be 1.55 square feet.

Luminaire is supplied with an EEI-NEMA standard three terminal twist lock type photoelectric control receptacle and jumper cap.

OPTIONAL SPECIFICATIONS: Photoelectric control — voltage to be specified.

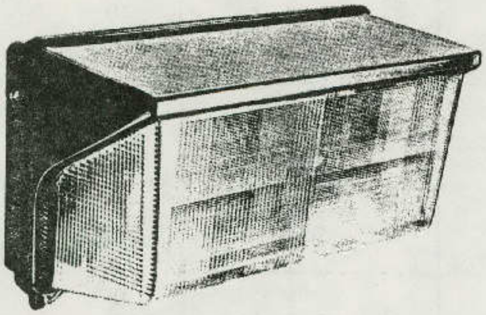
Norelco®

SPECIFICATION SHEET

NORTH AMERICAN PHILIPS LIGHTING CORPORATION

Type: Low Pressure Sodium Wall-Pack (SWP-465)

35/55 WATT SOX 4800/8000 LUMENS



Norelco Wall Packs are virtually maintenance free moulded polycarbonate and heavy die-cast aluminum construction.
The housing and refractor is one piece moulded prismatic polycarbonate material hinged and secured weather-resistant to rear aluminum mounting plate.
The luminaire is engineered for maximum utilization of light output and provides a wide area "Down and Out" type distribution.
The ballast is located on the rear mounting plate and concealed within fixture housing, eliminating unslightly external ballast housing.
The rear mounting plate provides access for surface conduit wiring and cast-in knock-outs for thru wall wiring as well as luminaire mounting points.
Standard finish is bronze.

Made in U.S.A.

HOW TO ORDER

Wattage	Ordering Code	Lamp Lumens	Volts (a)	Ballast Type	Fixture (b) Wt. Lbs.
35 55	33825 33826	4800 8000	120/240 120/240	HX-HPF HX-HPF	14 15
35(c) 55	09300 09301	4800 8000	SOX 35 LOW PRESSURE SODIUM LAMP SOX 55 LOW PRESSURE SODIUM LAMP		

(a) 120/240 volt units are factory pre-wired for 120 volts; fixtures can be reconnected easily in field for 240 volts. Fixtures also available pre-wired for 208, 277 or 480 volts.
(b) Including ballast, less lamp.
(c) Sox 35W and Sox 55W lamps are electrically interchangeable.

NOTE: LAMP MUST BE ORDERED SEPARATELY.

HOW TO SPECIFY

LUMINAIRE HOUSING AND REFRACTOR: Shall be one piece moulded polycarbonate material with integral prismatic design for precise beam control. Housing and refractor shall be hinged and secured to rear mounting plate by means of screws for water tightness.

REAR MOUNTING PLATE: Shall be precision Die Cast corrosion resistant aluminum providing mounting for all electrical components.

LUMINAIRE FINISH: Shall be bronze, being internally applied to housing and externally applied to rear mounting plate.

REFLECTOR: Shall be of textured anodized aluminum.

LAMP SOCKET: Shall have spring-loaded nickel plated contacts.

GASKET: Shall be of high temperature neoprene rubber providing continuous interface between housing and rear mounting plate.

BALLAST: Shall be H.P.F. type, suitable for high ambient temperature operation, mounted on rear plate for maximum heat dissipation and ease of field maintenance.

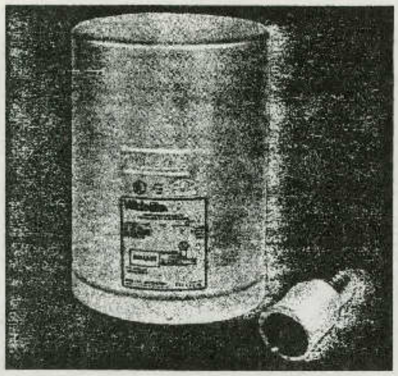
MOUNTING PROVISIONS: The rear mounting plate shall provide two side access holes tapped ½" NPS suitable for surface conduit wire entry. Shall also provide cast in knock-outs for alignment to standard recessed boxes for thru wall wiring.

Interchangeability of Lamps and Ballasts

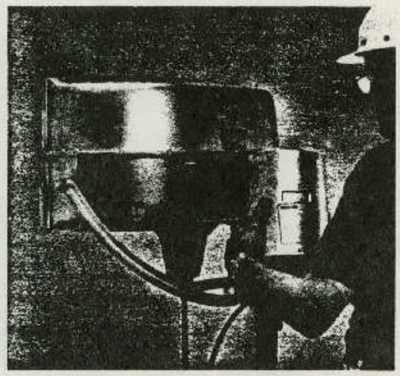
Ballast Types	Lumalux	Unalux	Metalarc	Metalarc Swingline	Super Metalarc	Mercury
	LAMP TYPES					
Standard HPS	OK	High Wattage Short Life	Unreliable Short Life	Unreliable Short Life	Unreliable Short Life	High Wattage Reduced Life
Metal Halide	NO	Short Life	OK	OK	OK	OK
CW or CWA no start capacitor	NO	Short Life or NO	NO	OK	NO	OK
CW or CWA with start capacitor	NO	Short Life or NO	NO	NO	NO	OK
Lag Mercury autotrans-former	NO	OK	NO	NO	NO	OK
Mercury reactor	NO	OK	OK*	NO	OK*	OK

*Only on 480 Volt Reactor, down to +50°F for 1000 Watt Lamps to -20°F for 175, 250, 400, Watt Lamps.

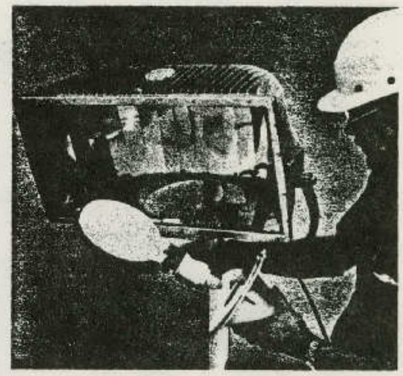
Retrofit kit converts F Series mercury floodlights to lower wattage HPS quickly, economically.



The retrofit kit consists of a replacement ballast for diffuse high pressure sodium lamp. (Socket extender provided for 400w HPS lamp only.)



All you do is remove three screws, replace the old ballast enclosure with the new, and make electrical connections . . .



. . . remove the flower pot, discard old mercury lamp. Then screw in the new HPS lamp, and replace the flower pot. That's it.

Now you can easily convert any F-1000 or F-400 mercury vapor floodlight to lower wattage high pressure sodium. Cut your power load 60% with equal light ouput with 400w HPS compared to 1000w mercury. Or replace 400w mercury with 250w HPS and get 50% more light for 40% less load.

Fast payback

Savings add up fast. This chart indicates what you save at different KWH/rates.

Savings Fixture/Year

KWH/Rate	400w HPS vs. 1000w mercury	250w HPS vs. 400w mercury
$.025	$ 60.50	$ 15.00
.030	72.60	18.00
.035	84.70	21.00
.040	96.80	24.00
.045	108.90	27.00
.050	121.00	30.00

(Savings based on 4000 hr/yr operation)

Excellent distribution

The diffuse HPS replacement lamp works equally well with any type F Series reflector. (See isolux diagrams.) A socket extender is provided for 400w HPS lamp for proper photometric alignment; none is required for 250w HPS lamp.

Ordering Guide

400w	250w
400-RKS-QV*	250-RKS-QV*
400-RKS-480v	250-RKS-480v

*120/208/240/277v taps

400w kit includes socket extender (not required for 250w).

Lamp Requirement

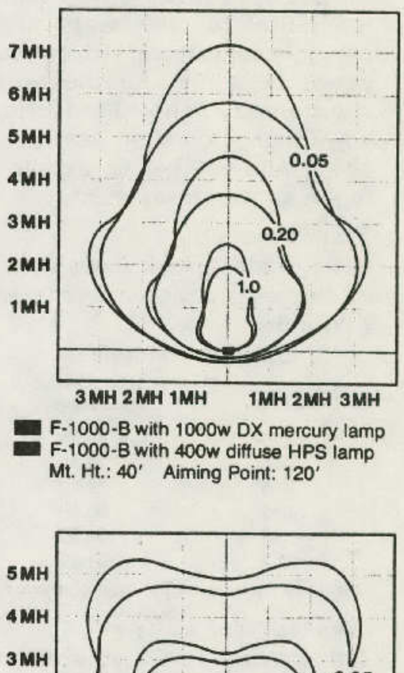
Kit requires one of the following diffuse HPS lamps for proper light distribution. (Lamp not included.) G.E. LU400D/BD or LU250D/BD Sylvania LU400/D or LU250/D

3-Year Warranty

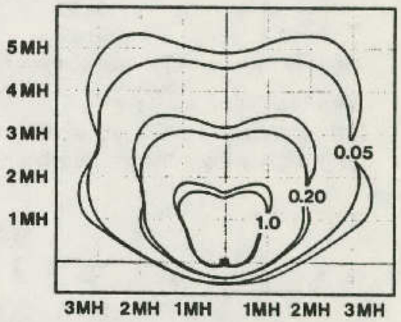
Ballast is covered by Wide-Lite's standard published three-year limited warranty.

Isolux diagrams

Based on mean lumens



F-1000-B with 1000w DX mercury lamp
F-1000-B with 400w diffuse HPS lamp
Mt. Ht.: 40′ Aiming Point: 120′

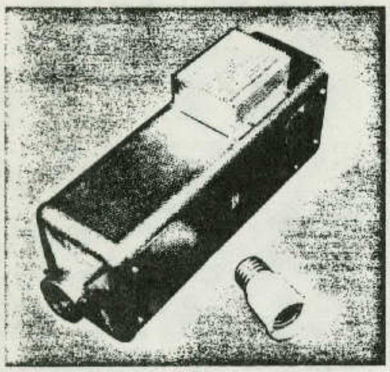


F-1000-A with 1000w DX mercury lamp
F-1000-A with 400w diffuse HPS lamp
Mt. Ht.: 40′ Aiming Point: 80′

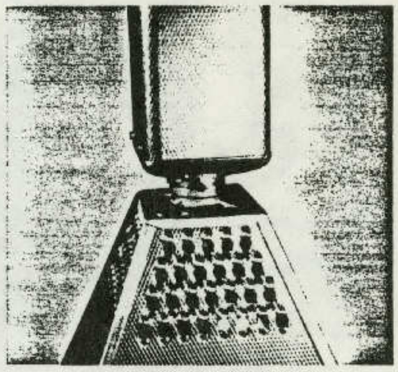
WideLite®

P.O. Box 606, San Marcos, Texas 78666

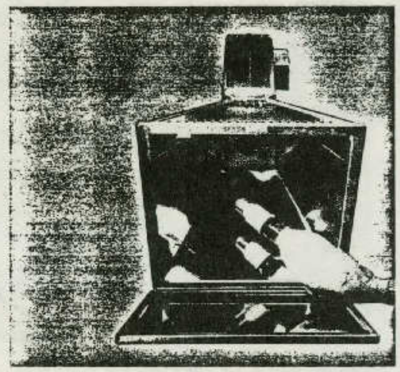
Retrofit kit converts ID and IL Series Luminaires from 1000w mercury to 400w HPS quickly, economically.



Retrofit kit consists of replacement ballast and socket extender for the 400 watt diffuse high pressure sodium lamp. (Lamp is not included.)



Keyed, slip-in ballast-to-fixture contact makes ballast change-out simple. Just slide in the new ballast, secure three locking set screws and reconnect branch circuit wiring.



The hinged lens assembly permits relamp from below. Because the optical assembly is sealed from the atmosphere, merely clean the outer lens surface to restore fixture to like-new condition.

Now you can easily convert any ID-1000 or IL-1000 mercury vapor luminaire to 400 watt high pressure sodium and reduce your power bills 60% for the same maintained light. Production stays high. Operating cost goes down. And you get an excellent return on your investment.

Fast Payback

Savings add up fast. This chart indicates what you save at different KWH/rates.

Savings Fixture/Year

KWH/Rate	400w HPS vs. 1000w mercury
$.025	$ 60.50
.030	72.60
.035	84.70
.040	96.80
.045	108.90
.050	121.00

(Savings based on 4000 hr/yr operation)

Excellent Distribution

The diffuse HPS replacement lamp works equally well with any type IL or ID Series reflector - specular or diffusing. A socket extender is provided for proper photometric alignment.

Ordering Guide

Catalog No./ Voltage	Ballast Type
400-IDS-120-RKS	Regulating, HPF
400-IDS-208-RKS	Regulating, HPF
400-IDS-240-RKS	Regulating, HPF
400-IDS-277-RKS	Regulating, HPF
400-IDS-480-RKS	Regulating, HPF
400-IDS-480R-RKS	Reactor, HPF

Lamp Requirement

Kit requires a G.E. or Sylvania LU400/D diffuse high pressure sodium lamp. Lamp is not included.

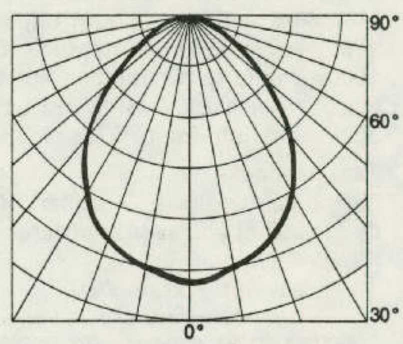
3-Year Warranty

Replacement ballast is covered by Wide-Lite's standard published three-year limited warranty.

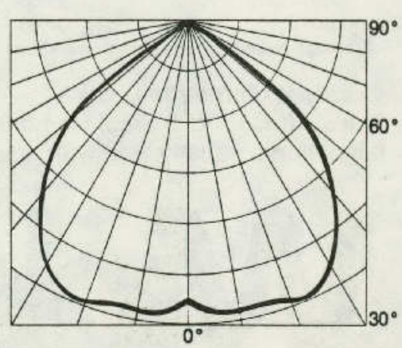
Widelite®

P.O. Box 606, San Marcos, Texas 78666

Typical Candlepower Distribution

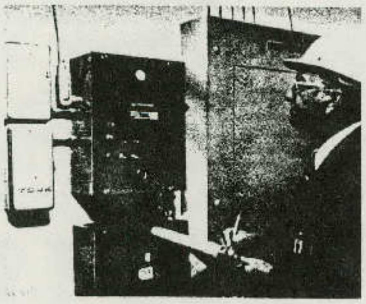


ID-1000-A (specular reflector) with 400 watt diffuse HPS lamp

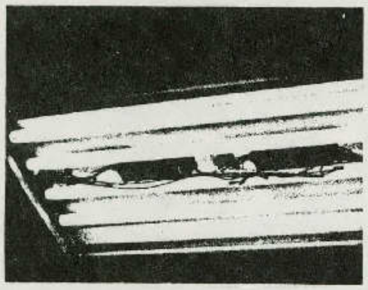


ID-1000-C (diffusing reflector) with 400 watt diffuse HPS lamp

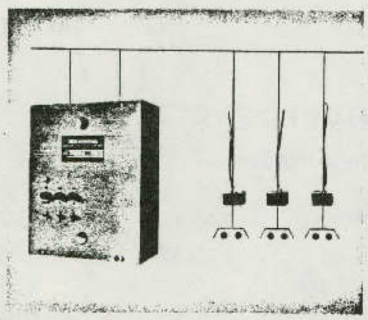
System Components*



Transmitter with timer control



Fixture modified with receiver



Existing lighting circuitry carries control signal from transmitter to receiver.

* All components UL listed

Energy Control Device Operational Instructions

Manual Operation:

Consists of using the toggle switches located on the E.C.D. control panel or a convenient remote location, for on/off operation of fixtures having E.C.D. control.

Automatic Operation:

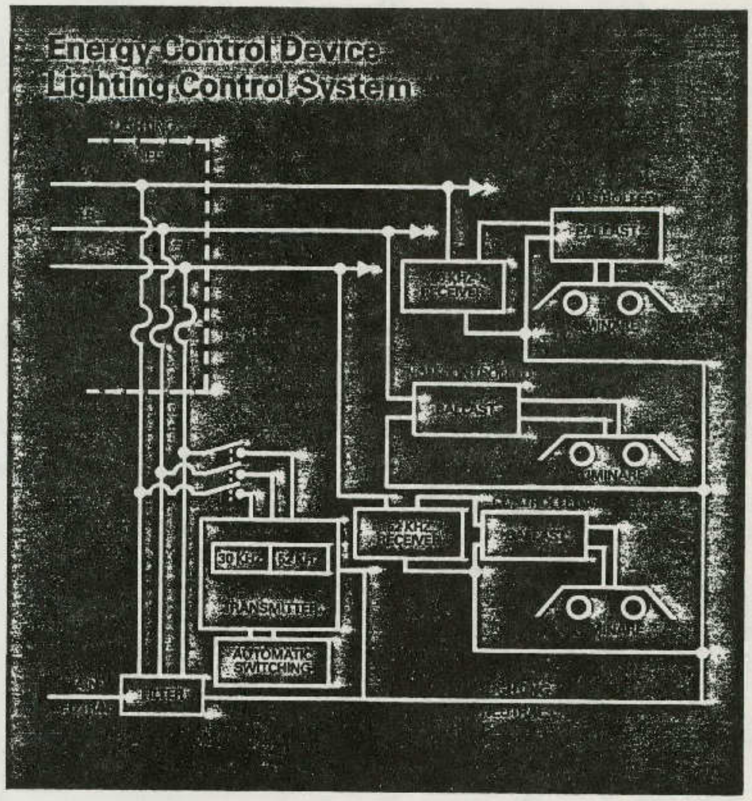
Consists of controlling on/off operation by use of automatic devices:

1. Timing devices are set to trigger the fixtures having E.C.D. control on/off at your choice of hourly operation. Time changes are easily accomplished should your hours of operation change.
2. Computer control gives maximum utilization of the E.C.D. system with exact timing, flexibility to control power increases and load shedding capability.

Override Capabilities

1. In all methods of automatic operation, if the E.C.D. controlled lighting should be off, manual override is possible with the toggle switch at the control panel.
2. Should the lights be on (in the automatic mode) they can be turned off by use of the manual switch on the control panel.

Note: Any change from the automatic mode must be corrected before automatic switching is again in control.



Energy Control Device Savings on F40 Lamps

I. 2-F40CW Lamps & 1 Ballast = 92W

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	131.6	3.95	5.26	6.58	7.90
7	2002	184.2	5.53	7.37	9.21	11.05
9	2574	236.8	7.10	9.47	11.84	14.21
11	3146	289.4	8.68	11.58	14.47	17.36

II. 4-F40CW Lamps & 2 Ballast = 184W

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	263.2	7.90	10.52	13.16	15.79
7	2002	368.4	11.06	14.74	18.42	22.10
9	2574	473.6	14.20	18.94	23.64	28.42
11	3146	578.9	17.37	23.15	28.94	34.73

III. 2-F40CW/SS Lamps & 1 Ballast = 78 W (Super Savers)

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	111.5	3.35	4.46	5.58	6.69
7	2002	156.2	4.69	6.25	7.81	9.37
9	2574	200.8	6.02	8.03	10.04	12.05
11	3146	245.4	7.36	9.82	12.27	14.72

IV. 4-F40CW/SS Lamps & 2 Ballast = 156W (Super Savers)

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	223.1	6.69	8.92	11.16	13.39
7	2002	312.3	9.37	12.49	15.62	18.74
9	2574	401.5	12.05	16.06	20.08	24.09
11	3146	490.8	14.72	19.63	24.54	29.45

LIGHTING

DOLLAR SAVING OPPORTUNITIES

NO/LOW COST

SURVEY WITH LIGHT METER

-REMOVE BULBS AND BALLASTS

-START USING ENERGY EFFICIENT BULBS

CLEAN BULBS

CLEAN FIXTURES

SET UP MANUAL LIGHTING SCHEDULE

RETROFIT

REMOVE FIXTURES

REWIRE SWITCHES

RETROFIT WITH ENERGY EFFICIENT BALLASTS

REPLACE INCANDESCENT FIXTURES WITH HID OR FLOURESCENT

REPLACE MERCURY WITH METAL HALIDE HPS, LPS

USE PHOTOCELLS

USE TIMERS

6

HVAC

Heating, Ventilating, Air Conditioning

Table of Contents

HEATING, VENTILATING AND AIR CONDITIONING

By far the biggest energy user in any building is the HVAC -- heating, ventilating and air conditioning -- system. HVAC, the environmental control system, often comprises 60% of the typical building's energy usage.

Two facts are particularly important:

1. Because of the complexity and high energy consumption of HVAC units, maintenance procedures are especially important to efficient, and thus less expensive, operation.

2. Most of today's public buildings have HVAC systems designed when energy was cheap. The theory behind such systems, and the accompanying poor weatherization, was that energy cost less than the necessary capital investment.

Therefore needed improvements are not at all hard to locate. And common sense logic is by far the most important tool the auditor needs.

General HVAC Systems Description and Modification Suggestions:

Here are comments about the major elements of the heating, ventilating and air conditioning systems, and the various types of equipment found in each:

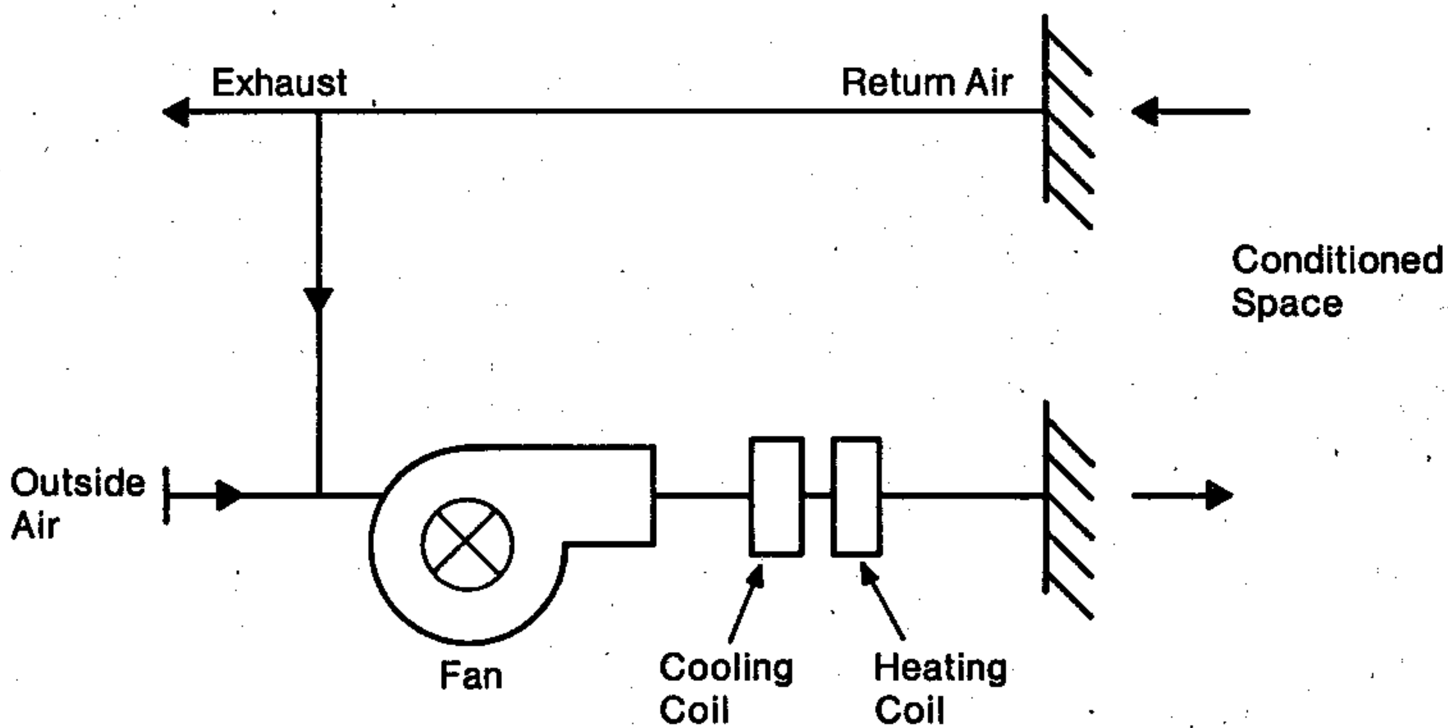
Single Zone System

A zone is an area or group of areas in a building which experience similar amounts of heat gain and heat loss. A single zone system is one which provides heating and cooling to one zone controlled by the zone thermostat. The unit may be installed within or remote from the space it serves, either with or without air distribution ductwork.

* In some systems air volume may be reduced to minimum required, therefore reducing fan power input requirements. Fan brake horsepower varies directly with the cube of air volume. Thus, for example, a 10% reduction in air volume will permit a reduction in fan power input by about 27% of original. This modification will limit the degree to which the zone serviced can be heated or cooled as compared to current capabilities.

* Raising supply air temperatures during the cooling season and reducing them during the heating season reduces the amount of heating and cooling which a system must provide. But as with air volume reduction, it limits heating and cooling capabilities.

Central Station Single-Zone



* Using the cooling coil for both heating and cooling by modifying the piping will enable removal of the heating coil, which provides energy savings in two ways. First, air flow resistance of the entire system is reduced so that air volume requirements can be met by lowered fan speeds. Second, system heat losses are reduced because surface area of cooling coils is much larger than that of heating coils, thus enabling lower water temperature requirements. Heating coil removal is not recommended if humidity control is critical in the zone serviced and alternative humidity control measures will not suffice.

Multizone System

A multizone system heats and cools several zones -- each with different load requirements -- from a single, central unit. A thermostat in each zone controls dampers at the unit which mix the hot and cold air to meet the varying load requirements of the zone involved. Steps which can be taken to improve energy efficiency of multizone systems include:

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

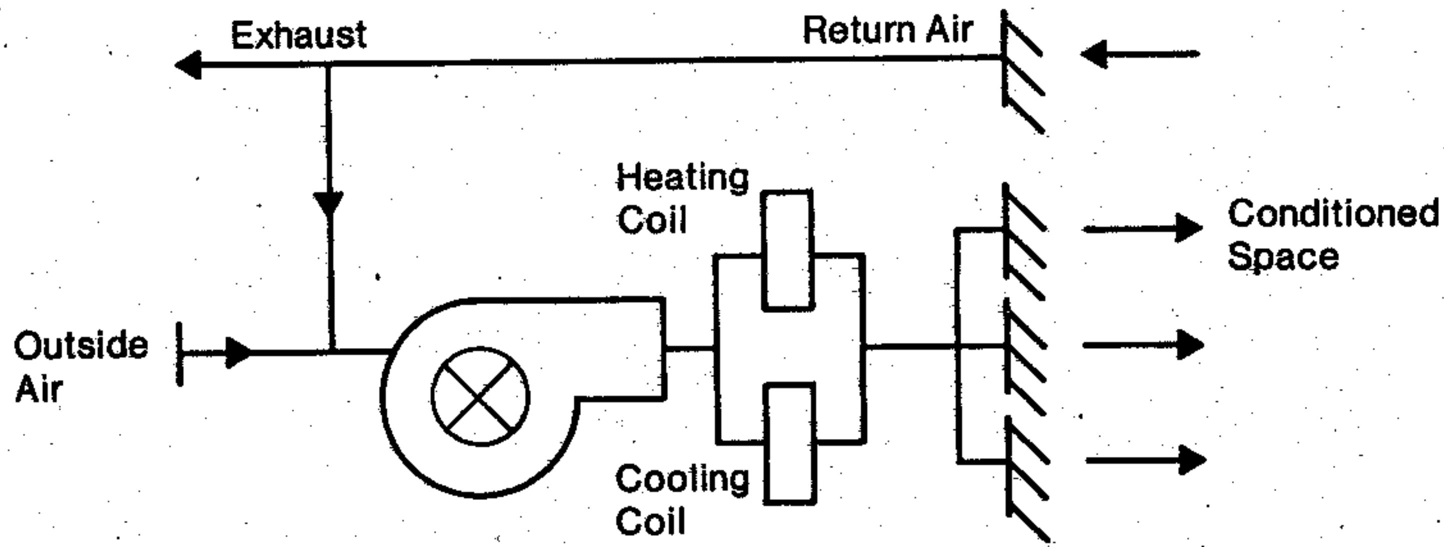
* Consider installing demand reset controls which will regulate hot and cold deck temperatures according to demand. When properly installed, and with all hot deck or cold deck dampers partially closed, the control will reduce hot and raise cold deck temperatures progressively until one or more zone dampers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

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

Terminal Reheat System

The terminal reheat system essentially is a modification of a single-zone system which provides a high degree of temperature and humidity control. The central heating/cooling unit provides air at a given temperature to all zones served by the system. Secondary terminal heaters then reheat air to a temperature compatible with the load requirements of the specific space involved. Obviously, the high degree of control provided by this system requires an excessive amount of energy. Several methods of making the system more efficient include:

Multi-Zone



* Reheat System
* Convert Interior Zones To VAV
* Change Control Settings To Require At Least One Cold Deck And One Hot Deck Damper To Be Closed At All Times
* Dampers Often Leak

* Reduce air volume of single zone units.

* If close temperature and humidity control must be maintained for equipment purposes, lower water temperature and reduce flow to reheat coils. This still will permit control, but will limit the system's heating capabilities somewhat.

* If close temperature and humidity control are not required, convert the system to variable volume by adding variable volume valves and eliminating terminal heaters.

Variable Air Volume System

A variable volume system provides heated or cooled air at a constant temperature to all zones served. VAV boxes located in each zone or in each space adjust the quantity of air reaching each zone or space depending on its load requirements. Methods of conserving energy consumed by this system include:

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

* Lower hot water temperature and raise chilled water temperature in accordance with space requirement.

* 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.

* Consider installing static pressure controls for more effective regulation of pressure bypass (inlet) dampers.

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

Constant Volume System

Most constant volume systems either are part of another system -- typically dual duct systems -- or serve to provide precise air supply at a constant volume. Opportunities for conserving energy consumed by such systems include:

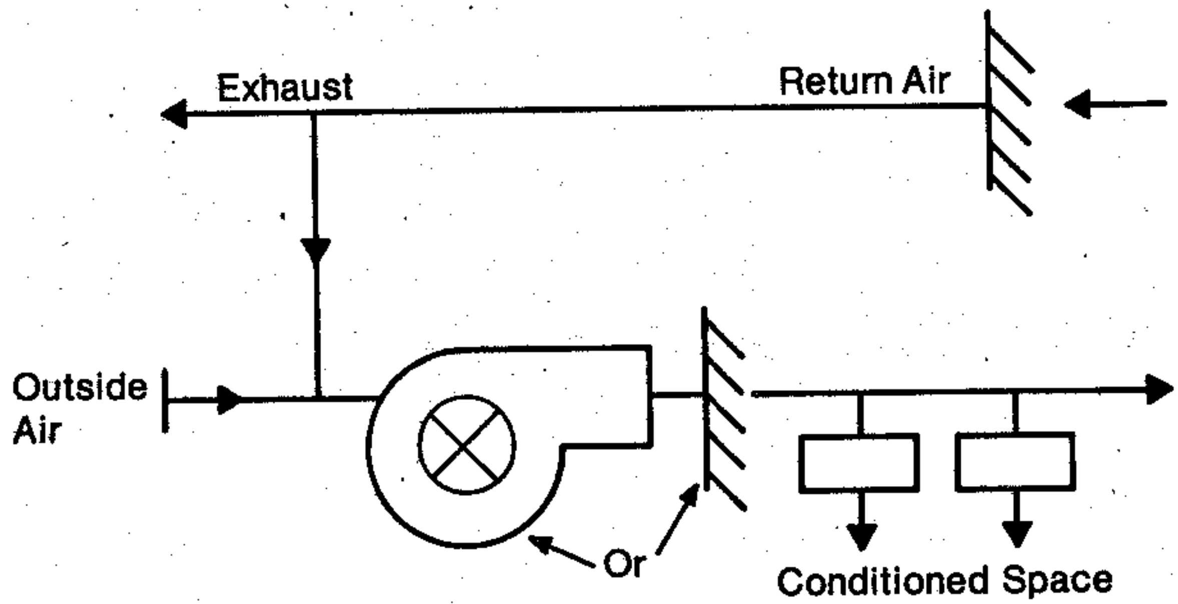
* Determine the minimum amount of airflow which is satisfactory and reset the constant volume device accordingly.

* Investigate the possibility of converting the system to variable (step controlled) constant volume operation by adding the necessary controls.

Induction Systems

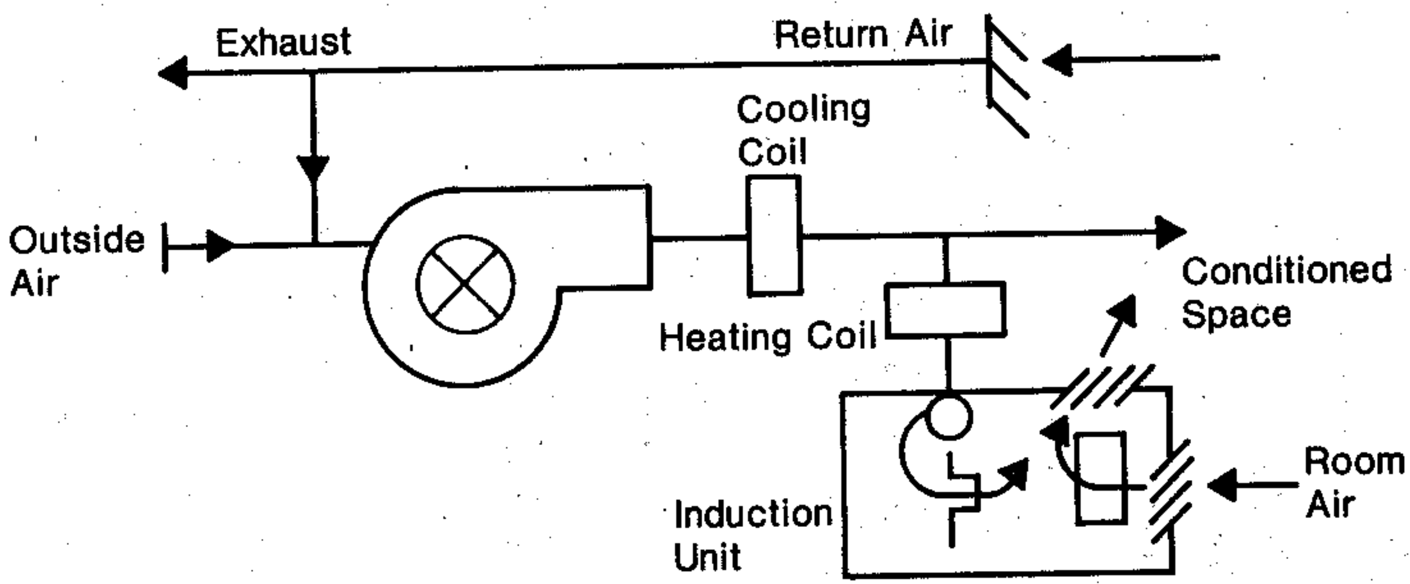
Induction systems comprise an air handling unit which supplies heated or cooled primary air at high pressure to induction units located on the outside walls of each

Variable Volume



* Generally A Very Efficient System
* Inlet Vanes Or Discharge Dampers
  Create Varying Volume

Induction



* High Pressure Delivery Requires
  Larger Horsepower Motors
* Reheat
* Restricted Room Air Flow Through Coil
* Dirty Coils Drastically Effect System
  Capacity By Hindering Induction

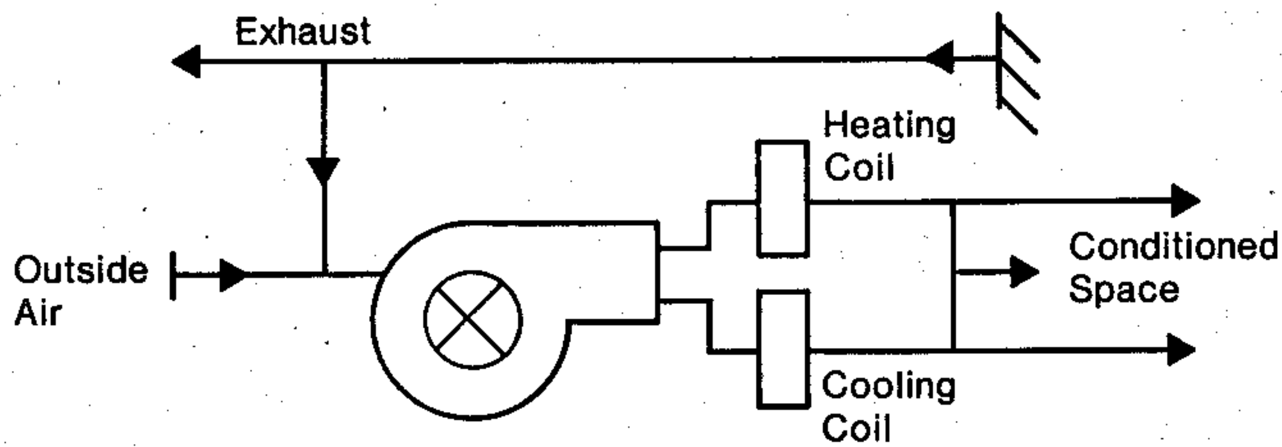
space served. The high pressure primary air is discharged within the unit through nozzles inducing room air through a cooling or heating coil in the unit. The resulting mixture of primary air and induced air is discharged to the room at a temperature dependent upon the cooling and heating load of the space. Methods for conserving energy consumed by this system include:

* Set primary air volume to original design values when adjusting and balancing work is performed.
* 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.
* Set induction heating and cooling schedules to minimally acceptable levels.
* Reduce secondary water temperatures during the heating season.
* Reduce secondary water flow during maximum heating and cooling periods by pump throttling or, for dual pump systems, by operating one pump only.
* Consider manual setting of primary air temperature for heating, instead of automatic reset by outdoor or solar controllers.

Dual-Duct System

The central unit of a dual-duct system provides both heated and cooled air, each at a constant temperature. Each space is served by two ducts, one carrying hot air, the other carrying cold air. The ducts feed into a mixing box in each space which, by means of dampers, mixes the hot and cold air to achieve that air temperature required to meet load conditions in the space or zone involved. Methods for improving the energy consumption characteristics of this system include:

Dual-Duct



- Reheat System
- Possible Solution:
  Close Off Heating Section And Repipe Cooling Coil Into 2-Pipe System, i.e., Either Heating Or Cooling.
- If Not, Reduce The Temperature Of The Hot Duct And Increase Temperature Of The Cold Duct To Point That Temperature Requirement Of Most Critical Zone Can Just Be Met.

* Lower hot deck temperature and raise cold deck temperature.

* Reduce air flow to all boxes to minimally acceptable level.

* When no cooling loads are present, close off cold ducts and shut down the cooling system. Reset hot deck according to heating loads and operate as a single duct system. When no heating loads are present, follow the same procedure for heating ducts and hot deck. It should be noted that operating a dual-duct system as a single duct system reduces air flow, resulting in increased energy savings through lowered fan speed requirements. But it also decreases air changes.

<u>Fan Coil System</u>

A fan coil system usually comprises several fan coil units, each of which consists of a fan and a heating and/or cooling coil. The individual units can be located either in or remote from the space or zone being served. Guidelines for reducing energy consumption of such systems include:

* Reduce air flow to minimally satisfactory levels.
* Balance water flows to minimally satisfactory levels.
* When heating and cooling loads are minimal, shut off fans so enabling the coil to act as a convector.
* Consider installing interlocks between the heating and cooling systems of each unit to prevent simultaneous heating and cooling.
* Consider face zoning two-pipe systems from four-pipe central system to avoid changeover losses.

<u>Refrigeration Equipment</u>

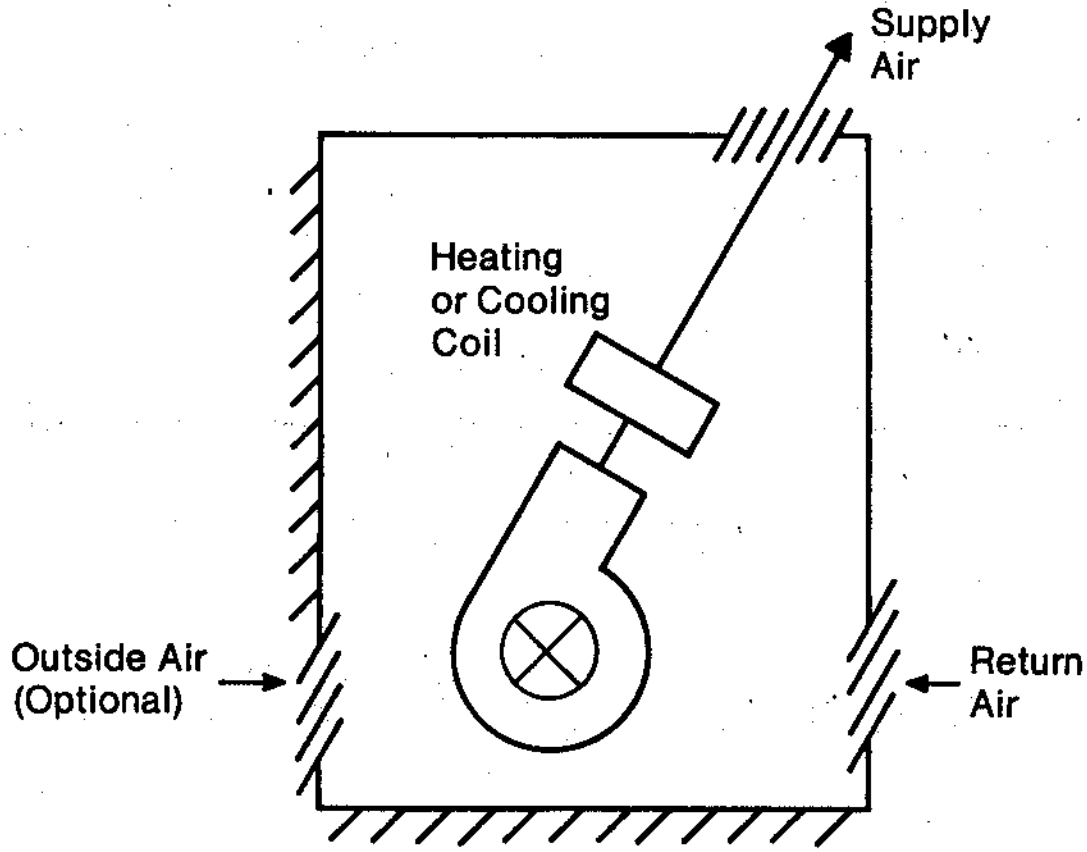
* Circuit and Controls

  -- Inspect moisture-liquid indicator on a regular basis. If the color of the refrigerant indicates "wet," it means there is moisture in the system. This is a particularly critical problem because it can cause improper operation or costly damage. A competent mechanic should be called in to perform necessary adjustments and repairs immediately. Also, if there are bubbles in the refrigerant flow as seen through the moisture-liquid indicator, it may indicate that the system is low in refrigerant. Call in a mechanic to add refrigerant if necessary and to inspect equipment for possible refrigerant leakage.

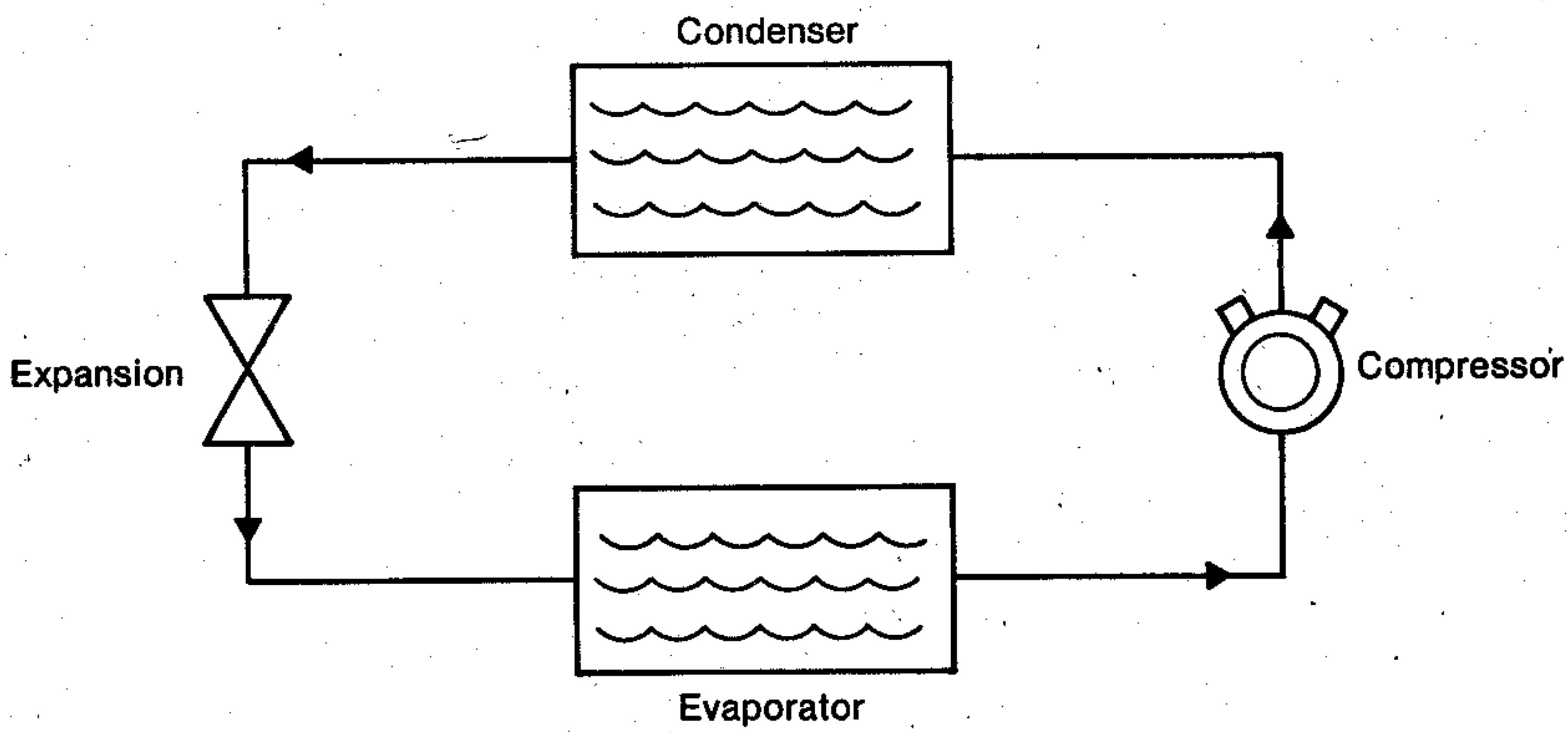
  -- Use a leak detector to check for refrigerant and oil leaks around shaft seal, sight glasses, valve bonnets, flanges, flare connections, relief valve on the condenser assembly and at pipe joints to equipment, valves and instrumentation.

  -- Inspect equipment for any visual changes such as oil spots on connections or on the floor under equipment.

Fan Coil Unit (2-Pipe)



Refrigeration Diagram:



-- Inspect the liquid line leaving the strainer. If it feels cooler than the liquid line entering the strainer, it is clogged. If it is very badly clogged, sweat or frost may be visible at the strainer outlet. Clean as required.

-- Observe the noise made by the system. Any unusual sounds could indicate a problem. Determine cause and correct.

-- Establish what normal operating pressures and temperatures for the system should be. Check all gauges frequently to ensure that design conditions are being met. Increased system pressure may be due to dirty condenser, which will decrease system efficiency. High discharge temperatures often are caused by defective or broken compressor valves.

-- Inspect tension and alignment of all belts and adjust as necessary.

-- Where applicable, lubricate motor bearings and all moving parts according to manufacturer's recommendations.

-- Inspect insulation on suction and liquid lines. Repair as necessary.

* Compressor

-- Look for unusual compressor operation such as continuous running or frequent stopping and starting, either of which may indicate inefficient operation. Determine the cause and, if necessary, correct.

-- Observe the noise made by the compressor. If it seems to be excessively noisy, it may be a sign of a loose drive coupling or excessive vibration. Tighten compressor and motor on the base. If noise persists, call a competent mechanic.

-- Check all compressor joints for leakage. Seal as necessary.

-- Inspect the purge for air and water leaks. Seal as necessary.

-- Inspect instrumentation frequently to ensure that operating oil pressure and temperature agree with manufacturer's specifications.

* Air-Cooled Condenser

-- Keep fan belt drive and motor properly aligned and lubricated.

-- Inspect refrigeration piping connections to the condenser coil for tightness. Repair all leaks.

-- Keep condenser coil clean to permit proper air flow.

-- Determine if hot air is being bypassed from the fan outlet to the coil inlet. If so, correct the problem.

* Evaporative Condenser

-- Inspect piping joints and seal all leaks.

-- Remove all dirt from the coil surface by washing it down with high velocity water jets or a nylon brush.

-- Inspect air inlet screen, spray nozzle or water distribution holes, and pump screen. Clean as necessary.

-- Use water treatment techniques if local water supply leaves surface deposits on the coil.

-- Follow guidelines for fan and pump maintenance.

* Watercooled Condenser

  -- Clean condenser shell and tubes by swabbing with a suitable brush and flushing out with clean water. Chemical cleaning also is possible, although it is suggested that a water treatment company be consulted first.

* Cooling Towers

  -- Perform chemical analysis to determine if solid concentrations are being maintained at an acceptable level.

  -- Check overflow pipe clearance for proper operating water level.

  -- Check fan by listening for any unusual noise or vibration. Inspect condition of V-belt. Align fan and motor as necessary.

  -- Follow guidelines for fan maintenance.

  -- Keep the tower clean to minimize both air and water pressure drop.

  -- Clean intake strainer.

  -- Determine if there is air bypass from tower outlet back to inlet. If so, bypass may be reduced through addition of baffles or higher discharge stacks.

  -- Inspect spray filled or distributed towers for proper nozzle performance. Clean nozzles as necessary.

  -- Inspect gravity distributed tower for even water depth in distribution basins.

  -- Monitor effectiveness of any water treatment program which may be underway.

* Chillers

  -- Chillers must be kept clean. Inspect on a regular basis. Clean as necessary.

  -- Inspect for evidence of clogging. A qualified mechanic should be called in to service equipment in accordance with manufacturer's specifications.

* Absorption Equipment

  -- Clean strainer and seal tank on a regular basis.

  -- Lubricate flow valves on a regular basis.

  -- Follow manufactures instructions for proper maintenance.

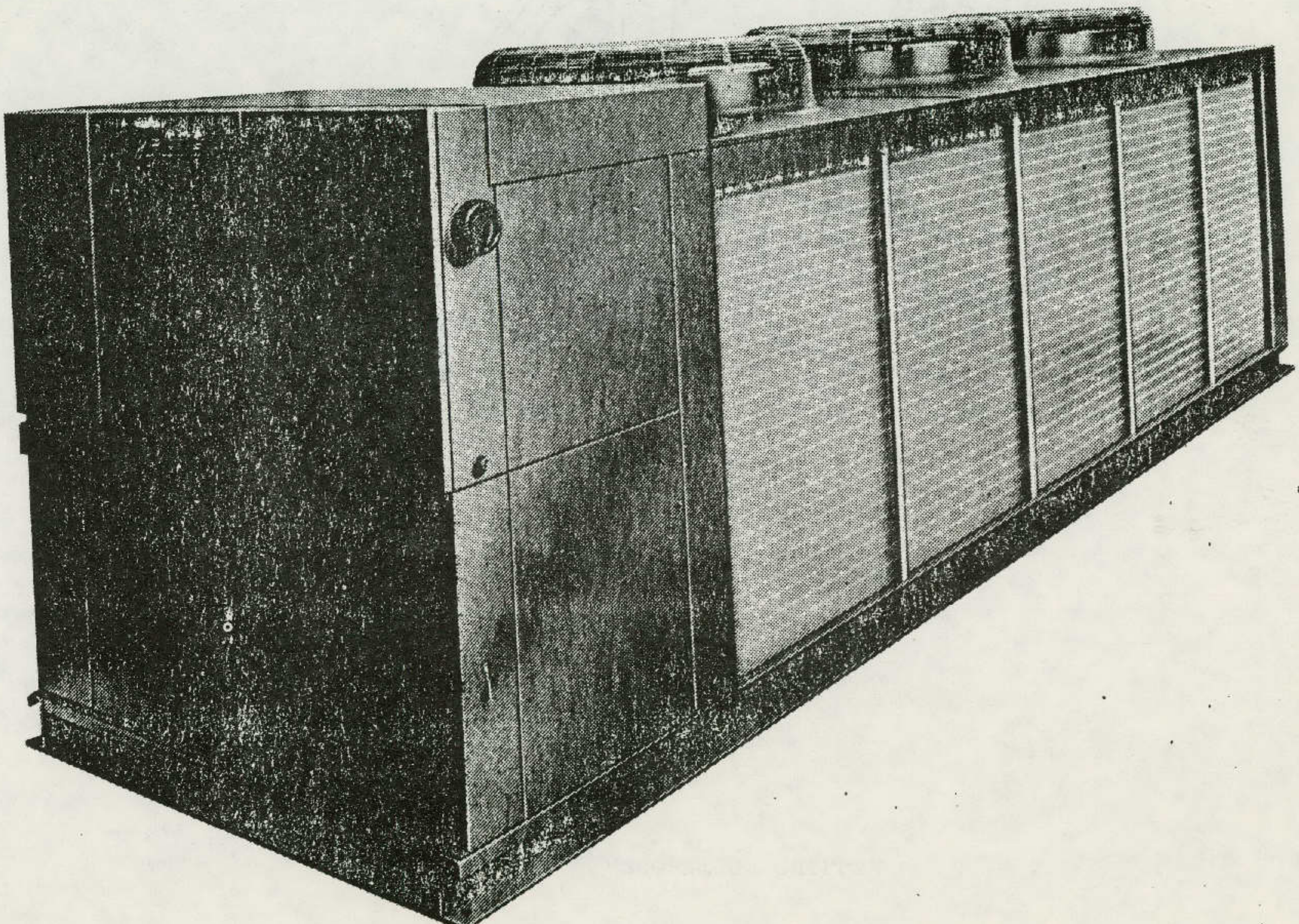
* Self-Contained Units (Windows and through-the-wall units; heat pump,etc.)

  -- Clean evaporator and condenser coils.

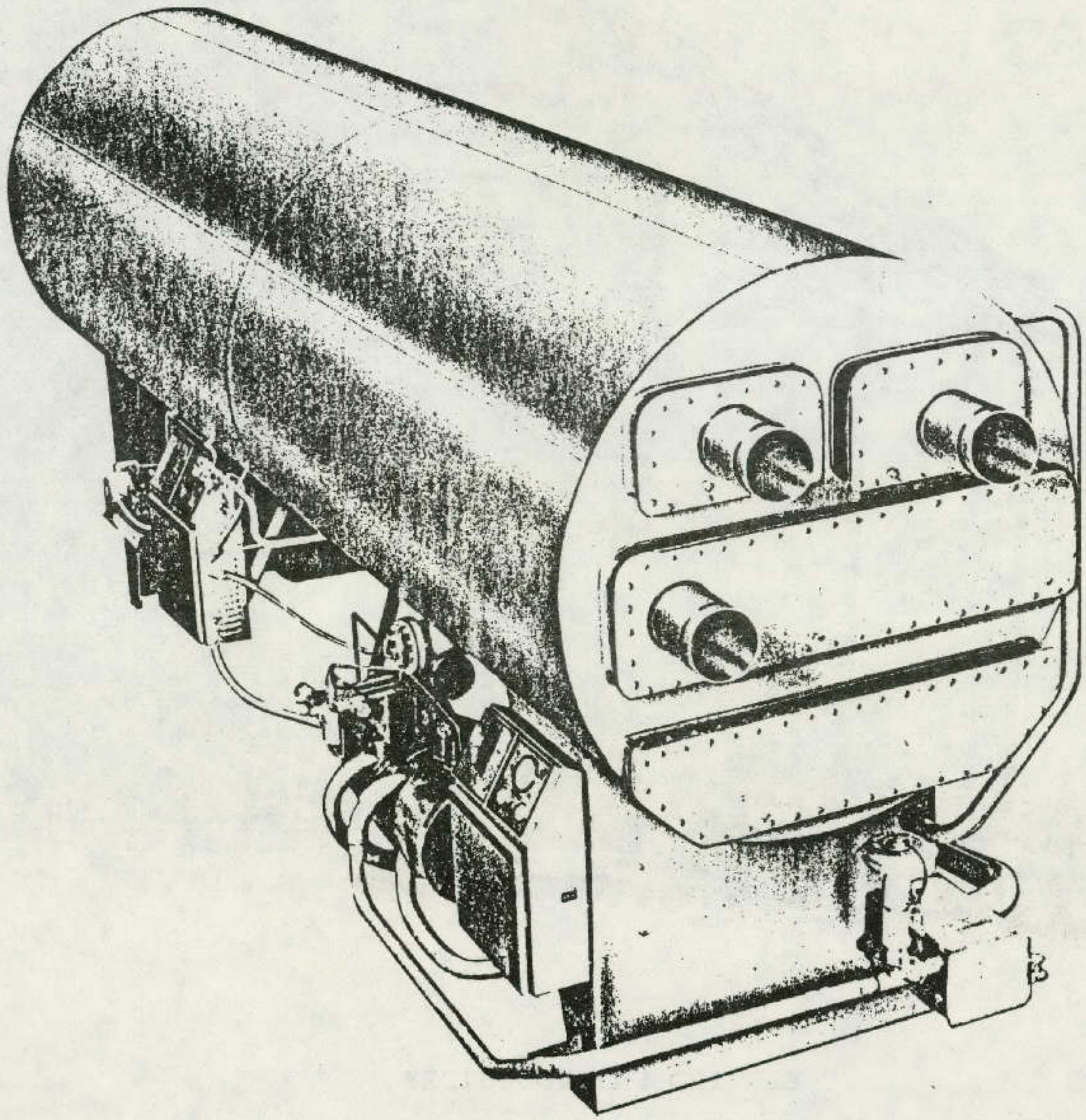
  -- Keep air intake louvers, filters and controls clean.

  -- Keep air flow from units unrestricted.

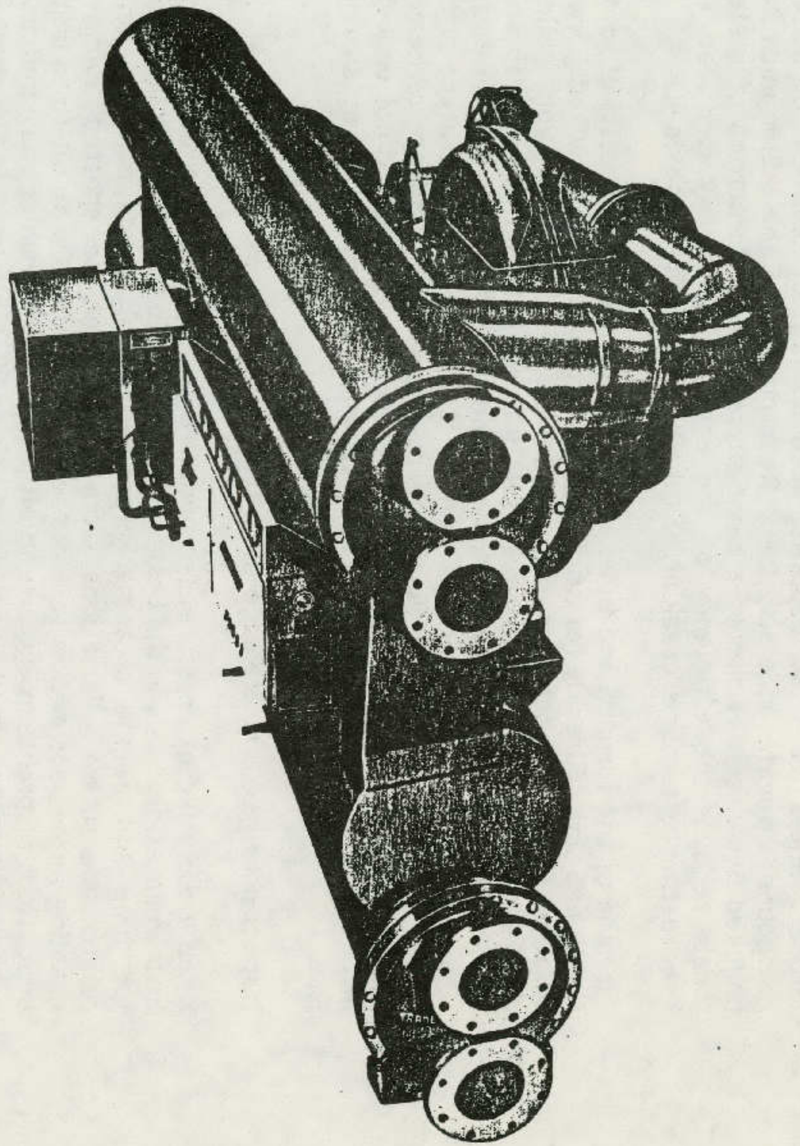
RECIPROCATING CHILLER



ABSORPTION CHILLER



CENTRIFUGAL CHILLER



-- Caulk openings between unit and windows or wall frames.

-- Check voltage. Full power voltage is essential for proper operation.

-- Follow applicable guidelines suggested for compressor, air-cooled condenser and fans.

<u>Heating Equipment</u>

There are also many different kinds of heating systems installed in existing office buildings and other public facilities. Certain common maintenance guidelines to improve efficiency of operation include the following:

* Boilers (General)

-- Inspect boilers for scale deposits, accumulation 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.)

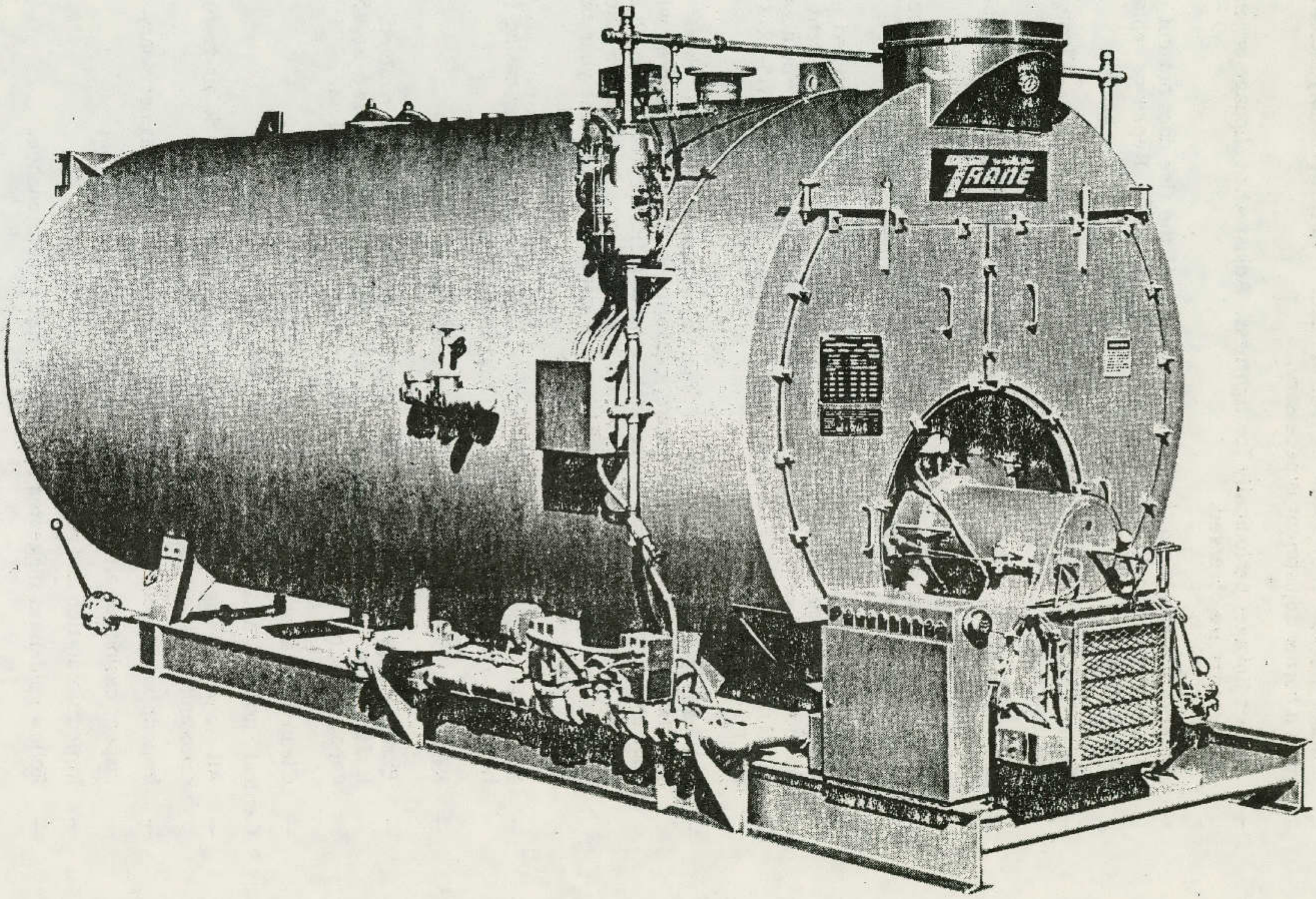
-- Fireside of the furnace and tubes must be inspected for deposits of soot, flyash and slag. Fireside refractory surface also must be observed. Soot on tubes decreases heat transfer and lowers efficiency. (If your boiler does not now have one, consider installation of a thermometer in the vent outlet. 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.

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

-- 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. On an oil-fired unit, indications of problems include an oil pressure drop, which may indicate a plugged strainer, faulty regulating valve, or an air leak, in the suction line. An oil temperature drop can indicate temperature control malfunction or a fouled heating element. On a gas-fired unit, a drop in gas pressure can indicate a drop in the gas supply pressure or malfunctioning regulator.

-- 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 $100^{o}F$ in five minutes.

FIRETUBE BOILER



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

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

-- 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.

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

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

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

-- Check analysis of the flue gas on a periodic basis. Check oxygen and carbon monoxide as well as carbon dioxide. Oxygen should be present to no more than 1 or 2%. There should be no carbon monoxide. For a gas-fired unit, CO_2 should be present at 9 or 10%. For #2 oil, 11.5-12.8%; for #6 oil, 13 to 13.8%.

-- The air-to-fuel ratio must be maintained properly. If there is insufficient air, the fire will smoke, cause tubes to become covered with soot and carbon, and thus lower heat transfer efficiency. If too much air is used, unused air is heated by combustion and exhausted up the stack, wasting heat energy. Most fuel service companies will test your unit free of charge or for a token fee only.

-- Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks. Repair and seal as necessary.

-- Replace all obsolete or little-used pressure vessels.

-- Examine operating procedures when more than one boiler is involved. It is far better to operate one boiler at 90% capacity than two at 45% capacity each. The more boilers used, the greater the heat loss.

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

* Central Furnaces, Make-Up Air Heaters and Unit Heaters

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

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

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

  -- Inspect insulation and repair or replace as necessary.

  -- Follow guidelines suggested for fan and motor maintenance.

SAVINGS FOR EVERY $100 FUEL COSTS BY INCREASING COMBUSTION EFFICIENCY

(Assuming constant radiation and other unaccounted-for losses)

From an original efficiency of:	To an increased combustion efficiency of:								
	55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	$9.10	16.70	23.10	28.60	33.30	37.50	41.20	44.40	47.40
55%		8.30	15.40	21.50	26.70	31.20	35.30	38.90	42.10
60%			7.70	14.30	20.00	25.00	29.40	33.30	37.80
65%				7.10	13.30	18.80	23.50	27.80	31.60
70%					6.70	12.50	17.60	22.20	26.30
75%						6.30	11.80	16.70	21.10
80%							5.90	11.10	15.80
85%								5.60	10.50
90%									5.30

* Radiators, Convectors, Baseboard and Finned Tube Units
    - Inspect for obstructions in front of the unit and remove whenever possible. Air movement in and out of convector unit must be unrestricted.
    - 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.
    - Heat transfer surfaces of radiators, convectors, baseboard and finned-tube units must be kept clean for efficient operation.
* Electric Heating
    - Keep heat transfer surfaces of all electric heating units clean and unobstructed.
    - Keep air movement in and out of the units unobstructed.
    - Inspect heating elements, controls and, as applicable, fans on a periodic basis to ensure proper functioning.
    - As appropriate, check reflectors on infrared heaters for proper beam direction and cleanliness.
    - Determine if electric heating equipment is operating at rated voltage as necessary.
    - Check controls for proper operation.

<u>Hot and Chilled Water Piping</u>

* Inspect all controls. Test them for proper operation. Adjust, repair or replace as necessary. Also check for leakage at joints.

* Check flow measurement instrumentation for accuracy. Adjust, repair or replace as necessary.

* Inspect insulation of hot and chilled water pipes. Repair or replace as necessary. Be certain to replace any insulation damaged by water. Determine source of water leakage and correct.

* Inspect strainers. Clean regularly.

* Inspect heating and cooling heat exchangers. Large temperature differences may be an indication of air binding, clogged strainers or excessive amounts of scale. Determine cause of condition and correct.

* Inspect vents and remove all clogs. Clogged vents retard efficient air elimination and reduce efficiency of the system.

<u>Steam Piping</u>

* Inspect insulation of all mains, risers and branches, economizers and condensate receiver tanks. Repair or replace as necessary.

* Check automatic temperature-control system and related control valves and accessory equipment to ensure that they are regulating the system properly in the various zones -- in terms of building heating needs, not system capacity.

* Inspect zone shut-off valves. All should be operable so steam going into unoccupied spaces can be shut off.

* Inspect steam traps. Their failure to operate correctly can have a significant impact on the overall efficiency and energy consumption of the system. Several different tests can be utilized to determine operations.

  -- Listen to the trap to determine if it is opening and closing when it should be.

  -- Feel the pipe on the downstream side of the trap. If it is excessively hot, the trap probably is passing steam. This can be caused by dirt in the trap, valve off steam, excessive steam pressure, or worn trap parts (especially valve and seats). If it is moderately hot -- as hot as a hot water pipe, for example -- it probably is passing condensate, which it should do. If it's cold, the trap is not working at all.

  -- Check back pressure on downstream side.

  -- Measure temperature of return lines with a surface pyrometer. Measure temperature drop across the trap. Lack of drop indicates steam blow-through. Excessive drop indicates that the trap is not passing condensate. Adjust, repair or replace all faulty traps.

Self-Contained Systems

Energy consumption of self-contained systems, such as roof-top, window, through-the-wall and other heating and/or cooling units, can be modified as follows:

* If multiple units are involved, consider installation of centralized automatic shut-off and manual override control.

* If units are relatively old, consider replacing them with more efficient air-to-air heat pumps or similar units have a higher equivalent efficiency rating.

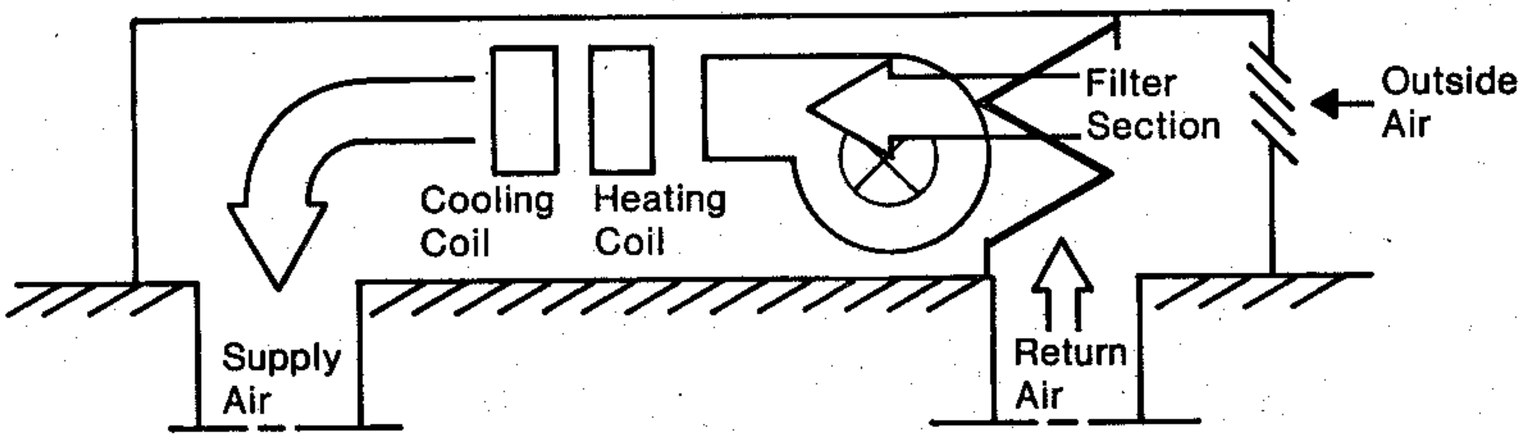
Distribution Systems

A distribution system comprises the equipment and materials necessary for conveying the heating and cooling media -- water, steam or air. Most versions of the nine general systems previously discussed employ one or more of the following distribution systems:

Hydronic Systems -- Hydronic systems are those which utilize water for transferring heating and cooling.

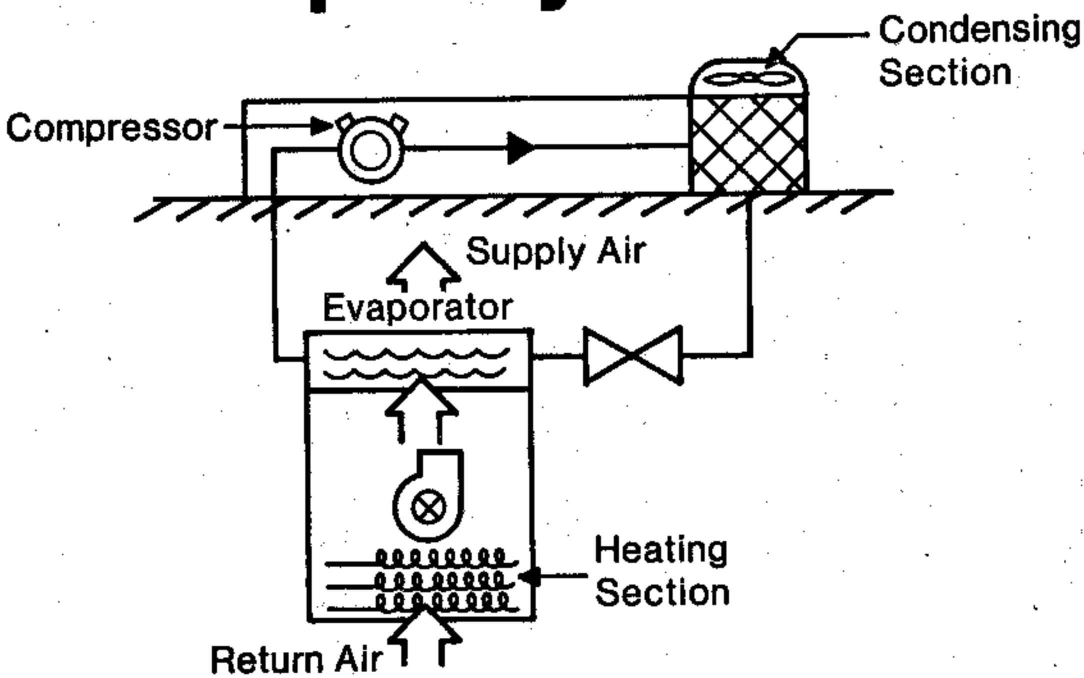
Steam Systems -- Steam systems are those which utilize steam as a heat source. The steam can be provided either by an on-site boiler or by district steam.

Rooftop Unit:



* Refrigerant Or Chilled Water Cooling
* Hot Water, Steam, Gas Or Electric Heat
* Single-Zone Or Multi-Zone System
* Resultant Savings Opportunities From
  Each Of The Various Components
  As Noted Previously

Split System:



* Very Common In Smaller Buildings Or As Additional Capacity For Large Buildings
* Primarily Maintenance Opportunities
* Turn Off When Not Needed
* Night Setback
* Reduce Temperature Settings

Air Distribution Systems -- Air distribution systems are those which use air for heating and/or cooling.

Adjusting HVAC Controls

The controls originally installed in your building probably were designed more in light of initial costs than they were for their ability to conserve energy. In addition, just five years use without adequate maintenance -- which seldom is performed -- can cause controls to go out of calibration, becoming even less sensitive. A program of control adjustment and modification should consider the following guidelines:

* Adjust controls at the time of testing, adjusting and balancing of all heating and cooling systems.
* Check operation of entire heating/cooling control system, including control valves and dampers. Correct all improper operations.
* Check control system for instrument calibration and set point, actuator travel and action, and proper sequence of operation.
* Inspect locations of thermostats. Relocate if they currently are positioned near outside walls, in areas that are seldom used, or if they are subject to outside drafts.
* Consider installation of key-lock plastic covers over thermostats to prevent building occupants from adjusting settings.
* Consider replacing pilots of gas burning equipment with electric ignition devices.

Reducing Ventilation Levels

Air brought into a building for ventilation must be heated or cooled and often humidified or dehumidified. Ventilation systems account for an estimated 10 percent of a building's overall energy consumption, yet it is generally agreed that most building codes demand levels of ventilation in excess of what is actually needed to provide for the safety and comfort of building occupants.

Building code ventilation standards should be examined to ensure that they are realistic in their appraisal of health and safety needs. Consider the following ventilation guidelines recommended by the National Bureau of Standards:

Oxygen Supply	3 CFM/person
Cafeterias	10-12 CFM/person
Smoking Areas	25-40 CFM/person
Odor Control	5 CFM/person
Toilet Exhaust	10-15 air changes/hour
Corridors	2 air changes/hour

Heating, Ventilating and Air-Conditioning Systems Guidelines

Consider the following guidelines in selecting a new HVAC system:

* Do not buy equipment with excess capacity. Most equipment works at maximum efficiency when running at full capacity. Most systems, however, are designed to meet extreme weather conditions, which seldom occur, resulting in inefficiency.

* Provide adequate zones of control. Without control zones, large areas often have to be overcooled or overheated to satisfy the needs of small areas. Zoning thus reduces the HVAC load.

* Group areas with similar heating, cooling and ventilation requirements to facilitate selective ventilation.

* Use waste heat. Until recently, the heat generated by a building's lights, machinery, and people was ignored. Rising energy prices, however, are stimulating a great deal of interest in waste heat recovery systems, which can retrieve up to 80 percent of waste heat, creating a two-fold energy benefit:

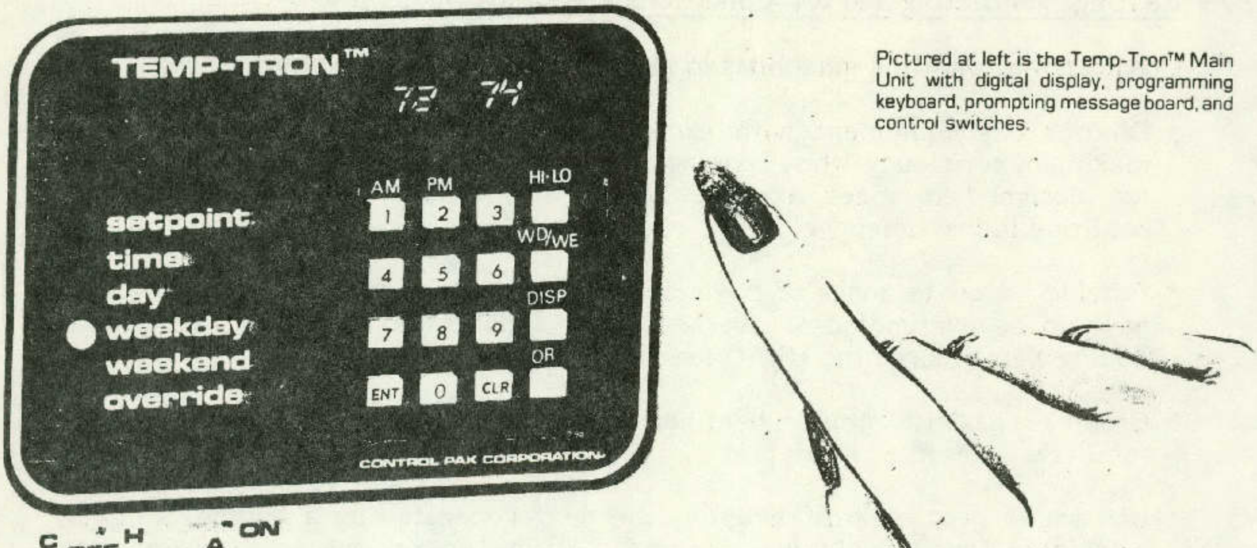
  -- Waste heat can be used to supplement, and sometimes replace, expensive fuel-based heat; and

  -- Removal of waste heat eliminates an expensive burden on the air-conditioning system.

These systems are expensive, but usually pay for themselves quickly with energy savings. The Smithsonian Institution installed a heat recovery system, which paid for itself in four months. An HVAC maintenance program should be initiated when the building is completed, based on guidelines outlined in the following section of this manual.

TEMP-TRON™

THE NEW STANDARD IN HOME AND COMMERCIAL TEMPERATURE CONTROL.



Pictured at left is the Temp-Tron™ Main Unit with digital display, programming keyboard, prompting message board, and control switches.

Control Pak Corporation introduces Temp-Tron,™ the new standard in home and commercial temperature control.

The Temp-Tron™ unit allows the user to custom tailor his heating and cooling needs to whatever schedule he requires and save money while doing it!

Housed in a beautiful contemporary aluminum case, the Temp-Tron™ unit makes possible through the use of state-of-the-art micro-computer technology, the precise programming of the users choice of temperature and schedule for maximum comfort and minimal use of expensive energy. Included with the unit, is an outdoor temperature sensor that allows the user to see the outdoor temperature displayed on the Temp-Tron™ unit at the push of a button.

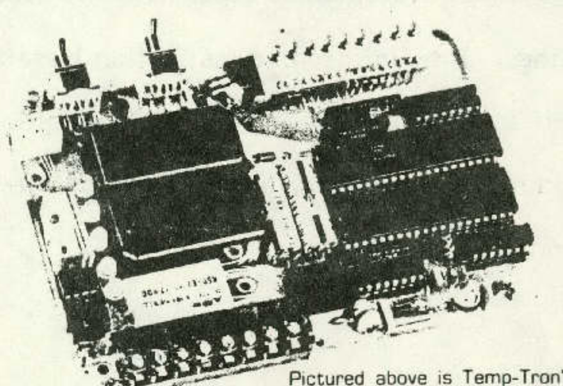
Don't be put-off by the programming procedure, if you can use a pushbutton telephone, you can program Temp-Tron.™

The unit can accommodate up to six changes per 24 hour period in two different 24 hour schedules.

Once the programs are entered, you set it and forget it! Try that on your current thermostat. An override mode is provided so that the user may select a different temperature immediately to handle any unusual circumstance. The Temp-Tron™ will stay at the selected override temperature until told to return to the preselected temperature and schedule.

Temp-Tron™ provides superior comfort to the conventional bi-metal coil thermostat.

Should a power failure occur, there is a back up power system that will retain your programming for a limited time. Also provided is an access code to prevent tampering with your programming by children or prankful guests!



Pictured above is Temp-Tron's Solid State Micro-Computer

CONTROL PAK corporation

44480 grand river ave.
novi, michigan; 48050

7

INSULATION/INFILTRATION

Insulation

Table of Contents

BUILDING ENVELOPE

David McCandless, Jr., A.I.A.
Planergy, Inc.

The total use of energy required in a commercial building for providing the proper environmental conditions of temperature, humidity, light and fresh air, involves not only the mechanical systems and services within the facility, but also the entire BUILDING ENVELOPE which must CONTAIN that man made environment and EXCLUDE the often adverse outside conditions.

Total energy management in a commercial building, therefore, must take into account all the possible ways that conductive and convective heat losses and gains, outdoors-to-indoors and indoors-to-outdoors, can occur through the BUILDING ENVELOPE, through the seasons of the year. It must also consider solar heat gains, helpful in winter and unwanted in summer. And, because of the oftentimes functional complexities of a commercial building, energy management should extend also to the separation of the environmental zones inside that building envelope.

A total energy management program must begin with a thorough energy audit of the commercial building and all its systems, not the least of which is the building envelope. That audit begins with a very thorough examination of all the physical conditions of the building which are subject to heat transfer. The items of that examination relate to those listed in the final section of this chapter under Dollar Savings Opportunities.

All the items found to exist in the basic audit, whether or not in need of repair or installation, should be scheduled for re-examination on an appropriate periodic basis so that cost-effective and energy-effective maintenance is achieved. This scheduling may be computerized as part of the overall building Energy Management Program. The conditions and effects of the building envelope would, in that way, become part of the monthly energy consumption analysis.

There are many small ways to conserve energy in the building envelope, as well as larger, more expensive improvements which can be made, and it is important to put these opportunities into some overall perspective. From the broad point of view there are five major areas of concern. They are, in order of importance for existing building considerations:

1. Reduction of infiltration and exfiltration
2. Reduction of solar heat gain through windows
3. Reduction of heat loss through windows
4. Reduction of heat gain and loss through walls, roofs, etc.
5. Reduction of internal heat transfer

A general analysis of each of these five subjects is presented in the discussion which follows. Some specific conditions are cited, but a more complete list of possible steps in energy conservation, especially for the many small efforts which add up to meaningful savings, are listed in the final section of this chapter under Dollar Savings Opportunities.

Infiltration and Exfiltration

The need for a large portion of the energy used for heating and cooling a typical commercial building results from the heat gains and losses through the building envelope. In the "typical" commercial building the major portion of that occurs as infiltration and exfiltration--air leakage through all kinds of cracks and crevices in the building envelope.

Outside air can leak through cracks around operative window sashes and doors, between the door or window frames and the wall materials they are set in, and through joints in the basic wall construction, especially in panelized wall systems.

There are many types of building exterior treatment and the chances for leakage in and out of the building envelope vary accordingly. Consider, for example, the increasing amount of crack-footage in the following list of facade-types:

a. Individual windows set in brick walls
b. Bands of windows set in brick walls
c. Precast panel systems, windows in some panels
d. Curtain wall treatment on 2 sides only
e. Curtain wall treatment on all 4 sides

At the same time consider the quality of the installation and the caulking materials used. These can vary from good to poor, and caulkings can change in quality with age. Happily, most of the curtain wall systems have very good details for holding the glass and for preventing leakage.

Infiltration and exfiltration vary with wind velocities and wind pressure, both positive and negative, on different sides of the building. Air pressures inside the building envelope can also be positive and/or negative, and these can combine with the exterior conditions to induce leakage wherever the potential exists.

There is also a stack effect in tall buildings, especially in such vertical spaces as stairways, elevators, and mechanical service shafts. Since warm air tends to rise, when outside air is cold there is a strong potential for infiltration at the bottom floors and exfiltration at the top.

Caulking between fixed systems and weather-stripping of movable window sashes and doors are the major means of reducing infiltration and exfiltration in the building envelope. There are probably as many types of caulking and weather-stripping materials as there are types of cracks to be filled. In general, the non-hardening, surface-skinning types of caulkings are best. Caulkings must have permanent adherence and should be chosen according to surfaces involved, and these surfaces must be clean and dry. For wide cracks a filler, or backer-rod can be used before the caulking. Weather-stripping includes compressible, closed cell foam, compressible "tubular" systems, and interlocking metal strip systems. Since there are so many different conditions which can exist for caulkings and weather-stripping it is wise to get expert advice on the subject.

Storm windows are often used to increase the thermal resistance through glass. Double glazing is also used for this purpose, but the storm window units have an advantage, generally, in increased control over leakage of air around the window frames. Depending on window framing and installation details, storm windows in secondary frames are usually more energy conserving than double glazing in a single frame, and they are often easier to accommodate in existing conditions.

Some examples of infiltration rates might illustrate the seriousness of this leakage which we cannot see and only rarely feel except in the utility bills.

infiltration

rate of
infiltration
thru window
frames

fig. 18

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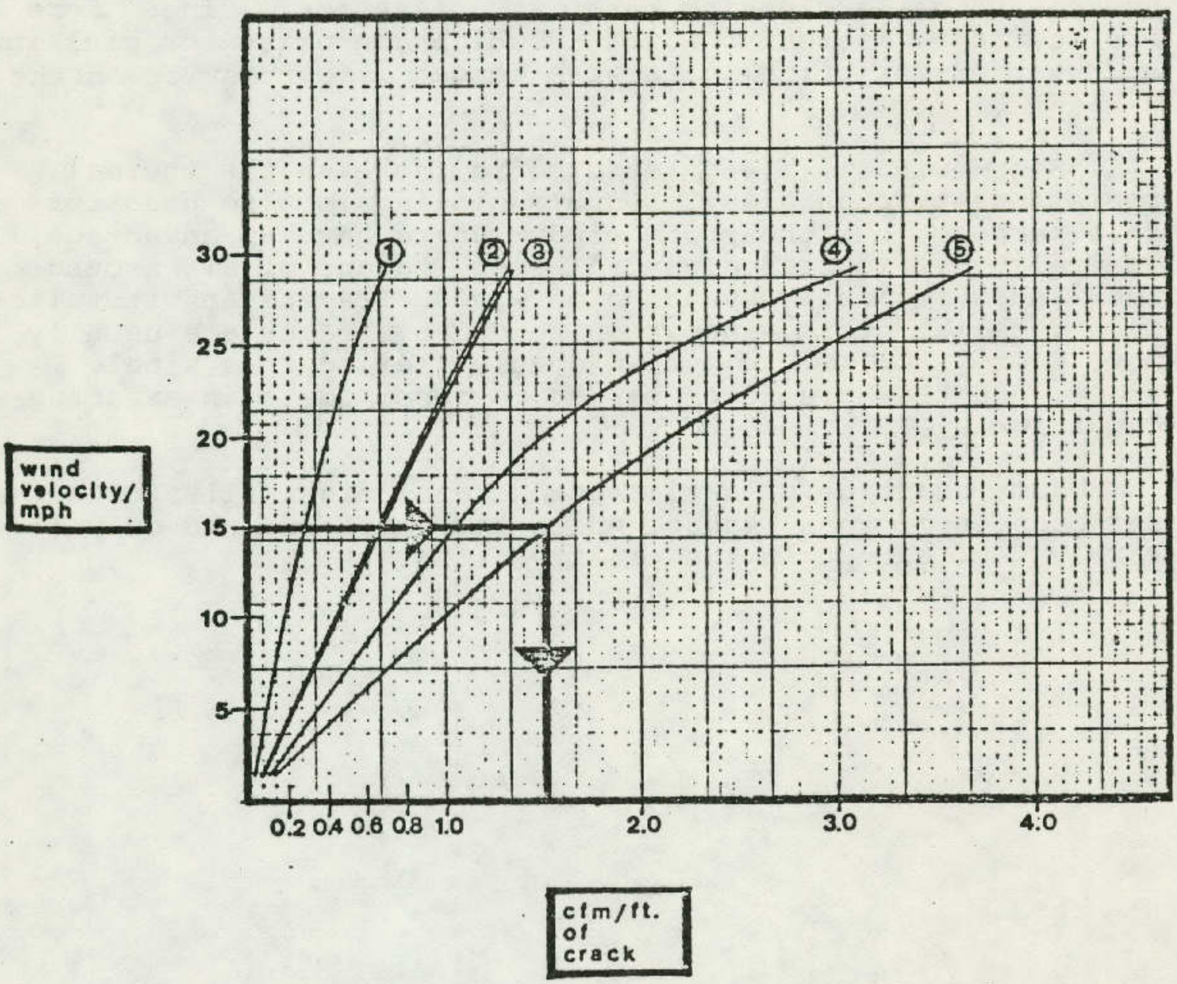
key to window infiltration chart			
(leakage between sash & frame)			
type ...	material	weatherstripped?	fit
① all hinged	wood metal	yes yes	avg. avg.
② all hinged dbl. hung	wood metal steel	no no no	avg. avg. avg.
③ all dbl. hung	wood steel	yes yes	loose avg.
④ casement	steel	no	avg.
⑤ all hinged	wood	no	loose



1. Window Leakage

Data from the a Building Audit:
Indoor Temperature 70
Winter Degree Days, Dallas, 2400
Winter Design Temperature, Dallas 19
Wind Speed 15 mph
Wind Direction N.W.
Window Dimensions, Sash: 3' x 2'
Window Type: Fixed glass with movable sash vent at bottom; steel frame without weather-stripping
Note: 30 windows per floor
Window perimeter - 10' per window
Total such crack length = 300' feet
From Figure 18, type 2: infiltration rate thru frame = 0.65 CFM/ft.
Total Infiltration due to cracks: 0.65 x 300 ft. = 195 CFM
Total Infiltration in one 24 hour period:
195 x 60 minutes x 24 hours = 280,800 cu. ft.

To put this in perspective, note: that there are about 202,000 cu. ft. of volume in a GOODYEAR BLIMP. Therefore, about 1.4 BLIMPS of AIR leak through the operable sash of the windows on the one floor of the building every day.

2. Door Leakage

Assume a typical 3' x 7' metal exit door. Assume also, for sake of simplicity, a ½ inch crack around all four sides.

Total crack = 3' + 7' + 3' + 7' = 20' long
Each foot of crack = 1 square inch air space
20 x 1 sq. inch = 20 sq. inch air space
Total crack is equivalent to a 4" x 5" hole in the door.

Further:
Assuming: infiltration rate = 1.5 CFM/ft.
Total infiltration = 20 x 1.5 = 30 CFM
1 day infiltration = 30 x 60 x 24 = 43,200 Cu.Ft.
For 5 such doors: 5 x 43,200 = 216,000 cu.ft.
216,000 = over 1 BLIMP per DAY 202,000

3. Electric Outlets

Research on infiltration in residential construction, conducted by the Texas Power and Light Company has shown that 20% of the leakage occurs through the wall outlets. This is a little more than the 19% for all the windows and doors combined in the "typical" houses measured. This 20% infiltration is from air that gets into the building framing system through various exterior cracks and "breathing" space, and travels along the paths of electrical runs and piping.

The building envelope of some buildings, especially one and two story structures, and some curtain wall systems, are undoubtedly similar in external and internal wall leakage.

Besides the opportunity to reduce air leakage through external caulkings of the wall structure system there is a type of gasket that can be placed behind the electrical outlet covers and switch plates. These gaskets, called Outlet Energy Savers, are a 3/16 inch open cell foam material, die cut to fit standard duplex receptacles and switches. When installed behind the face plates, these gaskets reduce air leakage significantly.

Solar Heat Gain

Heat gains from solar radiation through windows in Texas buildings can have a major impact on energy use, depending on such factors as orientation, exposure and shading, winter and summer, types of glass and glass treatment. Since Texas is in the southern part of this country where winters are not so severe, the need of cooling due to heat gain through windows is much more significant than for heating due to heat losses in the winter. This can be seen by a comparison of Figures 32 and 48 (from ECM-2), which show yearly heat losses and gains per sq. ft. of glass, for Houston and eleven other U.S. cities. The yearly heat gains indicated include both solar and conduction loads.

There is so much more heat gain from solar radiation than from conduction through the glass that radiative gains must be solved before considering the conductive heat transfer through the glass. When double glazing is then considered for reducing summer heat gains there will also be a real benefit in controlling heat losses in the winter season.

The effects of orientation are different for winter and summer. In winter the sun rises a little south of east, is low in the south sky at noon, and it sets correspondingly south of west. This sun movement allows a little east and west wall solar heat gain in the morning and afternoon, respectively,

YEARLY HEAT LOSS/SQUARE FOOT OF SINGLE GLAZING AND DOUBLE GLAZING

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH WINDOW BTU/FT.^{2} YEAR					
				NORTH		EAST & WEST		SOUTH	
				SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
MINNEAPOLIS	45°N	325	8,382	187,362	94,419	161,707	84,936	140,428	74,865
CONCORD, N.H.	43°N	300	7,000	158,770	83,861	136,073	73,303	122,144	67,586
DENVER	40°N	425	6,283	136,452	70,449	117,487	62,437	109,365	59,481
CHICAGO	42°N	350	6,155	147,252	75,196	126,838	65,810	110,035	58,632
ST. LOUIS	39°N	375	4,900	109,915	56,054	94,205	49,355	84,399	45,398
NEW YORK	41°N	350	4,871	109,672	54,986	93,700	48,611	82,769	44,580
SAN FRANCISCO	38°N	410	3,015	49,600	25,649	43,866	23,704	41,691	23,239
ATLANTA	34°N	390	2,983	63,509	31,992	55,155	28,801	51,837	28,092
LOS ANGELES	34°N	470	2,061	21,059	11,532	19,487	10,954	19,485	10,989
PHOENIX	33°N	520	1,765	25,951	14,381	22,381	12,885	22,488	12,810
HOUSTON	30°N	430	1,600	33,599	17,939	30,744	17,053	30,200	16,861
MIAMI	26°N	451	141	1,404	742	1,345	742	1,345	742

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fig. 32

YEARLY HEAT GAIN/SQUARE FOOT OF SINGLE GLAZING AND DOUBLE GLAZING

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH WINDOW BTU/FT.^{2} YEAR					
				NORTH		EAST & WEST		SOUTH	
				SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
MINNEAPOLIS	45°N	325	2,500	36,579	33,089	98,158	88,200	82,597	70,729
CONCORD, N.H.	43°N	300	1,750	33,481	30,080	91,684	82,263	88,609	76,517
DENVER	40°N	425	4,055	44,764	39,762	122,038	108,918	100,594	85,571
CHICAGO	42°N	350	3,100	35,595	31,303	93,692	83,199	87,017	74,497
ST. LOUIS	39°N	375	6,400	55,242	45,648	130,018	112,368	103,606	85,221
NEW YORK	41°N	350	3,000	40,883	35,645	109,750	97,253	118,454	102,435
SAN FRANCISCO	38°N	410	3,000	29,373	28,375	88,699	81,514	73,087	64,169
ATLANTA	34°N	390	9,400	59,559	50,580	147,654	129,391	106,163	87,991
LOS ANGELES	34°N	470	2,000	47,912	43,264	126,055	112,869	112,234	97,284
PHOENIX	33°N	520	24,448	137,771	97,565	242,586	191,040	211,603	131,558
HOUSTON	30°N	430	11,500	88,334	72,474	213,739	184,459	188,718	156,842
MIAMI	26°N	451	10,771	98,496	79,392	237,763	203,356	215,382	179,376

fig. 48

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and a lot of mid-day sun on the south walls and into south facing windows. In the summer, the sun rises a little north of east and it sets a little north of west, and at noon it is high overhead, barely shining on southerly walls and windows. Summer solar radiation, therefore, is more severe on eastern and western exposures and not so serious on southern exposures. North facing walls and windows get no sunshine in the winter and only early morning and later afternoon angular exposure to the sun in the summer.

Exterior architectural shading for windows must relate to these sun angles. On the east and west elevations such devices must be vertical, the full height of the windows, sometimes adjustable for the actual orientation and time of day. For south facing windows roof overhangs and horizontal, projecting "eyebrows", over each band of windows can be designed for complete summer shading yet allow winter solar gains. Such shading devices, when used, are usually part of the original design and construction. They are only occasionally installed on existing structures.

External shading devices are the most effective method of controlling solar heat gain because they prevent the sun from shining directly on the glass. There are some external louvered sun screens available which can be fixed to the window openings, and which provide meaningful shading, as shown in Figure 22 (from ECM-1) which indicates the shading coefficients for types of glass and shading devices. Sometimes these sun screens can be removed to allow winter solar heat gain.

Internal shading devices include drapes, venetian blinds, vertical louver blinds, roller blinds, and variations of these basic types. While less effective than other methods of solar heat gain, internal shades are relatively inexpensive and they are much more easily adjustable to the times of most solar gain and to the needs for light and view.

Tinted or reflective glass, and reflective polyester films applied to the inside of the glass may also be used to reduce solar heat gain. The tinted or reflective glass can be used to replace existing glass or to create double glazing (storm windows). The films are self-adhesive but require special care in application. With storm windows the film should be on the inner face of the outside layer of glass (do not put it on the inner glass or the reflected heat will be trapped).

An example of solar heat gain reduction involves the application of reflective solar film to 10,000 sq. ft. of east, south, and west windows in a 10 story office building in Miami, Florida. The annual energy savings calculated was 15% with a pay-back of just over 2 years.

fig. 22

SHADING COEFFICIENTS

GLASS	
1/8" Clear Double Strength	1.00
1/4" Clear Plate	0.93 - 0.95
1/4" Heat Absorbing Plate	0.65 - 0.70
1/4" Reflective Plate	0.23 - 0.56
1/4" Laminated Reflective	0.28 - 0.42
1" Clear Insulating Plate	0.80 - 0.83
1" Heat Absorbing Insulating Plate	0.43 - 0.45
1" Reflective Insulating Plate	0.13 - 0.31

SHADING DEVICE	WITH 1/4" CLEAR PLATE GLASS	WITH 1" CLEAR INSULATING GLASS
Venetian Blinds - Light Colored, Fully Closed	0.55	0.51
Roller Shade - Light Colored, Translucent, Fully Drawn	0.39	0.37
Drapes - Semi-Open Weave, Average Fabric Transmittance and Reflectance, Fully Closed	0.55	0.48
Reflective Polyester Film	0.24	0.20
Louvered Sun Screens - 23 Louvers/In.	0.15 - 0.35	0.10 - 0.29
- 17 Louvers/In.	0.18 - 0.51	0.12 - 0.45

In winter solar heat gain is beneficial and its usefulness must be balanced against solar gains in the summer, according to orientation, types of glass, reflective films, latitude, solar control devices and percentage of sunshine. Note that about 10% less sunlight penetrates double glazing than single glazing. However, double glazing reduces the heat load due to conduction, and the benefits from this more than offset the loss of solar radiation.

Heat Loss Through Windows

On the national scale it has been estimated that 20% of our energy goes to space conditioning in residential and commercial buildings. Of this, 25% results from heat losses and gains due to the relatively high thermal conductivity of windows -- an energy use equivalent to an average of 1.7 million barrels of oil a day.

Although, as was pointed out earlier, there is in Texas more of an energy concern for heat gain in summer than there is for heat loss through glass in winter, the heat loss is still significant. And there are some things which can be done to help save energy in this regard in Texas buildings.

The rate of conductive heat flow through various parts of the building envelope (glass, walls, roof, floors, etc.) is expressed as a "U"-value. This rating is in units of BTU's/hour/square foot of surface/degree F. of temperature difference inside to outside. The lower the U-value the higher the insulating value of the construction rated. Typical wall and roof construction vary from U=.4 down to U=.04 depending on the basic structural materials and the type and thickness of the insulation used. Single panes of glass in still air (less than 15 mph) have a U-value of 1.13. Double glazing reduces the U-value to about .55.

These values show that we should have a greater concern for heat flow through glass than through the "solid" parts of the building envelope, the exterior walls, the roof, and floors over unheated space. It is helpful to put this difference into some sort of perspective. We can do this by comparing their U-values and what would be equivalent areas for the same transmission of BTU's per hour.

Let us assume the following reasonable U-values for two windows and a wall:

a. Window with single glass: 1.1 U-value
b. Window with double glass: .55 U-value
c. inside = gypsumboard
insulation = R-17
wall .055 U-value
exterior = sheathing
plus wood panel, painted

We can see that the rate of heat flow through the solid wall is one-tenth that of the double glazed window which in turn is one half that of the single glass. Since this transmission rating is on a square foot basis we can also see that the same amount of heat would be transmitted through:

a. a single glass window: 2.5' x 4' = 10 sq.ft.
b. a double glazed window: 5' x 4' = 20 sq.ft.
c. the solid wall: 10' x 20' = 200 sq.ft.

Let us put these area comparisons into a little further perspective by relating them to the five types of exterior treatment discussed above in the section on infiltration. If individual windows set in a brick wall add up to only one tenth of the total wall area, and if the windows are double glazed, the heat transfer through wall and windows is equivalent. If those windows are in continuous bands they would probably equal about a third of the wall area, so there would obviously be more conductive heat gain and loss through the glass than through the solid wall. Precast panels with windows set into one of every five panels might still have glass areas equivalent to that of the basic brick design. In considering the curtain wall construction, if we assume that the spandrel panels are on opaque glass treatment, or some material of equivalent heat transmission, then the back up construction should include adequate insulation to achieve an appropriately low U-value for the full wall construction. In an all-glass building built before the national energy crisis began, it is very likely that the insulation behind the spandrel panels is inadequate by today's energy conservation standards.

As discussed above, using double glazing will reduce the conduction heat loss of single glazing by one half, but this will occasionally be modified somewhat by solar radiation and wind, and therefore by orientation. Wind destroys the exterior "air film" on the glass and this causes the U-value of the window to increase. Shutters, screens, trees, and other shielding devices will reduce this wind effect somewhat.

It is often easier to add storm windows to existing windows than it is to change to double glazing in the original frame. The choice will vary with the physical conditions, the present needs and replacement plans, etc., for each building. The use of storm windows may provide greater reduction in heat transfer through the windows because of the greater air space, and storm windows should give more control over air infiltration because of the second frame set tightly in the window opening.

The use of the various types of drapes, blinds, appropriate linings, etc. to cover the windows when not needed for light or view will also help reduce heat flow through windows. An added advantage provided by the drapes is that they will improve the Mean Radiant Temperature in a room or office.

The occupant will not feel so easily the "cold window" in the winter or the"heat from the window" in the summer. Eliminating this human response to radiant heat flow toward or from the glass will preclude the occupants' need for more heat or more cooling for human comfort.

When rooms or zones of the building are unused or closed off, the thermal transmission through the windows, in both winter and summer, can be meaningfully reduced by closing off the windows with various types of thermal barriers. Depending on the time the space is to be closed off, and on how the space heating and cooling is to be maintained, the thermal barriers can range from simple drapes and blinds to storm windows and even opaque, insulated panels.

Heat Flow Through Walls, Roof, Floors

In energy conservation we are concerned with the rate of conductive heat flow through various types of building construction. This is the "U"-value of each complete construction, inside-to-outside, including air films, as discussed above. By contrast, we are also concerned with thermal resistance of materials such as insulation, masonry, wood, plaster, etc. to heat flow through them. The thermal resistance of a material is its "R" value. The R-value of all materials in a wall construction can be added, and the resulting total R-value is the reciprocal of the U-value of the whole construction.

This relationship of the U-value to the total R-value, and then to the R-values of the parts of a construction, is meaningful in discussing the improvements that might be achieved by the addition of certain insulation materials. They are commercially rated by their R-values, even though we usually use the U-value as a rating of the total construction.

It is best to remember simply:

a. the higher the R-value, the better the "insulation"

and

b. the lower the U-value, the better the "insulation" of the whole construction.

For most constructions of walls, and also for roofs, the basic structural materials by themselves are inadequate as thermal barriers and various amounts and types of insulation are included in their design. Part of the physical examination of the building envelope in the basic energy audit of and existing building should be an analysis of the plans, details, and specifications of its construction to determine the resistance to heat flow of its many parts. This should be done for the various details of wall and roof construction, and for any floors over unconditioned spaces.

For most of Texas the heat gain of summer will be more of an energy concern than the heat loss in winter, but there are enough variables to consider that this should be determined for each situation. These variables include latitude, solar radiation, "degree hours" above 80°F, winter "degree days", building and wall orientation, surface heat absorption coefficients, seasonal wind patterns and velocities, as well as the theoretical U-value of each construction. A comparison of data, including yearly heat gains and heat losses, for walls and for roofs, in the city Houston, as shown in Figures 36, 40, 52 and 56, shows variations with these factors.

The mass of a wall does not give it a better, lower, U-value, per se. Mass simply provides a form of thermal inertia: it slows up the heat transfer and delays the impact of outdoor temperature changes on the inside conditioned space. The time delay allows the wall to act dynamically as a thermal storage system, smoothing out peaks in heat flow and reducing yearly heat loss somewhat. High mass walls of 80 to 90 lbs/sq. ft. have approximately 2% less yearly heat loss (or gain) than low mass walls of 10 to 20 lbs/sq.ft., assuming the same U-value and absorption coefficient for both walls.

When it is determined that the U-value of a wall should be lowered as an energy conservation measure, one naturally looks for methods to increase the insulation of the wall. It is seldom possible to do this without going to some extreme measures, such as removing the interior wall surfaces (gypsum board or plaster, usually) and then adding appropriately high R-value insulation before resurfacing the walls.

It is also possible to add insulation with a new facing over existing surfaces, as is shown in the following detail. When added to the exterior the treatment will have to be weathersealed and vapor-proofed, and it will give an entirely new look to the building unless a similar facing existed before. Such exterior treatment is feasible for low-rise structures, and difficult for tall buildings, and it causes little disruption inside.

YEARLY HEAT LOSS/SQUARE FOOT THROUGH WALLS

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH WALLS BTU/FT.² YEAR — NORTH U=0.39 a=0.3	NORTH U=0.39 a=0.8	NORTH U=0.1 a=0.3	NORTH U=0.1 a=0.8	EAST & WEST U=0.39 a=0.3	EAST & WEST U=0.39 a=0.8	EAST & WEST U=0.1 a=0.3	EAST & WEST U=0.1 a=0.8	SOUTH U=0.39 a=0.3	SOUTH U=0.39 a=0.8	SOUTH U=0.1 a=0.3	SOUTH U=0.1 a=0.8
MINNEAPOLIS	45°N	325	8,382	74,423	70,651	20,452	19,335	70,560	62,229	19,378	16,787	66,066	51,298	18,109	13,530
CONCORD, N.H.	43°N	300	7,000	68,759	64,826	18,895	17,714	64,674	55,363	17,743	14,972	59,759	43,667	16,370	11,344
DENV[illegible]	40°N	425	6,283	57,337	53,943	15,755	14,824	53,726	44,937	14,763	12,198	48,780	34,095	13,405	8,720
CHIC[illegible]O	42°N	350	6,155	58,516	55,356	16,081	15,210	55,219	47,678	15,169	12,865	50,684	37,339	13,847	9,743
ST. [illegible]IS	39°N	375	4,900	45,046	42,149	12,379	11,565	41,981	35,192	11,533	9,476	38,038	26,344	10,425	6,660
NEW [illegible]RK	41°N	350	4,871	45,906	42,950	12,615	11,804	42,843	35,368	11,774	9,594	38,385	25,231	10,548	6,406
SAN [illegible]ANCISCO	38°N	410	3,015	23,258	21,120	6,392	5,803	20,916	15,631	5,748	4,118	16,948	9,812	4,645	1,743
ATLA[illegible]A	34°N	390	2,983	26,922	24,803	7,398	6,771	24,475	19,206	6,716	5,103	20,639	12,399	5,562	2,587
LOS [illegible]GELES	34°N	470	2,061	9,900	8,549	2,720	2,349	8,392	5,758	2,306	1,316	6,139	3,040	1,520	155
PHOE[illegible]X	33°N	520	1,765	11,861	10,533	3,259	2,878	10,283	7,316	2,826	1,811	8,077	4,619	2,062	555
HOUS[illegible]N	30°N	430	1,600	14,592	12,956	4,011	3,557	12,888	9,379	3,542	2,351	10,878	6,760	2,909	1,142
MIAMI	26°N	451	141	210	106	7	0	92	0	0	0	6	0	0	0

fig. 36

YEARLY HEAT LOSS/SQUARE FOOT THROUGH ROOF

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH ROOF BTU/FT.^{2} YEAR			
				U=0.19		U=0.12	
				a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	8,382	35,250	30,967	21,330	18,642
CONCORD, N.H.	43°N	300	7,000	32,462	27,678	19,649	16,625
DENVER	40°N	425	6,283	26,794	22,483	16,226	13,496
CHICAGO	42°N	350	6,155	27,489	23,590	16,633	14,190
ST. LOUIS	39°N	375	4,900	20,975	17,438	12,692	10,457
NEW YORK	41°N	350	4,871	21,325	17,325	12,911	10,416
SAN FRANCISCO	38°N	410	3,015	10,551	8,091	6,381	4,784
ATLANTA	34°N	390	2,983	12,601	9,841	7,619	5,832
LOS ANGELES	34°N	470	2,061	4,632	3,696	2,790	2,142
PHOENIX	33°N	520	1,765	5,791	4,723	3,487	2,756
HOUSTON	30°N	430	1,600	6,045	4,796	3,616	2,778
MIAMI	26°N	451	141	259	130	139	55

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fig. 40

YEARLY HEAT GAIN/SQUARE FOOT THROUGH WALLS

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH WALLS BTU/FT.^{2} YEAR											
				NORTH				EAST & WEST				SOUTH			
				U=0.39		U=0.1		U=0.39		U=0.1		U=0.39		U=0.1	
				a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	2,500	364	2,442	19	390	1,346	7,665	164	1,747	1,601	7,439	164	1,574
CONCORD, N.H.	43°N	300	1,750	141	1,950	0	180	787	6,476	41	1,264	1,222	7,093	59	1,179
DENVER	40°N	425	4,055	321	2,476	0	291	1,361	8,450	66	1,597	1,513	8,138	78	1,301
CHICAGO	42°N	350	3,100	503	2,500	46	429	1,492	7,889	233	1,835	1,698	8,088	225	1,793
ST. LOUIS	39°N	375	6,400	2,246	5,966	419	1,386	4,165	14,116	950	3,571	3,994	12,476	779	3,074
NEW YORK	41°N	350	3,000	906	3,751	103	820	2,394	10,278	477	2,651	2,626	11,185	420	2,707
SAN FRANCISCO	38°N	410	3,000	0	0	0	0	0	3,268	0	262	43	3,459	0	297
ATLANTA	34°N	390	9,400	1,901	5,806	309	1,301	3,882	14,658	812	3,609	3,422	12,085	634	2,897
LOS ANGELES	34°N	470	2,000	0	774	0	10	180	6,575	0	889	527	7,182	0	980
PHOENIX	33°N	520	24,448	17,448	24,423	4,749	6,526	21,461	36,937	5,784	9,868	20,880	34,728	5,502	9,322
HOUSTON	30°N	430	11,500	5,002	10,687	1,178	2,643	7,895	22,431	1,981	5,521	6,985	20,893	1,605	4,713
MIAMI	26°N	451	10,771	7,507	15,717	1,912	4,052	12,358	31,745	3,164	8,416	11,778	29,906	2,814	8,057

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fig. 52

YEARLY HEAT GAIN/SQUARE FOOT THROUGH ROOF

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH ROOF BTU/FT.² YEAR			
				U=0.19		U=0.12	
				a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	2,500	2,008	8,139	1,119	4,728
CONCORD, N.H.	43°N	300	1,750	1,891	7,379	1,043	4,257
DENVER	40°N	425	4,055	2,458	9,859	1,348	5,680
CHICAGO	42°N	350	3,100	2,104	7,918	1,185	4,620
ST. LOUIS	39°N	375	6,400	4,059	12,075	2,326	7,131
NEW YORK	41°N	350	3,000	2,696	9,274	1,543	5,465
SAN FRANCISCO	38°N	410	3,000	566	5,914	265	3,354
ATLANTA	34°N	390	9,400	4,354	14,060	2,482	8,276
LOS ANGELES	34°N	470	2,000	1,733	10,025	921	5,759
PHOENIX	33°N	520	24,448	12,149	24,385	7,258	14,649
HOUSTON	30°N	430	11,500	7,255	20,931	4,176	12,369
MIAMI	26°N	451	10,771	9,009	24,594	5,315	14,716

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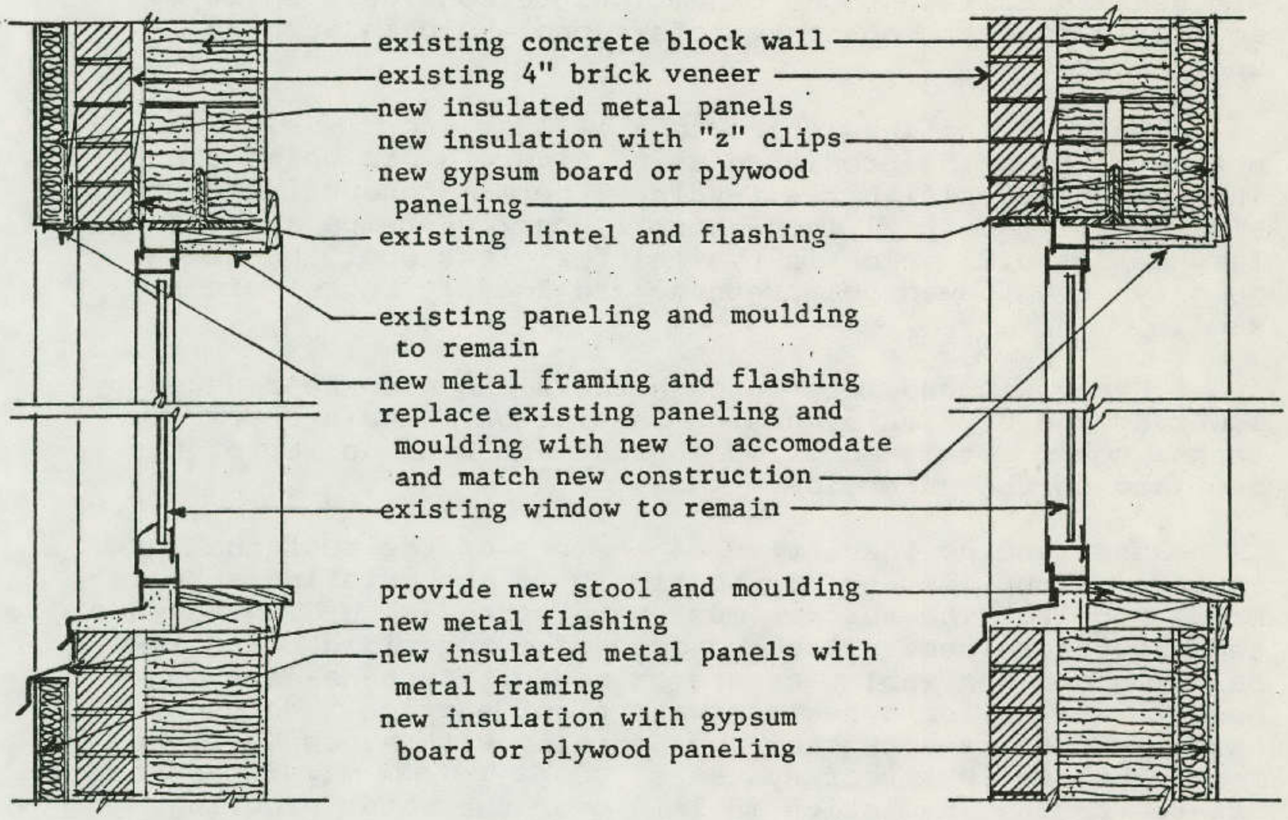
fig. 56



Insulation on exterior face

Insulation on interior face

When added to the interior, such treatment is easier in tall buildings but it is disruptive to normal operations. In either case there are likely to be architectural and mechanical complications not readily discernable, and there are usually building code conditions to consider, so it is advisable to get competent professional help in such an undertaking.

When adding insulation to a wall of known U-value the new U-value can be predicted using Figure 37 in which the insulation material has a K-value (thermal conductivity, in BTU's per 1 sq. ft./1 inch thick/1 hour/1°F temperature difference) of 0.25 which is typical for glass wool, beaded polystyrene, foamed polyurethane and loosely packed mineral wool.

Heat gain and loss through roofs can also be reduced by lowering the U-value by adding insulation. Again there are techniques for this additional treatment both on top of the roof and on the underside.

When adding insulation to the top of the roof the work is less disruptive and may be timely if the existing surface needs repair. The surface must be prepared according to what techniques are used. Both sprayed foam and rigid board insulation are available for use on roofs. Each has its own best treatment for a new top waterproof surface. When the existing roof is acceptable, especially with a new built-up roof, the new IRMA roof system of Dow Styrofoam may be appropriate, as the insulation is laid over the water proofing, shielding it from the sun's heat. Each case should be given the guidance of professional consultation.

Adding insulation below the roof structure may be achieved by applying it to the underside of that structure by spray application or with fitted pieces of insulation board. The complications of working above and around existing utility lines, pipes, ducts and structural members may be the determining factors involved. The need for insulating the pipes, ducts, etc., should not be overlooked, nor should their location in the attic space allow some area of the roof underside to go untreated. If the insulation is laid over the existing ceiling it is important to consider the pipe and duct insulation and possibly the need for attic ventilation.

As a rule of thumb, the inches of duct insulation required is one fifteenth of the temperature difference between the conditioned air inside the duct and the unconditioned air in the attic space.

heating

effect of insulation on 'u' value

fig. 37

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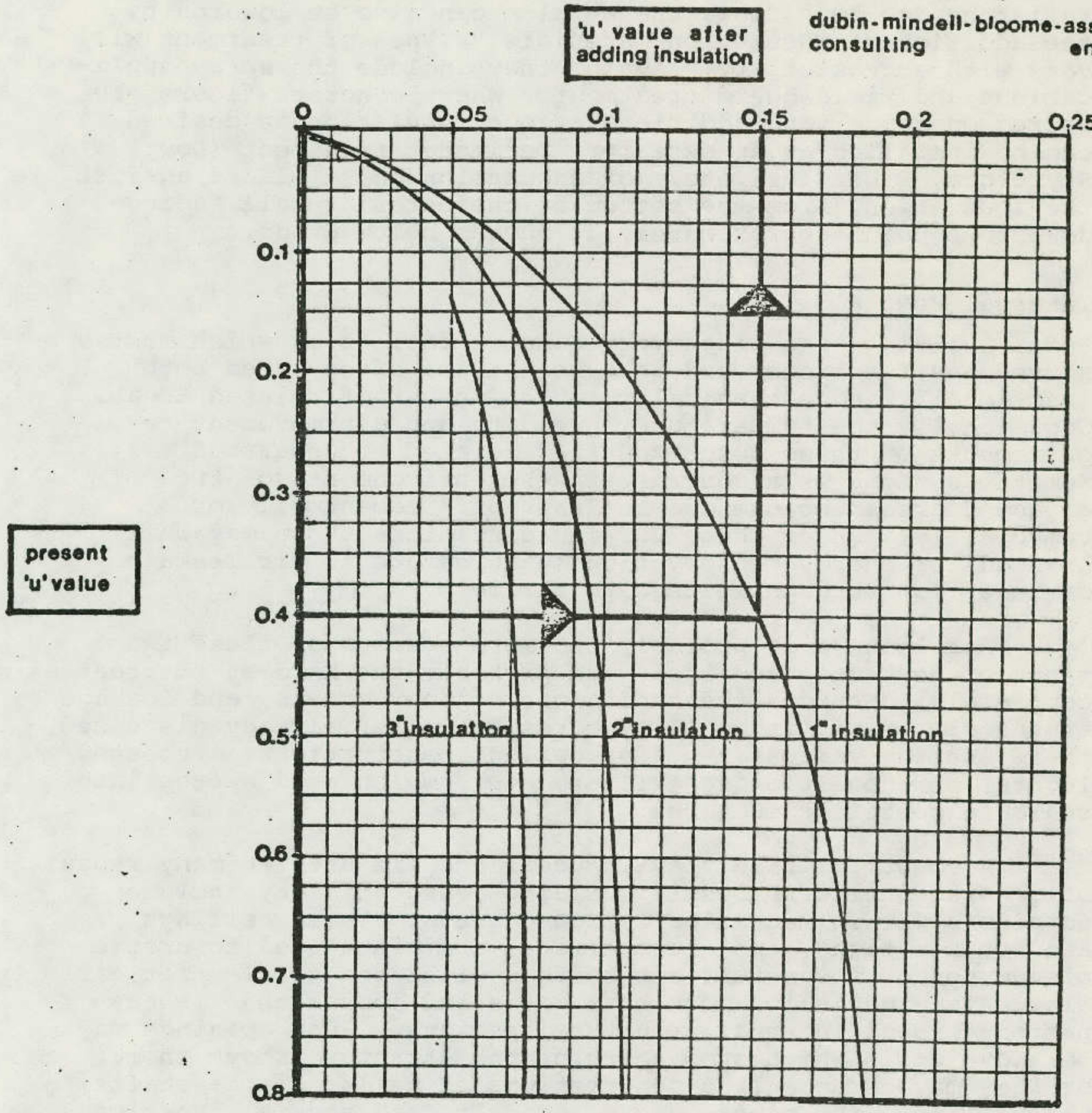


When floors over unconditioned spaces (crawl spaces, vented and unvented; pipe and mechanical spaces, rough storage spaces; outdoor spaces) are deemed to have inadequate resistance to heat flow, the U-value can also be lowered by the addition of insulation materials. Types of treatment will vary with accessibility. Again, they include the spray applications and rigid board treatment. Where concrete floors are poured on grade, and additional floor insulation is desired it can be installed as an exterior, perimeter treatment (Dow Styrofoam, Fiberglas, etc.) of insulation board placed against the foundation, from the bottom of the exterior wall facing down to a point approximately 24 inches below grade.

Internal Heat Flow

Buildings are often very complex facilities which must house many functions, and as a result are often zoned both functionally and mechanically into a number of related areas. Occasionally the temperature, humidity and air movement requirements of these zones must be isolated or separated. Sometimes there is a contrast in the environments of two adjacent areas because one is "shut-off" momentarily or temporarily. Under these varying conditions there may well be need for energy conservation measures due to air leakage or heat flow through inadequate barriers.

Air leakage is probably the more serious of these two types of heat gain and loss, and probably the hardest to treat completely. Besides the conditions of door cracks, and leakage around electrical and utility boxes in walls, already discussed, there are the various types of ceiling penetrations: recessed lights, air conditioning grilles, etc., which need appropriate seals in certain situations.

Accoustical tile "lay-in" ceilings are used in many types of general public spaces in buildings, and this may include corridors within mechanically zoned areas. These ceilings are not air tight, and, furthermore, are often used to create plenum spaces for return air systems with open grilles for air flow. They may allow more heat gains and losses than is suspected through internal structure openings. Such openings may be above walls which stop short of the structure above them; or they may be uncaulked penetrations of walls, slabs, shafts, chases, etc., for pipes, ducts, conduit, and special function services.

By its very nature, the construction of a commercial building must accommodate many mechanical systems and services, and plenums, shafts and pipe chases must be used. Many types of wall penetrations and openings which cannot be seen above ceilings do occur.

The mechanical systems engineer for the building may be the first to suspect energy losses through such hidden paths of internal leakage: they may even be causing imbalances in his systems. Such leakage should be investigated by him and by the maintenance personnel, both on a "suspicion" basis and in the basic energy audit of the building, and treatment should be performed according to what is found.

Conductive heat flow through walls, floors, ceilings, and such internal barriers, will be of concern only when one area is much hotter or much colder than the adjacent occupied space. Such conditions should be anticipated by the building staff, especially the mechanical systems engineer and those responsible for the energy management program for the facility. They should be able to plan accordingly, even to the installation of additional insulation treatment, as well as control of air leakage.

Conclusions

While many small efforts can be made for energy conservation in the existing building envelope, some of the more complicated measures are both expensive and disruptive. Such treatment should not be viewed with dismay. Not only can the expensive, disruptive opportunities for energy conservation be planned to be carried out in any remodelling which goes with expansion, but also the experience of energy audits and total energy management can make a major impact on the planning of future facilities.

The importance of controlling (1) INFILTRATION AND EXFILTRATION, and (2) SOLAR HEAT GAIN should not be lost in considering the other concerns of this chapter. These two first concerns are the only two Major Energy Conservation Opportunities which related to the BUILDING ENVELOPE out of the 20 ECO's discussed in the very complete and detailed study, Guidelines for Saving Energy in Existing Buildings. This manual is divided into two parts: Building Owners and Operators Manual, ECM-1 and Engineers, Architects and Operators Manual, ECM-2. It was prepared by Dubin-Mindell-Bloome Associates for the Federal Energy Administration, 16 June 1975. Both volumes are available through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

DOLLAR SAVINGS OPPORTUNITIES

In a commercial building there are numerous Dollar Savings Opportunities (DSO's) which relate to the Building Envelope and its interior partitioning. These opportunities to save energy and operating costs range from changes in simple human habits to those in elementary maintenance, to those in major maintenance and even to substantial changes with justifiable payback. The simplest DSO's can sometimes be the most important as they relate to the big concerns of infiltration and solar gains.

In each case the DSO's presented below are arranged in order of energy conservation effectiveness as well as by minimal and significant cost.

A. Minimal Expense:

1. Replace broken or cracked window panes.
2. Replace worn or broken weather-stripping around operable windows. If possible, install weather-stripping where none was installed previously.
3. Weatherstrip operable sash if crack is evident.
4. Caulk around window frames (exterior and interior) if cracks are evident.
5. Rehang misaligned windows.
6. Be certain that all operable windows have sealing gaskets and cam latches that are in proper working order.
7. Replace any worn or broken weather-stripping on doors, and install weather-stripping where none was installed previously.
8. Rehang misaligned doors.
9. Caulk around all door frames.
10. Inspect all automatic door closers to ensure that they are functioning properly. Consider adjustments to enable faster closing.
11. Inspect gasketing of garage and other overhead doors. Repair, replace or install as necessary.
12. Caulk, gasket or otherwise weatherstrip all exterior joints, such as those between wall and foundation or wall and roof, and between wall panels.
13. Caulk, gasket or otherwise weatherstrip all openings, such as those provided for entrance of electrical conduits, piping, through-the-wall cooling and other units, outside air louvers, etc.

14. Where practical, cover all window and through-the-wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.
15. Inspect condition of indoor shading devices such as drapes and blinds which can reduce heat gain as much as 50%. Keep indoor shading devices clean and in good repair.
16. During the heating season, close all interior shading devices before leaving to reduce night time heat losses.
17. Use opaque or translucent insulating materials to block off and thermally seal all unused windows.
18. Consider posting a small sign next to each operable window instructing occupants not to open window while the building is being heated or cooled.
19. Consider placing a small sign next to each door leading to the exterior or unconditioned spaces advising occupants to keep door closed at all times when not in use.
20. Consider installing signs on exterior walls near delivery doors providing instructions to delivery personnel on operation of doors.
21. Establish rules for all building personnel regarding opening and closing of doors, directing them to keep them closed whenever possible.
22. Consider installing automatic door closers on all doors leading to exterior or unconditioned spaces.
23. If the building has a garage but does not have a garage door consider installing one, preferably motorized to enable easier opening and closing.
24. Consider use of a card-, key- or radio frequency-operated garage door which stays closed at all times except when in use.
25. Where roof insulation is not practical, consider insulating the top floor ceiling. This can be done easily with blown insulation. In most cases, ceiling insulation also will require a vapor barrier placed on the warm side of the ceiling - if not integral with the insulation - to prevent structural damage caused by rot, corrosion or expansion of freezing water.

26. If remodelling or modernization is contemplated consider adding insulation to all exterior walls as well as those which separate conditioned and nonconditioned spaces.
27. Add or improve insulation under floors, over garages, or in other unconditioned areas.
28. Repaint or clean exterior finish to improve reflective characteristics.
29. Repaint or resurface roof to make it more reflective.
30. Install baffles to prevent wind from blowing directly into an outdoor air intake.
31. Inspect electrical outlets, switches, and other recessed utility services for air infiltration and exfiltration and caulk or gasket, air-tight, as required.
32. Inspect recessed ceiling fixtures for air leakage and caulk as required.
33. Inspect lay-in ceiling systems and construction above such ceilings for infiltration, especially between interior zones of differently conditioned air, and seal walls, etc. as required.
34. Inspect skylights for air leakage; caulk and weatherstrip accordingly. Also consider the benefits and losses associated with light and solar heat gain in winter and in summer.
35. Provide window shades, blinds, and double glazing or storm windows to reduce the human comfort demands associated with adverse Mean Radiant Temperatures of glass in both winter and summer extremes.
36. Where water or moisture leakage occurs check also for air leakage, heat flow and damage to insulation or caulking materials.

B. Significant Expense

1. Install tight fitting storm windows where practical.
2. Consider adding reflective and/or heat-absorbing film to glazing to reduce solar heat gains by as much as 80%. Be aware that such films will reduce substantially the benefits of natural lighting and solar heat gain in winter.

3. Consider adding reflective materials to the window side of draperies to reflect solar heat when draperies are drawn.

4. Install indoor shading devices where none now exist, even if exterior shading devices are used. They should be light colored and opaque.

5. Consider installation of outdoor shading devices such as sunshades which reflect solar heat before it has a chance to enter the building, and which dissipate heat outdoors rather than indoors. Adjustable sunshades enable entrace of warming rays during the heating season.

6. Consider reglazing with double or triple-glazing, or with heat absorbing and/or reflective glazing materials.

7. Consider installation of insulating glass windows with adjustable shading louvers between the glass.

8. Consider adding roof deck insulation, especially if your building is 20 years old or older. Assuming that the roof-ceiling sandwich is not used as a return air plenum, a thermal transmission value (U-value) of 0.05 (maximum in Texas) BTU/Hr./Sq.Ft.(°F.) is considered to be an attainable goal through roof-ceiling sandwich.

   Note: In Texas, if the roof-ceiling sandwich is a return plenum, a roof deck U-value of 0.03 is suggested. This should be verified by the mechanical engineer for each such situation.

9. Consider making delivery entrances smaller. The larger the opening the greater the air infiltration when doors are open.

10. Consider using an expandable enclosure for delivery ports. It reduces infiltration when in use because it can be adjusted to meet the back of a truck reducing substantially the amount of air which otherwise would infiltrate.

11. Consider installation of an air curtain or a kinetic air barrier, especially in delivery areas. The device prevents penetration of unconditioned air by forcing a layer of air of pre-determined thickness and velocity over the entire entrance opening. (An expert in the field should be consulted

before obtaining such a device, especially when high rise structures are involved. The degree of stack effect, among other things, determines its usability.)

12. Consider installation of a vestibule for the front entrance of a building, where practical. It should be fitted with self-closing weather-stripped doors. It is critical that sufficient distance between doors is provided.
13. Consider using revolving doors for main access. Studies have shown that such devices allow far less air to infiltrate with each entrance or exit. Use of revolving doors in both elements of a vestibule is most effective. If high peak traffic is involved, swinging doors can be used to supplement revolving doors.
14. In locations where strong winds occur for long durations, consider installing wind screens to protect external doors from direct blast of prevailing winds. Screens can be opaque, constructed cheaply from concrete block, or can be transparent, constructed of metal framing with armored glass. Careful positioning is necessary for infiltration control.
15. Study developments in the glass industry on a regular basis, and consider changes where improvements in glazing materials or techniques appear to be both energy conserving and cost effective.

COEFFICIENT OF HEAT TRANSMISSION ("U")

OVERALL COEFFICIENT OF HEAT TRANSMISSION OR THERMAL TRANSMITTANCE (AIR TO AIR); THE TIME RATE OF HEAT FLOW USUALLY EXPRESSED IN BTUH PER SQUARE FOOT PER FAHRENHEIT DEGREE TEMPERATURE DIFFERENCE BETWEEN AIR ON THE INSIDE AND AIR ON THE OUTSIDE OF A WALL, FLOOR, ROOF OR CEILING. THE TERM IS APPLIED TO THE USUAL COMBINATIONS OF MATERIALS, AND ALSO TO SINGLE MATERIALS, SUCH AS WINDOW GLASS, AND INCLUDES THE SURFACE CONDUCTANCE ON BOTH SIDES. THIS TERM IS FREQUENTLY CALLED THE "U" VALUE.

RESISTANCE FACTORS (R-FACTORS)

THE THERMAL RESISTANCE VALUE FOR ANY SPECIFIC THICKNESS OF INSULATION. R-FACTOR IS THE RECIPROCAL OF THE THERMAL TRANSMITTANCE (1/U) OR THE HEAT FLOW IN BTU PER HOUR THROUGH A SQUARE FOOT OF ANY GIVEN THICKNESS OF A HOMOGENOUS OR COMPOSITE MATERIAL. R-FACTORS ARE SIGNIFICANT BECAUSE THEY ARE THE ONLY FACTORS THAT CAN BE HANDLED ARITHMETICALLY, AND THEY ARE USED TO DETERMINE THE OVERALL RESISTANCE ("U" VALUE) OF VARIOUS COMPONENTS IN THE BUILDING ENVELOPE. THE RECIPROCAL OF THE SUM OF VARIOUS R-FACTORS EQUALS THE "U" VALUE.

$$Q = U \cdot A \cdot \Delta T$$

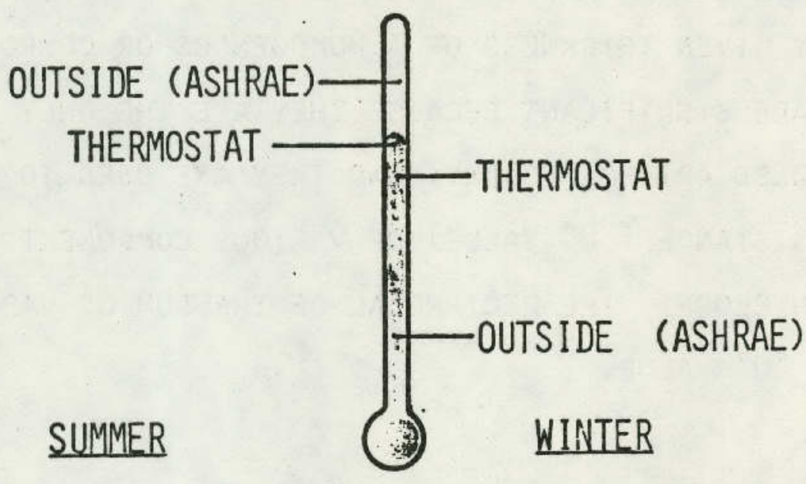
Q IS BTUH: HEAT FLOW PER HOUR

U = U-VALUE, FOR EACH TYPE OF WALL, GLASS, CEILING, ETC.

$$\text{U-VALUE} = \frac{1}{\text{R TOTAL}}$$

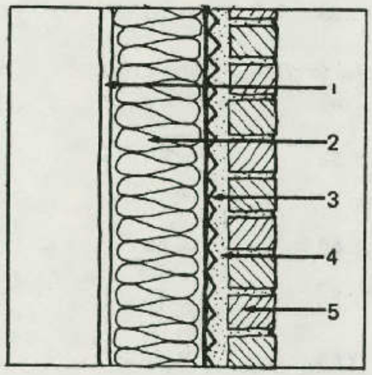
A = SQ. FT. AREA OF WALL, ETC.

ΔT = "DELTA-T" = DIFFERENCE IN THE DESIGN TEMPERATURES



TYPICAL WALL SECTIONS

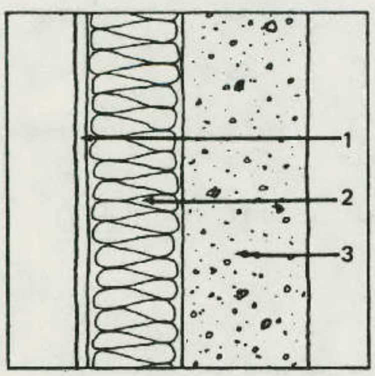
HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



WEIGHT 48.2 lb./ft^2

List of Construction Components		**R cooling**	**R heating**
1.	5/8" Gypsum Board	.56	.56
2.	Insulation	(refer to graph)	(refer to graph)
	3½" Furring Space (without insulation)	.85	.95
3.	Paperback Metal Lath	—	—
4.	1" Grout	.20	.20
5.	3" Brick Veneer (130 lbs/ft^3)	.33	.33
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		**2.87**	**2.89**

HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY

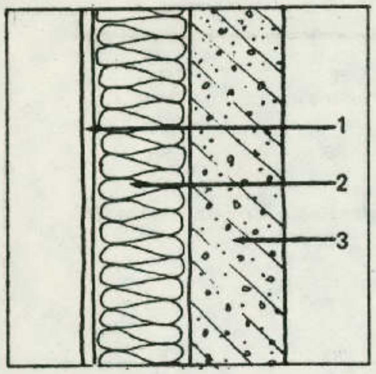


WEIGHT 95.5 lb./ft^2

List of Construction Components		**R cooling**	**R heating**
1.	5/8" Gypsum Board	.56	.56
2.	Insulation	(refer to graph)	(refer to graph)
	1½" Furring Space (without insulation)	.85	.95
3.	8" Concrete (140 lb/ft^3)—not dried	.64	.64
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		**2.98**	**3.00**

TYPICAL WALL SECTIONS

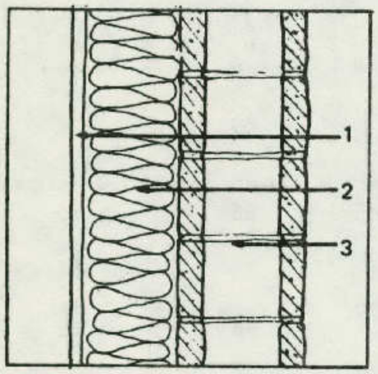
HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation 1½" Furring Space (without insulation)	(refer to graph) .85	(refer to graph) .95
3.	6" Precast Concrete (140 lb/ft^3) oven-dried aggregate	.66	.66
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		3.00	3.02

WEIGHT 72.2 lb./ft^2

HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation 1½" Furring Space (without insulation)	(refer to graph) 0.85	(refer to graph) 0.95
3.	8" Concrete Block (3 oval core sand and gravel aggregate open core)	1.11	1.11
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		3.45	3.47

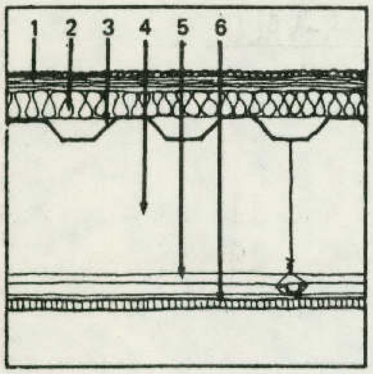
TYPICAL INSULATION MATERIALS

WALL INSULATION

	R-VALUE
BLANKET AND BATT	
Rock Wool, Fiberglass	
3-3½ inches	11
5¼-6½ inches	19
BOARD, INSULATING	
Extruded Polystyrene (Styrofoam)	
3/4 inch	4.05
1 inch	5.41
1½ inch	8.11
2 inch	10.81
Super-Sheath (with aluminum facing)	
1 inch	6.15
High-R Sheating (Owens-Corning)	6.00
Thermax Sheating (Celotex)	
3/4 inch	6.00
1 inch	8.00

TYPICAL ROOF SECTIONS

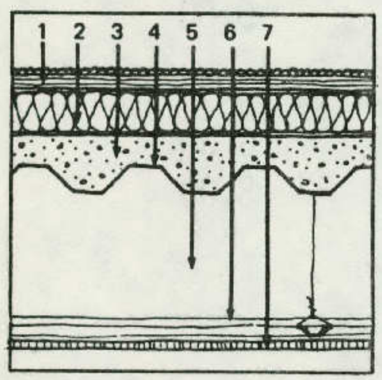
HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



WEIGHT 7.9 $lb./ft^2$

List of Construction Components	R cooling	R heating
1. 3/8" Built-up Roofing	.33	.33
2. Rigid Insulation	(refer to graph)	(refer to graph)
3. 1½" Metal Decking	—	—
4. Air Space	.80	.80
5. Metal Furring Channels	—	—
6. Suspended Acoustic Tile 1/2"	1.25	1.25
Inside Surface Air Film	.92	.61
Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)	3.55	3.16

HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY

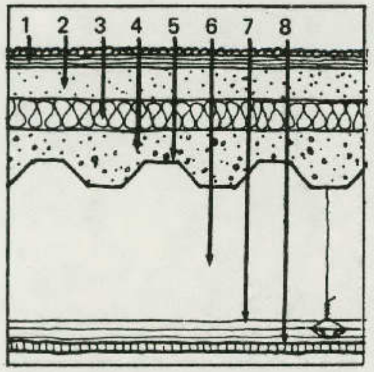


WEIGHT 26.7 $lb./ft^2$

List of Construction Components	R cooling	R heating
1. 3/8" Built-up Roofing	.33	.33
2. Rigid Insulation	(refer to graph)	(refer to graph)
3. 2" Lightweight Concrete 80 $lb/ft.^3$	.80	.80
4. 1½" Metal Decking with Concrete Fill (avg. depth 3/4") 80 lb/ft^3	.30	.30
5. Air Space	.80	.80
6. Metal Furring Channels	--	--
7. Suspended Acoustic Tile 3/4"	1.89	1.89
Inside Surface Air Film	.92	.61
Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)	5.29	4.90

TYPICAL ROOF SECTIONS

HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



WEIGHT 31.7 lb./ft^2

List of Construction Components		R cooling	R heating
1.	3/8" Built-up Roofing	.33	.33
2.	2" Insulating Concrete 30 lb./ft^3	2.22	2.22
3.	Rigid Insulation	(refer to graph)	(refer to graph)
4.	2" Lightweight Concrete 80 lb./ft^3	.80	.80
5.	1½" Metal Decking w/Concrete Fill (avg. depth ¾") 80 lb./ft^3	.30	.30
6.	Air Space	.80	.80
7.	Metal Furring Channels	--	--
8.	Suspended Acoustic Tile 3/4"	1.89	1.89
	Inside Surface Air Film	.92	.61
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		7.51	7.12

TYPICAL INSULATION MATERIALS

ROOF INSULATION

	R-VALUE
CELOTEX TEMPCHEK	
1.2 "	8.33
2"	14.3
3"	22.2
CELOTEX THERMAX	
1.2"	8.3
2"	14.3
ZONOLITE CONCRETE	
2"	4.5
4"	7.5
2" WITH 2" INSULPERM*	12.5
2" WITH 4" INSULPERM	20.0
4" WITH 2" INSULPERM	15.0
4" WITH 4" INSULPERM	23.0
FESCO BOARD (JOHNS-MANVILLE)	
1½"	6.67
2"	10.00
3¼"	20.00

*INSULATING BOARD

MODEL CODE
FOR
ENERGY CONSERVATION

MAXIMUM ALLOWABLE U VALUE (U_O)

$$U_O = \frac{A_{OW}U_{OW} + A_{OR}U_{OR} + A_{OF}U_{OF}}{A_{OW} + A_{OR} + A_{OF}}$$

A_{OW} = OVERALL WALL AREA

A_{OR} = OVERALL ROOF AREA

A_{OF} = OVERALL FLOOR AREA

HEAT TRANSMISSION COEFFICIENTS
BTU/HR/SQ.FT./^{O}F
(U-VALUE)

	HIGH	LOW
WINDOWS		
SINGLE GLASS	1.10	.88
DOUBLE GLASS	.78	.46
ROOF	.59	.025
WALLS	.504	.058

MODEL CODE FOR ENERGY CONSERVATION

ALLOWABLE INFILTRATION RATES

WINDOWS	0.5 CFM PER FT OF OPERABLE SASH CRACK
DOORS*	11.0 CFM PER LINEAR FOOT OF CRACK

MODEL CODE FOR ENERGY CONSERVATION

AIR LEAKAGE

EXTERIOR JOINTS AROUND WINDOWS AND DOOR FRAMES; OPENINGS BETWEEN WALLS AND FOUNDATIONS, BETWEEN WALLS AND ROOF/CEILINGS AND BETWEEN WALL PANELS; OPENINGS AT PENETRATIONS OF UTILITY SERVICES THROUGH WALLS, FLOORS AND ROOFS; AND ALL OTHER SUCH OPENINGS IN THE BUILDING ENVELOPE SHALL BE CAULKED, GASKETED, WEATHERSTRIPPED OR OTHERWISE SEALED IN AN APPROVED MANNER.

*SWINGING, SLIDING, REVOLVING DOORS.

8

SOLAR/HEAT RECOVERY/MOTORS

Solar/Heat Recovery/Motors

Table of Contents

13.11a/Soc

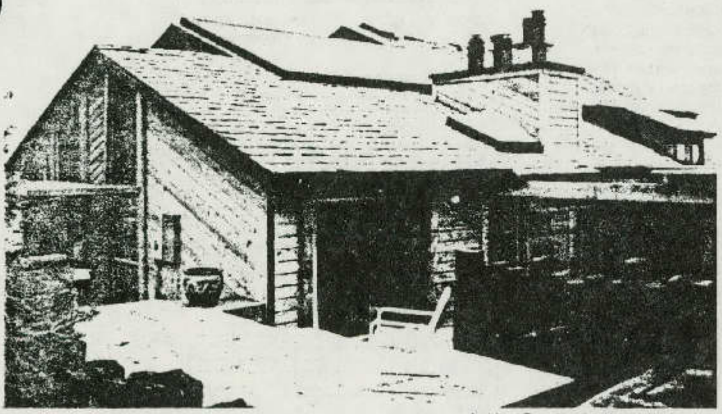
ASSEMBLY

RESIDENTIAL, COMMERCIAL, INDUSTRIAL AND AGRICULTURAL SOLAR SYSTEMS

SOLARON®

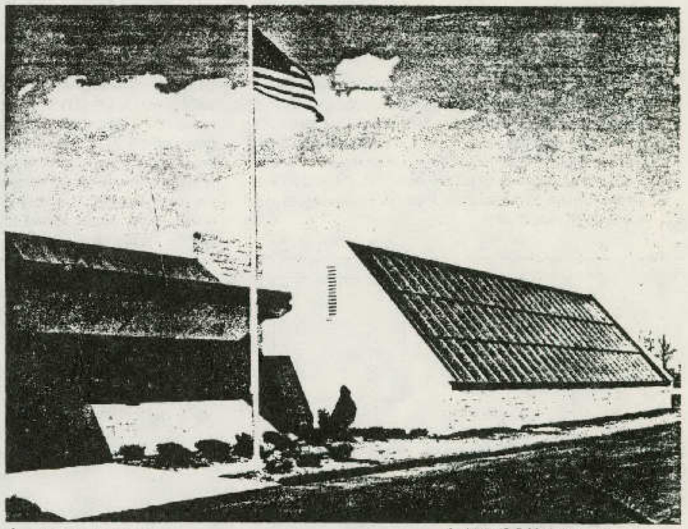
SOLAR ENERGY SYSTEMS

TM



RESIDENTIAL — Architect/Downing, Leach and Assoc., Inc.

Forced Air Space Heating/Pool Water Heating/Domestic Water Heating



COMMERCIAL — Architect/O.E.M. Assoc., Inc.

Space Heating/Domestic Water Heating/Ventilation Air Heating

MR-MANUFACTURER

Solaron Corporation is an international marketing and manufacturing company recognized as a world leader of air-type solar heating systems based upon over 20 years of continuous performance.

PP-PRODUCT PRESENTATION

EXCELLENCE OF FORM AND FUNCTION

Air vs. Water—". . . the air heating system provided 40% more solar energy for space and water heating than the liquid heating system . . . the air system operated over a longer period of the day . . . it collected 16% more of total available radiation . . . ." (findings of side-by-side testing at the Solar Energy Application Laboratory, Colorado State University). (See page four of this brochure, "Solar System Performance Equation.")

The SOLARON AIR COLLECTOR advantages:

- 35 years' research and development by Dr. George O. G. Löf.
- Limited Manufacturer performance warranty.
- Safe, reliable, predictable, virtually maintenance-free operation.
- No damage from freezing or boiling.
- No pipes which can rust, corrode, or leak.
- No antifreeze required.
- No stagnation pressure relief controls.
- Approved by HUD and ERDA for federally-funded projects.
- Cost effective.

Design Assistance: Contact Solaron for its complete design manual covering solar system engineering, architectural requirements and economics. Technical personnel are available to assist on special applications. To contact the nearest Solaron dealer, call the SWEETS BYLINE.

PP—PRODUCT PRESENTATION

The Solar Air Heating System

SOLARON® CORPORATION

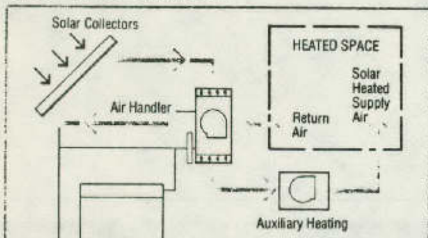
The business of Solaron Corporation is the practical application of solar energy. We design, manufacture and market solar heating systems for residential and commercial buildings for industrial complexes and agricultural process heating.

Our system is marketed throughout the U. S. and parts of Canada by distributors and dealers in the heating, ventilating and air conditioning (HVAC) industry. The distributors, who maintain complete stocks of Solaron and HVAC major brands, work with dealers who are HVAC installing contractors. These Solaron dealers are established contractors of heating equipment and ductwork. Both distributors and dealers are thoroughly trained by Solaron in solar heating, design, equipment application and installation. Solaron engineers and field servicemen support the distributors and dealers, as required, complete to on-site assistance.

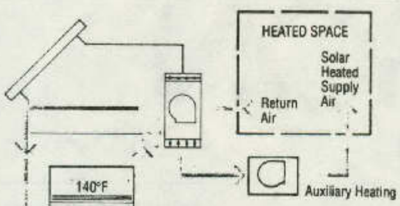
The HVAC contractor installs the Solaron collector, air handler, controller and ductwork. The general contractor usually builds the heat storage container. The system is then thoroughly tested through all operating modes for proper operation.

OP—OVERALL PRODUCT, IN PLACE

SYSTEM OPERATION

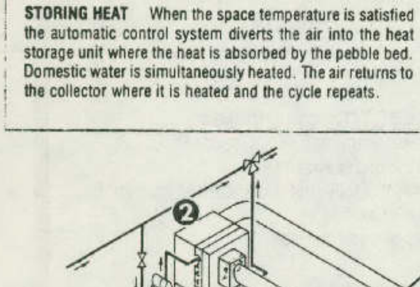


HEATING FROM COLLECTOR Air, the circulating heat transfer medium is drawn through the collector where it is normally heated to about 120-150°F. When the space requires heat, the solar heated air is drawn through the air handling unit in which motorized dampers are automatically opened to direct the hot air to the space. The air then returns to the collector where it is again heated and the cycle repeats itself.



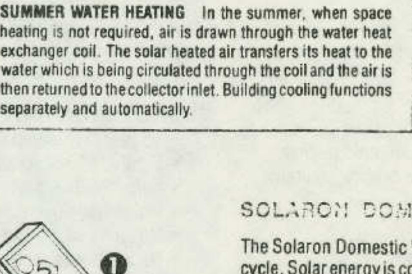
HEAT STORAGE UNIT. The **heat stratification** provides a good supply air temperature to heat the building.

HEATING FROM STORAGE At night or on cloudy days when solar energy is unavailable and when heat is needed in the space, the automatic control system directs the building return air into the bottom of the heat storage unit, up through the pebbles where the air is heated, across the domestic water coil, through the air handler and into the space. When the solar heated air does not maintain the space thermostat setting, the automatic control turns on the auxiliary heater to add the required heat.



HEAT STORAGE UNIT. The **heat stratifies in the rock** (i.e., HOT on top—COLD on bottom). This allows optimum collector efficiency since INLET temperature is low.

STORING HEAT When the space temperature is satisfied the automatic control system diverts the air into the heat storage unit where the heat is absorbed by the pebble bed. Domestic water is simultaneously heated. The air returns to the collector where it is heated and the cycle repeats.



SUMMER WATER HEATING In the summer, when space heating is not required, air is drawn through the water heat exchanger coil. The solar heated air transfers its heat to the water which is being circulated through the coil and the air is then returned to the collector inlet. Building cooling functions separately and automatically.

TYPICAL COLLECTOR ARRAYS

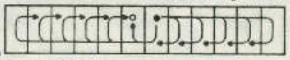
All configurations can contain up to 30 collectors.

Collector Model No.

ONE HIGH VERTICAL ARRAY

No more than 12 collectors in this configuration.

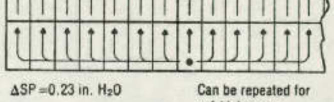
3015



$\Delta SP = 0.23$ in. H_2O

TWO HIGH VERTICAL ARRAY

3011

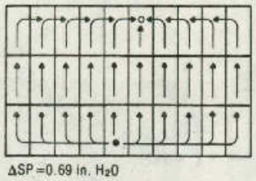


$\Delta SP = 0.23$ in. H_2O

Can be repeated for a 4 high array.

THREE HIGH VERTICAL ARRAY

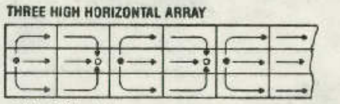
3011
3014
3011



$\Delta SP = 0.69$ in. H_2O

THREE HIGH HORIZONTAL ARRAY

3011
3011
3011

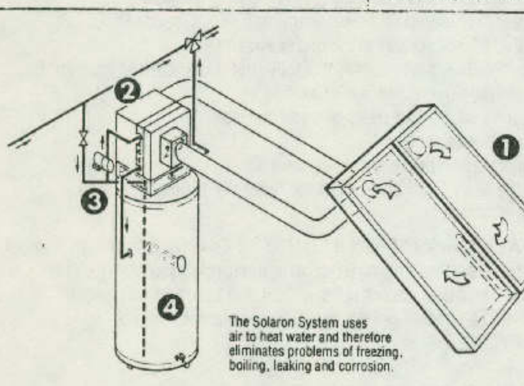


$\Delta SP = 0.23$ in. H_2O

○ = Collector Outlet

● = Collector Inlet

ΔSP = Static Pressure Drop between inlet and outlet @ 2 SCFM/FT²



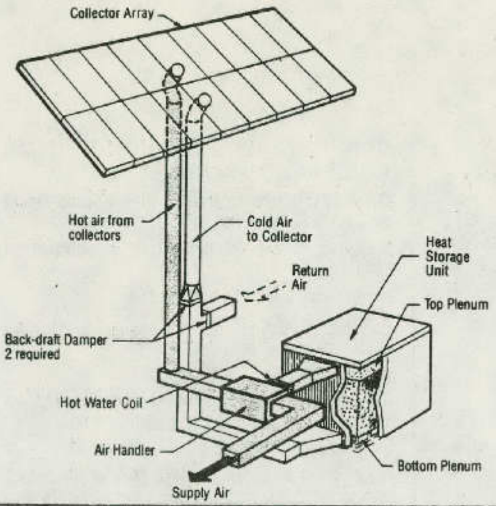
The Solaron System uses air to heat water and therefore eliminates problems of freezing, boiling, leaking and corrosion.

SOLARON DOMESTIC WATER HEATING SYSTEM

The Solaron Domestic Water Heating System involves a very simple operating cycle. Solar energy is collected by the south facing collector (**1**). Air is circulated by the heat exchange unit (**2**) where the solar energy is transferred to the water being circulated by the domestic water circulating pump (**3**). Solar heated water is continuously circulated into the water tank (**4**) as long as the Solaron control unit indicates that solar energy is available at the collectors (**1**) and until the water in the tank reaches its set temperature. If additional heat is required, the tank's auxiliary heat unit will turn on.

NOTE: A TWO TANK System can also be used.

OP—OVERALL PRODUCT, IN PLACE



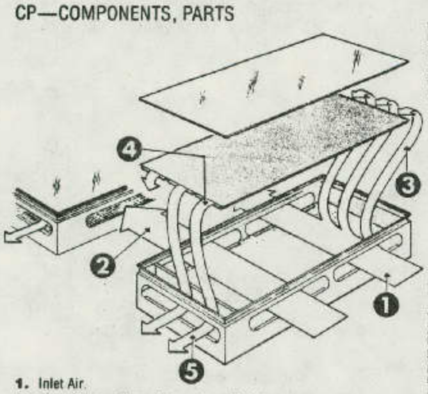
GENERAL SYSTEM DESCRIPTION

A drawing of a typical installation is shown to the left. The collectors can be grouped as shown or in any of the configurations shown on page 2, Typical Collector Arrays. Due to the Solaron internal manifolding technique (i.e., air flows from one panel to another internally) the external duct connections are minimized as shown (i.e., one inlet and one outlet for 30 panels, 563 ft.²). This technique reduces field labor and air leaks and leads to an economical installation.

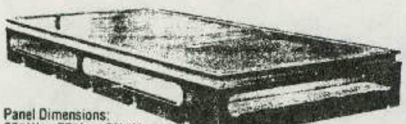
Contact Solaron to obtain system schematics showing how to combine solar heating with:

- Air conditioning
- Heat pumps
- V.A.V. systems
- Multiple zones
- Process water heating
- Make-up air heating
- Process air htg.-drying
- Swim pool water heating
- Industrial and agricultural heating

CP—COMPONENTS, PARTS



1. Inlet Air.
2. Air going to adjacent internal manifold.
3. Air entering absorber duct.
4. Air flowing under selective absorber.
5. Air flowing to next series 3000 collector.



Panel Dimensions:
35" W × 77" L × 8¾" H
Weight 135 lbs.

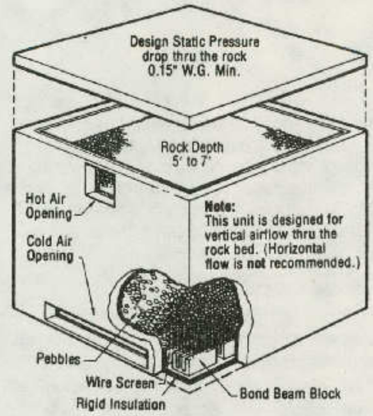
THE PATENTED SOLARON 3000 COLLECTOR PANEL

Protected by Patent 4,073,283

Completely modular, the 3000 is the most advanced air heating flat plate collector in the industry. Expanded internal manifolding distributes the air flow, minimizes heat transfer loss and requires only minimal ducting. Other installation simplifications include mounted silicone gaskets for between-collector sealing and attractive capping and perimeter strips for weathertight security, simplified collector hold-down.

Solaron Series 3000 features:

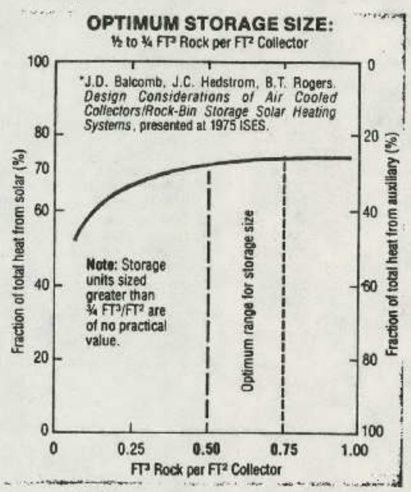
- Collector Glazing—single, lightly textured, ⅛" thick, low iron tempered glass.
  Easily removable for replacement
- Absorber Coating—black chrome over nickel.
  Absorptivity—0.95 minimum
  Emissivity—0.15 maximum
- Pan—20-gauge steel.
- Insulation—2.5 inches of glass batt plus 0.5 inch semi-rigid foil backed; R-13 insulation value.
- Connection Ports—unique flange configuration gives automatic airtight seal as modules are installed.
- Cap Strip—aluminum with high quality porcelain enamel finish provides weather sealing between panels.



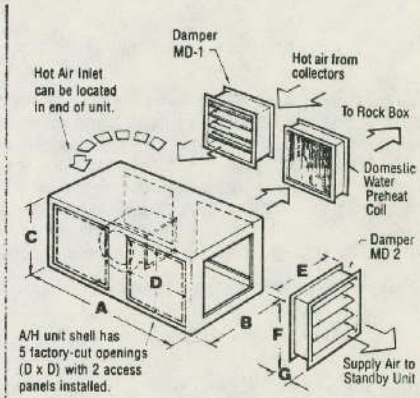
PEBBLE-BED HEAT STORAGE UNIT

The pebble bed allows heat to be stored at nearly the outlet temperature of the collector. This is possible because of the high degree of stratification exhibited by the pebble bed and the flow direction reversal between "storing heat" and "heating from storage."

When "storing heat," the high temperature air from the collector outlet enters the top of the pebble bed where it gives up its heat to the pebbles and returns to the collector as cool air. This allows the collector to operate at the highest possible efficiency.



The heat storage unit must be built and installed by the local contractor to Solaron standard drawings and specifications. Contact Solaron for a copy of these specs.



Model No.	Air Handling Unit (in.) A	B	C	D	Dampers & Coil E	F	G	C.F.M. Range at 1.2" S.P.
AU—0400	42	20	18	14	16	16	8	300 to 1400
AU—0500	51	24	22	18	20	20	10	1200 to 2400
Larger, custom built air handlers are also available.								

AIR HANDLING UNIT

Solaron provides standard factory pre-assembled air handling units including blowers and motor driven dampers. A separate backdraft damper pair is furnished for mounting in the duct system.

A typical installation for the air handling unit, near the auxiliary heater and heat storage, is shown in the General System Description (upper left). The air handler can be mounted either vertically or horizontally with proper orientation and clearance to receive all connecting ducts without interference.

SOLARON AUTOMATIC CONTROL UNIT

The automatic temperature control unit is included as part of the Solaron system. The controller handles all of the operational modes which are shown in the schematics on page 2. The controller operates the solar side of the system and ties into a 2-stage thermostat to provide solar and/or auxiliary heat to the space as required. A standard Solaron controller is available to interface with heat pumps or other types of auxiliary heating systems. Solaron can provide technical assistance to design special controllers for large projects or unique applications.

SOLAR SYSTEM PERFORMANCE COMPARISON

Comparison of various types of solar heating systems can only be done properly if the entire solar *system* is evaluated over an *entire heating season*. Collector efficiency is an instantaneous point in time in time measurement and is not a valid parameter to evaluate the solar system performance. The ideal situation for a solar system is to keep the fluid inlet temperature to the collector as low as possible and have a high usable temperature for space heating. Therefore, the ideal solar system has heat stratified in the storage unit. An air solar sytem using rocks as the thermal storage provides this stratification. Therefore, the inlet temperature to an air collector is typically 70° F where the liquid collector inlet temperature is 130° F.

$$Q_U/A_C = F_R[H_T\tau\alpha - U_L(T_i - T_a)] = \frac{BTU}{Ft.^2\,Hr.}\ ^*$$

output	gains	losses	output

Two collectors of similar construction can be compared using the performance equation shown above. When the average liquid collector inlet temperature (T_i) is used, the liquid systems produce less heat output than the air system.

$$\text{AIR: } \frac{Q_U}{A_C} = 0.64[(300)(0.77) - (1.3)(\mathbf{70°} - 40°)] = 123\ \frac{BTU}{Ft.^2\,Hr.}$$

$$\text{LIQUID: } \frac{Q_U}{A_C} = 0.90[(300)(0.77) - (1.3)(\mathbf{130°} - 40°)] = 103\ \frac{BTU}{Ft.^2\,Hr.}$$

However, this is still an instantaneous point in time measurement which doesn't take into account the fact that the air system will typically collect for longer periods of time and therefore deliver more total heat output. When these systems are evaluated over an entire season, the results are as reported by the C.S.U. report #COO-2868-1. ". . . . Because of the stratification, the temperature of the air returning to the collector from the bottom of storage is always near room temperature. Thus, the air collector can deliver useful heat from early morning to late afternoon: the liquid system starts up later in the morning and shuts off earlier in the afternoon. . . ." Therefore, when *system performance* is evaluated over an *entire season* it shows that *AIR solar systems actually produce more usable energy than liquid systems of the same size.*

*Ref: Hottel, H.C. and Woertz, B.B.A.S.M.E. Transactions 64,91 1942 *Performance of Flat Plate Solar Heat-Collectors.*

SOLARON SYSTEM SIZING CRITERIA

Solaron provides the designer with a complete solar system sizing procedure for approximately 250 locations in the U.S. and Canada. The procedure is summarized below:

1. Solar Collector Area: The collector area can be determined by using the Solaron Conversion Factors (SCF) which are available from the Solaron Distributors and Dealers. The collector area is determined by dividing the building UA (i.e. building design heat loss ÷ the design temperature difference = BTU per hour°F) by the Solaron Conversion Factor. This provides the solar collector area required for a given annual fuel savings percentage.
2. Air Flow Rate: 2 SCFM to 3 SCFM per ft.² of solar collector area. Contact Solaron for special applications such as makeup air heating, outside air heating for drying or industrial or agricultural process heating.
3. Heat Storage Size: ½ to ¾ ft.³ rock per ft.² of solar collector area. Rock size ¾" to 1½" dia.

Selection Example:

1. Assume that the S.C.F. have been used to determine that a specific project requires 1000 ft.² of collector.
2. Flow rate = (2 SCFM per ft.²) x (collector area) = (2) x (1000) = 2000 SCFM
3. Heat storage unit = (½ ft.³ rock per ft.²) x (collector area) = (½) x (1000) = 500 ft.³ rock volume

This can be obtained with a storage unit having inside dimensions of 10' W. x 10' L. x 5' rock depth. The air plenums on top of the rock make the box about 7 ft. high inside.

CORRECTIONS FOR NON-OPTIMAL ORIENTATION AND TILT

EXAMPLE: 26 collector array at 40°N. latitude, facing 40° East of South at 30° tilt.

The effect of the non-optimal tilt is obtained as follows:

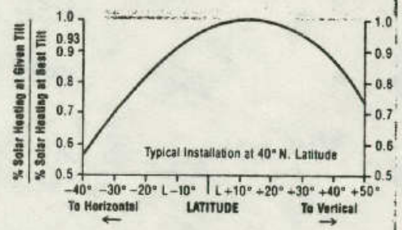
30° tilt = latitude (40°) minus 10°

$\frac{\%\ \text{solar heating at 30° tilt}}{\%\ \text{solar heating at best tilt}}$ is obtained from the graph at latitude minus 10° = 0.93.

The effect of the non-optimal orientation is obtained from the graph at 40° East of South = 0.93.

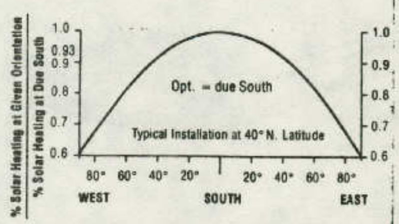
The combined effect is 0.93 × 0.93 = 0.86.

The collector array will produce 86% of the output from an optimally oriented and tilted array. To find the approximate number of collectors to equal the output of the optimal array divide 26 by 0.86 = 30 collectors.



COLLECTOR TILT

Space Heating Best Tilt = Lat. +5° to Lat. +15°
Year Round Heating Best Tilt = Lat. -5° to Lat.
(Ex.: Domestic Water, Process & Outside Air)



COLLECTOR ORIENTATION

AC-AVAILABILITY, COST

SOLARON DISTRIBUTOR LOCATIONS

Al.	Noland Company	(205) 323-6322
Ar.	A. W. Johnson Co. (Ok.)	(501) 376-4471
Ca.	Lillard Company	(415) 934-8752
	Haldeman, Inc.	(213) 726-7011
Co.	Capture Energy Products	(303) 744-2431
Ct.	Conn. Air Conditioning Co.	(203) 795-6011
De.	Bell Supply Co. (Pa.)	(302) 658-6565
Fl.	Cain & Bultman	(904) 356-4812
	Noland Company	(904) 244-4131
Ga.	Noland Company	(404) 522-8034
Id.	Thermal Efficiency	(206) 622-6767
Il.	May Company (Ia.)	(309) 762-3611
	Mid-Way Heating Supply Co.	(312) 872-5481
	Mott Brothers Co.	(815) 962-3711
In.	Indiana Air Products Co.	(812) 479-6939
	K & S Distributing Co.	(317) 635-4422
Ia.	Iowa Supply Co.	(515) 244-6291
Ks.	Solaron Mid-America Corp.	(913) 384-4484
Ky.	Controls Service Corp.	(502) 267-9636
	Noland Company	(502) 842-9401
Md.	Noland Company	(301) 663-9541
Ma.	Conn. Air Conditioning Co.	(203) 795-6011
Mi.	Behler-Young Company	(616) 531-3400
Mn.	Goodin Company (Wi.)	(612) 341-6555
Ms.	Noland Company	(601) 354-5441
Mo.	Solaron Mid-America Corp.	(913) 384-4484
Mt.	Thermal Efficiency	(206) 622-6767
Nv.	Lillard Company	(702) 329-0851
NJ.	Montgomery Engineering Co.	(201) 227-9550
NM.	Enersol Company	(505) 883-2985
NY.	Climate Equipment Co.	(716) 254-6440
	Hagle Supply Co.	(914) 561-3592
	S. W. Anderson Sales Co.	(516) 822-5631
NC.	Noland Company	(919) 832-2071
ND.	Goodin Company	(612) 341-6555
Oh.	Famous Supply Co.	(216) 762-9621
	Johnston Supply, Inc.	(614) 383-5291
Ok.	Swan Air Cond. Co.	(405) 525-0551
Or.	Thermal Efficiency, Inc.	(206) 622-6767
	Lillard Company	(415) 934-8752
Pa.	Lebanon Plumbing Supply	(717) 273-9375
	Environmental Equip. & Engr.	(717) 236-7941
	Famous Supply Company	(412) 225-8330
SC.	Noland Company	(803) 744-8213
SD.	Goodin Company	(612) 341-6555
	Iowa Supply Co.	(712) 255-3583
Tn.	Noland Company	(615) 525-7171
	A. T. Distributors (Ar., Ms.)	(901) 278-7211
Tx.	Enersol Company	(214) 349-3022
Va.	Noland Company	(804) 874-8000
Wa.	Thermal Efficiency, Inc.	(206) 622-6767
WV.	Famous Supply Co.	(304) 232-3310
Wi.	Mid-Way Heating Supply	(414) 552-7712
	Mott Brothers Co.	(608) 222-4645
Wy.	Capture Energy Products	(303) 744-2431
Canada:	Westburne Ind. Enter.	(613) 722-8371

SOLARON®
SOLAR ENERGY SYSTEMS
TM

300 GALLERIA TOWER • 720 SOUTH COLORADO BLVD.
DENVER, CO 80222 • (303) 759-0101 • TWX 910-931-2580

Printed in U.S.A.

Air Solar Collector

SOLARON®

Series 3000 Collector Technical Data

SOLARON CORPORATION Solar Energy Systems

FEATURES

An Air Heating Solar Collector with a Patented Manifold System.

- High Thermal Efficiency.
- Black Chrome Selective Absorber Surface.
- Durable Construction.
- Uses Air for Reliability and Long Life.
- No Pipes to Corrode or Freeze.
- Factory Assembled.
- Labor Saving Internal Manifold.
- Simple Installation.
- Suitable for Retrofitting.
- Architecturally Attractive.

Panel Dimensions Installed:
35" W x 77" L x 8½" H
Weight 134 lbs. = 7.2 lbs./ft.^{2}

APPLICATIONS

- Space Heating.
- Heating Outside Air for Ventilation or Process Heating.
- Heating Water or Process Fluids via the Air Collector and an Air to Water Heat Exchange Coil.

COLLECTOR AREA = 18.72 FT^2/PANEL

The Solaron Series 3000 flat plate air-type solar collector incorporates cost effective and field labor saving features that have been developed in over thirty-five years of research and testing. Solaron collectors have been proven to be efficient and reliable components in the many Solaron solar heating systems installed in both northern and southern climates throughout the United States and in Europe, Africa and the Far East.

The collector utilizes a patented air manifold system to minimize field installation labor and assure uniform high performance. The internal manifold system replaces most of the ductwork normally used to interconnect air heating collectors.

The air flow in the Series 3000 collector passes beneath the absorber in a duct that is formed by the absorber and a second metal sheet. This allows the selective coated absorber to be insulated by a dead air space between it and the glazing. This design makes for a more efficient collector in most applications and protects the absorber surface from dust or other airborne contamination.

The collectors can be held in place by two methods. The first method fastens the collector to the roof using the integral recessed mounting holes in the sides of the collector with screws applied from above the roof. The second method uses self-tapping screws driven from inside a mounting structure into the 20-gauge steel collector base. The Solaron Series 3000 collector installation is completed with factory-supplied cap strips and insulated perimeter flashing curb.

FEATURES AND SPECIFICATIONS

Glazing – The translucent cover consists of one sheet of patterned 1/8 inch thick tempered, low iron glass with a weather-resistant, synthetic rubber (EPDM) edge gasket.
Absorber – The absorber surface is black chrome electro-plated on 24-gauge steel with a 1/2 mil thick undercoating of nickel. This black chrome coating possesses high performance and durability.
Collector Base – The collector base is made of 20-gauge zinc plated steel and painted with a high quality coating.
Manifold Ports – The collector pan has the necessary internal manifold port area to allow a single inlet and outlet to serve up to 40 collector panels. Special porting arrangements for unusual, large volume applications are available by contacting Solaron.
Insulation – A special fiberglass batt with high temperature binder is used to provide an R13 insulation of the collector body.
Cap Strip – The cap strip provided by Solaron is used to assure a weather-tight seal between collectors and between collectors and perimeter flashing. This sturdy cap strip is an aluminum extrusion finished with a high quality coating.
Perimeter Curb – The insulated perimeter strip and its matching parts provide an attractive weather-tight R19 insulated curb/flashing for the collector array.

Specifications

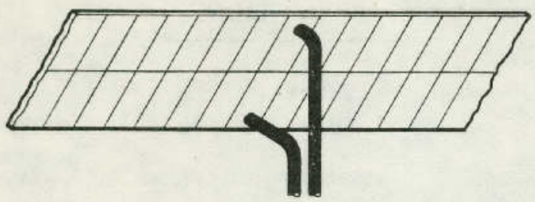
Gross Collector Area - 18.72 square feet (35" X 77") / Aperture Area - 17.07 square feet / Ratio of Aperture Area to Gross Area - 0.91 / Glass Cover, single glazing - 1/8 in. thick; tempered low iron; transmittance 0.90; patterned / Absorber Coating - black chrome over nickel – absorptivity 0.95 minimum; emissivity 0.15 maximum / Recommended Air Flow Rate Through Collector – 2 to 4 SCFM/ft.^{2} of gross collector area; 37.4 to 74.9 SCFM per collector / Insulation - Fiberglass – 2.5 inches batt; 0.5 inches semi-rigid foil backed; R13 insulation value / Collector Net Weight – 134 pounds; 7.2 pounds per square foot.

INTERNAL MANIFOLDING SYSTEM

Patent 4 073 283

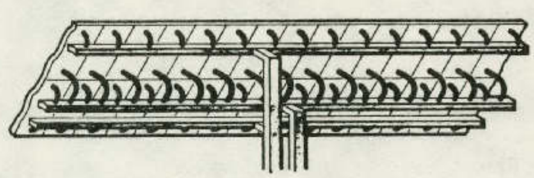
Solaron's patented internal manifolding system allows air flow from one panel to another without an external duct connection. This internal manifolding can be used to connect up to as many as 40 collectors with ONE inlet and ONE outlet duct connection.

Comparison of Solar AIR Collectors with and without internal manifolding



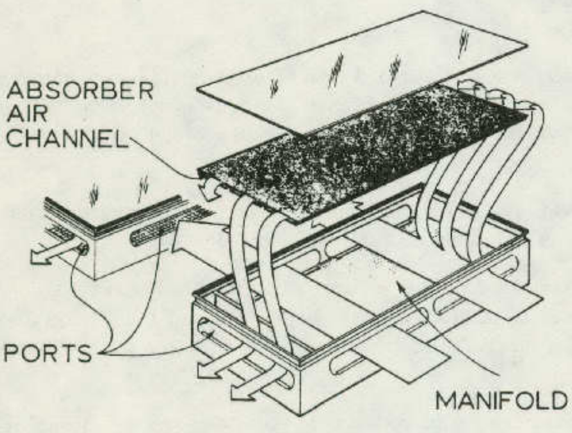
SOLARON INTERNAL MANIFOLDING

The Solaron system can have up to 40 collectors with ONE inlet and ONE outlet.



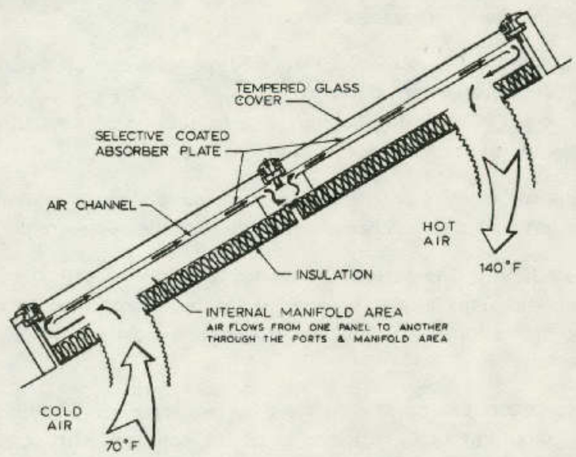
NO INTERNAL MANIFOLDING

Systems without internal manifolding could have up to 80 duct connections vs. Solaron's TWO duct connections.



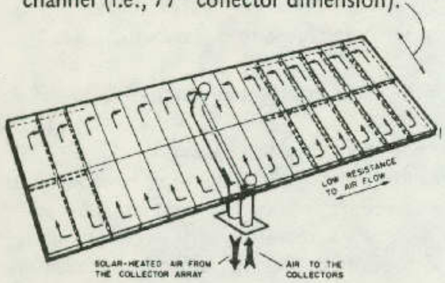
AIR FLOW DIAGRAM

This exploded view shows how the air flows through the collector ports, manifold section and absorber air channel. (This is Model 3011, additional models are shown on page 4.)



CROSS SECTIONAL VIEW SHOWING AIR FLOW THRU TWO SERIES 3000 SOLARON COLLECTORS.

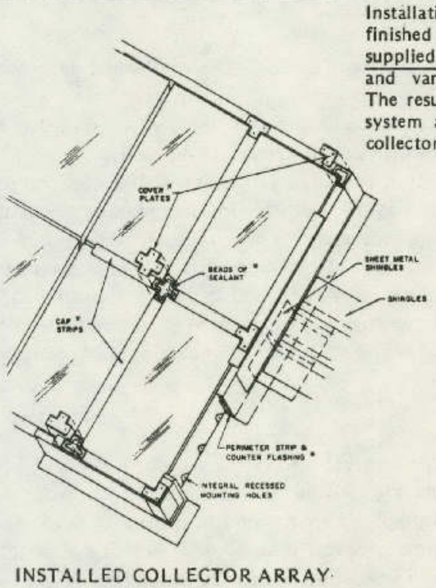
Most of the pressure drop occurs in the air channel (i.e., 77" collector dimension).

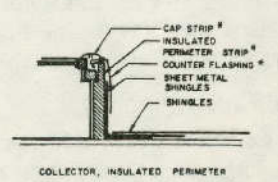


TYPICAL COLLECTOR ARRAY

Solaron collector arrays are self balancing because the air will evenly distribute in the Manifolds before it flows through the Air Channel. This is accomplished by the design of the collector which has a very low resistance to air flow through the ports and manifolds compared to the air resistance pressure drop through the air channel. Therefore the pressure drop for the air flow in the 35" dimension is negligible compared to the pressure drop in the 77" dimension.

Installation of the collector array is finished with the mounting of factory-supplied cap strip pieces, cover plates and various perimeter flashing parts. The result is a complete roof mounting system and insulated enclosure for the collector array.





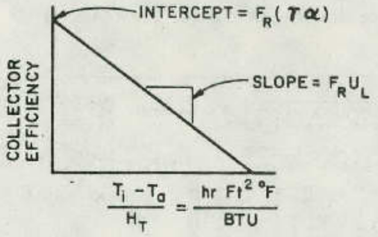
COLLECTOR, INSULATED PERIMETER STRIP & COUNTER FLASHING SECTION

* FACTORY SUPPLIED

INSTALLED COLLECTOR ARRAY

PERFORMANCE DATA

The industry-accepted standard for showing collector performance is the efficiency curve as shown. The two parameters that characterize the curve are the intercept and the slope. These change as a function of the collector flow rate and number of panels connected in series. Therefore, the parameters are presented in this table. The performance data was determined by an independent testing agency. i.e., Desert Sunshine Exposure Test, Incorporated, using the ASHRAE 93-77 test method.



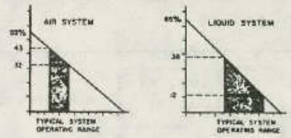
F_R = Heat Removal Factor
τ = Cover Transmittance
α = Plate Absorptance
U_L = Overall loss coeff.
T_i = Coll. inlet temp.
T_a = Ambient Air Temp.
H_T = Solar Energy Available

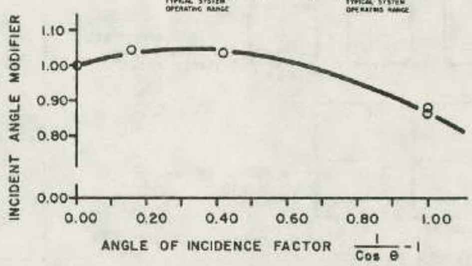
NOTE: Because of the unique nature of the measured incident angle modifier for the Solaron Series 3000 collector, conventional methods of calculating long-term solar system performance (e.g., f-chart) will yield a conservative estimate of system performance.

SOLARON COLLECTOR EFFICIENCY - Series 3000

FLOW RATE ($SCFM/FT^2$)	No. of PANELS IN SERIES	$F_R(\tau\alpha)$	$F_R U_L$
2	2	0.522	0.846
	3	0.568	0.921
3	2	0.618	1.001
	3	0.623	1.010
4	2	0.653	1.059

SPACE HEATING OF A BUILDING: EFFICIENCY CURVES
Note: Even though the AIR collector may have a lower instantaneous efficiency curve, the system operating efficiency range is higher for AIR than LIQUID systems when the air systems are used for space heating with pebble bed storage.





PRELIMINARY SIZING CRITERIA

1. Solar Collector Area: The collector area can be determined by using the Solaron Conversion Factors shown on the right. The number of collectors required for a project are calculated at a specific location, collector tilt and annual fuel savings percentage.

$$\#\text{of Panels} = \left(\frac{\text{Design Heat Loss}}{\text{Design } \Delta T}\right) \div (\text{S.C.F.})$$

Recommendations – Annual fuel savings for space heating should equal 20% to 75%. Annual fuel savings for applications with a more uniform load throughout the year can be higher than 70%.

2. Air Flow Rate: 2 SCFM to 3 SCFM per ft^2 of solar collector area. Contact Solaron for special applications such as make-up air heating, outside air heating for drying or industrial or agricultural process heating.

3. Heat Storage Size: ½ to ¾ ft^3 rock per ft^2 of solar collector area. Rock size ¾" to 1½" diameter in a container with a rock depth of 5' to 7'.

SELECTION EXAMPLE

Given that: A commercial building with a design heat loss = 180,780 BTU/HR, the location is Denver, Colorado and the desired annual fuel savings is 50% and design temperature difference = ΔT = 69° F.

1. Collector area : S.C.F. at 50% = 52.4

$$\left(\frac{180{,}780}{69}\right) \div (52.4) = 50 \text{ panels}$$

(50 panels) (18.72 ft^2/panel) = 936 ft^2

2. Flow rate:

(936 ft^2) (2 CFM/ft^2) = 1872 CFM

3. Heat Storage Unit:

(936 ft^2) x (¾ ft^3/ft^2) = 702 ft^3 rock

SOLARON CONVERSION FACTORS (S. C. F.)

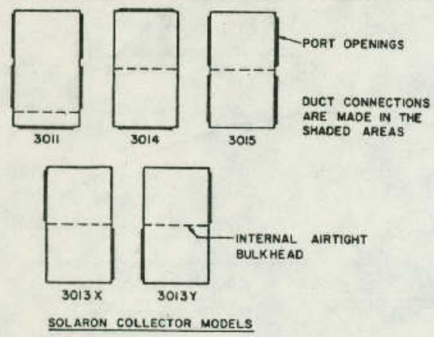
These factors are derived from a computer simulation program developed at the University of Wisconsin called "f-chart". These factors are based on a collector tilt of 53°.

LOCATION	Annual Fuel Savings 20%	50%	65%	LOCATION	Annual Fuel Savings 20%	50%	65%
AL, Birmingham	140.7	48.8	33.0	NJ, Trenton	103.9	32.3	21.6
AK, Annette	80.2	19.9	11.0	NM, Albuquerque	199.5	63.2	43.9
AZ, Phoenix	593.7	164.1	113.0	NY, Albany	58.9	16.9	10.9
AR, Little Rock	119.1	41.8	28.8	NY, Ithaca	52.0	14.4	9.3
CA, Fresno	197.4	60.8	36.7	NY, New York	63.0	18.6	12.3
CA, Los Angeles	733.4	242.4	165.7	NC, Charlotte	144.7	51.5	36.2
CA, Sacramento	207.7	61.2	37.8	NC, Raleigh	125.1	40.6	27.7
CA, San Francisco	317.5	103.8	69.3	ND, Bismarck	58.3	16.1	10.3
CO, Denver	159.7	52.4	35.9	ND, Fargo	47.3	12.2	7.7
CO, Grand Junction	132.0	41.5	27.9	OH, Akron	46.5	12.2	7.9
CT, Hartford	51.5	14.7	9.7	OH, Dayton	55.7	15.5	10.1
DE, Wilmington	82.1	24.3	16.3	OK, Oklahoma City	130.7	44.7	31.1
DC, Washington	89.2	26.9	17.8	OR, Corvallis	125.3	39.1	26.0
FL, Gainesville	676.2	249.0	179.7	PA, Philadelphia	77.7	22.7	15.4
GA, Atlanta	129.3	45.1	30.8	PA, Pittsburgh	87.2	25.7	17.1
ID, Boise	105.7	28.8	18.2	RI, Newport	96.2	29.3	20.1
IL, Lemont	76.6	23.0	15.4	SC, Columbia	178.8	62.3	42.2
IL, Springfield	75.0	21.8	14.5	SD, Rapid City	85.0	25.4	16.4
IN, Evansville	79.7	23.2	15.3	TN, Memphis	115.6	40.2	27.2
IN, Indianapolis	57.4	16.1	10.4	TN, Oak Ridge	105.3	31.7	21.3
IA, Ames	75.6	23.6	15.8	TX, Dallas	219.6	75.1	48.9
KA, Manhattan	104.1	31.7	21.4	TX, Houston	312.1	93.2	63.8
KY, Lexington	74.6	21.3	14.0	TX, Midland	276.8	98.1	68.1
LA, Baton Rouge	314.8	88.6	59.8	TX, San Antonio	382.8	106.1	71.9
ME, Portland	46.5	13.7	9.2	UT, Salt Lake City	120.0	36.1	22.9
MD, Annapolis	107.9	32.2	21.9	VT, Burlington	47.2	12.3	7.8
MA, Amherst	56.5	16.3	10.3	VA, Norfolk	133.2	42.3	28.5
MA, Boston	63.7	18.4	12.1	WA, Pullman	97.4	27.7	16.3
MI, Detroit	48.6	12.8	8.1	WA, Seattle	88.8	21.0	12.3
MI, Lansing	61.5	17.8	11.5	WV, Charleston	67.0	18.6	12.0
MN, Minn-St. Paul	49.0	13.5	8.6	WI, Madison	55.4	15.8	10.1
MS, Jackson	197.3	67.4	43.5	WY, Lander	133.2	44.7	30.1
MO, Kansas City	88.0	26.6	17.9	AT, Edmonton	64.5	18.4	11.0
MO, St. Louis	88.4	26.8	18.0	AT, Lethbridge	86.3	25.1	15.9
MT, Billings	83.1	24.1	15.3	BC, Vancouver	54.5	13.2	8.8
MT, Great Falls	76.9	21.5	13.2	MA, Winnipeg	60.1	18.1	11.5
NE, Lincoln	100.6	31.1	21.0	NB, Moncton	48.3	13.6	8.2
NV, Las Vegas	294.9	103.4	69.7	NF, St. Johns	42.5	11.7	7.3
NV, Reno	165.3	54.6	36.2	OT, Toronto	54.5	15.7	10.0
NH, Concord	47.8	13.6	8.7	QU, Montreal	43.9	11.6	7.2
NJ, Newark	74.9	22.5	15.1				

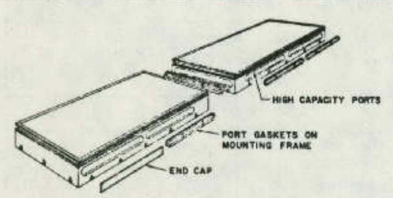
TYPICAL COLLECTOR ARRAYS

Solaron collectors are designed to be installed with a total airflow length of two or three collectors in series. The airflow length of a single collector is not recommended and can be avoided through proper choice of collector models (See "Typical Collector Arrays".). In order to achieve various collector arrangements, Solaron offers five variations of the basic collector panel. (See drawings below.) Solaron can also provide additional collector configurations on a special order basis for a minimum order quantity of 240 panels.

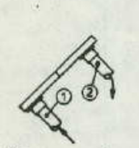
Solaron provides a port gasket on a mounting frame which fits into the port opening to obtain an airtight seal between two collectors. NOTE: THERE IS ONE PORT GASKET PER TWO MATCHING PORTS. The unused ports around the perimeter of the collector array are sealed airtight with a Solaron-furnished end cap and gasket. (See drawing below for port gaskets and end caps.)



SOLARON COLLECTOR MODELS

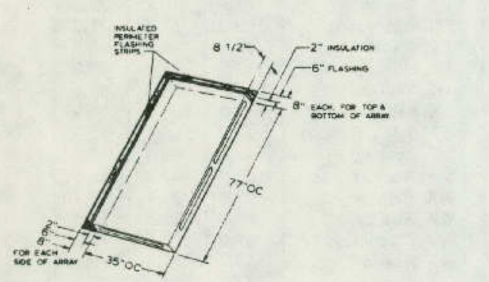


COLLECTOR STATIC PRESSURE DROP VS FLOW RATE			
ARRAY —	1 HIGH	2 HIGH & HORIZ	3 HIGH
No. of PANELS IN SERIES	2	2	3
FLOW RATE ($SCFM/FT^2$)	PRESSURE DROP BETWEEN COLLECTOR INLET & OUTLET (inches water gage)		
2.0	0.27"	0.27"	0.74"
2.5	0.38"	0.38"	1.07"
3.0	0.51"	0.51"	1.46"
3.5	0.65"	0.65"	1.90"
4.0	0.81"	0.81"	NOT REC'D



ΔP measured between ① & ② (includes duct collar losses)

DIMENSIONS - COLLECTOR AND PERIMETER FLASHING



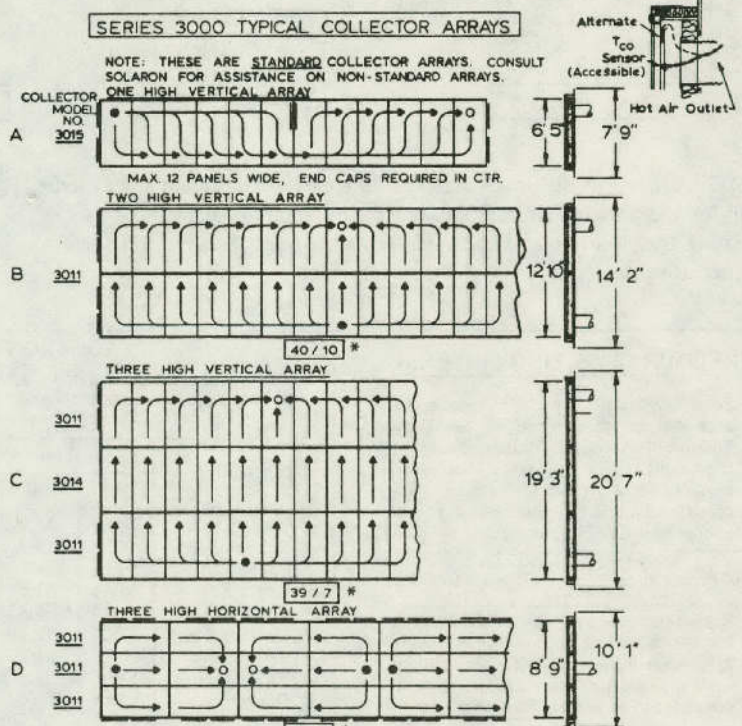
COLLECTOR AREA

$$35'' \times 77'' \Rightarrow 18.72 \frac{Ft.^2}{Panel}$$

Additional information on the Solaron system can be found in the Sweets File Section 13.11a/SOC and 13.11a SOL and ASHRAE 1977 Fundamentals' p. 104, 105 and ASHRAE 1978 Applications p. 56.

SERIES 3000 TYPICAL COLLECTOR ARRAYS

NOTE: THESE ARE STANDARD COLLECTOR ARRAYS. CONSULT SOLARON FOR ASSISTANCE ON NON-STANDARD ARRAYS.



| = End Cap
O = Collector Outlet
● = Collector Inlet

* #/# 1st # is the maximum no. of panels served by one inlet/outlet. 2nd # is the maximum no. of panels wide that the air can flow from / to an inlet/outlet.

Note: Sensor T_{co} must be located in a hot air outlet (absorber air channel) and at the top of array.

FLOW RATE: $SCFM/FT^2_{COLL}$ ↓	MAXIMUM NO. OF COLLECTORS FOR A GIVEN DUCT DIA.											
DUCT DIA. →	6"	7"	8"	9"	10"	11"	12"	14"	16"	18"	20"	22"
1	4	8	10	14	20	24	32	40	–	–	–	–
→ 2	2	4	4	6	10	12	16	24	34	40	–	–
→ 3	2	2	3	4	6	8	10	16	22	30	40	–
4	–	2	3	3	4	6	8	12	16	22	30	40

STANDARD DESIGN FLOW RATES (rows 2 and 3)

EXAMPLE: 2 HIGH, 10 WIDE ARRAY 20 PANELS @ 2 $SCFM/ft^2$ ⇓ 14" DUCTS

ROUND DUCT IS SHOWN FOR SIMPLICITY ONLY. RECTANGULAR DUCTS OF EQUIVALENT CROSS SECTIONAL AREA CAN ALSO BE USED.

REV. 1 12/78

Complete details on solar heating systems, design criteria, calculation procedures, architectural criteria, economics and installation techniques are available in Solaron's APPLICATION ENGINEERING MANUAL. Contact the nearest Solaron distributor or representative.

SOLARON®
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Solar Energy Systems

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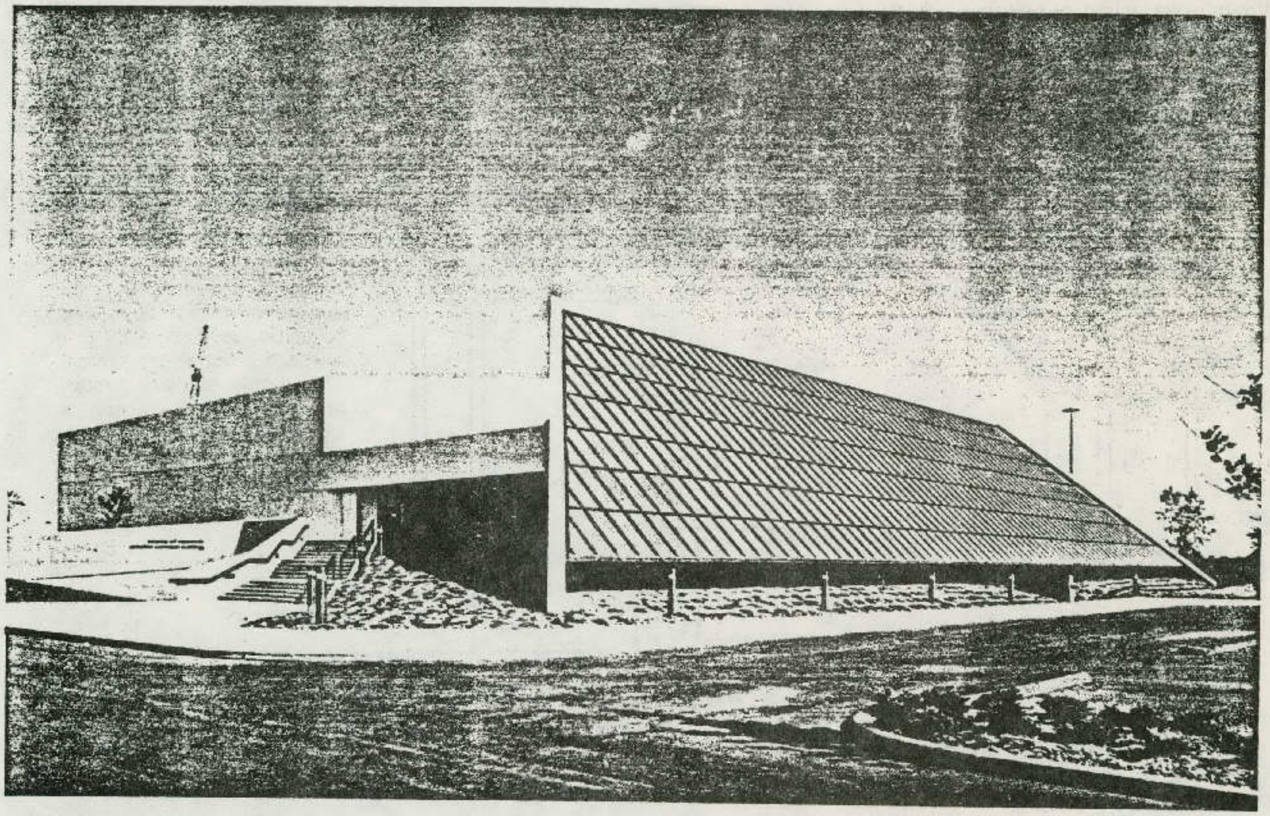
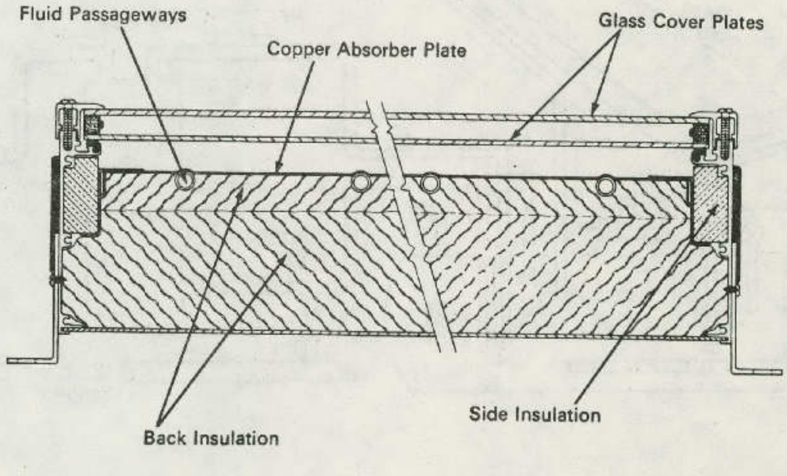
INDUSTRIES

How a PPG Solar Collector works



The PPG flat plate solar collector absorbs direct as well as diffused solar radiation during daylight hours. Solar energy passes through the tempered glass plates covering the face of the collector panel and is absorbed by the special black coating on the copper absorber plate. The sun's rays are converted to heat energy which is trapped by the glass face plates. This trapping, or "greenhouse effect" reduces the front heat loss from the absorber plate. The heat that has been collected on the absorber plate is transferred to a fluid, usually water, that is circulated through copper tubing soldered to the back of the copper absorber plate. This heated fluid is then pumped from the array of solar collectors to a storage tank, where it will be used for hot water and heating needs as required.

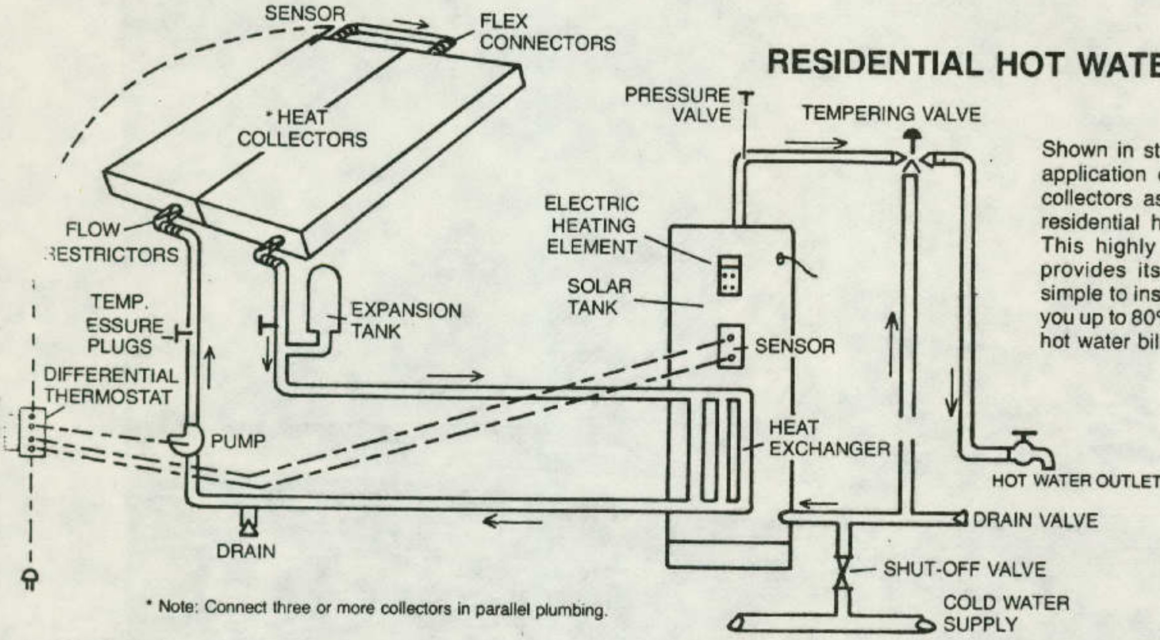
PPG Type II Solar Collector



KING *solar energy system.*

The economy of any solar hot water system is based on collector efficiency; the amount of useable energy the system provides versus its cost. American Solar King recommends that prospective buyers compare independently verified efficiencies of our systems with those of other systems they may be considering.

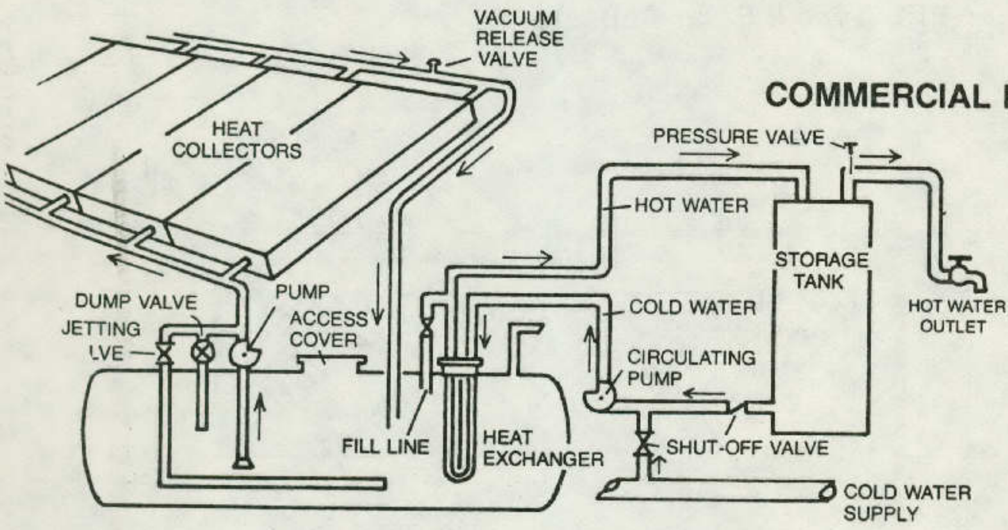
RESIDENTIAL HOT WATER SYSTEM



* Note: Connect three or more collectors in parallel plumbing.

Shown in stylized form is the application of our solar heat collectors as they relate to a residential hot water system. This highly efficient system provides its own backup, is simple to install, and can save you up to 80% on your monthly hot water bill.

COMMERCIAL HOT WATER SYSTEM



The stylized diagram illustrates a heavy duty, high performance commercial hot water system. This system could also serve to heat process fluids such as oils and other closed fluid systems. Solar King engineers and system specialists are available with computer analysis for your individual solar energy commercial requirements.

How Solar Systems Work

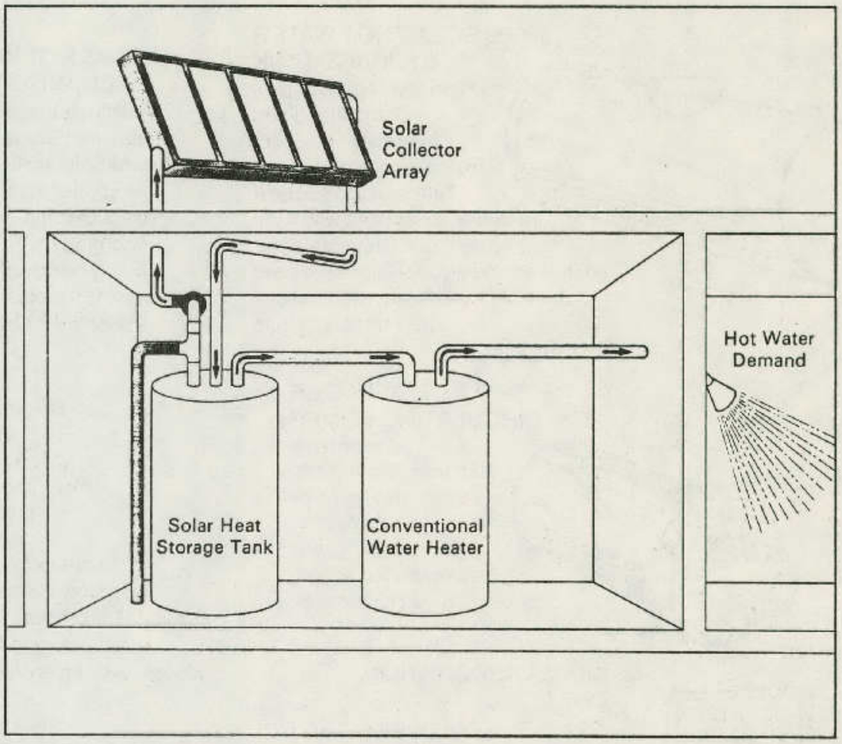
PPG Solar Collectors are designed to collect heat energy from sunlight and transfer this solar energy to a circulating fluid, usually water. This energy, in turn, may be used for a variety of heating or preheating tasks in residential, industrial, or commercial applications. Among the most common uses of solar systems are the heating of domestic hot water and the heating of living and working spaces.

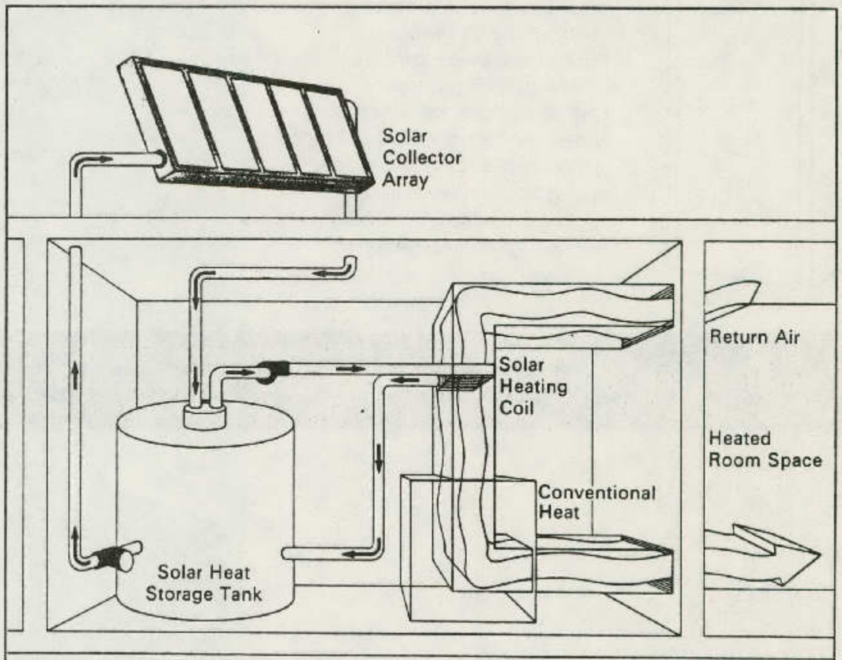
Domestic Hot Water Heating

In a typical solar energy hot-water heating system, the transfer fluid receives its heat energy from remotely-located solar collectors and is then circulated to, and stored in, the insulated solar system storage tank for ultimate transfer to the domestic hot water tank. Circulation is interrupted when the fluid in the storage tank becomes hot enough, or when the collectors fall below the desired temperature. The conventional heating unit in the hot water tank is only used when the solar preheated water is not sufficient to meet the hot water demand.

Space Heating

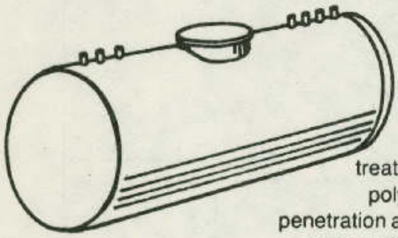
In a typical solar energy space heating system, solar heated water is circulated to an insulated storage tank. From there, it is pumped on demand through a heat transfer coil located in the return air duct of a conventional forced-air furnace. During those periods of extreme cold or prolonged cloudiness when the heating requirements may exceed the capabilities of the solar collector array, a conventional furnace is signalled to start up to provide the extra needed heat. During those periods when more solar heat is being provided than is needed, fluid circulation will continue through the collectors and energy will be held in the storage tank for future use.





Note: In either system, where freeze protection is required to protect the collectors or other parts of the system, an automatic "drain down" principle can be employed, or anti-freeze solutions or heat exchangers can be used in the system.

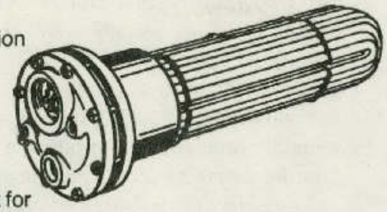
HEATING AND AIR CONDITIONING SYSTEMS MAJOR COMPONENTS



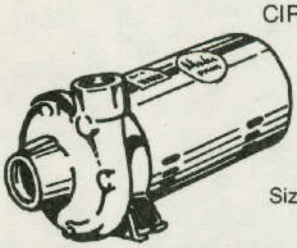
SK-28 SOLAR HOT WATER STORAGE TANK

Plate steel construction. Completely lined internally and spark tested for complete seal. Tanks—External tank treated and insulated with 4" of polyurethane. Prevents water penetration and electrolysis to the steel outer wall. Tank Sizes—285 gallons thru 12,000 gallons

SK-45 HOT WATER HEAT EXCHANGERS



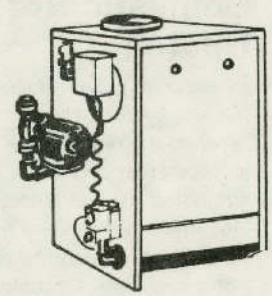
Eliminates cross connection between Domestic water and Solar tank water.
All copper tube bundle, 2 pass U-Bend Heat Exchangers.
Easily removed from tank for maintenance.
Designed for High Recovery demand loads.



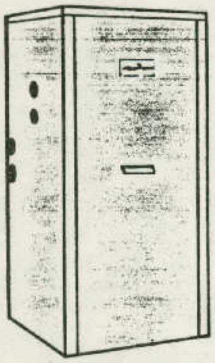
SK-7 & 9 HOT WATER CIRCULATING PUMPS

All bronze or stainless steel pump eliminates any rust problems.
Quiet running, low power consumption.
Sizes from ¼ H.P. and up.

SK-47 BOILER



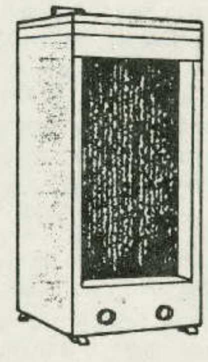
Large water capacity for jobs involving large diameter, existing pipes. New, improved design and high heater rating for abundant hot water. Slide-out burner tray for easy servicing. Converts easily to use natural or LP gas. All controls on the left side and fully approved for alcove (3-sided enclosure) installation.



SK-46A ABSORPTION CHILLER.

This chiller is designed for solar-operated comfort air conditioning applications, but can also be used in small industrial process cooling applications. The unit shown is nominally rated at 3 tons, but design flexibility allows for operation over a wide range of cooling capacities. Commercial chillers with over 100 ton capacity are also available.

SK-48 COOLING TOWER



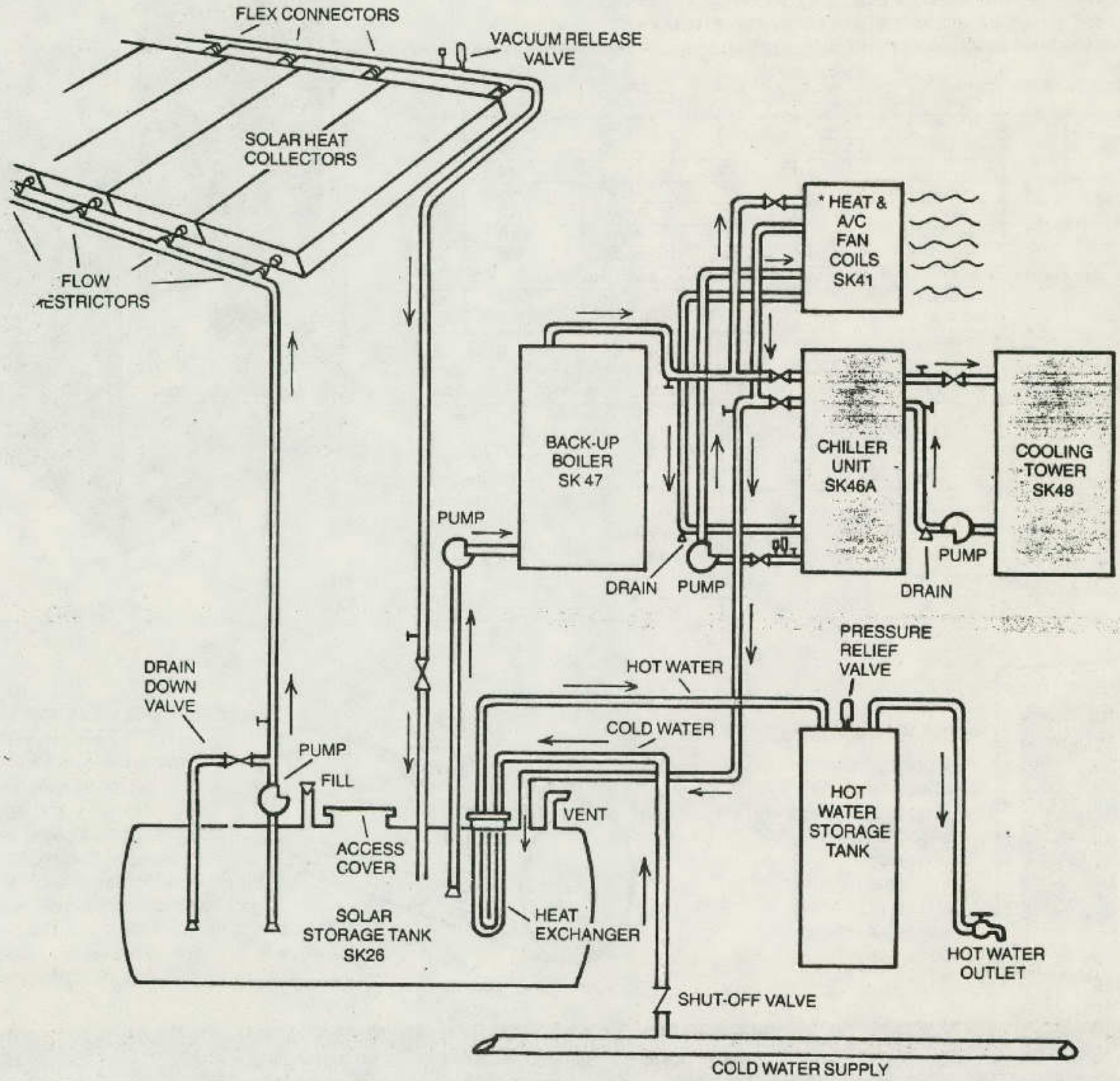
Cooling towers specified by Solar King are high quality, efficient towers, operated thermostatically to insure maximum electrical energy conservation.

Note: Residential and commercial heating and air conditioning systems include many more components than the "major" system components shown above. Your Solar King distributer or dealer will be happy to provide a complete list of materials upon request.

DISTRIBUTORS FOR AMERICAN SOLAR KING CORPORATION
6801 NEW McGREGOR HIGHWAY WACO, TEXAS 76710 • (817) 776-3860

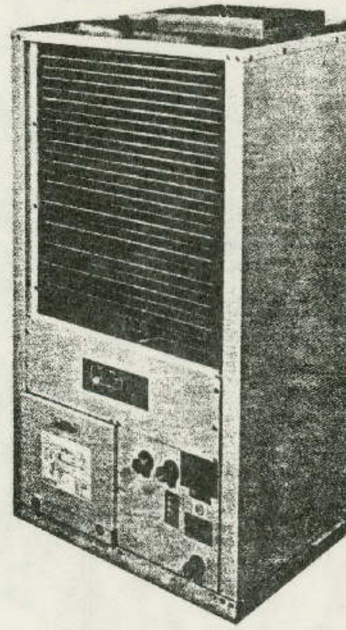
RESIDENTIAL AND COMMERCIAL HEATING AND AIR CONDITIONING SYSTEM

This stylized diagram illustrates a heavy-duty, high performance residential or commercial heating and air conditioning system. This highly efficient system provides hot water as well as heating and air conditioning needs. Solar King engineers and system specialists are available with computer analysis for your individual solar energy residential or commercial requirements.



* Heating Coil is ordered as a separate component of the SK41.

SOLAR SOURCE HEAT PUMP SYSTEM MAJOR COMPONENTS



SK-39 HEAT PUMPS...

Provide year-round air-conditioned comfort in a sound insulated package backed by laboratory testing and a history of trouble-free operation and reliability. A.R.I. Ratings are among the industry's highest.

Units are factory charged, pre-wired and pre-piped for minimum on-site labor.
Hermetically sealed and internally protected compressor with lock-out relay.
Controls and components located for easy inspection access.

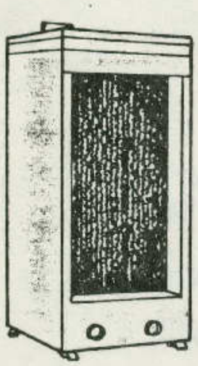
PERFORMANCE DATA

DESIGNATION	G.P.M.	COOLING CAPACITY (BTUH)	COOLING POWER INPUT (Watts)	EER (BTUH/WATTS)	HEATING CAPACITY (BTUH)	HEATING POWER INPUT (Watts)	COP
*1 ton	3	12,000	1,550	7.7	17,800	1,750	3.0
*2 tons	6	27,000	2,900	9.3	34,500	3,000	3.4
2.5 tons	7½	32,500	3,550	9.2	42,000	3,450	3.6
3 tons	9	40,000	4,550	8.8	62,000	5,600	3.2
4 tons	12	50,000	5,900	8.5	71,000	6,700	3.1
5 tons	15	64,000	7,600	8.4	94,000	8,300	3.3
6 tons	18	80,000	9,090	8.8	124,000	11,300	3.2
*Additional sizes available include 8, 10, 12, 15, 18, 20, 25 tons. Rooftop models available up to 45 tons.							
* 10 tons		119,000	11,700	10.2	145,000	10,500	4.0
* 20 tons		248,000	24,500	10.1	313,000	24,200	3.7

*Solar assisted; available both vertically and horizontally ducted

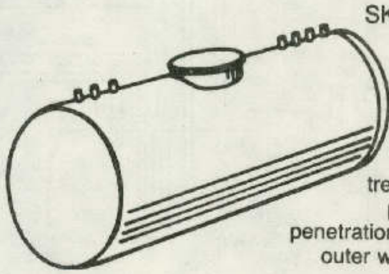
PHYSICAL DATA

DESIGNATION	CFM	FAN MOTOR HP	SHIPPING WEIGHT	PIPE SIZE	HEAT EXCHANGER	ELECTRICAL
1 ton	400	1/6	350	1	Hydrostatic	208
2 tons	800	1/4	360	1	pressure	to
2.5 tons	950	1/4	380	1	tested	230 Volt
3 tons	1200	1/3	400	1	to	1 Phase
4 tons	1600	1/3	530	1	2250 lbs.	(3 Phase
5 tons	2000	3/4	550	1		optional)
6 tons	2400	1	1000	1		60 HZ
*ADDITIONAL SIZES (see above)						
10 tons	3000-4800	2	1100	1		
20 tons	6000-9600	5	1800	1½		



SK-48 COOLING TOWER

Cooling towers specified by Solar King are high quality, efficient towers, operated thermostatically to insure maximum electrical energy conservation.



SK-28 SOLAR HOT WATER STORAGE TANK

Plate steel construction. Completely lined internally and spark tested for complete seal. Tanks—External tank treated and insulated with 4" of polyurethane. Prevents water penetration and electrolysis to the steel outer wall. Tank Sizes—285 gallons thru 12,000 gallons

Note: Residential and commercial systems include many more components than the "major" system components shown above. Your Solar King distributor or dealer will be happy to provide a complete list of materials upon request.

DISTRIBUTORS FOR AMERICAN SOLAR KING CORPORATION
6801 NEW McGREGOR HIGHWAY WACO, TEXAS 76710 · (817) 776-3860

THE SOLAR SOURCE HEAT PUMP SYSTEM

This stylized diagram illustrates a heavy duty, high performance Solar Source Heat Pump system. For heating and hot water applications, this system integrates a direct solar, a solar augmented and also a solar assisted sequence of operation as follows:

Solar Augmented (Direct Solar): When solar fluid temperatures are above 90°F, all heating is provided directly from the solar collectors. (Optimum design: 65-75% of average winter weather conditions)

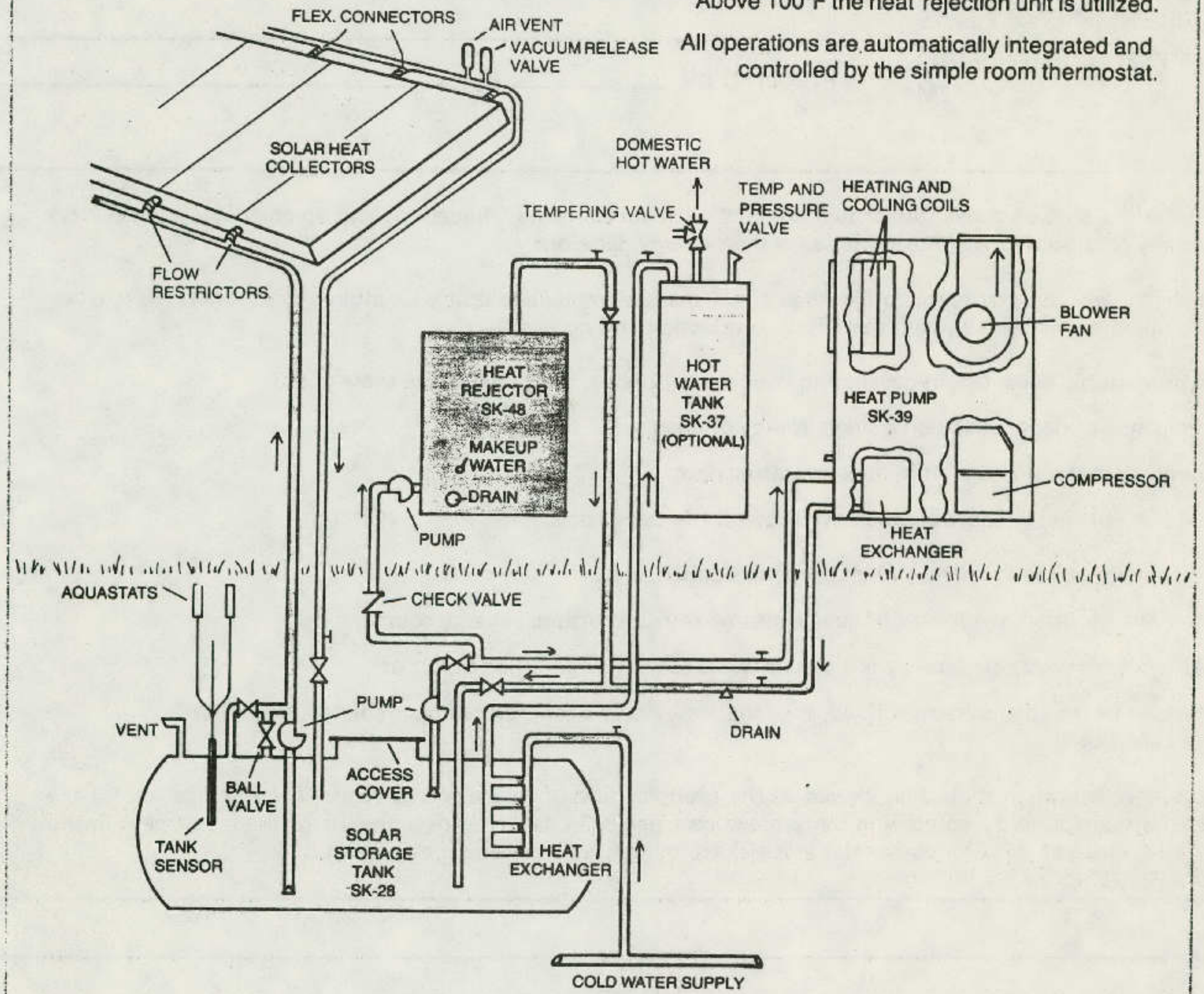
Solar Augmented and Assisted: When solar fluid temperatures are below 90°F, heating is provided directly by solar, but then is augmented as necessary by the heat pump.

Solar Assisted: As solar fluid temperatures drop to 60°F, the heat pump's compressor cycle extracts the required heat from the fluid.

Back-up: If fluid temperatures drop below 60°F the heat system is backed-up by a two stage electrical resistance coil or back-up boiler to provide full-rated heating.

For air conditioning operation the system works in reverse. Excess heat is rejected from the building and stored in the storage tank for water or pool heating. Above 100°F the heat rejection unit is utilized.

All operations are automatically integrated and controlled by the simple room thermostat.



SOLARON
SOLAR ENERGY SYSTEMS
Profit from the sun
TM

Commercial /Industrial Life Cycle Cost Analysis

Prepared for ______________________________

Address ______________________________

____

Telephone ______________ Date ______________

Application ______________________________

____

Prepared by ______________________________

The spiraling cost of conventional fuel coupled with curtailments, allocations and emergency cutbacks have drastically changed the way businesses view their energy decisions.

Availability and long term economic impact overshadow immediate quick fix alternatives. Energy is a necessity to operate. Without energy, there is no production and no profit.

Most prudent businessmen, in developing their energy policy, basically pursue these goals:

- Avoidance of dependency on a single source of energy
- Energy conservation, i.e., minimize operating costs
- Selection of energy sources which offer lowest life cycle costs

The advantages of solar energy, when properly applied, are:

- Solar energy offers the lowest life cycle cost of any conventional energy source.
- The availability of solar energy is a certainty. It cannot be curtailed or cut off.
- The cost of the solar system is fixed, thus the future cost of energy can be predicted, capitalized and controlled.

A solar energy system should be viewed as the capitalization of future energy costs. The justification for the system can be found by comparing the average cost per BTU delivered over the life of the investment to the alternative cost per BTU for conventional fuels, assuming a realistic rate of escalation.

SUMMARY

Cost per million BTU's for solar energy $________ (#18)   Cost per million BTU's for conventional energy $________ (#28)

General Information

1. Type of application ______________________________
____
____
2. Type of conventional fuel is ______________________________
3. Corporate tax rate is ________%
4. Interest on borrowed capital is ________%
5. Conventional fuel escalation rate is ________% per year
6. Period of analysis is ________ years

Solar System Energy Output

7. Average daily heat output per square foot of collector (See Solaron) ______________ BTU/DAY FT^2
8. Annual collector utilization ______________ DAYS/YEAR
9. Yearly energy output per square foot of collector (line 7 X line 8) ______________ BTU/FT^2 YR
10. Life cycle energy output per square foot of collector (line 6 X line 9) ______________ BTU/FT^2 LIFE CYCLE

Life Cycle Solar Cost per Million BTU After Taxes

11. Estimated installed cost per square foot of collector $ ______________ /FT^2
12. Interest expense over period of analysis ________ years at the interest rate on borrowed capital ________% (see table 1) $ ______________
13. Tax savings on interest expense (line 12 X line 3) $ (______________)
14. Tax savings on depreciation (line 3 X line 11) (This assumes system is fully depreciated within life cycle.) $ (______________)
15. State tax credit, if applicable $ (______________)
16. Federal tax credit, if applicable $ (______________)
17. Installed cost after taxes (line 11 + line 12 minus lines 13, 14, 15, 16) $ ______________ /FT^2
18. Average cost of solar per million BTU for the life cycle (line 17 divided by line 10) (multiplied by one million) $ ______________ /MILL. BTU

Note: If projected life of system exceeds the period of analysis, a portion of the installed cost should be allocated to the future period thereby reducing line 18.

Conventional System Energy Output

19. Conventional energy type________________________
20. Energy content per unit of measure (see table 2) __________BTU/________ (Unit)
21. System efficiency __________%
22. Energy output per unit of measure (line 20 X line 21) __________BTU/________ (Unit)

Life Cycle Conventional Fuel Cost per Million BTU After Taxes

23. Cost of conventional fuel $____________ /______ (Unit)
24. First year cost per million BTU (line 23 divided by line 22, multiplied by one million) $__________/Mill. BTU
25. Cumulative fuel expense escalated over the period of analysis. (line 24 multiplied by selected number on table 3) $__________/Mill. BTU Total
26. Average cost per million BTU over the period of analysis (line 25 divided by line 6) $________/Mill. BTU/YR
27. Tax savings on fuel expense (line 26 X line 3) $ (________)
28. Average cost of conventional fuel per million BTU for the period of analysis (line 26 minus line 27) $__________/Mill. BTU

TABLE 1

MULTIPLIER FOR TOTAL INTEREST PAID

Assumes: Total loan paid back in equal amount payments.

% Interest Per Year

YEARS OF LOAN	6%	7%	8%	9%	10%
5	.16	.19	.22	.25	.28
10	.33	.39	.46	.52	.59
15	.52	.62	.72	.83	.94
20	.72	.86	1.01	1.16	1.32

Example Problem: The total interest expense on a $20,000 loan at 9% interest for 10 years = $20,000 X .52 = $10,400.

TABLE 2

AVERAGE CONVENTIONAL FUEL BTU CONTENT*

Natural Gas	1000 BTU/Ft^3
Propane	2550 BTU/Ft^3 21,600 BTU/pound 91,300 BTU/gallon
Fuel Oil No. 2	140,000 BTU/gallon
Electricity	3,413 BTU/KWH
Coal - bituminous	12,000 BTU/pound
sub-bituminous	10,000 BTU/pound
lignite	7,500 BTU/pound

*At sea level, derate for altitude.

TABLE 3

MULTIPLIER FOR CUMULATIVE FUEL EXPENSE

ANNUAL FUEL COST ESCALATION PERCENT

CUMULATIVE YEARS OF FUEL EXPENSE	6%	7%	8%	10%	12%	14%	16%	18%	20%
4	4.375	4.440	4.506	4.641	4.779	4.922	5.067	5.215	5.368
5	5.637	5.751	5.866	6.105	6.353	6.611	6.876	7.154	7.442
6	6.975	7.154	7.335	7.716	8.115	8.536	8.978	9.442	9.930
7	8.394	8.655	8.922	9.488	10.089	10.731	11.414	12.142	12.916
8	9.898	10.261	10.636	11.437	12.300	13.233	14.240	15.327	16.499
9	11.492	11.979	12.487	13.581	14.776	16.086	17.518	19.086	20.799
10	13.181	13.817	14.486	15.939	17.549	19.338	21.321	23.521	25.959
11	14.972	15.784	16.645	18.533	20.655	23.045	25.732	28.755	32.151
12	16.870	17.889	18.977	21.386	24.134	27.271	30.849	34.931	39.581
14	21.015	22.551	24.215	27.976	32.393	37.581	43.671	50.818	59.196
16	25.673	27.889	30.324	35.950	42.754	50.980	60.925	72.939	87.442
18	30.906	34.000	37.450	45.599	55.750	68.393	84.141	103.740	128.116
20	36.786	40.997	45.762	57.275	72.053	91.024	115.381	146.627	186.687

EXAMPLE PROBLEM: Assuming fuel oil presently costs $4.08 per million BTU, example output from line 24, the total fuel expense over ten years escalated at 12% annually equals:

17.549 X $4.08/million BTU = $71.60/million BTU
(Table 4) (Line 24) (Line 25)

Friedrich®
CENTRAL COOLING AND HEATING

Hot Water Generator™

for use with Friedrich RCA/RCB Condensing units or Friedrich RYA/ECC Split Heat Pump

DHW Series

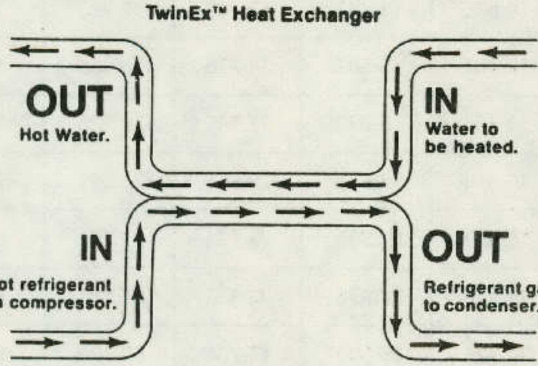
Description

- Hot Water Generator™ captures waste energy from compressor and uses it to heat hot water for the home.
- Can substantially reduce hot water heating costs, providing up to 100% of daily domestic hot water heating requirements, depending on use of air conditioning condensing unit. Hot Water Generator™ operates when condensing unit is on cooling cycle, or it operates year round with Friedrich Heat Pumps.
- When compressor is operating, hot water is available normally without additional energy from either gas or electric water heater.
- Uses exclusive TwinEx™ heat exchanger to transfer heat from refrigerant to hot water.
- By-pass is automatically controlled by hot water temperature. When water temperature falls below preset level, water is diverted through heat exchanger to be heated. If water temperature is above preset level, water by-passes heat exchanger and is immediately available.
- Hot Water Generator™ must be installed indoors within 25 feet of condensing unit, and not more than 25 feet from household hot water tank.
- HWG Hot Water Generator™ also is ideal for restaurants and other commercial establishments that keep air conditioning running year round and have continuing demand for hot water.

Features

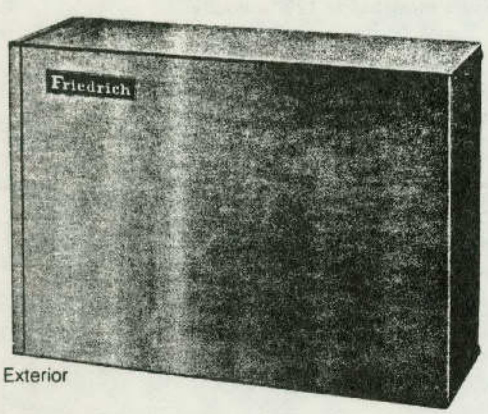
1. Exclusive, double-wall tube-type TwinEx™ heat exchanger is enclosed in insulated cabinet. System is designed to prevent refrigerant or lubricant contamination of water.
2. Adjustable water temperature thermostat allows higher overall water temperatures for heavy usage.
3. Automatic two-speed pump has magnetically driven impeller; no shaft is needed, reducing potential problem area. There are no seals to leak.
4. Sealed ball bearings on pump motor eliminate need for oiling.
5. Factory assembled package is designed to be matched with correct Friedrich condensing units or heat pump.
6. Low refrigerant side pressure drop results in increased capacity compared to high pressure drop on some competitive models.

TwinEx™ Heat Exchanger

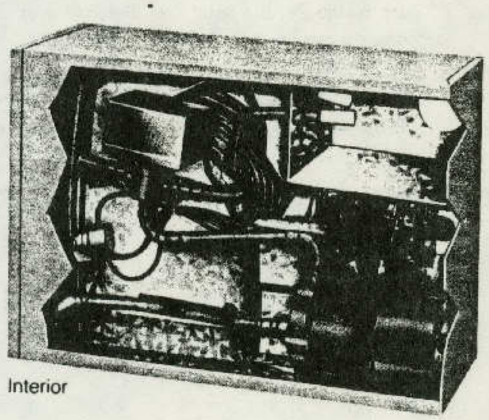


TwinEx—patent pending

Hot Water Generator™



Exterior



Interior

Another Energy Economizer Product from Friedrich

Friedrich Hot Water Generator™ **DHW** Series

for use with Friedrich RCA /RCB Condensing units or Friedrich RYA /ECC Split Heat Pumps

Remote Air Cooled Heat Pumps

	Cooling Mode						Heating Mode					
				Utilization Efficiency (4)						Utilization Efficiency (4)		
Heat Pump Model #	Unit (1) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Separate (EER)	Combined (EER)	Combined Energy Reduction (%)	Unit (1) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Separate (COP)	Combined (COP)	Combined Energy Reduction (%)
RYA 018	17500	2200	3.8	7.0	9.2	23	16700	2100	3.6	2.4	2.8	16
024	23000	3100	5.3	6.5	8.4	23	22900	2900	5.0	2.4	2.9	16
030	29500	4600	7.8	6.6	8.9	26	27700	3500	6.0	2.2	2.5	13
036	35000	5500	9.4	6.2	8.3	25	31700	3900	6.7	2.1	2.4	12
042	40000	6200	10.6	6.3	8.4	25	37000	4400	7.5	2.2	2.4	11
048	48000	6800	11.6	6.7	9.0	25	42200	4800	8.2	2.3	2.6	13

Remote Air Cooled Condensing Unit

				Utilization Efficiency (4)		
Condensing Unit Model #	Unit (2) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Separate (EER)	Combined (EER)	Combined energy Reduction (%)
RCA 018	17500	3500	6.0	5.6	7.8	28
024	24000	4600	7.9	6.0	8.4	28
030	30000	5700	9.8	6.2	8.7	29
036	34000	6400	11.0	6.0	8.3	29
042	41000	7200	12.3	6.5	9.1	28
048	47000	7600	13.0	6.9	9.6	28

				Utilization Efficiency (4)		
Condensing (2) Unit Model #	Unit Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Separate (EER)	Combined (EER)	Combined Energy Reduction (%)
RCB 024	23000	3900	6.7	7.0	10	30
030	28000	5200	8.9	6.5	9.2	30
036	36000	6400	11.0	6.6	9.4	29
042	41000	6900	11.8	6.7	9.4	28
048	48000	7300	12.8	7.2	10.1	28
060	55000	7500	12.9	7.7	8.8	24

(1) Rating in accordance with ARI Standard 240-76 with inside condition of 70°F DB and outside of 47°F DB, 43°F WB, and in cooling with inside condition of 80°F DB, 67°F WB and outside condition of 95°F DB.
(2) Rating in accordance with ARI Standard 210-75 with inside condition of 80°F DB, 67°F WB and outside condition of 95°F DB.
(3) Rate of recovery. gallons per hour, when heating water from 70°F to 140°F.
(4) Utilities Efficiency is a ratio of the sum of the air cooling (or air heating) and hot water heating output capacities to the power input.
—Combined Utilities Efficiency is the ratio of such output to power input for a Friedrich heat pump equipped with a Hot Water Generator.
—Separate Utilities Efficiency is the ratio of such output to power input for a Friedrich heat pump, and for an equal amount of hot water heating performed solely in the owner's electric hot water heater.
When the efficiency is stated in EER, it is the sum of the air cooling and hot water heating capacities expressed in BTUH, divided by the power input in watts.
When the efficiency is stated in COP, it is the sum of the air heating and hot water heating capacities expressed in watts, divided by the power input in watts.

Installation

As an accessory package, Friedrich Hot Water Generator™ is easy to install for use with Friedrich air cooled units, 17,500 to 48,000 Btu/hr. Interconnects with storage type gas or electric hot water heaters, and produces up to 100% of hot water requirements.

Designed for 208 /230 volt systems, 2 amps /30 watts. Suitable for connection with refrigerant R-22. Maximum capacity of 2-speed pump is 3 gallons per minute.

Hot Water Generator™ must be mounted indoors and must be located as close as possible to the outdoor unit, not exceeding 25 feet.

Recommended refrigerant line sizes:

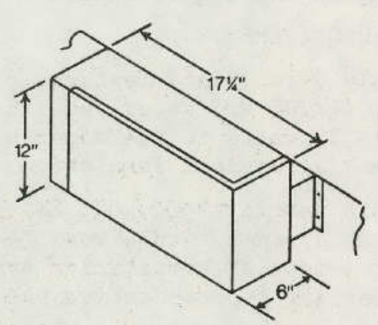
Condensing Unit Size (Btu/hr)	Copper OD"
18,000 to 24,000	3/8
30,000 to 48,000	1/2

Piping sizes between Friedrich Hot Water Generator™ and hot water heater should be in accordance with the following (distances should not exceed 25' because of pump capacity):

Distance between hot water heater and Friedrich Hot Water Generator™	Minimum recommended water line size (nom)
0- 5 feet	1/4" (3/8" OD)
5-25 feet	3/8" (1/2" OD)

Recommended: Refrigerant lines and water piping should have minimum of 1/4" thick closed cell piping insulation, such as Armaflex or Rubatex. Insulate hot water outlet line to prevent losses to ambient.

Brackets provided with unit for wall mounting



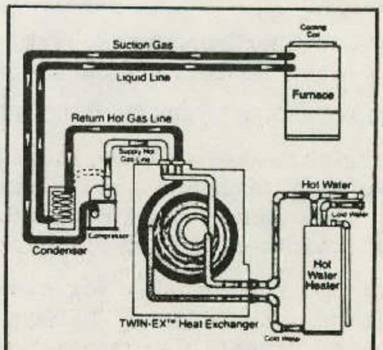


Diagram shows how the Hot Water Generator™ fits into a new or existing system.

Continuing research results in steady improvements. Therefore, these specifications are subject to change without notice.

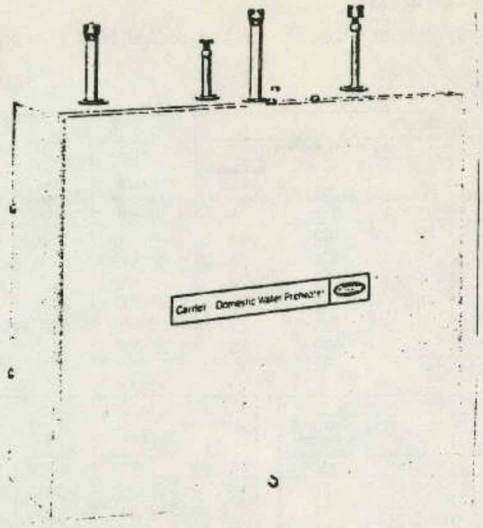
Friedrich Air Conditioning & Refrigeration Co.
4200 North Pan Am Expressway, San Antonio, Texas 78295
Telephone (512) 225-2000

Friedrich
A Division of Wylain, Inc.

Printed in U.S.A.

CARRIER
HOT SHOT
HEAT RECLAIM DEVICE
for domestic hot water systems

38
38HQ900011
2800 - 8500 Btuh



.....PROVIDES UP TO 9 GALLONS OF FREE HOT WATER FOR EACH HOUR YOUR AIR CONDITIONING SYSTEM RUNS*

Introducing the Hot Shot, Carrier's unique heat reclaim device that automatically recycles heat energy from your air-conditioning or heat pump system to your domestic hot water.

REUSING ENERGY IS LIKE REUSING YOUR OWN MONEY.

The Hot Shot begins paying for itself immediately because it takes heat energy that you've already paid for to air-condition your home, and instead of throwing it away, reclaims it for use in your hot water heater. Here's the basic principle: An air-conditioned home stays comfortable on summer days because heat from hot, humid indoor air is mechanically removed and dispersed outdoors. The Hot Shot takes that unwanted heat and uses it to heat your hot water. Inside the Hot Shot, superheated refrigerant is brought into contact with water (about 60 F), heating it to the desired temperature (about 140 F); then it's delivered to your hot water tank. Whenever your air-conditioning system is running, the Hot Shot adds hot water...so in effect, your hot water heater runs significantly less, and your water costs significantly less.

INSTALLS IN ONLY MINUTES

The Hot Shot connects quickly, directly to the inlet and outlet lines of your hot water heater. Mounts easily on ceiling or wall.

QUALITY CONSTRUCTION MEETS HUD REQUIREMENTS.

The light, compact Hot Shot (only 5-in. wide) features a double wall tube-in-tube heat exchanger and a small (1/200 HP) water pump that not only moves water, but also contributes most of its 35 watts to the water heating process as well. The cabinet is lined with thermal/acoustical insulation.

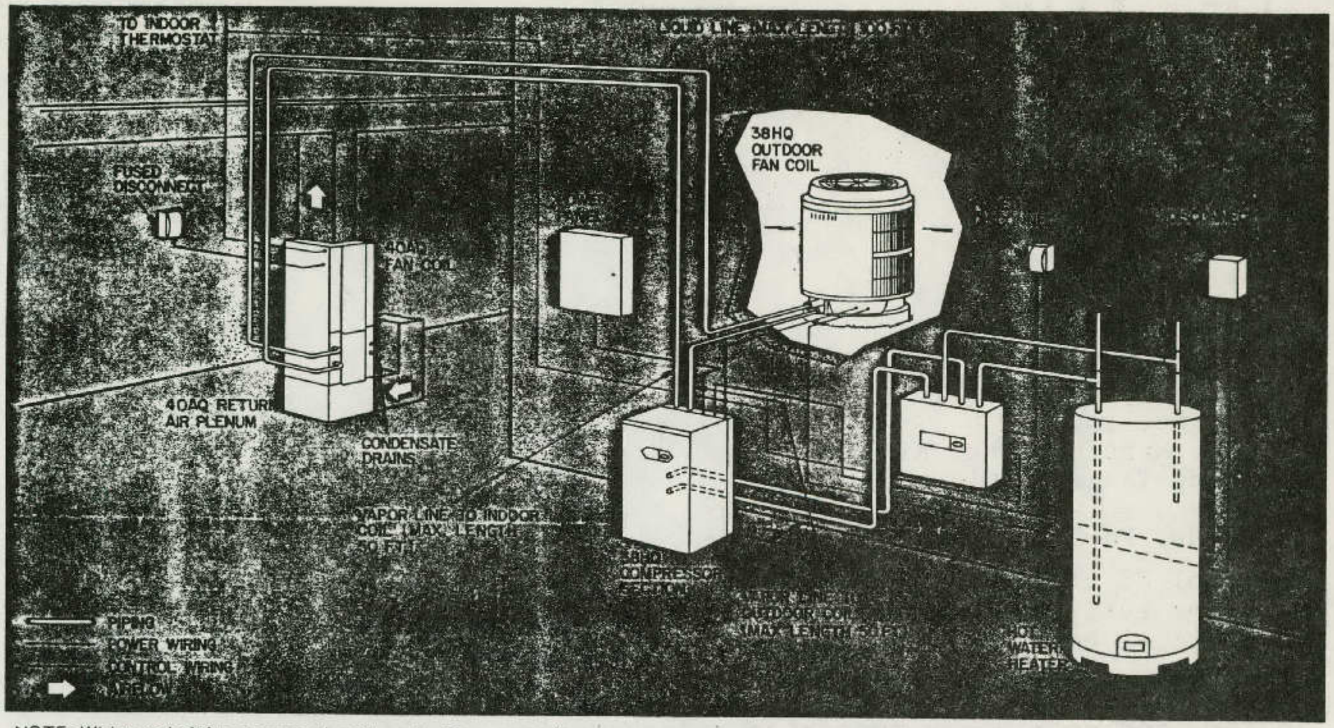
Although recommended for use with Carrier 38CE, CU, EE, GS, SE, and UE cooling systems and 38CQ and HQ heat pump systems thru 4 tons (48,000 Btuh), the Hot Shot is also compatible with a wide variety of competitive systems, depending on accessibility of components. Your carrier representative has the details.

*based on a typical 36,000 Btuh system with 60 F entering water and 140 F leaving water.

Carrier

form 38-1P

Typical piping and wiring



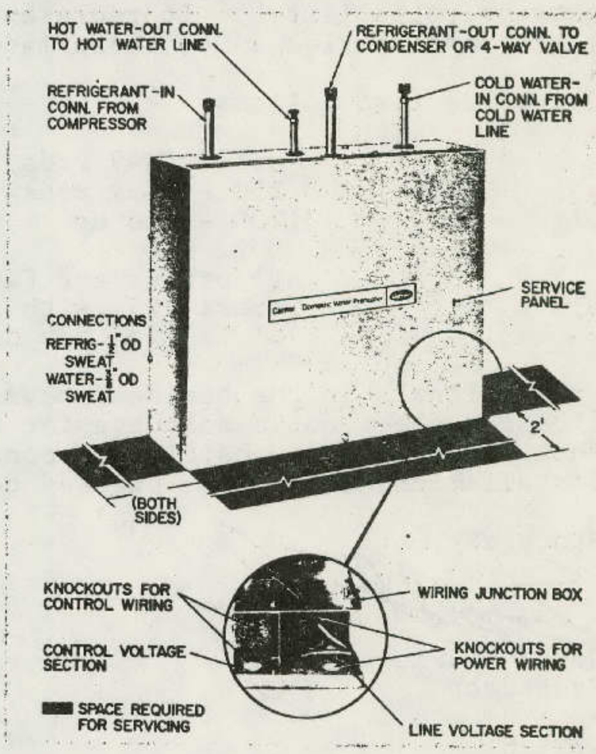
NOTE: Wiring and piping are general guides only. They are not intended for a specific installation.

TYPICAL HOT SHOT PERFORMANCE

AIR COND SYSTEM CAPACITY (Btuh)	HOT WATER SUPPLIED (gph)	UNIT OF ENERGY SAVED PER DAY
18,000	4.7	15.5 Kw of elec 76 cu ft of gas .53 gal of oil
24,000	6.0	
30,000	7.3	
36,000	8.9	
42,000	11.1	
48,000	12.7	

Based on 80 F water temperature rise, family of 4 using 80 gallons of hot water per day. For gas and oil hot water heating, an efficiency of 70% is assumed.

Dimensions and connections



Tab 4 Form 38-1P New Printed in U.S.A. 10-77 PC 101 Catalog No. 523–854

Book	1	4
Tab	5a	5a

TEXXOR
CORPORATION

June 14, 1979

Mr. Delbert M. Fowler
Planergy, Inc.
901 W. Martin Luther King Blvd.
Austin, Texas 78701

Dear Mr. Fowler:

Thermol 81 Energy Storage Rods have become an immediate reality for active and passive solar systems, plus industrial and commercial heat reclamation and conservation.

Nearly all of the major trade publications covering heating, solar, and energy are preparing major stories on this significant break-through in energy storage and phase change materials.

Thermol 81 in not a eutectic salt, rather, it is a congruent-melting compound which Dow Chemical states will perform "with extreme reliability". It represents a design life of 20-40 years, and carries a Dow performance warranty for 10 years.

Our price list follows:

1 - 249 rods	-	\$29.80
250 - 1199 rods	-	\$28.20
1200 - and up	-	\$25.90

All prices are F.O.B., Fenton, MO
Terms: 25% with order;
75% ten days before shipment

Professionals in the business have found the attached specification sheet quite adequate for designing and installation. Should you be in a position to consider an energy rod storage installation, we will be pleased to work with you.

Sincerely,

Gould B. Flagg, Jr.
President

GBF:ch
Enclosure

POST OFFICE BOX 14337 OMAHA, NEBRASKA 68124 TELEPHONE (402) 393-2509

PSI

ENERGY STORAGE DIVISION

Thermol 81®
Energy Storage Rods

Specifications and description of an encapsulated phase change material for use in thermal systems designed for heat reclamation and heat storage.

The R & D Assignment:

TASK 1–To develop a phase change material with an optimal melting point for environmental heating comfort; low enough to be easily charged yet high enough to discharge effectively.

TASK 2–To develop this phase change material from a congruent melting compound so that it will not stratify and is, therefore, capable of phase change with no loss of efficiency.

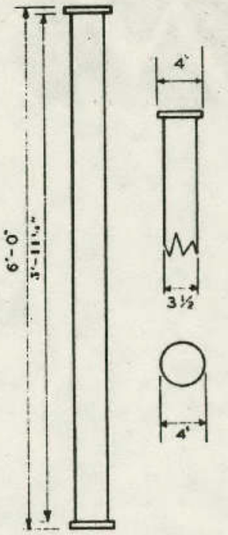
TASK 3–To encapsulate this phase change compound with materials and production techniques so that it will not need maintenance or replacement for thirty years.

Thermol 81® Energy Storage Rods

The Thermol 81® Energy Storage Rod is an efficient and practical thermal storage concept. Heat is stored as latent heat of fusion in crystals. These crystals change phase at 81°F (27°C). While changing phase from a crystalline structure to a melted state, they absorb 82 BTU per pound of PCM. The PCM is a congruent melting compound that will not stratify and is designed to retain efficiency for many years.

The PCM is encapsulated in ultra-high molecular weight high density polyethylene with carbon black. Thermol 81® Energy Storage Rods are constructed to provide adequate air spacing. When installed in a thermal storage chamber, in a honeycomb configuration, the cylindrical shapes of the energy storage rods generate irregular air flow patterns which encourage turbulance. This turbulance provides a surface to volume ratio allowing for excellent heat exchange. The Thermol 81® Energy Storage Rods are permanently heat fusion sealed and should not need maintenance or replacement for many years under normal conditions.

THERMOL 81® ENERGY STORAGE RODS

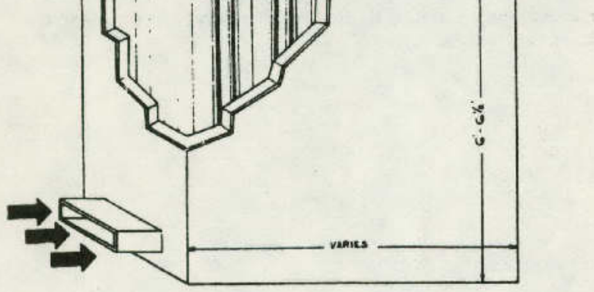


Thermal Storage Chamber

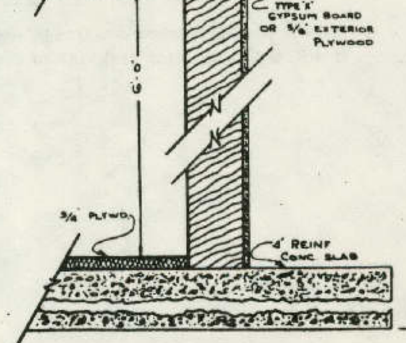
The thermal storage chamber can be constructed utilizing a variety of methods and materials. A simple design for a storage chamber is easily fabricated from sheet insulation and plywood. A rectangular configuration provides an efficient, economic application.

When a heat storage chamber of Thermol 81® Energy Storage Rods is charged, both the BTU output and the length of hours can be varied according to CFM of airflow through the storage and the temperature of the incoming air. Thus, the given BTU storage can be dispensed on a multi-variable basis depending upon the changing needs for environmental heating conditions. In almost all cases, this can be pre-engineered and programmed by adjusting sensors and thermostats.

Typical Storage Design



Typical Storage Construction



Thermol 81®
Energy Storage Rods

A New Storage Medium for Broad Application

For the Solar Industry

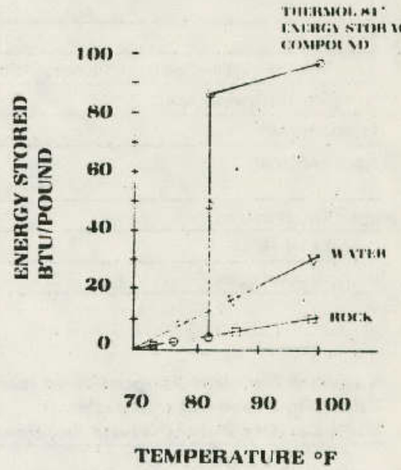
The solar industry has already proven that the sun's energy can be efficiently collected to heat water and air. The missing link has been the technical and scientific void in the area of practical heat *storage*. This frustration, at the scientists' level, left the industry with storage mediums focused primarily upon rather primitive devices...rock or water. While certainly feasible, these mediums require massive installations to approach even minimum storage needs.

Thermol 81® Energy Storage Rods' unique properties clearly represent a major break through for the solar industry. It's compactness, efficiency, and longevity dramatizes Dow Chemical's research and developmental achievement, as shown in the table (below) and in the graph (right.).

Quantity of Materials Required to Store 300,000 BTU's

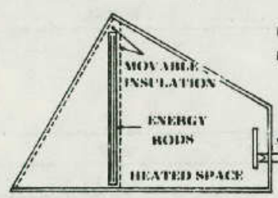
	Weight pounds	Weight tons	Volume ft³	Volume gallons
Rocks[1]	37,000	18.5	480	3,600
Water[2]	12,000	6.0	380	2,900
Thermol-81® Energy Storage Rods	3,700	1.8	78	600

COMPARISON OF STORAGE MATERIALS

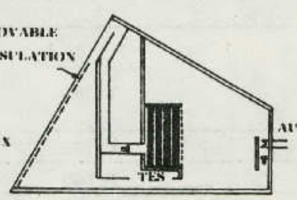


We fully expect the alert and aggressive solar industry to quickly develop countless new uses and variations, not discussed here, for optimizing Thermol 81® Energy Storage Rods, the new "heart" of a solar system.

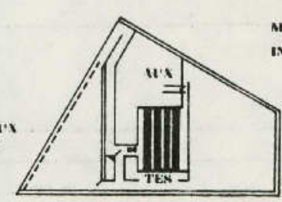
PASSIVE SOLAR SYSTEM



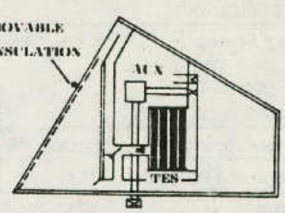
HYBRID PASSIVE/ACTIVE SYSTEM



FORCED AIR SOLAR SYSTEM



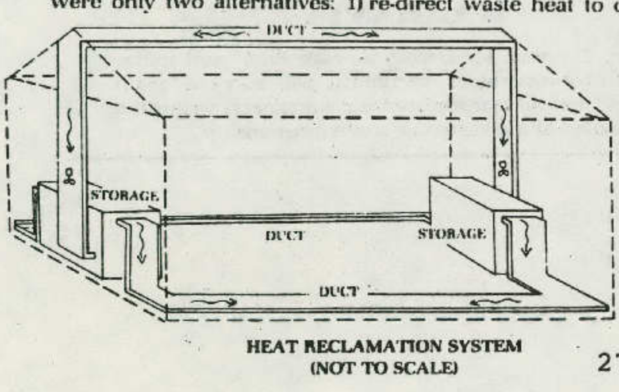
HEAT PUMP-COUPLED SYSTEM



For Commercial Heat Reclamation and Conservation

Factories, processing plants, restaurants and even offices generate excess heat during certain hours. Until now there were only two alternatives: 1) re-direct waste heat to other areas of need, or 2) vent it to the atmosphere. Thermol 81® Energy Storage Rods can store this unused, excess heat during the day, and feed it back to plant or office areas at other times.

Many American industrial companies have displayed unusual creativity in conserving waste heat and re-directing it, but until now, they have had no practical economical method available to store this heat for future use. The multi-application and versatility of Thermol 81® Energy Storage Rods now offers these economy and conservation minded people countless new ways to accelerate their energy conservation programs.



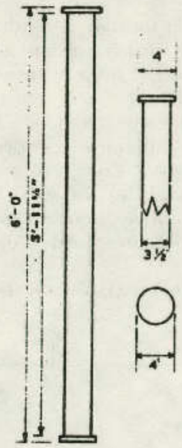
HEAT RECLAMATION SYSTEM
(NOT TO SCALE)

SPECIFICATIONS

The Thermol 81® Energy Storage Rod

Phase Change Material

THERMOL 81®
ENERGY STORAGE RODS



Property	Value
PCM Thermol 81® Energy Storage Compound	
melting temperature	81°F (27°C)
latent heat	82 BTU/lb
specific heat	.53 BTU/lb/°F liquid .34 BTU/lb/°F solid
specific gravity	1.71 solid
weight of PCM	30 lbs.
shipping weight	35 lbs.

Nominal Physical Properties of the Ultra-High Molecular Weight High Density Polyethylene Encapsulant

Property	ASTM Test	Value
Density, GMS/CC	D 1505	0.955
Melt Flow (Condition F), GMS/10 Min.	D 1238	1.5
Environmental Stress Cracking Resistance, (Hrs.) Conditon A, B & C	D 1693	►1500 No Failures
Tensile Strength, Yield, psi 20 In./Min. 2 In./Min.	D 638 Die IV	4800 3200
Elongation, % 2 In./Min.		►600
Impact Strength, Ft. Lbs./In. Notch, Specimen Thickness 0.250 Inch 0.125 Inch	D 256	7 12
Vicat Softening Temperature, °F	D 1525	257
Brittleness Temperature, °F	D 746	◄-180
Thermal Conductivity, BTU, In./Ft.²/Hrs.°F	C 177	3.7
Flexural Modulus, PSI	D 790	140M
Modulus of Elasticity, PSI	D 638	100M
Hardness, Shore D	D 2240	65
Coefficient of Linear Thermal Expansion, In./In./°F	D 696	1.2x10⁴

Manufactured By:
PSI Energy Storage Division
1533 Fenpark Dr.
Fenton, Missouri 63026
(314) 343-7666

WARRANTY

Every Thermol 81® Energy Storage Rod, used under normal recommended conditions, will carry a "plain language" ten (10) year replacement warranty covering the performance of the materials and workmanship.

ENERGY MISER Fractional Hp Motors belong in your total "energy-saving" program

When electric power was cheap, and availability of supply posed no problem, emphasis was placed in motor design and NEMA standards on physical size, rating, and over-all performance—all at the most economical price.

Conditions have changed. Power usage efficiency is becoming more and more a major consideration for every motor buyer.

Westinghouse meets this challenge with a new line of motors—the ENERGY MISER—conforming to all NEMA standards and the best tradition of Westinghouse quality, but with added benefits of lower energy cost and longer life.

For specialized applications, Westinghouse will work with equipment manufacturers in developing a customized ENERGY MISER design.

Hp	Rpm	Volts	Frame	Amps	Speeds	Shaft Length	Style No.	List Price	Notes	Typical Full Load Efficiency③ Std. Line	EM Line	Typical % Eff. Improvement	$.04/KWH KWH=(Hp)(.746)(Hrs)/Eff. Power Consumption Cost Std.	EM	Savings
Direct Drive, Furnace Blower/Air Conditioning Evaporator Blower Motors **Sleeve Bearing,** Type FLL, Open, Reversible															
													—3100 Hrs/Yr—		
¼	1075	115	FT48	3.5	3	3.50	323P273	$ 72.70	1, 2, 4, 9	56	62	10.7	$ 41.30	$37.30	$ 4.00
¼	1075	230-208	FT48	1.7	3	3.50	274	73.40	1, 2, 3, 4, 9	56	66	17.9	41.30	35.04	6.26①
⅓	1075	115	HT48	4.1	3	3.50	275	76.70	1, 2, 4, 9	57	63	10.5	54.04	48.89	5.15
⅓	1075	230-208	HT48	2.4	3	3.50	276	77.40	1, 2, 3, 4, 9	57	66	15.8	54.04	46.67	7.37①
½	1075	115	KT48	7.5	3	3.50	277	84.50	1, 2, 4, 9	57	64	12.3	81.14	72.27	8.87
½	1075	230-208	KT48	3.3	3	3.50	278	85.20	1, 2, 3, 4, 9	57	67	17.5	81.14	69.03	12.11①
Direct Drive, Room Air Conditioner Motors **Sleeve Bearing,** Type FLL, Semi-Enclosed, CCW Rotation, Length Adapter Kit Not Included															
													—2000 Hrs/Yr—		
⅙	1075	115	DT48	1.9	3	6.78/6.52	323P279	74.90	1, 2, 4, 5, 9	54	58	7.4	18.46	17.18	1.28
⅙	1075	230-208	FT48	1.0	3	6.53/6.27	280	75.60	1, 2, 3, 4, 5, 9	57	65	14.0	17.49	15.33	2.16①
¼	1075	115	FT48	3.5	3	6.53/6.27	281	78.90	1, 2, 4, 5, 9	56	62	10.7	26.64	22.95	3.69
¼	1075	230-208	FT48	1.7	3	6.53/6.27	282	79.60	1, 2, 3, 4, 5, 9	56	66	17.9	26.64	22.61	4.03①
⅓	1075	115	HT48	4.1	3	6.28/6.02	283	82.90	1, 2, 4, 5, 9	54	63	16.7	36.81	31.55	5.26
⅓	1075	230-208	HT48	2.4	3	6.28/6.02	284	83.60	1, 2, 3, 4, 5, 9	62	66	6.5	32.05	30.11	1.94①
½	1075	230-208	KT48	3.3	3	6.03/5.77	285	91.40	1, 2, 3, 4, 5, 9	64	67	4.7	46.63	44.54	2.09①
Direct Drive, Outdoor Condenser Fan Motors **Sleeve Bearing,** Type FLL, Semi-Enclosed, Reversible															
													—2000 Hrs/Yr—		
¼	1075	230-208	FT48	1.7	2	4.88	323P286	72.80	1, 3, 4, 6, 9, 11	56	66	17.9	26.64	22.60	4.04①
⅓	1075	230-208	HT48	2.4	2	4.88	287	76.80	1, 3, 4, 6, 9, 11	59	66	11.9	33.68	30.11	3.57①
Direct Drive, Outdoor Condenser Fan Motors **Ball Bearing,** Type FLL, Semi-Enclosed, Reversible															
													—2000 Hrs/Yr—		
¼	1075	230-208	FT48	1.7	2	4.88	323P288	80.80	1, 3, 4, 6, 9, 11	56	66	17.9	26.64	22.60	4.04①
⅓	1075	230-208	HT48	2.4	2	4.88	289	84.80	1, 3, 4, 6, 9, 11	59	66	11.9	33.68	30.11	3.57①
½	1075	230-208	KT48	3.3	2	4.88	290	97.80	1, 3, 4, 6, 9, 11	59	67	13.6	50.58	44.54	6.04①
Belt Drive, Furnace Blower Motors **Sleeve Bearing,** Type FHL, Reversible															
													—3100 Hrs/Yr—		
¼	1725	115	A48	3.8	1	1.62	325P128	66.00	4, 7, 8, 10	54	64	18.5	42.83	36.13	6.70
⅓	1725	115	B48	4.4	1	1.62	129	75.00	4, 7, 8, 10	59	68	15.2	52.21	44.89	7.32
½	1725	115	B48	5.7	1	1.62	130	101.00	4, 7, 8, 10	63	73	15.9	73.42	63.36	10.06

① Data at 230 Volts.
③ Percent Efficiency Data at Nameplate Hp, Rpm, High Speed.

Discount Symbol W-1B
Prices Effective January 1, 1978
and Subject to Change Without Notice
(Refer to Selling Policy 2700)

Notes:

1. Extended studs, resilient rings or belly band.
2. Motor has 30 inch color coded leads.
3. Hp rating is at 230 volts. Suitable for use on 208 volts at reduced Hp.
4. Capacitor included.
5. Rotation viewed from lead end.
6. Must be mounted horizontal or shaft up. Moulded water shield required for shaft up. Enclosed frame, enclosed end bell on shaft end, open end bell on lead end.
7. Resilient base.
8. This motor base has mounting holes adaptable for either 48 or 56 front mounting and ⅝ inch shaft adapter and key.
9. Automatic Reset Thermal Protection, locked rotor protection only—recognized by UL, File E-3021.
10. Type A Automatic Reset Thermal Protection, locked and running—recognized by UL, File E-3021.
11. Motor has 24 inch line leads, 12 inch ground lead.

Westinghouse Electric Corporation, Small Motor Division, P.O. Box 566, Lima, Ohio U.S.A. 45802

SA10735 A78
File 2800

Printed in U.S.A.

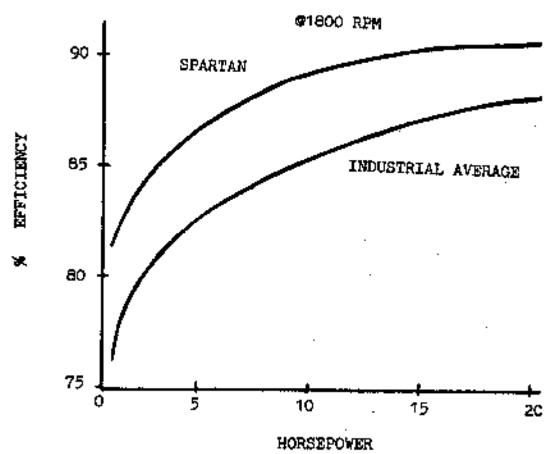
Pacemaker Spartan High Efficiency Motors

One of industry's most basic raw materials is energy, and electric motors account for 75% of that energy. With energy supplies dwindling, the cost of electrical power will be rising rapidly. Industry will be faced with rising production costs and challenged to curb wastefulness.

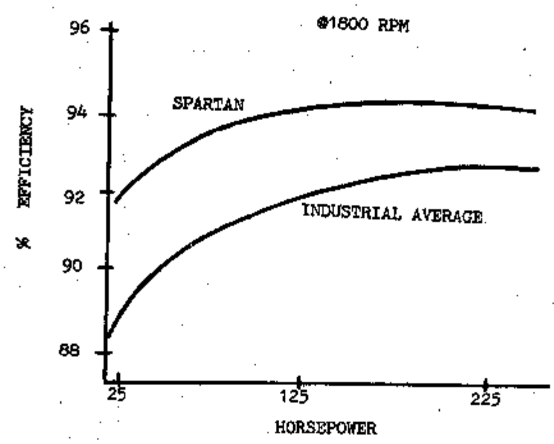
To help industry meet that challenge successfully, Louis Allis introduces the Pacemaker SPARTAN line of energy efficient electric motors – the first truly complete line of high efficiency electric motors.

Here's how it works. The stator and rotor are longer than normal, to reduce flux/density and iron losses. Specially processed low loss lamination steel is used, further reducing eddy current and hysteresis losses. As in all Pacemaker Motors, windings are completely copper and are designed in such a manner as to reduce resistance and cut winding losses. Precise air gap dimensions have been utilized to reduce magnetizing current and thereby reduce losses, improving power factor.

The charts following give the story. Note the greatest percent improvement in efficiency is attainable through 20 HP sizes.



However, substantial economic gain based on the greater amounts of power saved can be had on units above 25 HP.



Compare these features with those of any other motor:

A. High Efficiency for reduced operating costs, lower operating temperature, and longer life.

B. Cast iron construction. The rugged cast iron housing and bearing brackets resist hostile environments for long, trouble-free dependable life.

C. Modifiable. The SPARTAN line is offered with a wide range of electrical and mechanical modifications.

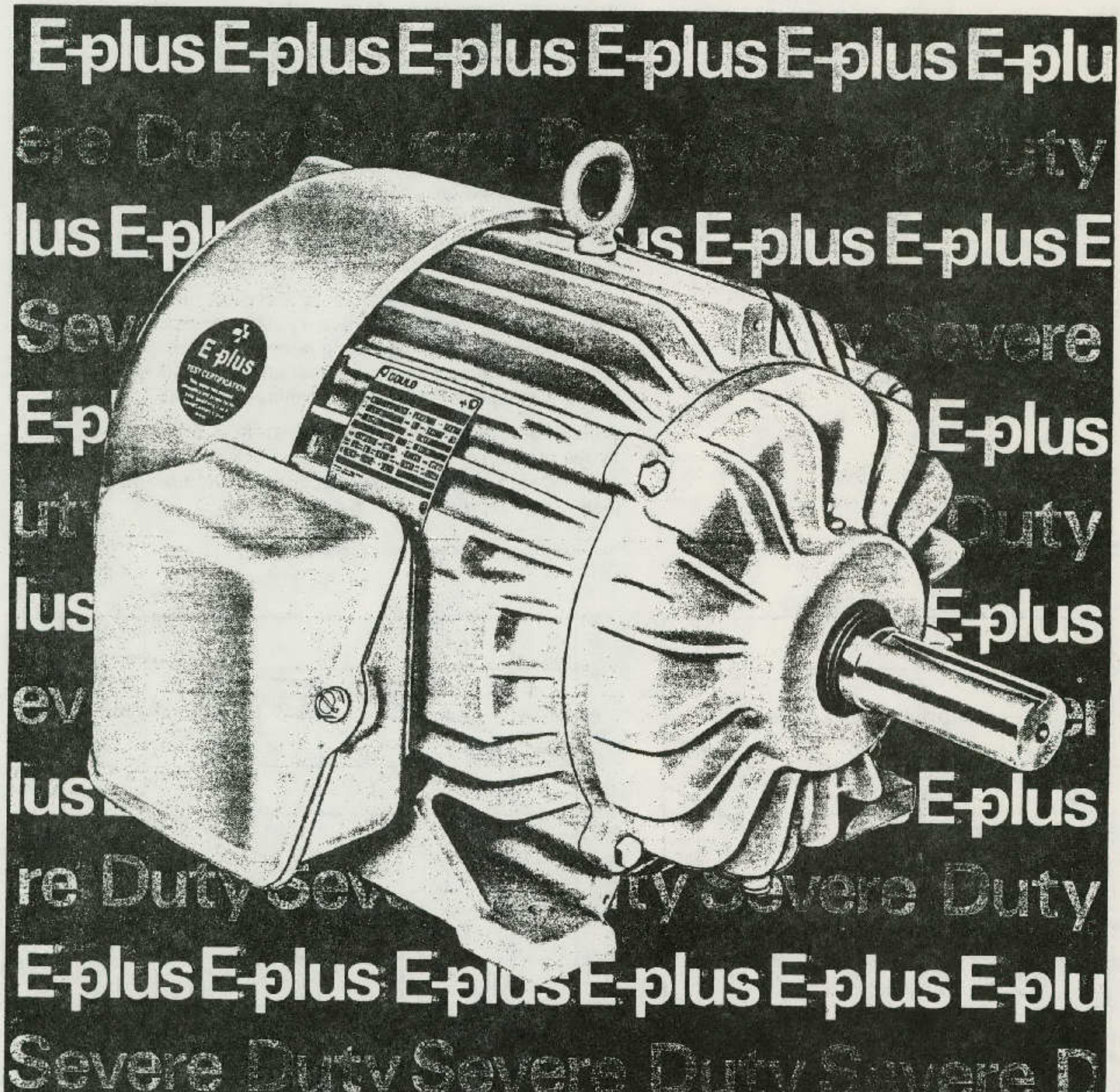
BEHIND THE MOTORS . . .

Louis Allis' reputation and way of doing business assure satisfaction. We've been engineering and building electric motors, drives and systems since 1901. We've earned a solid reputation of leadership through rigid quality control measures, thorough testing of every product before shipping, and by a dedication to comprehensive competent service before, during and long after the sale is made. All this stands behind Louis Allis SPARTAN high efficiency motors and all our products.

Learn more from your nearest Louis Allis Distributor, or district office, or contact Louis Allis, Box 2020, Milwaukee, WI 53201.

Bulletin 3305

Gould E-plus™ Energy-Efficient Severe Duty Motors



Three-Phase Squirrel Cage
Totally-Enclosed Fan-Cooled
1-25 HP

GOULD

The E-plus™ Severe Duty Motor is designed to...

- **operate in hostile environments**
- **save up to 15% on total power charges***

Here is an electric motor you can install in just about any kind of environment and be assured that it will keep working long after a conventional motor would fail. And it does its job at a much lower operating cost.

Every vulnerable component, from the enclosure to the windings, is protected so it can shrug off the attacks of contaminants. The tough epoxy finish will endure many times the exposure to contamination when compared to a standard totally-enclosed motor. The design features that make this possible are detailed on the facing page.

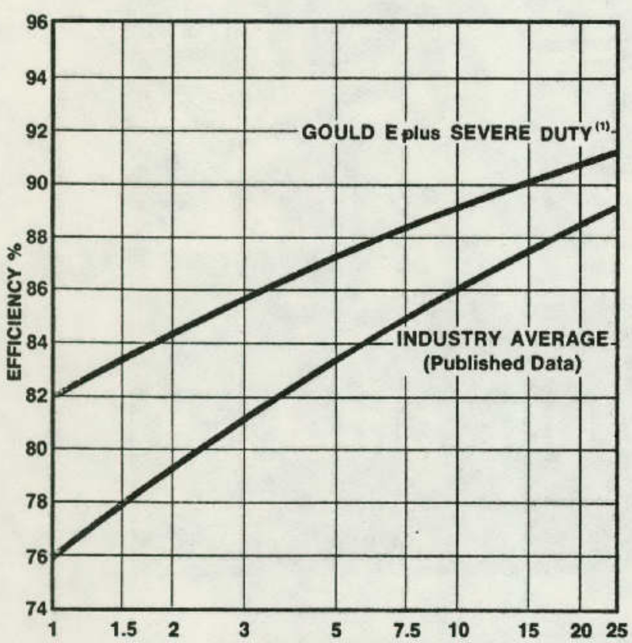
But the E-plus Severe Duty is not just a tough motor, it is an efficient motor as well. The reduction in its operating cost is achieved by an improved electrical design that slashes electrical losses 20 to 43%. This results in an increase in efficiency of as much as 8.5%; an increase in power factor of up to 17.8%; and an increase in apparent efficiency of as much as 27.9%.

The payoff is substantial. Take the example of a plant utilizing 300, 7½ Hp Gould E-plus Severe Duty motors. Operating on a two-shift day, five-day week schedule, these motors would save approximately $10,000 each year based on a power cost of 3¢ per kilowatt hour when compared to conventional industrial motors. During the life of these motors, the total savings would skyrocket to over $90,000, considerably more as power costs escalate.

In addition to improving efficiency and power factor, the E-plus design provides significant performance benefits, including reduction in operating temperature for increased life, ability to accelerate larger inertial loads, and less power factor sensitivity with line voltage changes.

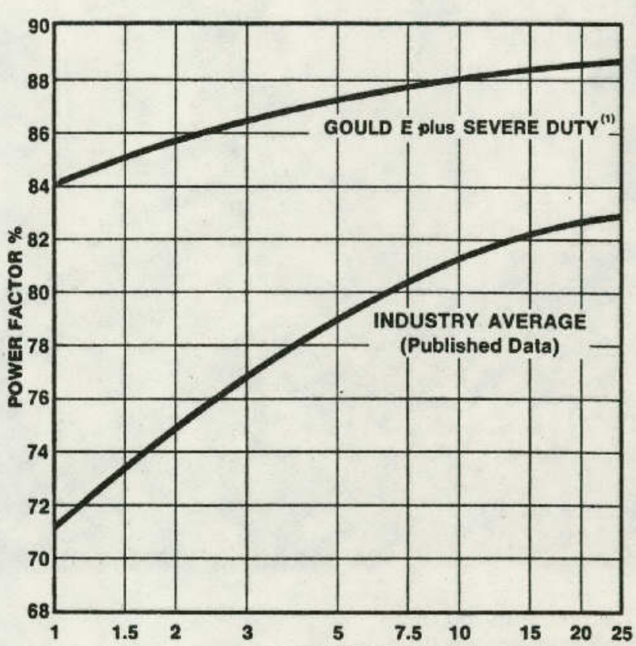
A major part of the E-plus economy story is documented by the two comparison graphs shown below. You will want to learn about the other supporting data from your local Gould representative. Call him today.

*Demand, power factor and power charges.



Efficiency comparison of Gould E-plus versus industry average

(1) All values are nominal and may vary slightly with individual machines.



Power factor comparison of Gould E-plus versus industry average

you save on other operating costs.

Reduced power factor penalties.

Many utilities have the authority to levy "power factor penalties" or surcharges on those users whose power factor is below a specified level, usually 85%. Many companies reduce this expense by using capacitors to boost power factor to an acceptable level, but this correction method has inherent risks. Motor damage can result when improper power factor correction capacitors are applied at the motor terminals. Quickly detecting defective capacitors is impossible. Defective capacitors result in phase unbalanced power factor correction and unbalanced voltages.

E-plus motors already have an acceptable power factor rating. So you avoid costly capacitors and power factor penalties.

Table 2 shows the equivalent investment in power factor correction capacitors that would be necessary to improve power factor from the industry average up to the E-plus values.

the motor. This means you can run more motors on the same circuit and thereby increase your plant's capacity without costly rewiring. This reduced feeder current lowers line losses and also lets you cut costs in new plants by using smaller feeder circuits and transformers.

Extra performance benefits.

Because E-plus motors have lower losses, operating temperatures are significantly reduced. The result is cooler operation, which increases motor insulation and bearing life.

E-plus also has a reduced power factor sensitivity to line voltage variation. Improvement is especially dramatic at load levels below 100%. Even if your motors are not loaded at full rated horsepower, power factor levels are higher than conventional motors under similar conditions, as Figure 6 indicates. Notice at full load, the typical motor power factor varies 15 points while the E-plus motor varies only 5 points.

These advantages, along with the lower energy consumption and costs associated with E-plus motors, make their premium price a real bargain.

Table 1—Savings Per Year—Various Horsepower Ratings and Electric Rates*

To calculate your annual savings, find your present KWH cost and appropriate Hp ratings. Then multiply the corresponding dollar savings by the number of motors you have for each Hp rating.

KWH COST	1 Hp	1½ Hp	2 Hp	3 Hp	5 Hp	7½ Hp	10 Hp	15 Hp	20 Hp	25 Hp
1¢	2.90	4.08	5.01	6.19	8.37	12.07	13.76	17.68	18.56	21.91
2¢	5.79	8.16	10.02	12.38	16.74	24.13	27.51	35.35	37.11	43.82
3¢	8.68	12.25	15.04	18.57	25.11	36.20	41.26	53.02	55.67	65.73
4¢	11.58	16.33	20.05	24.76	33.48	48.27	55.02	70.70	74.23	87.64
5¢	14.47	20.42	25.07	30.95	41.85	60.34	68.77	88.37	92.79	109.55
6¢	17.37	24.50	30.08	37.14	50.22	72.40	82.53	106.05	111.34	131.47
7¢	20.26	28.59	35.10	43.34	58.59	84.47	96.28	123.72	129.90	153.38
8¢	23.16	32.67	40.11	49.53	66.96	96.54	110.04	141.40	148.46	175.29

* E-plus dripproof motors compared to the industry average and assuming running time of 4160 hours per year (two shifts a day for five days a week, 52 weeks).

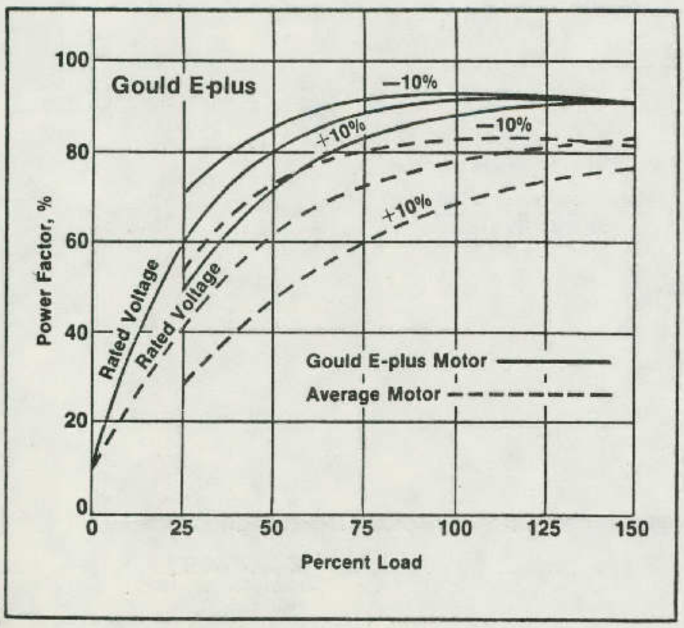


Figure 6. Typical Power Factor — Motor Load Comparison

HP ratings	Capacitor dollar investment 480V-600V capacitors at $15 per KVAR	Capacitor dollar investment 240V capacitors at $30 per KVAR
1	$ 5.10	$ 10.20
1½	6.75	13.50
2	8.85	17.70
3	10.80	21.60
5	14.10	28.20
7½	17.85	35.70
10	24.00	48.00
15	30.45	60.90
20	40.65	81.30
25	50.25	100.50

Table 2 — Equivalent Capacitor Dollar Investments, 480V-600V and 240V Capacitors

EFFICIENCY, POWER FACTOR AND ENERGY RELATED FORMULAS

$$\text{Efficiency} = \text{Eff.} = \frac{746 \times \text{HP output}}{\text{Watts input}}$$

$$\text{Power Factor} = \text{PF} = \frac{\text{Watts input}}{\text{Volts} \times \text{Amps} \times 1.73}$$

$$\text{Apparent Eff.} = \text{Eff.} \times \text{PF}$$

$$\text{KW saved} = 746 \times \text{HP} \times 10^{-3} \times \left(\frac{1}{\text{Eff. motor X}} - \frac{1}{\text{Eff. motor Y}}\right)$$

$$\text{KVA saved} = 746 \times \text{HP} \times 10^{-3} \times \left(\frac{1}{(\text{Eff. motor X}) \times (\text{PF motor X})} - \frac{1}{(\text{Eff. motor Y}) \times (\text{PF motor Y})}\right)$$

Energy dollars saved = KW saved x cost per KWH x hours running per year

Various ways of calculating demand charge. Method varies depending on power company.

Demand dollars saved per year = 1. Based on KW demand:

$$\text{KW saved} \times \frac{\text{Demand charge}}{\text{Month}} \times 12$$

2. Based on KVA demand:

$$\text{KVA saved} \times \frac{\text{Demand charge}}{\text{Month}} \times 12$$

3. Based on the greater of either KW demand or .85 KVA demand:

   a. If overall plant PF $>$ 35%, calculate the same as line 1.

   b. If overall plant PF $<$85%, calculate

$$.85 \times \text{KVA demand} \times \frac{\text{Demand charge}}{\text{Month}} \times 12$$

$$\text{Total dollars saved per year} = \frac{\text{Energy \$ saved}}{\text{yr.}} + \frac{\text{Demand \$ saved}}{\text{yr.}}$$

or alternate method:

Total dollars saved per year = KW saved x average cost per KWH x hours running per year

$$\text{where: average cost per KWH} = \frac{\text{your total electric bill}}{\text{total KWH usage}}$$

$$\text{Payback in years} = \frac{\text{Price Motor X} - \text{Price Motor Y}}{\text{Total \$ saved per year}}$$

PRINTED IN U.S.A.
1,2,3,5E

Gould Inc., Electric Motor Division
1831 Chestnut Street, St. Louis, Missouri 63166
Telephone (314) 342-2500

PAYBACK ANALYSIS

CALCULATE YOUR OWN PAYBACK

$$\text{Efficiency} = \frac{746 \times \text{horsepower output}}{\text{Watt input}}$$

$$\text{Kilowatts Saved} = 746 \times \text{HP} \times 10^{-3} \times \left(\frac{1}{\text{Eff. motor X}} - \frac{1}{\text{Eff. motor Y}}\right)$$

$$\text{Average KWH cost} = \frac{\text{Total electric bill}}{\text{Kilowatt-hours consumed}}$$

Price Premium = (Price of motor X) minus (Price of motor Y)

$$\text{Payback in years} = \frac{\$\ \text{Price Premium}}{\text{KW saved} \times \text{average KWH cost} \times \text{hours running per year}}$$

Example: What is the payback on a Gould E-plus 15 HP motor with an efficiency of 89.8% and costing $372.60? This motor is being considered as an alternate to a 15 HP motor rated at 87.4% efficiency and costing $298.08. The motor runs an average of 4000 hours per year and the average KWH cost is 3 cents.

$$\text{KW saved} = 746 \times 15\ \text{HP} \times 10^{-3} \left(\frac{1}{.874} - \frac{1}{.898}\right) = .342\ \text{KW}$$

Price Premium = $372.60 – $298.08 = $74.52

$$\text{Payback} = \frac{\$74.52}{.342\ \text{KW} \times \$0.03\ \text{per KWH} \times 4000\ \text{hr. per year}} = 1.81\ \text{years}$$

CALCULATE YOUR OWN PAYBACK HERE:

1,2,3,5E

'Old' Invention Stuns Motor Industry

By PAUL VIDICH

WASHINGTON — The formal announcement last week by the National Aeronautics and Space Administration (NASA) of a device that can substantially reduce the electricity consumed by electric induction motors has caught some in the electric meter industry by surprise, even though the produce has been on the market for at least a year, and was originally developed two years ago.

The device, which is generically known as the Power Factor Controller, has already been licensed to 10 firms, six of which are now delivering units to customers (see Oct. 16 EUN, page 12). While the power savings in motors would vary considerably, the device's inventor, Frank Nola, says the savings should usually fall between 5 and 8 percent.

Actual installations by one of the licensees, Electronic Relays, Downers Grove, Ill., have resulted in electricity savings of 33 to 40 percent, the firm reports. In one case, a device connected to a 3-phase, 15-horsepower oil derrick pump, paid for its $500 price in three months. Electronic Relays admits this is an unusual situation and states that paybacks among its customers run from 9 to 15 months.

Electric motor manufacturers were caught by surprise by last week's announcement. An engineer at Westinghouse refused to comment on the Power Factor Controller until he had seen the technical information. An engineer at General Electric said only: "They seem to have something that is real."

The Power Factor Controller cuts a motor's electric bills by reducing the voltage supplied to the motor. While the voltage supplied to all induction electric motors by a local utility is relatively stable, the voltage needs of an electric motor can vary depending on the variations in its load.

For instance, the voltage needed for a department store escalator carrying one shopper will be different if it is loaded with fifty shoppers. Until now, there has been no practical way to vary the voltage going into a motor as the motor's load varies. Voltage applied but not used is wasted, and is given off as heat.

The Power Factor Controller, Neports Nola, continuously senses load and line voltage variations and forces the motor to run at a constant predetermined optimum power factor.

Optimizing power factors in electric motors can be done with existing devices known as capacitors. The novelty of Mr. Nola's invention is that it optimizes power factor electronically, and it forces the motor's voltage needs to vary with the motor's load.

Thus, while optimizing power factor does little or nothing for a user's electric bill — savings show up only in the utility's electrical distribution system — reducing the motor's voltage will result in lower electric bills.

These points, while perhaps academic, have nevertheless been the cause of considerable confusion among electric motor manufacturers and electric motors users. Nola, aware of the confusion, said in a telephone interview that the name, Power Factor Controller, was a misnomer. The device actually senses the phase angle of voltage and current, which is the cosine of power factor.

"When I invented this thing four or five years ago, I didn't think that much about it. Now I wish I had called it the 'Nola Controller,' or the 'Nola Energy Saver,'" Nola said.

One of the ironic aspects of last week's press conference which "introduced," Mr. Nola's invention is that the device had originally been introduced two year's ago. The earlier announcement was largely ignored by the press, which reported on the invention sparingly but with few hints of its significance.

Just how significant the device is will depend on who is asked. The promoters of the device point to several statistics collected in a 1978 A.D. Little Inc. study done for the Department of Energy.

The study reports that electric motors consume two-thirds of all electric energy in the U.S. and that a one percent reduction in electric motor energy consumption could save the equivalent of 60,000 barrels of oil per day.

Thus, should all motors in the U.S. be equipped with the Power Factor Controller, and the motors reduced their electric consumption 5 percent on average, the U.S. would save 300,000 barrels of oil per day.

Warns Against Numbers Game

Albert Hayes, of DOE, who monitored production of the A.D. Little study, says these numbers games must be played tongue-in-cheek, for in the real world, Mr. Nola's invention does not have value for all electric motors.

Electricity consumption of efficient motors that operate at their design loads (that is, without varying loads) would not be affected by the addition of the power factor controller. Similarly, electric consumption in inefficient motors which operated at design loads might not be affected.

Firms that have been licensed to make the Power Factor Controller include: Electronic Relays Inc., Downers Grove, Ill.; IN-VECO, Huntington Beach, Calif.; W.J. Purcell, Cincinnati; ADELET-PLM Div., Scott & Felzer Co., Cleveland; Electronic Assemblies Co., Richmond, Va.; Energy Masters Inc., Costa Mesa, Calif., N.R.C.G. Products Inc., Vineland, N.J.; Clinton Industries, Carlstadt, N.J.; Energy Vent Inc., Dayton, Ohio and, Controlled Power Corp., Torrance, Calif.

Because the invention was made by the government, licensees pay no royalties, and any firm may apply to be a licensee, NASA reports.

Propane Data Sought

WASHINGTON — The Energy Regulatory Commission is soliciting analyses of how propane supply, demand and prices would change between now and 1985 under current regulations and under a hypothetical decontrol.

ERA says such analyses, due by April 6 under docket ERA-R-79-3 in 15-copy filings, will be used "to aid us in our evaluation of whether we can and should propose ... to deregulate propane."

9

ENERGY AUDIT

ENERGY AUDIT

of

SHOPPING MALL

March 5-6, 1979

PLANERGY Audit Team: Delbert M. Fowler, P.E.
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Section I
General

The shopping mall was completed in 1971, contains some 56 different stores and an indoor ice rink, and has a master gas and electricity meter for everyone except Wards and Dillards. Montgomery Ward occupies 151,600 square feet of the total space of 435,903 and provides their own electricity; hence it is metered separately. Wards is provided, however, hot and chilled water for heating and cooling from the central plant, and this space has therefore been included in the energy use computations. The other major occupant is Dillards, and they provide their own heating, cooling, and electrical service. Thus Dillards has been totally excluded from this audit and from the energy use computations.

<u>Square Feet</u>

Tenants, other than Montgomery Ward and Dillards	156,303
Common areas, hallways, etc.	60,000
Montgomery Ward	151,600
Consolidated Maintenance	68,000
	435,903

The central plant provides hot water for heating from two 6695 million BTU/Hr. boilers fired with natural gas, and two 40 hp hot water pumps circulate the hot water to the various air handlers. Chilled water for cooling is provided by a cooling system made up of two 750 ton centrifugal chillers, two 125 hp chilled water circulating pumps, two 50 hp condenser water circulating pumps, and two 40 hp cooling tower fans.

The ice rink, now operated by the shopping mall, is operated from a completely separate cooling system with three 100 hp compressors, two 50 hp circulating pumps, and one cooling tower fan which would be about 10 hp.

Lighting is the largest year-round user of electricity, and based on our survey sample, we estimate installed lighting and miscellaneous equipment to be at least 5 watts per square foot in leased space.

The other major user of energy is the motor which drives the fan in the air handling unit. Most of the 56 stores have one air handling unit, and a few have two. The theater, for example, has six such air handlers.

Management and building operating personnel are obviously energy-conscious. They start and stop the chiller manually, based on outside temperature and during very hot weather when it would normally run all the time, the chiller is started at 7 a.m. and shut of at 9 p.m. Timers have been placed on outside lights and entry way lights.

At the same time, the fact that the building operates on master meters limits the actions which management can make. The tenant agreement on electric energy at Appendix A serves to illustrate this difficulty.

Section II

A. Total Energy Management

The energy audit is an important step in establishing an energy management program which results in real dollar savings. But it is only one of many steps which are necessary if these cost savings are to be achieved and, more importantly, maintained and improved upon. We view the energy audit in the context of total energy management illustrated by the enumeration of the six steps shown below.

Steps and Actions in Establishing Overall Energy Management:

1. Decide to implement Overall Energy Management System.

   *assign responsibility
   *sell idea

2. Set up system to track energy use in BTU/Sq.Ft./Month and BTU/?/Month where (?) is any other unit of measure desired.

   *past year(s)
   *future

3. Develop Overall Energy Management Program with involvement at all levels.

   *orientation, education, program for all employees or occupants
   *operations and maintenance
   *plant modifications, mechanical and lighting systems, building shell

4. Conduct an energy audit.

   *preliminary energy audit, walk-through survey or mini-audit
   *computerized analysis
   *detailed energy analysis or maxi-audit

5. Establish tough and measurable energy use goals, using energy tracking system for measurement.

   *implement all no-cost actions
   *implement selected capital improvement retrofit projects and measure energy savings

6. Report the results in both energy and dollar terms.

B. Demand Audit

Electricity rate structures are, generally speaking, made up of four principal parts: a flat rate customer charge; an energy charge for kilowatt-hours in a declining block rate structure; a flat rate demand charge for the maximum demand for the billing period in kilowatts; and a flat rate fuel charge for each kilowatt-hour used. The January 1979 bill for this building is shown in detail on the following page, followed by a copy of the actual bill, the meter reader's worksheet, a copy of the graphical demand register, and TESCO rate schedule G. This tabulation is necessary and will be used for computing savings in Sections II, III and IV in terms of both demand in KW and consumption in KWH.

From the tabulation it can be seen that the various parts make up the total bill as follows:

Energy Charge (KWH)	11.8%	
Fuel Charge (KWH)	31.3%	
Energy & Fuel Charge (KWH)		43.1%
Demand Charge (KW)		50.7%
Sales Tax (5% of above)		4.7%
Excess Facilities		1.5%
		100.0%

The attached detailed tabulation of the December bill shows that each KW of demand costs $5.13, including tax.

TYPICAL ELECTRICITY COMPUTATIONS

FOR

SHOPPING MALL

January 1979 — 695,220 KWH
2088 KW of Demand
$.0090660/KWH Fuel Adjustment
$20,109.91 Total Bill

		Energy Charge	Demand Charge
a.	2,500 KWH @ $.0336	$ 84.00	
b.	3,500 KWH @ $.022	77.00	
c.	249,360*KWH @ $.022		
	(1) 249,360 @ $.0188/KWH		$ 4,687.97
	(2) 249,360 @ $.0032/KWH	797.95	
d.	439,860** @ $.0032/KWH	1,407.55	
e.	$2.65/KW in excess of 10 KW 2088 - 10 = 2078 x $2.65		5,506.70
		$ 2,366.50	$ 10,194.67

Energy Charge	$ 2,366.50
Demand Charge	10,194.67
Fuel Charge***	6,302.86
Customer Charge	9.00
Sales Tax	943.65
Excess Facilities	293.23
TOTAL	$20,109.91

*(2088 - 10)(120) = 249,360
**695,220 - 2500 - 3500 - 249,360 = 439,860
***695,220 @ $.0090660/KWH = $6,302.86

Marginal Cost per KWH = (.0032 + .009066)1.05 =$.0128793

$$\text{Average Cost per KW} = \frac{(\$10,194.67)1.05}{2088} = \$5.13/\text{KW}$$

For Dollar Savings Opportunity Calculations: use last increment of KWH

Each KWH = $.0128793
Each KW = $5.13

Meter Readings Previous	Present	MULT	Kilowatt Hours Used	Description	Sales Tax	AMOUNT Incl. Sales Tax
51746	63333	60	695220	BASE RATE	628.51	13198.68
				FUEL	315.14	6618.00

KILOWATTS – 1968
BILLING KW IS 2088

ELECTRIC AMOUNT 19816.68 *
EXCESS FACILITIES 293.23

*3% LATE PAYMENT CHG ADDED
IF PAID AFTER MAR 15 1979.

AMOUNT DUE 20109.91

TEXAS ELECTRIC SERVICE COMPANY 100 W ABRAM ST P O BOX 887 ARLINGTON TX 76010 PHONE 336-9454	Fuel Cost Per Kilowatt Hour	Service Period	Past Due After
	$0.0090660	DEC 27 To JAN 26	FEB 15 1979
	Service Address		Your Account Number
			RATE G

MEMO METER READING DATA

SPO404D 3-72

NAME

ADDRESS

32
324-98520

1-26-79
DATE ON 12-27-7

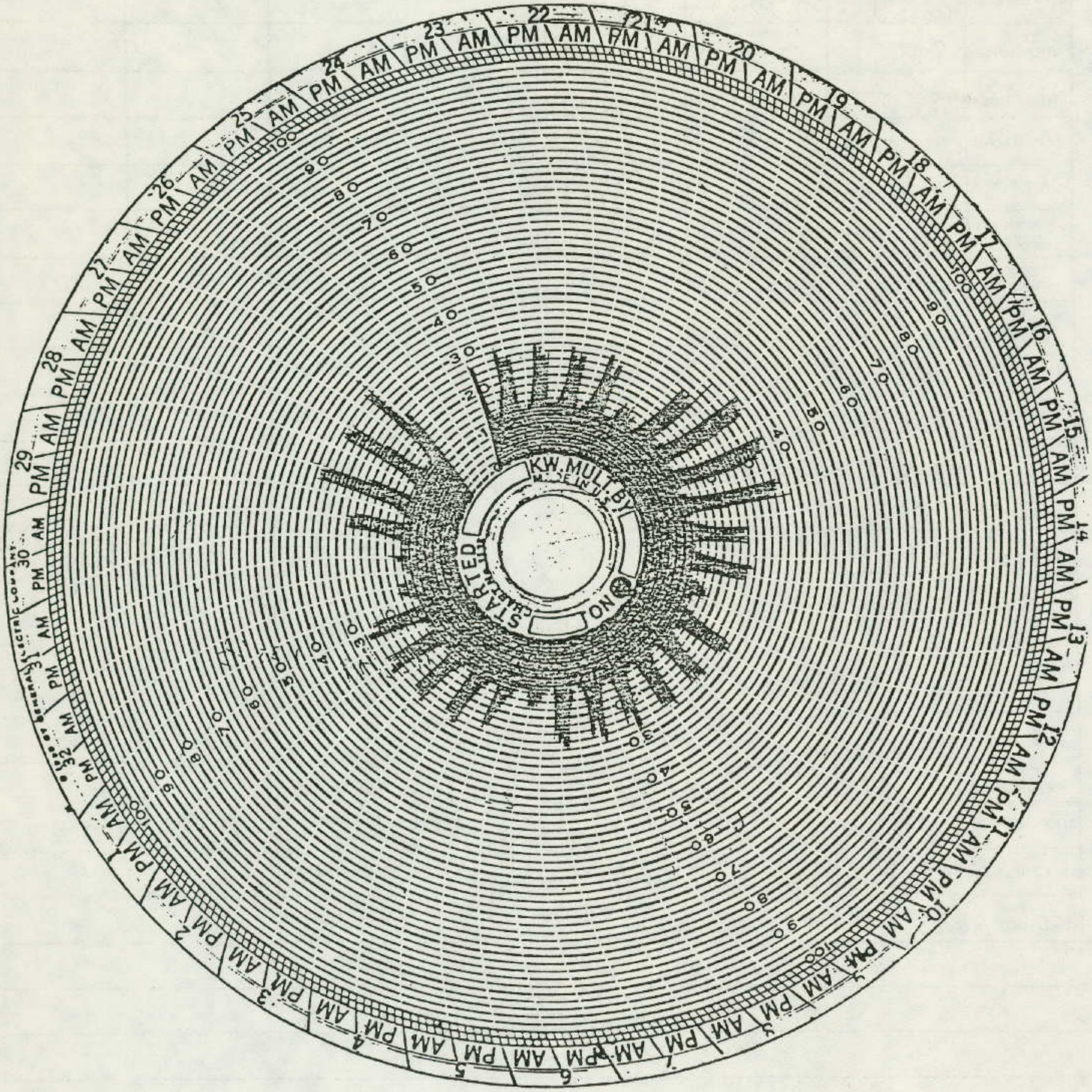
	PAD NO.	1	2	3	4	5	6	7
WATTHOUR METERS	METER NO.	6133	1033/1333	7344				
	OFF READING	8661	3580	0895				
	ON READING	8607	3056	9706				
	DIFFERENCE	54	524	1189				
	MULTIPLIER	1000	1000	100				
	KWH USED	54,000	524,000	118,900				
INPUT	OFF READING	473598	414569					
	ON READING	438213	065772					
	DIFFERENCE	35385						
	MULTIPLIER	1.5	1.5	1.5				
	KWH USED	53077.5	523196					

OUTPUT	OFF READING	63333	55000-1033	TOTAL KWH WATTHOUR METERS	696,900
	ON READING	51746	468196-1333		
	DIFFERENCE	11587		TOTAL KWH IN-PUT	—
	MULTIPLIER	60			
	KWH USED	695220		TOTAL KWH OUT-PUT	695220
DEMAND	OFF READING	22636	5794 × 120		
	ON READING	16842	115880	TOTAL KWH DEMAND	695200
	DIFFERENCE	5794	5794		
	MULTIPLIER	120	695200	RELAY NUMBER	
	KWH USED	695200		DEMAND NUMBER	

REMARKS

TOTAL KW MULT 48X =

5


KW. MULT. BY
STARTED
ON

CON	UNIT	FOLIO	ON DATE	TIME	OFF DATE	TIME
32	324	98520	12-27-78	9:35 AM	1/26/79	1:35 PM

CUSTOMER

LOCATION

WATT METER	NO.	NO.	DEMAND REGISTER	KWH CHECK	
OFF READING	63335		22636	KWH PER DEM REG	
ON READING	51746		16342	KWH PER WH METER	
DIFF				DIFF	
CONST	60		120	CHART READING	
KWH				CONST	48
WRITE LIGHTLY—DO NOT MAR CHART				KW	

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.

Electricity Meters

KWH

The building is served by the Texas Electric Service Company. The meters for the building are located in the consolidated maintenance building and in the ice rink. As can be seen from the meter reader's worksheet, the two KWH meters in the consolidated maintenance area have meter multipliers of 1000, and the one in the ice rink has a multiplier of 100. To get the total KWH consumption for the shopping mall, the three readings are added together. For example, on the meter reader's worksheet attached for January 1979, the total of 696,900 KWH is obtained by adding the KWH used for KWH meters 1, 2, and 3. But note that this figure is not the one on the actual bill; that figure is 695,220, and is obtained from a separate digital meter which measures actual KWH a little more accurately. The two readings in this case serve as checks, one for the other.

Knowing that the output figure on the digital meter is the one which is used for total KWH for the billing period, it would be a very simple matter to have operating personnel report the total KWH consumption for the previous 24 hour period. Simply read the output register on the digital meter, subtract the reading for the previous day and multiply by 60.

KW or Demand

Demand is recorded for all three KWH meters on one graphical demand meter. A copy of that graphical demand chart is attached to the meter reader's worksheet. In this case, the meter reader neglected to note the total KW under remarks, but a check of the graph shows the reading was 41; the multiplier for this meter is 48, so the KW demand on the bill is computed by multiplying the reading off the graph by 48.

$$48 \times 41 = 1968 \text{ KW}$$

Since the demand charge for the monthly billing period is the highest demand recorded during any one of the 2880 or so 15 minute intervals, it would be even simpler to have operating personnel read the demand meter on a daily basis and calculate the demand in KW. If, for example, 50 is read off the graphical demand chart for the previous day, multiply that by 48 to obtain actual KW of demand.

$$50 \times 48 = 2400 \text{ KW}$$

And referring to the $5.13/KW calculated earlier will permit a calculation of the actual monthly charge.

$$2400 \times \$5.13 = \$12,312$$

This calculation also permits a look at what one added increment on the demand graph reflects. Let's say the day after the reading of 50, we read a new peak demand of 51. What is the added demand charge which has accrued?

$$1 \times 48 \text{ (meter multiplier) } \times \$5.13/\text{KW} = \$246.24$$

The sharp "spike" recorded for January 1979 on the graphical demand chart for the peak demand leads us to look at when these spikes occur and on what days.

41 x 48 = 1968	Thursday, December 27 about 1 p.m.
40 x 48 = 1920	Saturday, December 29 about 11:30 a.m.
38 x 48 = 1824	Wednesday, January 17 about 11:00 a.m.

We also note that this single spike is higher than any other demand for that day; for December 27 is it 4 units higher; for December 29 it is 3 units higher; and for January 17 it is 2 units higher. From this we can see that if the reason for that spike can be found and eliminated, a major saving is possible each month, and perhaps for all year as we shall see later when we discuss demand "ratchets". In this case for example elimination of the three spikes would have reduced the maximum demand to 37, 37, and 36 respectively, or 4 units on the graph less than that recorded.

$$4 \text{ units } \times 48 \text{ (meter multiplier) } \times \$5.13/\text{KW} = \$984.96$$

Such a saving on a $20,000 bill is not insignificant, particularly since it can be saved each month. How these spikes may be eliminated is discussed later in the report.

Winter Demand

Ice Rink Equipment

The only major activity which uses electricity, outside of lights, heating, and cooling is the ice rink. For that reason, it might be worthwhile to read the demand in KW and the energy consumption in KWH more frequently than every 30 days. The demand can be computed from the following formula:

$$\text{KW} = \frac{\text{(disc revolutions) (Kh) (3.6) (meter multiplier)}}{\text{time in seconds}}$$

All that needs to be done to calculate demand is to count the number of revolutions in a given number of seconds, and note the Kh factor and meter multiplier from the meter. For the skating rink meter the Kh factor is 1.8 and the meter multiplier is 100.

The ice rink equipment consists of three 100 HP compressors, a chilled water pump of 50 HP and a cooling tower pump of around 10 HP, for a total HP of 360. In January 1979, the load is probably never going to require more than one of the three 100 HP compressors, so the winter total HP would not likely be more than 160, or 119 KW (160 x .746).

Lighting and Other Electrical Appliances

Exterior

The 15 parking lot lamp poles have 4-1000 watt deluxe white mercury lamps in each. Each bulb operates from a separate ballast which would be rated normally at 75 watts. The total parking lot light load would be:

$$(15)\ (1000 + 75)\ (4) = 64.5 \text{ KW}$$

Interior

Lighting loads were calculated for the sales areas in Gordon's Jewelers and for Austin Shoes. The lighting level was checked with a light meter in both, and in several other stores. Lighting in general ranged from 60 - 150 footcandles, depending on where the light meter reading was made in each store. For Gordon's Jewelers, the connected lighting in the sales area amounted to about 8 watts per square foot, including fluorescent ballasts; for Austin Shoes it was over 8 watts per square foot. Storage and office areas would obviously not have the same light levels and would bring the average connected load down. The theater, for example, would also bring down the overall average lighting level in the leased space. Our estimate is that the average overall connected lighting and miscellaneous equipment load level in leased space would be 5 watts per square foot. We also estimate a similar load in the consolidated maintenance building of 1.5 watts per square foot and in the common areas of 2 watts per square foot.

156,303 SF x 5 watts/SF =	782 KW
68,000 SF x 1.5 watts/SF =	102 KW
60,000 SF x 2.0 watts/SF =	120 KW
	1004 KW

So the interior lighting connected load we estimate to be 1004 KW. There are two options in the later computations on energy use in BTUs/Sq.Ft/Year or month. The Montgomery Ward space in square feet can be added to the total square feet of conditioned space or it could be omitted. If it is included, then their connected lighting and air handler loads must be added in to give a true picture. If it is excluded, then the heating and cooling loads for Montgomery Ward would, in similar fashion, need to be excluded. The former solution will provide a more accurate result, so the lighting load for that store is estimated as 758 KW.

$$151,600 \times 5 \text{ watts/SF} = 758 \text{ KW}$$

Air Handlers

An inventory from the plans of the 16 air handlers in the common areas shows a total of 66.5 HP for the 60,000 square feet served by these air handlers; this gives us roughly one HP for every 900 square feet. Lease areas A & B were also surveyed from the plans, and the figure of one HP for every 900 square feet seemed to be reasonably accurate. This factor will give us the estimate of air handler horsepower as follows:

$$\frac{284,303 \text{ square feet}}{900} = 316 \text{ HP}$$

This 316 HP will require power of 236 KW; this figure will be used in rationalizing below the winter and summer demands.

However, for energy use calculations, an estimate of air handler loads for Montgomery Ward is also required. Using the factor of 1 HP/900 square feet discussed earlier, Montgomery Ward would have 168 total horsepower with a total connected

$$\frac{151,600}{900} = 168 \times .746 = 125 \text{ KW}$$

load of 125 KW.

Cooling System

The chilled water cooling system is made up of:

2- 750 ton (606 KW) chillers
2- 125 HP chilled water circulating pumps
2- 50 HP condensing water circulating pumps
2 40 HP cooling tower fans

For the winter months, only one of the chillers will operate, and then only at partial load since a centrifugal chiller has the capacity to operate at a level to meet the load. When the one chiller is operating, only one of the chilled water (CW) circulating pumps, one of the condensing water (cond W) circulating pumps, and one of the cooling tower fans will operate. With the demand limiter on the chiller set at 60%, the load there will be 606 KW x .6 or 364 KW.

One chiller (60% load)	364 KW
One CW circulating pump	93 KW
One Cond W circulating pump	37 KW
One cooling tower fan	30 KW
	524 KW

Total Winter Demand

	KW
Ice Rink Cooling Equipment	119
Lighting, Miscellaneous Equipment, Domestic Hot Water	
Exterior	65
Interior	1004
Air Handlers	236
Cooling System	
One chiller	364
One chilled water circulating pump	93
One condensing water circulating pump	37
One cooling tower fan	30
	1948

This audit survey of winter demand comes close to the metered demand for January 1979 of 1968 KW. From these figures, percentages of potential electrical energy use are as follows:

Ice Rink Cooling Equipment	6%
Exterior Lighting	3%
Interior Lighting and Miscellaneous Loads	52%
Air Handlers	12%
Cooling System	27%

Summer Demand

Although the longer hours of daylight in the summer help reduce the lighting consumption to some degree, the major changes in electrical demand will result from increased operation of the ice rink cooling equipment and of the building central cooling system.

When all three compressors in the ice rink operate, the electrical load will be 360 HP x .746 or 269 KW. For this survey, it is assumed that only two of the three will operate, so that the electrical load is 260 HP x .746 or 194 KW.

Both chillers for the central building cooling system will operate on the hottest days. Both chillers operating at 67% load create an electrical demand of 812 KW.

(606 KW) (.67) (2) = 812 KW

The peak summer demand for 1968 occurred in August and amounted to 2640 KW. This audit survey estimates this demand resulted from the following loads:

	KW
Ice Rink Cooling Equipment	194
Lighting, Miscellaneous Equipment, Domestic Hot Water	
Exterior lights	65
Interior	1004
Air Handlers	236
Cooling System	
Two chillers, each at 67% load	812
Two chilled water circulating pumps	186
Two condensing water circulating pumps	74
Two cooling tower fans	60
Total	2631

The proportions of energy use are measurably changed in the summer months.

Ice Rank Cooling Equipment	7%
Exterior lighting	3%
Interior lighting and miscellaneous loads	38%
Air Handlers	9%
Cooling System	43%

Electricity Bill Analysis

The electricity bill for January 1979 has been computed by increments as provided in Texas Electric Service Company Rate G, General Service. The computation and a copy of the rate schedule were previously referred to and included.

As long as this rate structure is in effect, savings in energy will result in cost savings as follows:

$5.13 per KW

1.28793¢ per KWH

Both of these figures include the current 5% sales tax.

C. Energy Utilization Index

We have analyzed the gas and electricity bill information provided us and our calculations and a graphical display of these calculations are attached. Our analysis shows energy use of approximately 137,222 BTU/Sq.Ft./Year for the 12 months of 1978 for this mall. Because of the Montgomery Ward situation, this figure is the result of the following computations made so as to include Wards in the total computation.

Air Handlers: $\frac{151{,}600 \text{ SF}}{900 \text{ SF/HP}} \times .746 \text{ KW/HP} \times 720 \text{ hrs.} =$

90,474 KWH

Lights: (at 5W/SF)

$\frac{151{,}600}{1{,}000} \times 5 \times 10 \text{ Hrs./Day} \times 30 \text{ Days} =$ 227,400 KWH

Total 317,874 KWH

*Load factor for shopping mall for January 1979

These are so-called "base loads", so the total of 317,874 KWH, or 1,084,903,962 BTUs has been added to each month's total energy consumption. This figure might be compared with:

1. The results of the Department of Energy's research on building performance standards for the Dallas area of:

   (a) 80,000 BTU/Sq.Ft./Year required by the average energy efficient store in Dallas
   (b) 125,000 BTU/Sq.Ft./Year required by the median energy efficient restaurant in Dallas.

These latter two targets are based on operating profiles for both these categories which provides indoor design temperatures as follows:

Winter occupied	68° F
Winter unoccupied	60° F
Summer occupied	78° F
Summer unoccupied	Equipment off

2. The Federal Government target of the General Services Administration of:

   (a) 55,000 BTU/Sq.Ft./Year for newly constructed energy efficient buildings, and
   (b) 75,000 BTU/Sq.Ft./Year for old buildings after energy efficient retrofit.

3. It should be noted that lighting of 5 watts/sq.ft., if operated merely 8 hours a day, six days a week, for 52 weeks, produces an electrical load of 12.48 KWH/ Sq.Ft./Year, which

$$\frac{5 \times 8 \times 6 \times 52}{1000} = 12.48 \text{ KWH/Sq.Ft./Year}$$

is equivalent to 42,594 BTU/Sq.Ft./Year.

BTU/SQ.FT./YEAR

	Actual Energy Use Jan. 78 - Dec. 78	DOE Research Average Dallas Store	National GSA Target Existing Office Bldgs. After Retrofit	GSA Target for New Energy-Efficient Office Buildings	DOE Research Median Restaurant
Shopping Mall including Montgomery Wards (435,903 sq.ft.)	137,222	80,000	75,000	55,000	125,000

ENERGY USE IN COMMERCIAL BUILDINGS

As part of its effort to develop building performance standards, the Department of Energy had AIA Research Corp. survey 6,254 recently completed buildings to estimate how much annual energy use the structures require per gross square foot per year. The nonresidential results are summarized below.

One way to view the results is to see how much more efficient than the median were the top 20 percent of the category's buildings. Regulators could argue that a level reached 20 percent of the buildings might eventually by reached by 50 percent, particularly if the differences among survey results from different climatic zones are modest. Using this approach, the greatest room for improvement lies in warehouses, secondary schools and hospitals.

Another way to view the results is to compare them with the nationwide median for high-rise apartment buildings, which is 49,000 British thermal units per year per square foot, and which would be 49 in the table below. The statistics are based on design characteristics, not actual energy consumption. The estimates exclude energy needs for hot water, office equipment, commercial equipment and the like.

DEFINITION OF CLIMATIC ZONES: The Minneapolis zone, with maximum heating and little cooling, also includes Binghamton, Madison (Wis.), and Milwaukee. The Chicago zone, with heavy heating and little cooling, also includes Akron, Allentown, Boston, Columbus, Denver, Detroit, Hartford, Johnstown (Pa.), Omaha, and Spokane. The Newark zone, with substantial heating and little cooling, also includes Albuquerque, Charleston (West Va.), Kansas City (Mo.), Louisville, Portland (Ore.), and Washington (D.C.). The Dallas zone, with moderate heating and much cooling, also includes Bakersfield and Las Vegas. The San Francisco zone, with moderate heating and little cooling, also includes Atlanta, Birmingham (Ala.), Raleigh, and Sacramento. The Miami zone, with little heating and much cooling, also includes Baton Rouge, Mobile, Phoenix, and San Antonio. The Los Angeles zone, with little heating and little cooling, also includes San Diego. The two levels of climatic air-conditioning needs are divided at 2,000 cooling degree-days per year. The five levels of climatic heating needs are divided at 2,000 heating degree-days per year and then at 4,000, 5,500 and 7,000. Degree days are a measure of how much and how often the outside temperature differs from 65 degrees.

In thousands of British thermal units of heat needed annually per gross square foot:

	Required By Median Bldg. In Category	Category's Extreme Cases	Mid-Range After Excluding Top 20% And Bottom 20%	Percent Saving In Energy Over Median Achieved By Worst Bldg. In Top 20%
OFFICE BULDINGS:				
Nationwide	61	26-199	48-80	21
Minneapolis zone	61	38-109	55-75	30
Chicago zone	71	28-199	63-76	11
Newark zone	59	30-140	49-82	17
Dallas zone	65	26-128	52-68	20
San Francisco zone	57	34-132	45-68	21
Miami zone	48	31-92	39-58	19
Los Angeles zone	51	29-92	34-54	33
RESTAURANTS:				
Nationwide	140	49-392	105-210	25
Minneapolis zone	138	89-390	114-184	17
Chicago zone	150	84-392	111-221	28
Newark zone	160	82-352	106-232	34
Dallas zone	125	54-279	104-157	17
San Francisco zone	137	49-379	102-153	28
Miami zone	120	76-280	104-154	13
Los Angeles zone	113	71-193	89-155	21
STORES:				
Nationwide	84	25-230	62-99	26
Minneapolis zone	88	56-190	72-120	18
Chicago zone	99	25-230	67-134	28
Newark zone	87	46-150	69-97	21
Dallas zone	80*	44-114	—	—
San Francisco zone	80	55-98	72-91	10
Miami zone	83	44-120	55-100	34
Los Angeles zone	62	31-141	40-86	35
THEATERS:				
Nationwide	53	20-166	40-69	25
Minneapolis zone	58*	35-83	—	—
Chicago zone	62	39-163	46-103	26
Newark zone	61	33-166	53-75	13
Dallas zone	57*	24-99	—	—
San Francisco zone	47	21-117	42-58	11
Miami zone	57	20-153	33-102	42
Los Angeles zone	34	27-142	30-45	12
ELEMENTARY SCHOOLS:				
Nationwide	50	23-165	47-79	6
Minneapolis zone	114*	80-135	—	—
Chicago zone	67	29-149	54-84	19
Newark zone	61	44-95	51-86	16
Dallas zone	57*	23-82	—	—
San Francisco zone	61	29-165	53-80	13
Miami zone	48	23-71	38-55	21
Los Angeles zone	49	30-91	39-65	20
SECONDARY SCHOOLS:				
Nationwide	49	16-242	35-66	29
Minneapolis zone	77*	52-100	—	—
Chicago zone	64	33-242	45-78	30
Newark zone	48	32-98	37-75	23
Dallas zone	34*	27-61	—	—
San Francisco zone	47	19-141	39-55	17
Miami zone	36	16-68	29-54	19
Los Angeles zone	34	22-66	24-49	29
WAREHOUSES:				
Nationwide	61	20-179	38-83	38
Minneapolis zone	75*	40-122	—	—
Chicago zone	72	33-179	61-99	15
Newark zone	69	22-93	48-80	30
Dallas zone	39*	20-56	—	—
San Francisco zone	50*	38-61	—	—
Miami zone	37*	22-44	—	—
Los Angeles zone	36*	31-45	—	—
CLINICS:				
Nationwide	60	33-162	52-79	13
Minneapolis zone	84*	42-162	—	—
Chicago zone	70	43-151	49-90	30
Newark zone	71*	46-127	—	—
Dallas zone	59*	45-78	—	—
San Francisco zone	65*	43-103	—	—
Miami zone	59*	33-104	—	—
Los Angeles zone	61*	38-104	—	—
HOSPITALS:				
Nationwide	160	85-493	113-231	29
Minneapolis zone	—	—	—	—
Chicago zone	209*	106-493	—	—
Newark zone	171*	91-301	—	—
Dallas zone	197*	91-442	—	—
San Francisco zone	227*	152-489	—	—
Miami zone	230*	200-238	—	—
Los Angeles zone	207*	85-380	—	—
COLLEGE BUILDINGS:				
Nationwide	56	31-168	41-88	27
Minneapolis zone	67*	39-103	—	—
Chicago zone	70*	51-124	—	—
Newark zone	46*	31-125	—	—
Dallas zone	83*	36-168	—	—
San Francisco zone	59*	38-134	—	—
Miami zone	73*	70-123	—	—
Los Angeles zone	87*	83- 89	—	—

* Asterisk means average is used rather than the median because too few buildings were surveyed to use distribution percentages. The average of the numbers one, three and eight is four, the sum divided by three. The median, the case ranked in the middle, is three.

Source: AIA Research Corp., "Phase One Base Data for the Development of Energy Performance Standards for New Buildings."

D. UTILITIES USE GRAPH AND COMPUTATIONS
BTU/SQ.FT./YR.
BTU/SQ.FT./MO.

ENERGY USE IN BTUs PER SQUARE FOOT
SHOPPING MALL

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
1977	CONSUMPTION KWH	CONSUMPTION MILLION BTU	DEMAND ACTUAL	DEMAND BILLED	COST TOTAL	COST PER KWH	MCF	MILLION BTU	COST TOTAL	COST PER MCF	W/O WARDS MILLION BTU	W/WARDS MILLION BTU	BTU PER SQ.FT.**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN													
FEB	815,160	2,782,141,080	1824	1877	$13,214.57	1.62¢	2049	2,110,470,000	$3,411.20		4,892,611,080	1,084,903,962	13,712
MAR	882,000	3,010,266,000	1824	1877	15,818.52	1.79	680	700,400,000	967.06		3,710,666,000	1,084,903,962	11,001
APR	883,080	3,013,952,040		1968	16,958.67	1.92	142	146,260,000	314.77		3,160,212,040	1,084,903,962	9,739
MAY	960,180	3,277,094,340		2400	18,198.19	1.90	40	41,200,000	84.44		3,318,294,340	1,084,903,962	10,101
JUN	1,243,800	4,245,089,400		2592	21,366.34	1.72			6.82		4,245,089,400	1,084,903,962	12,227
JUL	1,097,500	3,745,835,760		2400	18,604.65	1.70					3,745,835,760	1,084,903,962	11,082
AUG	1,078,680	3,681,534,840		2256	19,044.97	1.77					3,681,534,840	1,084,903,962	10,935
SEP	1,079,640	3,684,811,320		2352	19,165.91	1.78					3,684,811,320	1,084,903,962	10,942
OCT	905,880	3,091,768,440		2304	17,192.05	1.90	87	89,610,000	200.99		3,181,378,440	1,084,903,962	9,787
NOV	829,500	2,831,083,500		2016	16,284.35	1.96	151	155,530,000	338.16		2,986,613,500	1,084,903,962	9,340
DEC	912,420	3,114,089,460		2034	21,563.61	2.36¢	1213	1,249,390,000	2780.47		4,363,479,460	1,084,903,962	12,499

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

* No Bill - Planergy Estimate

** Note: BTU per Square Foot: Divide columns 12 plus 13 by number of square feet of conditioned (heated and/or cooled) space in building or facility metered for gas and electricity; in this case 435,903 square feet, including Wards

1977 USE (11 mos.) - 121,365 BTU/SQ.FT/11 MOs.
11,033 BTU/SQ.FT./MO.

ENERGY USE IN BTUs PER SQUARE FOOT
SHOPPING MALL

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST		W/O WARDS	W/WARDS	
1978	KWH	MILLION BTU	ACTUAL	BILLED	TOTAL	PER KWH	MCF	MILLION BTU	TOTAL	PER MCF	MILLION BTU	MILLION BTU	BTU PER SQ.FT.**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN	676,260	2,308,075,380	1920	2034	$17,612.60	2.60c	2255	2,322,650,000	$5,212.90	$2.31	4,630,725,380	1,084,903962	13,112
FEB	709,980	2,423,161,740	1824	2034	19,431.01	2.74c	2805	2,889,150,000	11,756.72	4.19	5,312,311,740	1,084,903962	14,676
MAR	739,860	2,525,142,180	1920	2034	19,992.44	2.70c	1369	1,410,070,000	3,255.64	2.38	3,935,212,180	1,084903,962	11,517
APR	830,220	2,833,540,860	1968	2034	18,425.26	2.22c	282	290,460,000	653.33	2.32	3,124,000,860	1,086,903962	9,656
MAY	885,840	3,023,371,920		2064	20,948.57	2.36c	282	290,460,000	775.40	2.75	3,313,831,920	1,084,903962	10,091
JUN	1,172,340	4,001,196,420		2592	27,436.49	2.34c					4,001,196,420	1,084,903962	11,668
JUL	1,215,780	4,149,457,140		2592	27,929.18	2.30c					4,149,457,140	1,084,903962	12,008
AUG	1,147,740	3,917,236,620		2640	28,204.90	2.46c					3,917,236,620	1,084,903962	11,475
SEP	1,148,340	3,919,284,420		2544	26,096.59	1.75c					3,919,284,420	1,084,903962	11,480
OCT	854,280	2,915,657,640	1968	2072	18,115.66	2.12c					2,915,657,640	1,084,903962	9,178
NOV	890,100	3,037,911,300	2064	2088	21,520.52	2.42c	226	232,780,000	536.93	2.38	3,270,691,300	1,084,903962	9,992
DEC	766,860	2,617,293,180		2304	22,145.27	2.89c	1526	1,571,780,000	3,710.09	2.43	4,189,073,180	1,084,903,962	12,099

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

* No Bill - Planergy Estimate

** Note: 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; in this case 435,903 square fee, including Wards.

1978 USE--137,222 BTU/SQ.FT./YR.
11,435 BTU/SQ.FT./MO.

ENERGY USE IN BTUs PER SQUARE FOOT
SHOPPING MALL

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST		W/O WARDS	W/WARDS	
1979	KWH	MILLION BTU	ACTUAL	BILLED	TOTAL	PER KWH	MCF	MILLION BTU	TOTAL	PER MCF	MILLION BTU	MILLION BTU	BTU PER SQ.FT.**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN	695,220	2,372,860	1968	2088	$20,109.91	2.89¢	2903	2,990,090,000	$7,247.93	$2.50	5,362,875,860	1,084,903,962	14,792
FEB													
MAR													
APR													
MAY													
JUN													
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													

Column 3 = Column 2 x .003413

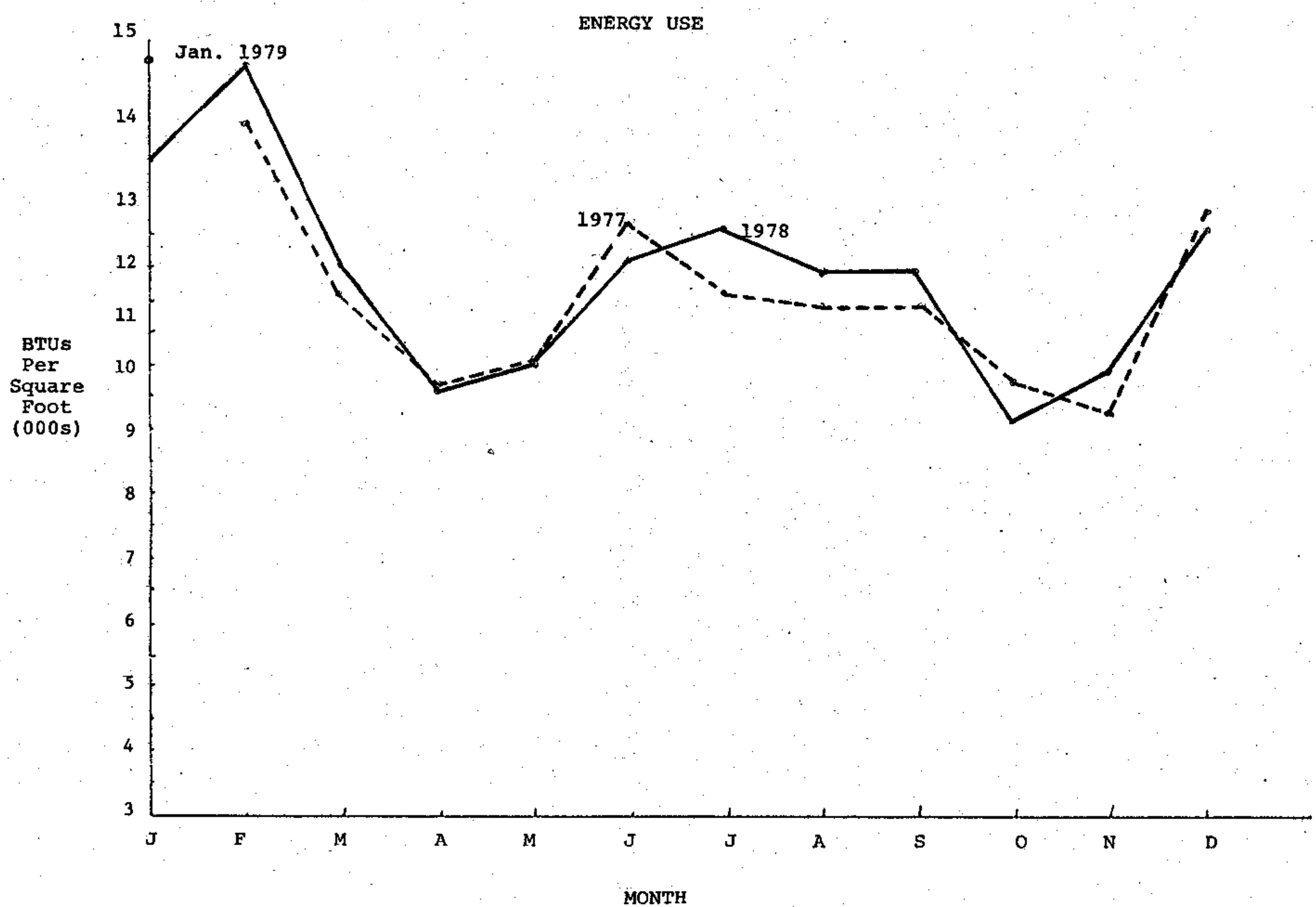
Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

* No Bill - Planergy Estimate

** Note: BTU per Square Foot: Divide column 12 by number plus 13 by number of square feet of conditioned (heated and/or cooled) space in building or facility metered for gas and electricity; in this case 435,903 square feet, including Wards.


ENERGY USE
Jan. 1979
1977
1978
BTUs Per Square Foot (000s)
15
14
13
12
11
10
9
8
7
6
5
4
3
J
F
M
A
M
J
J
A
S
O
N
D
MONTH

E. EXTRA COMPUTATION FORM

ENERGY USE IN BTUs PER SQUARE FOOT

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													
FEB													
MAR													
APR													
MAY													
JUN													
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													
TOTAL													

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

* Note: 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.

Total Square Feet ____________

F. Demand "Ratchet" Analyses

<u>1977 Rate -- Texas Electric Service Company</u>

<u>Demand</u>:

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 50 KW.

<u>1978 Rate</u> (effective October 26, 1978)

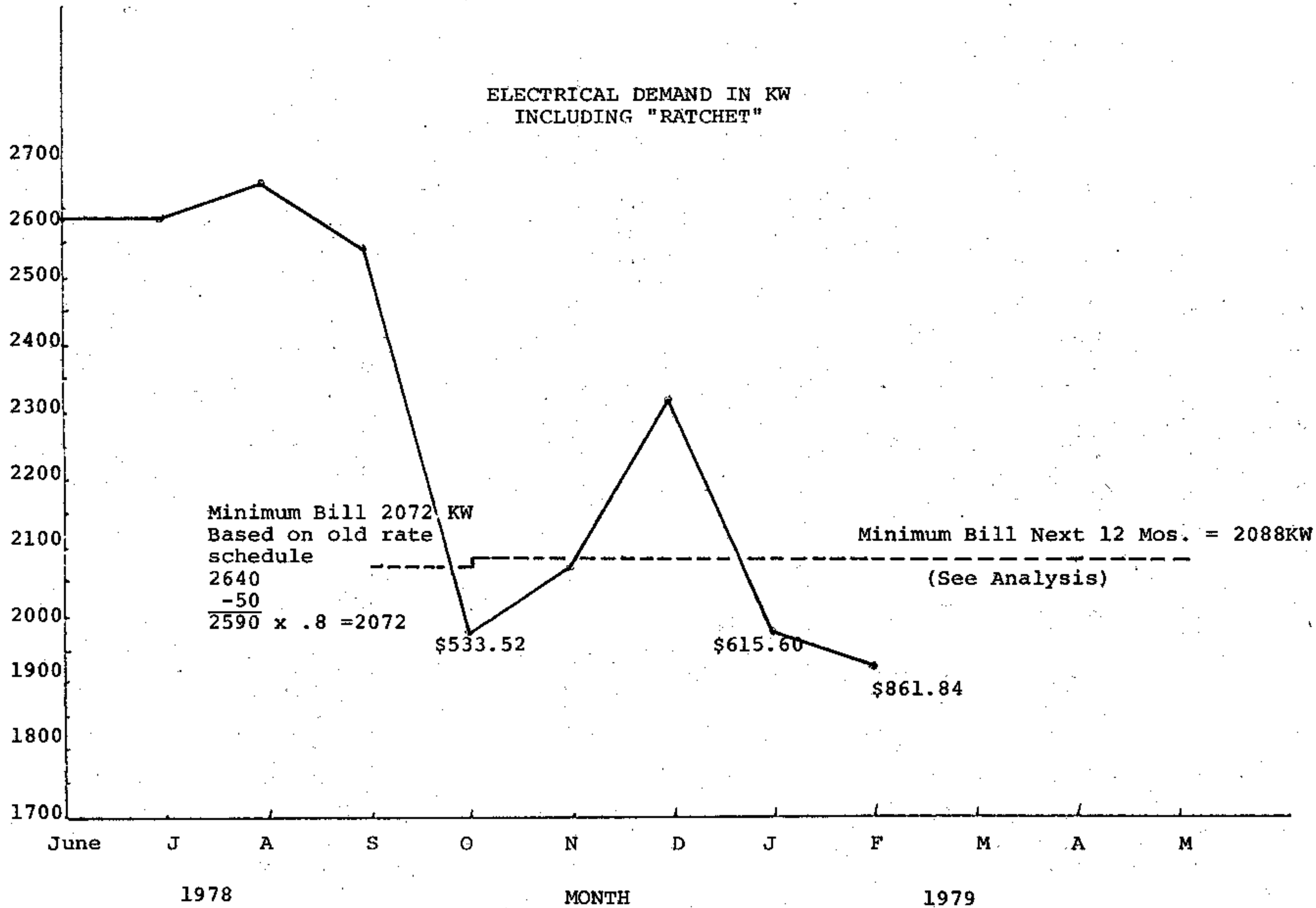
Identical to 1977 except "exceeds 50 KW" is changed to "exceeds 30 KW".

	1977 Demand	1978 Demand
June	2,592	2,592
July	2,400	2,592
August	2,256	2,640
September	2,352	2,544
October	2,304	1,968
Highest	2,592	2,640
Less	50	30
	2,542	2,610
	.8	.8
"Ratchet" =	2,034	2,088

Lowest in winter of 1978 was 1,824 KW in February

All winter months of 1979 will be billed for minimum of 2,088 KW

This minimum bill has to date cost $533.52 in October, a small amount in November, $615.60 in January, and $861.84 in February for a peak demand set in August of 1978; these added costs were not for energy used, but for demand capacity which the utility must provide.


ELECTRICAL DEMAND IN KW
INCLUDING "RATCHET"
MONTHLY DEMAND IN KW
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
Minimum Bill 2072 KW
Based on old rate
schedule
2640
-50
2590 x .8 =2072
Minimum Bill Next 12 Mos. = 2088KW
(See Analysis)
$533.52
$615.60
$861.84
June
J
A
S
O
N
D
J
F
M
A
M
1978
MONTH
1979

G. Load Factor

The attached chart provides electrical load factor computations for the building for each month of 1978. Load factor is defined as the ratio of energy usage in KWH to the peak demand in KW for the month multiplied by the number of hours in the month. In other words, load factor is the ratio of what was used in KWH to the maximum that could possibly have been used, given the peak demand for the month.

For example, in December of 1978, the building used 766,860 KWH and had a peak demand that month of 2304 KW.

$$\text{Load factor} = \frac{766,860}{2304 \text{ X } 720} = 46.2\%$$

The building load factor was 46.2% for December, which means that, on the average, there was an energy peak or peak demand of 53.8% (1-46.2) that could be deferred to low demand periods. This assumes logically, of course, that all non-essential loads, such as excessive lighting, have been removed. Essential loads include most of the lighting and equipment which for whatever reason cannot be cycled off and on. Non-essential loads include heating, cooling, air-handling, pumps, and the like. These non-essential loads can be turned off for short time periods (sometimes called duty-cycling) without affecting productivity or comfort.

In general, and with close control, the building demand can be reduced by an amount equal to (one minus the load factor) times the non-essential load in KW. Since the peak of 2640 KW of demand was set in August of 1978 and provides the basis for the minimum bill for the succeeding twelve months, it is the load factor of 60.4 in August which we should examine most closely. Using the general rule-of-thumb (one minus the load factor), it should be possible theoretically to reduce the peak demand by 39.6%. Such a saving with a peak of 2640 KW and a cost per KW of $5.13, would ammount to:

2640 X .396 X $5.13 = $5363.11 per month.

This possible saving will be covered in more detail in Sections III and IV of this report.

LOAD FACTOR CALCULATION 1978 Building: Shopping Mall

Month	Days in Billing Period	Hours in Billing Period	Demand in KW	Maximum KWH Possible	Actual KWH	Load Factor (%)	
1	2	3	4	5	6	7	8
Jan	30*	24	1920	1,382,400	676,260	48.9	
Feb	30	24	1824	1,313,280	709,980	54.1	
Mar	30	24	1920	1,382,400	739,860	53.5	
Apr	30	24	1968	1,416,960	830,220	58.6	
May	30	24	2064	1,486,080	885,840	59.6	
Jun	30	24	2592	1,866,240	1,172,340	62.8	
Jul	30	24	2592	1,866,240	1,215,780	65.1	
Aug	30	24	2640	1,900,800	1,147,740	60.4	
Sep	30	24	2544	1,831,680	1,148,340	62.7	
Oct	30	24	1968	1,416,960	854,280	60.3	
Nov	30	24	2064	1,486,080	890,100	59.9	
Dec	30	24	2304	1,658,880	766,860	46.2	

Col 3 x Col 4 → (Col 5)

Col 6 ÷ Col 5 → (Col 7)

* Assumed for ease of computation

LOAD FACTOR CALCULATION 1979 Building: Shopping Mall

Month	Days in Billing Period	Hours in Billing Period	Demand in KW	Maximum KWH Possible	Actual KWH	Load Factor (%)	Comment
1	2	3	4	5	6	7	8
Jan	30	24	1968	1,416,960	695,220	49.1	
Feb							
Mar							
Apr							
May							
Jun							
Jul							
Aug							
Sep							
Oct							
Nov							
Dec							

Col 3 x Col 4 → (Col 5)

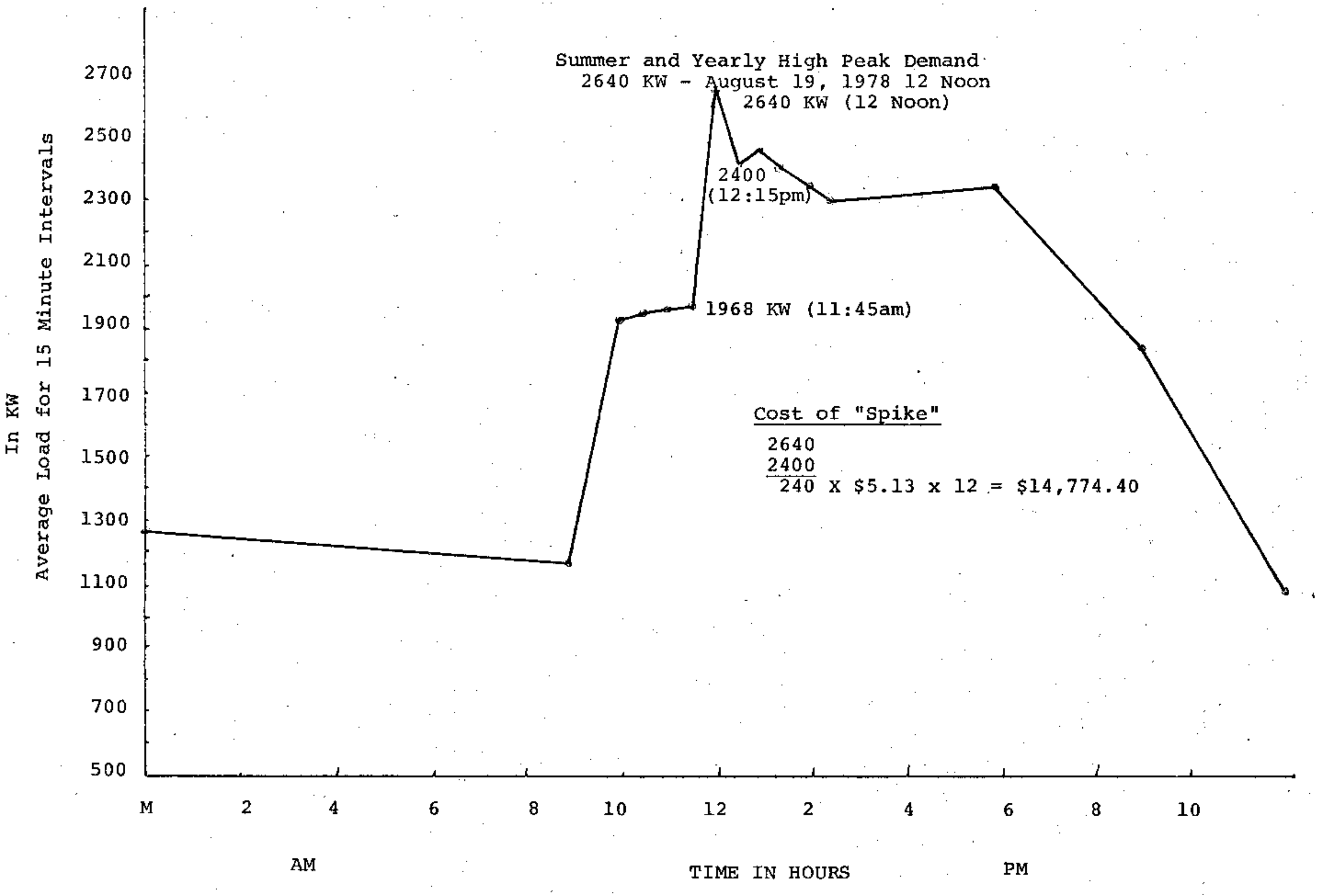
Col 6 ÷ Col 5 → (Col 7)

H. Load Profile

A graph of the load profile in KW for August 19, 1978, is attached; it was drawn from the information on the graphical demand record for August. This day is important because of the demand "ratchet" in the rate structure which provides that the peak demand set in June, July, August, September or October establishes a minimum bill for the next twelve months. It is important to know if the peak was arrived at gradually, or if it was a "spike", what contributed to it and what might be done to reduce it.

The spike apparently occurs when the second chiller and associated equipment it turned on. On August 19, the spike was 240 KW higher than it was 15 minutes later, and at $5.13 per KW, the spike that day cost $1231.20 in demand charges. And with this spike establishing the minimum bill for 12 months the real cost could be 12 times that, or $14,774.40.

24 HOUR LOAD PROFILE



SECTION III
No/Low Cost Recommendations
For Tenants of the Shopping Mall

III-A Lighting, Miscellaneous Equipment, Domestic Hot Water

Most of the mall is lighted and equipped with energy using motors and heaters at a level of about 5 watts per square foot. For 10 hours a day, 30 days a month, 12 months a year, this equates to 61,434 BTU/SQ.FT./YR.

$$\frac{5 \times 10 \times 30 \times 12 \times 3413}{1000} = 61,434$$

In 1978 the mall used 137,222 BTU/SQ.FT./YR.; so lighting and appliances use about 50% of all the energy used. And when we consider that lights and motors contribute much of the heat which the cooling system must remove, the load of lights and appliances is probably closer to 60%.

Cleaning

The attached chart shows how the light level from fluorescent fixtures and bulbs decreases with age and dirt. Light levels in most of the stores in the mall could be increased from 20 - 40% by periodic cleaning of bulbs and fixtures.

Turn Off Lights When Stores Close

If store lights in general are not turned off when stores close, a major saving is possible by leaving on only those showroom lights and security lights which are necessary. Tenants, including Montgomery Ward's, have a total of 307,903 square feet. There are stores in the Mall with lighting levels in merchandising areas of 9 watts per square foot. If the average lighting level throughout the mall is 4 watts per square foot, turning off those lights for 12 hours a day and for 24 hours a day on Sundays would save 118,235 KWH per week.

$$\frac{(4 \times 307,903)\ (6 \times 12 + 24)}{1000} = 118,235$$

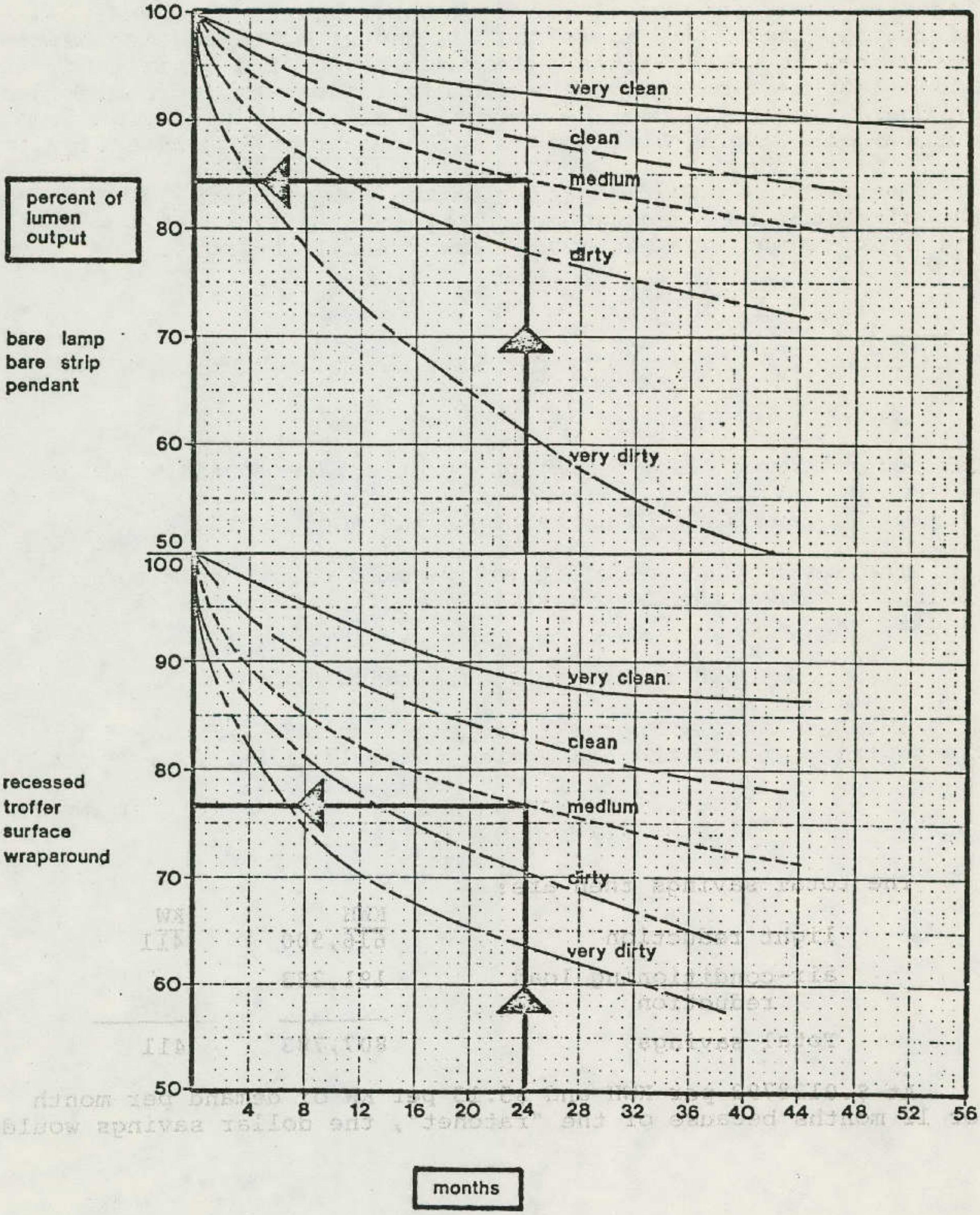
At $.0128793 per KWH, the saving for the year would be:

118,235 x 52 x $.0128793 = $79,185 per year

Peak demand would not be reduced by this action, since the peak occurs during the daytime hours when outside temperatures are highest and the cooling requirement is greatest. Thus, the dollar

lighting fixture cleaning cycle fig.28

dubin-mindell-bloome-associates
consulting engineers



saving is minimized because of the relatively low cost per KWH.

This is the total saving which would result if all tenants were to follow this guideline. Since individual tenants, except for Ward's, do not have individual electric meters, it will not be possible to determine exact savings for each tenant.

Reduce Lighting in Summer Months

For all practical purposes, all the electricity used in lighting turns into heat. In the winter months this heat is, of course, useful and minimizes the amount of energy the heating system has to use. In the summer months, on the other hand, this added heat must be removed by the cooling system, which incidentally is operating at the peak periods of electricity use. Thus reduction of lighting will reduce both demand in KW and energy in KWH.

We recommend that lighting in the summer months of June through October be reduced by all tenants by 1/3. At 4 watts per square foot, present power demand for lighting is

$$\frac{4 \times 307{,}903}{1000} = 1232 \text{ KW}$$

A reduction of 1/3 would result in a demand reduction of

$$1232 \times 1/3 = 411 \text{ KW}$$

The reduction in KWH consumption for the five months would be

$$411 \text{ KW} \times 10 \text{ hours/day} \times 150 \text{ days} = 616{,}500 \text{ KWH.}$$

The saving in air-conditioning would result from not having to remove the 2+ trillion BTUs of heat generated by the lights.

$$616{,}500 \times 3413 = 2{,}104{,}114{,}500 \text{ BTUs}$$

With an overall Energy Efficiency Ratio of around 11 for the cooling system, the KWH saving in cooling would be 191,283 KWH.

$$\frac{2{,}104{,}114{,}500 \text{ BTU/Season}}{(11.0 \text{ BTU/WATT HOUR})(1000)} = 191{,}283 \text{ KWH}$$

The total savings then are:

	KWH	KW
light reduction	616,500	411
air-conditioning load reduction	191,283	
Total savings	807,783	411

At $.0128793 per KWH and $5.13 per KW of demand per month for 12 months because of the "ratchet", the dollar savings would be:

807,783 KWH ($.0128793)	= $10,404
(411 KW x $5.13) x 12 months	= $25,301
	$35,705

If lights are not wired so that one-third can be switched off, there are remote switching systems available today which can be installed to permit selection switching or dimming. Commercial literature for two such systems is attached.

Use Energy Efficient Fluorescent Bulbs

The second generation of energy efficient fluourescent bulbs is now available. They provide essentially the same light level as regular bulbs, but at a saving in energy of about 14%.

A Sylvania F40CW, or Cool White bulb, has an average rated life of 20,000 hours, lumen output of 3,150 lumens, a suggested retail price of $2.13 and uses 40 watts. The F40W/LW/RS/SS, or Lite White, Super Saver II, has the same life, lumen output of 3,050, a suggested retail price of $2.95 and uses only 35 watts.

A General Electric F40CW, or Cool White bulb, has an average rated life of 20,000 hours, lumen output of 3,150 lumens, and uses 40 watts. A GE Watt-Miser II, F40LW/RS/WM, or Lite White, has the same life, lumen output of 3,050 and uses only 35 watts.

A Westinghouse F40CW rapid start, or Cool White, has an average rated life of 20,000 hours, lumen output of 3150, and uses 40 watts- A Westinghouse Econ-o-white Econ-o-Watt, F40EW/RS/EW-II, or Econ-o-white, has the same life, lumen output of 3050, and uses 34 watts.

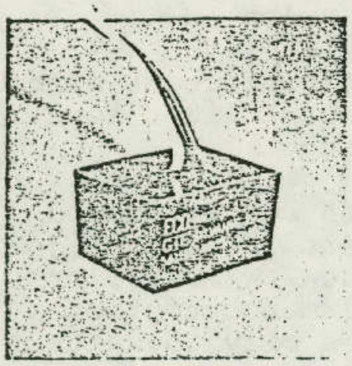
Other manufacturers have similar products on the market. We recommend all tenants begin using one of these energy-efficient bulbs whenever possible, being sure to use them on proper ballasts. Since a ballast also uses energy, and it's use is proportional to that used by the bulb, the net saving by using this type of bulb is 14%.

When all the tenants have completely switched to the new type of fluourescent bulb, and considering that at least half of the total lighting load of 4 watts per square foot is fluorescent lighting, the total saving would be:

$$\frac{14\% \text{ (2 x 307,903 x 10 hrs/day x 30 days/mo x 12 mos)}}{1000} = 310{,}366 \text{ KWH}$$

SYLVANIA LIGHTING SERVICES CORP
100 Endicott Street, Danvers, Massachusetts 01923

NEW SERVICE INFO



E C D
ENERGY CONTROL DEVICE

E.C.D. CAN UPDATE YOUR LIGHTING SYSTEM WITHOUT THE COSTLY EXPENSE OF REWIRING

The E.C.D. system consists of a Solid State Transmitter located adjacent to – and wired into the main lighting panel. On command a continuous RF signal is transmitted over the existing lighting circuitry to all lighting fixtures on that panel. A receiver placed in the primary circuit of the ballast blocks or passes voltage to that ballast, depending upon the absence or presence of the transmitter signal. Only those fixtures having receivers are effected by the transmitter signal. Our Dual Frequency Control System enables two frequencies to be imposed on the line (without system interference) increasing lighting control flexibility.

The E.C.D. system gives you the ability to reduce your energy dollars by switching off excess lighting as daily work tasks change.

Sylvania Lighting Services can service you from 29 service centers located in major cities across the United States.

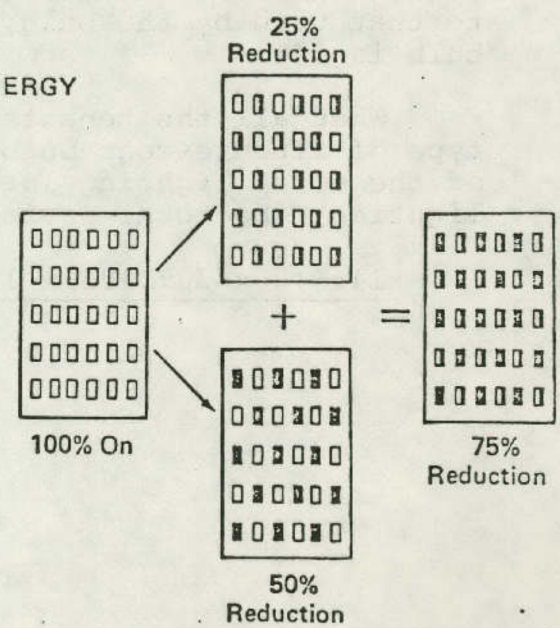
E.C.D. CAPABILITIES:

1. Control of 120 Volts to 277 Volt systems.
2. Receiver load not to exceed 2.0 Amps.
3. Control of 300 fixtures with Dual Frequency operation.
4. Control a fixture 300 feet from transmitter.
5. Control 24 hours/day and 7 days a week.

LIGHTING FLEXIBILITY FOR BETTER UTILIZATION OF ENERGY
4 LAMP – F40 FIXTURE LAYOUT

25% Reduction
- Planned load shedding
- Non-productive periods (including lunch hours)
- Perimeter lighting

50-75% Reduction (Dependent upon initial light levels)
- Janitorial service hours
- Night time restocking hours
- Rough or medium maintenance task
- Periods of minimum sales activity (days or hours)

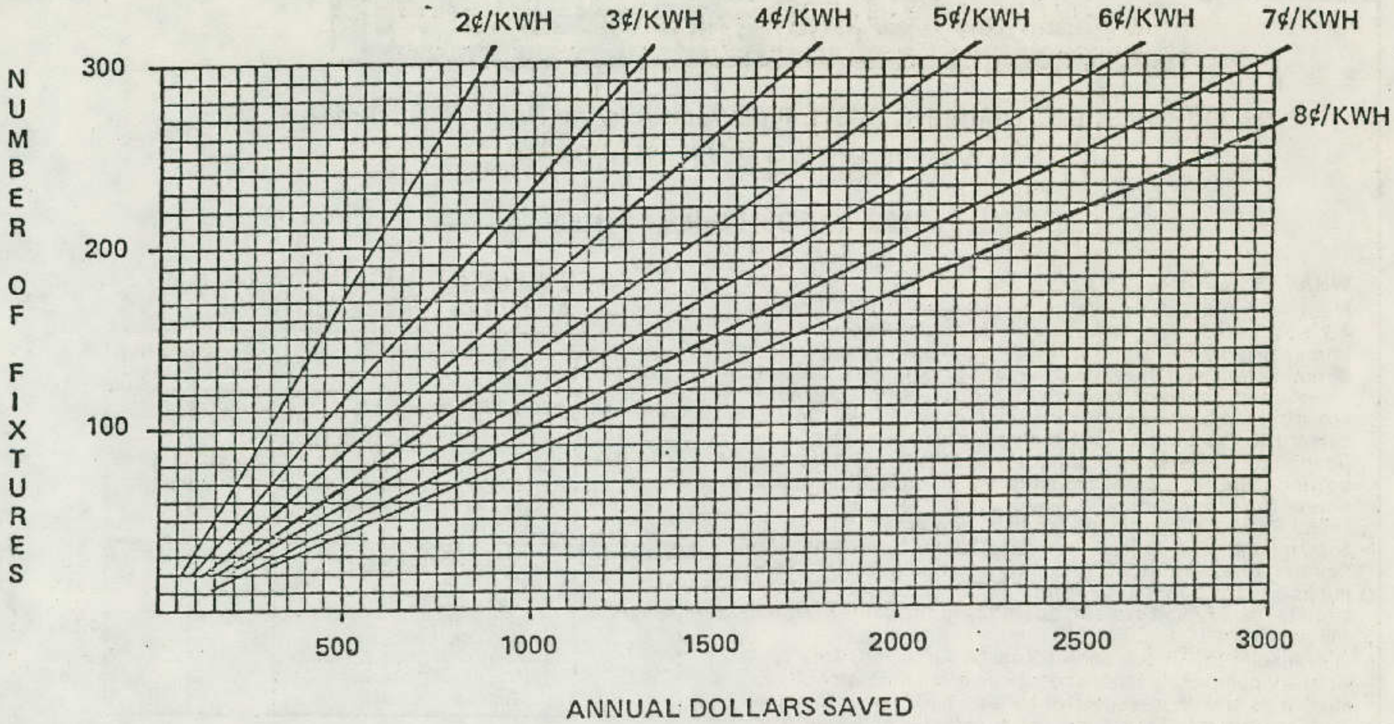


(SLS-1)
8/77

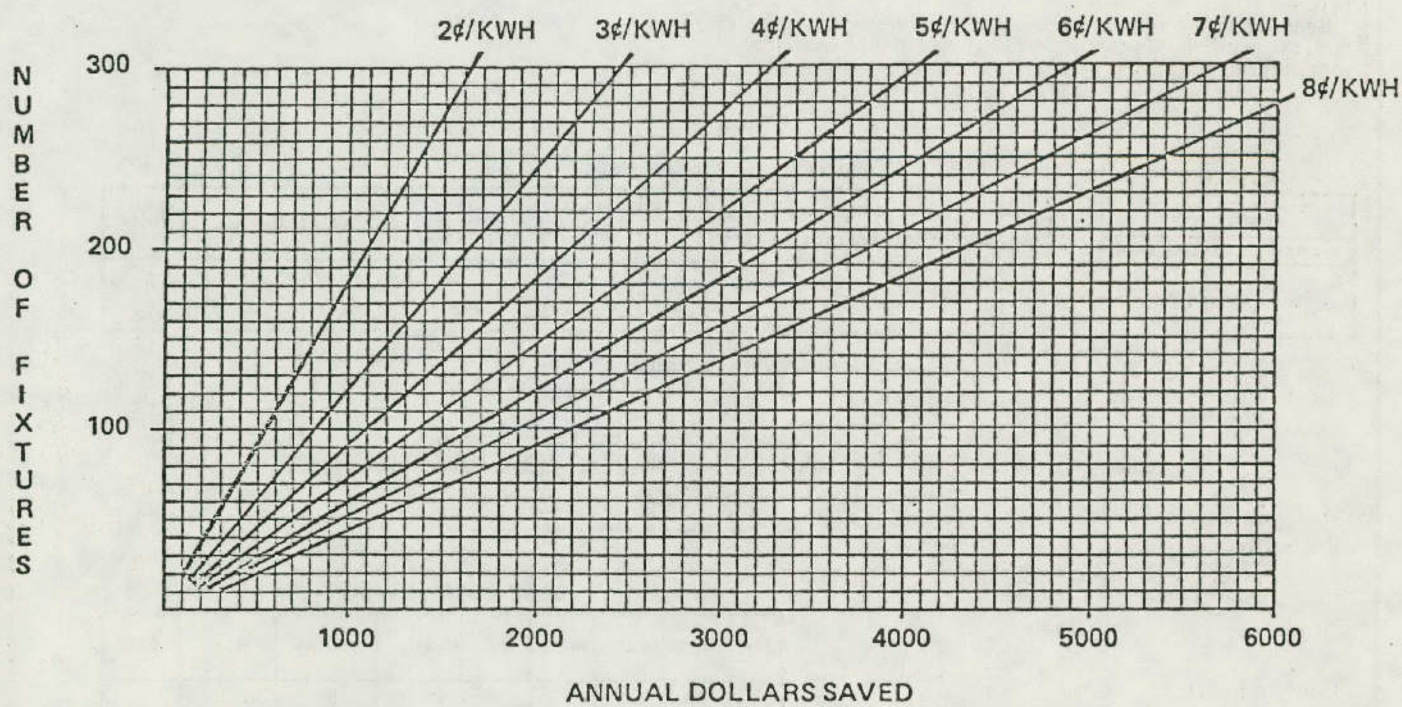
UL LISTED

POTENTIAL ECD DOLLAR SAVINGS

4 Lamp – F40 Fixture – Controlled 30 Hours Per Week



2 Lamp – F96 Slimline – Controlled 30 Hours Per Week



FOR MORE INFORMATION CONTACT MARKETING DEPARTMENT – SYLVANIA LIGHTING SERVICES
100 ENDICOTT STREET
DANVERS, MA 01923
617-777-1900 Ext. 2541/2542

FLUOR-A-DIM®

the FLUORESCENT DIMMING SYSTEM that controls the BALLAST to dim the LAMP
Unique circuitry increases lamp life

120/277 Dual Voltage System

WHAT IS FLUOR-A-DIM?

Fluor-A-Dim is Jefferson's complete system for dimming 40 watt rapid start lamps from full light output to an immeasurably low level—*with no flicker.* You get the greatest dimming range on the market—a ratio greater than 700 to 1.

Jefferson's system, through its control—a Potentiometer—controls the auxiliary, *which in turn* limits the flow of current to the ballast. This then controls each lamp independently. Jefferson circuitry eliminates any interaction between lamps. A defective lamp *will not* affect the operation of the other lamps.

The Fluor-A-Dim system consists of a small control, an *auxiliary* unit, and special *"dimming"* ballast. One ballast is needed for each lamp. One control and one auxiliary, working as a team, can handle from 4 to 20 lamps on a 120 volt circuit. The 277 volt system, operating in the same manner, will dim from 10 to 50 lamps.

A special two-in-one control can be furnished. This provides for completely independent operational control of two auxiliaries and their respective ballasts and lamps from one location—sharply increasing the functional and aesthetic benefits.

HOW IS THE FLUOR-A-DIM SYSTEM INSTALLED?

The Potentiometer and its knob will fit into a standard wall box. The special dimming ballasts (one for each lamp) are mounted in each fixture. While the auxiliary can be remotely mounted, chances are it will be installed in one of the fixtures.

Because of the unique circuitry of the Fluor-A-Dim system, the components cannot be integrated or interchanged with other dimming systems.

EQUIPMENT INCLUDED WITH AUXILIARY AND CONTROL

CATALOG NUMBER		DIMEN-SIONS	WIRING DIAG.
251-014	120/227V Single System consists of 1—251-114 Dimmer Auxiliary 1—251-015 Control 1—Mounting Strap & Screws 1—Mounting Plate and Screws	A2	1
251-019	120/227V Dual System consists of 2—251-114 Dimmer Auxiliaries 1—251-020 Control 1—Mounting Strap & Screws 1—Mounting Plate and Screws	A2	2

DRI-LOK BALLASTS—60 HERTZ

LAMPS OPERATED BY BALLASTS		LAMP WATTS	LAMP CURRENT	NOMINAL LINE VOLTAGE	CATALOG NUMBER	MINIMUM STARTING TEMP.	LINE CURRENT IN AMPS.	INPUT WATTS	DIMEN.	LEAD LENGTH CHART NO.
NUMBER	DESCRIPTION									
1	F40T12	40	.430	120	251-201-860	+50°F	.85	48	A-1	1
				277	251-208-860	+50°F	.37	48	A-1	1

DIMENSIONS

No.	a	b	c	d
1	8 57/64	9 3/8	2 3/8	1 11/16
2	8 57/64	9 3/8	2 3/8	1 1/2

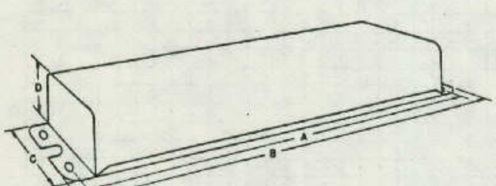
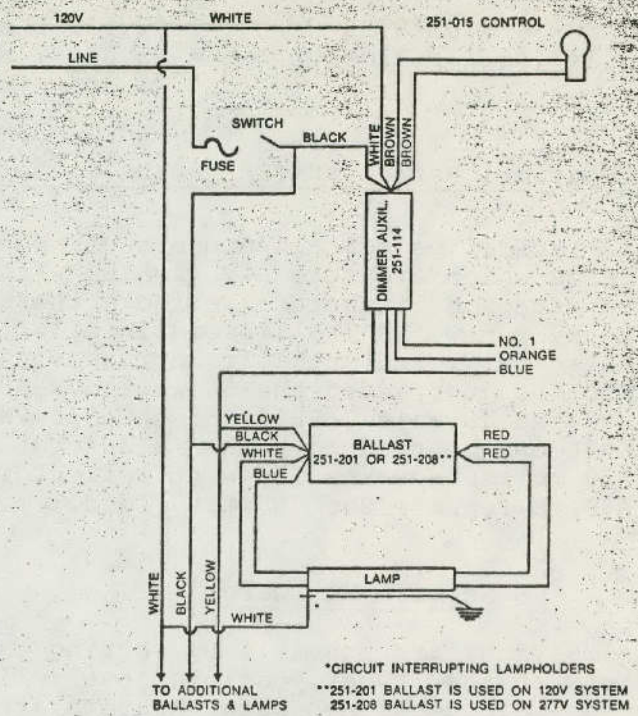


FIG. A

LEAD LENGTH CHART

NO.	WHITE	BLACK	BLUE	YEL.	RED	BROWN	BLK.	ORG.
1	29	9	29	9	29-29			
2	24	24	24	24		24-24	24	24

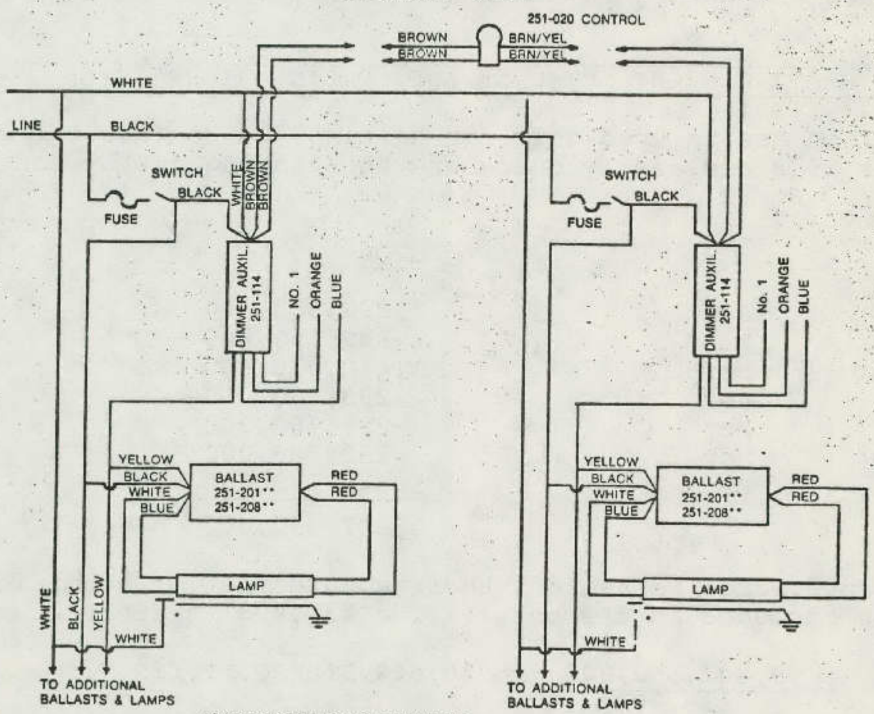
WIRING DIAGRAM FOR SINGLE SYSTEM 120/277 VOLT



*CIRCUIT INTERRUPTING LAMPHOLDERS

**251-201 BALLAST IS USED ON 120V SYSTEM
251-208 BALLAST IS USED ON 277V SYSTEM

WIRING DIAGRAM FOR DUAL SYSTEM 120/277 VOLT



*CIRCUIT INTERRUPTING LAMPHOLDERS

**251-201 BALLAST IS USED ON 120V SYSTEM
251-208 BALLAST IS USED ON 277V SYSTEM

Dollar savings would be:

(310,366 KWH) @ $.0128793	= $3,997	energy saving
(616 KW)(.14)($5.13)(12mos.)	= $5,309	demand saving
	$9,306	total saving

Use Ellipsoidal Reflector (ER) Bulbs to Replace Spotlights

All retail facilities contain numbers of recessed or so-called can light fixtures which are normally lighted with reflector flood lights. As the attached literature reflects, these reflector floods can be replaced by a new "ER", ellipsoidal reflector, bulb which cuts energy use in half, and actually increases usable light. General Electric has just added the 50 watt 50ER30 to their line. Sylvania markets the 75 watt 75ER30 and the 120 watt 120ER40. The 120 watt ER40 can be used to replace a 300 watt reflector flood, the 75 watt ER30 to replace the 150 watt reflector flood, and the 50 watt ER30 to replace the 75 watt flood.

Service Hot Water

Additional savings are possible by setting thermostats on hot water heaters at the lowest possible level; 110^{o} is adequate for lavatory use. Since the hot water heaters are all electric, and since much of the energy for hot water is lost while the hot water merely stands in the tank (standby losses), further savings are possible by placing timers on the hot water tanks so they can be turned off at night and on week-ends.

III-B HEATING NIGHT SET-BACK AND COOLING NIGHT SETUP

Since gas is used only for heating, we can add the BTUs of gas for 1978 and easily calculate the heating energy consumption in BTU/SQ.Ft/YR.

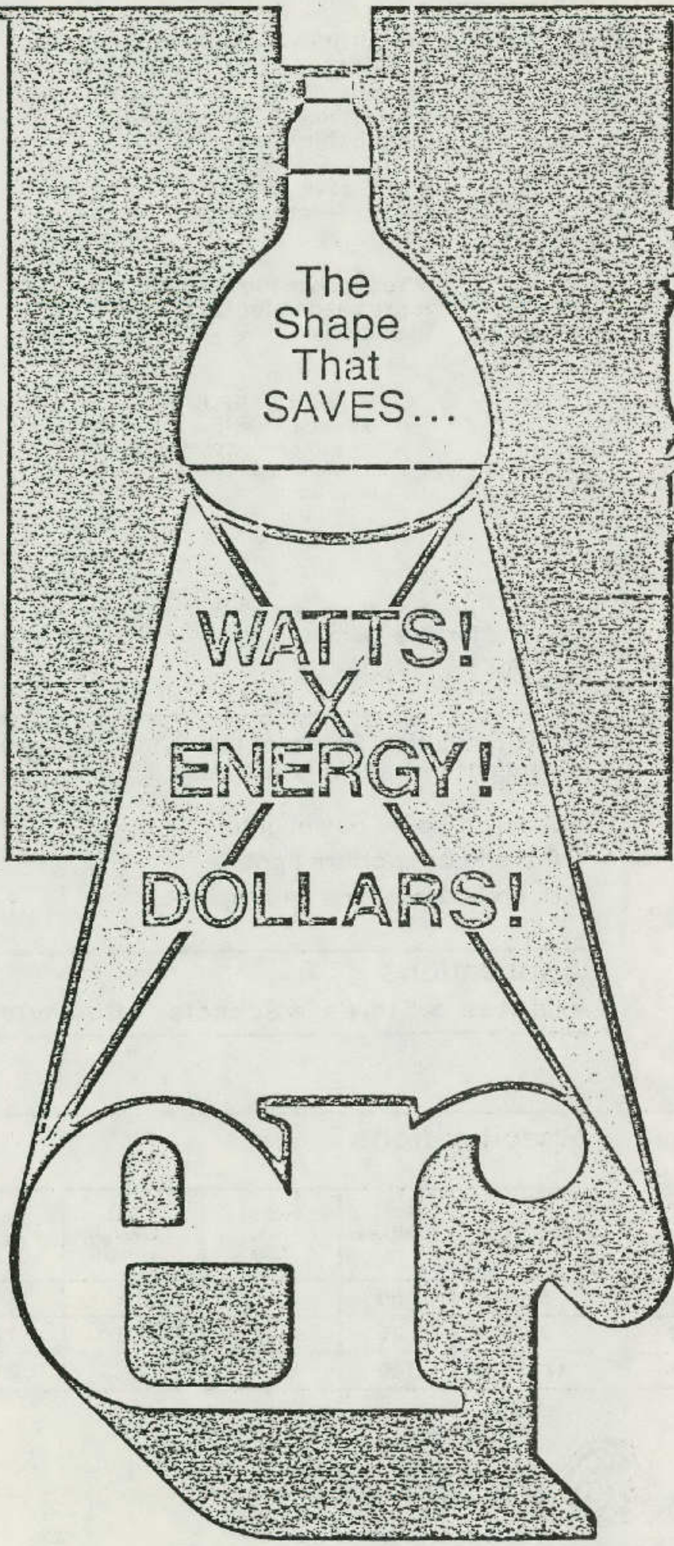
	BTUs
Jan	2,322,650,000
Feb	2,889,150,000
Mar	1,410,070,000
Apr	290,460,000
May	290,460,000
Nov	232,780,000
Dec	1,571,780,000
Total	9,007,350,000

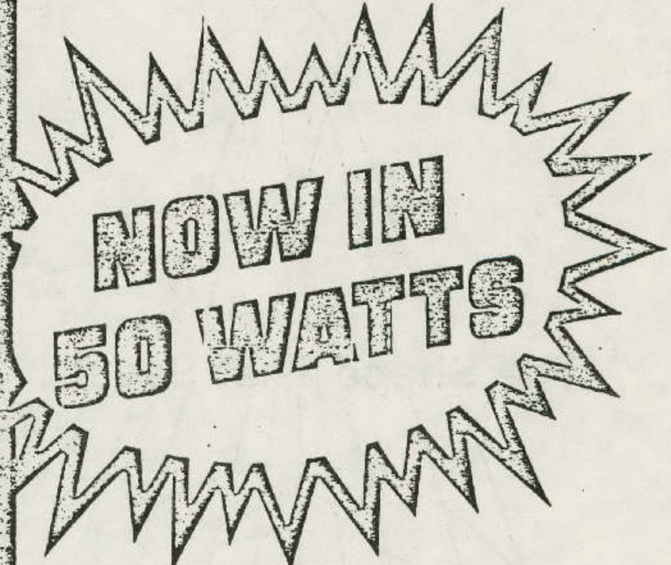
Since Wards is heated, their square feet of conditioned space will be included in the total. The 435,903 square feet require

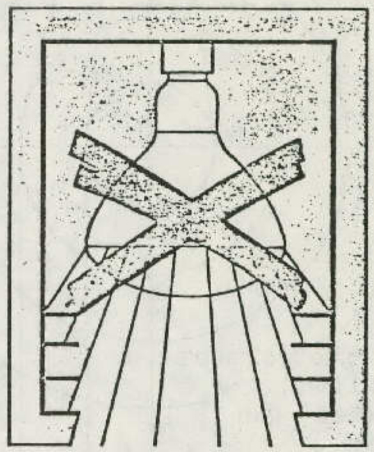
$$\frac{9,007,350,000}{435,903} = 20,664 \text{ BTU/SQ.FT./YR}$$

Energy-Savers for Downlighting Jobs...

ELLIPTICAL REFLECTOR LAMPS







Replace your standard reflector flood lamps...

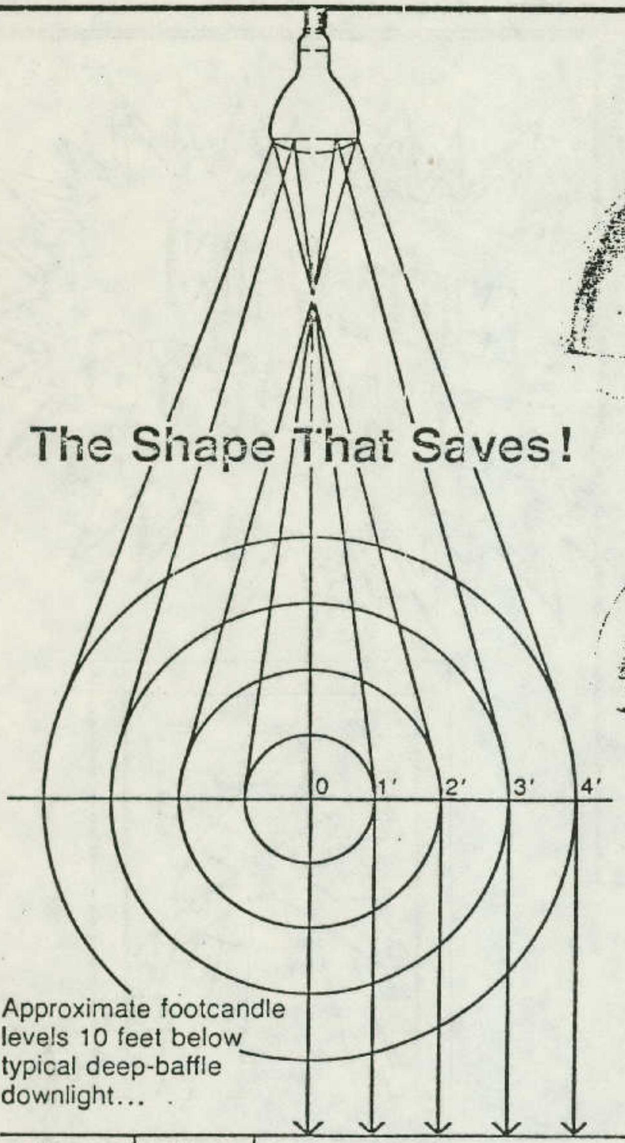
Three Energy-Saving Wattages:

- 50 Watts
- 75 Watts
- 120 Watts

ELLIPTICAL REFLECTOR LAMPS...

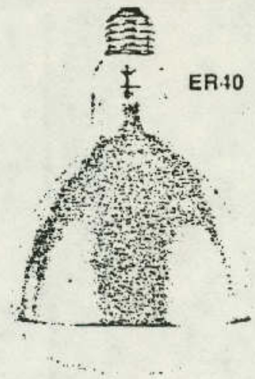
reduce your downlighting wattage by 20% to 50% and get as much or more light from deep-baffle fixtures!

The Shape That Saves!



Approximate footcandle levels 10 feet below typical deep-baffle downlight...

Lamp Type	Power Costs	Average Initial Footcandles				
75R30/FL	$ 5.25	4	4	3	3	2
50ER30	3.50	12	11	9	6	3
150R/FL	10.50	10	10	8	6	4
75ER30	5.25	16	14	11	7	4
300R/FL	21.00	18	17	15	11	7
120ER40	8.40	24	23	18	10	5



The elliptical reflector shape of GE 'ER' lamps doubles the efficiency of most standard reflector flood lamp-equipped deep-baffle downlights...

- **You save watts and energy dollars—for example, $5.25* per lamp;**
- **You reduce the number of fixtures needed for large-area installations.**

*When a 75ER30 lamp replaces a 150R/FL, dollar savings in energy over 2,000-hr. average rated life at 3.5¢/kwh is $5.25.

In bare lamp equipment, uncomfortable glare is reduced by 70% to 90%.

Use GE Elliptical Reflector lamps in many types of downlight or tracklight fixtures...

- **Stacked-baffle downlights**
- **Pinhole or aperture spots**
- **Deep bullets, cans and top hats**

Applications

- **Offices** • **Stores** • **Schools** • **Restaurants**

Specifications

Ordering Code	Wattage	Approx. Hrs. Life	Max. Overall Length	Std. Pkg.
50ER30	50	2,000	6⅜"	24
75ER30	75	2,000	6⅜"	24
120ER40	120	2,000	7⅜"	24

GENERAL ELECTRIC

205-836
2/78

Entering the attached chart with 2363 degree days for the Dallas area and 20,664 BTU/SQ.FT./YR. heating cost, we can read the saving which corresponds to a particular setback. For example, for a 10° setback we read a 9300 BTU/SQ.FT./YR. saving. This saving, at \$2.50 per MCF (1,030,000 BTUs) of gas, is

$$\frac{9300 \times 435,903}{1,030,000} \times \$2.50 = \underline{\underline{\$9840}}$$

Thus, if all tenants installed an automatic temperature scheduler (time clock) similar to that in the attached literature, about 1/3 of the total season heating cost could be saved. Note also that model TS102 can be used to set up cooling temperatures at night for additional savings during the cooling season.

III-C Adjust Outside Air Amounts

Each cubic foot of air brought into the building must be heated or cooled and, in the case of cooling, partially dehumidified. Hence, strict control over the amount of such air is very important in energy conservation; particularly since common practice typically results in use of excessive amounts of air at all seasons of the year.

Ventilation is the function which provides outdoor air or treated air for the physical needs of the building occupants and which exhausts stale, contaminated air. The rate of exhausting stale or used air should be balanced with the intake of fresh air so that a slight positive pressure is maintained inside the building to retard infiltration of outside unconditioned air into the building.

The physical needs of the occupants include oxygen for breathing and the removal of unwanted pollutants, including tobacco smoke, and odors. The amount of oxygen required to support physical needs can be supplied by one to two cubic feet per minute (CFM) per person, and one to four CFM are usually adequate for control of very light smoking and odors. The trend is toward providing no more than 5 CFM per person in most facilities, and credit may be taken for infiltration as part of the outdoor air requirement.

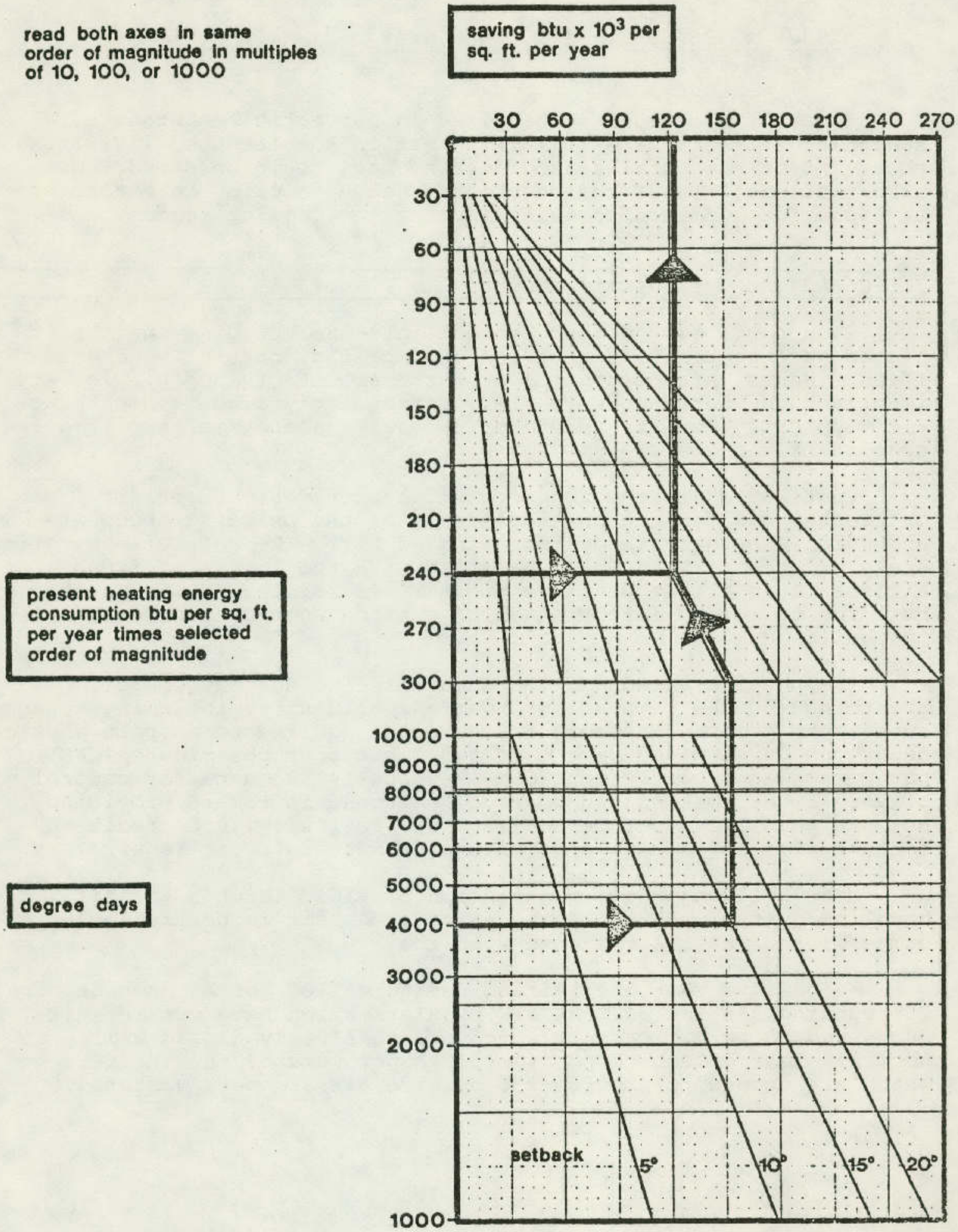
Most buildings have ventilation provided through the air handling system, where the amount of fresh air is controlled by dampers; and that is the case with the mall.

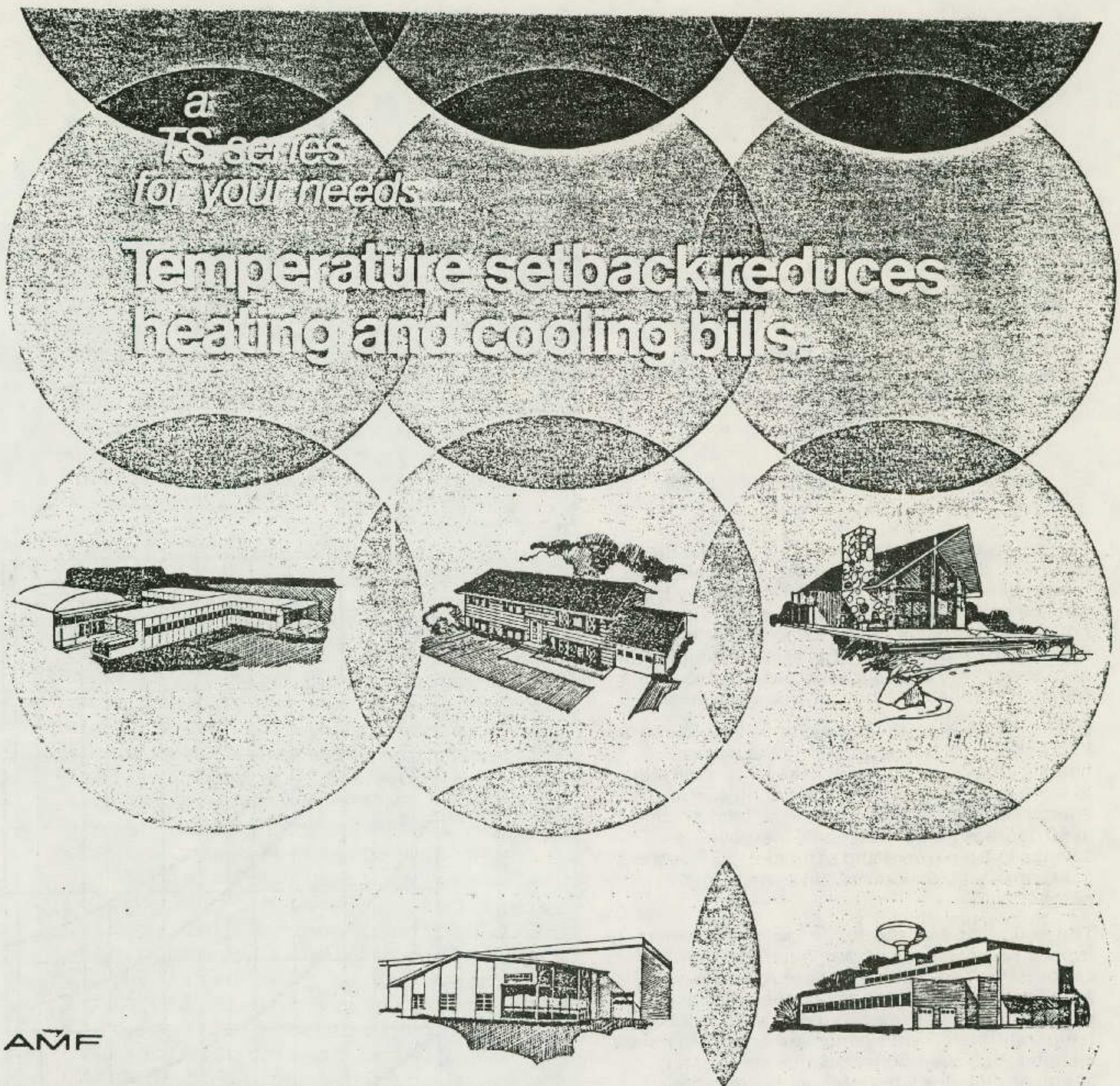
We believe that the initial design called for as much as 25% outside air for all the air handlers which have outside air ducts and dampers. Dampers which are completely closed will normally leak enough to provide 5 CFM per person; thus dampers which are opened to provide 25% outside air are very wasteful.

heating

energy saved by night setback

read both axes in same order of magnitude in multiples of 10, 100, or 1000





AMF

Paragon

Automatic Temperature Scheduler

Bulletin 3030-4
January 1978
Supercedes Bulletin 3030-3

Helping you manage energy. Efficiently.

Why Temperature Setback?

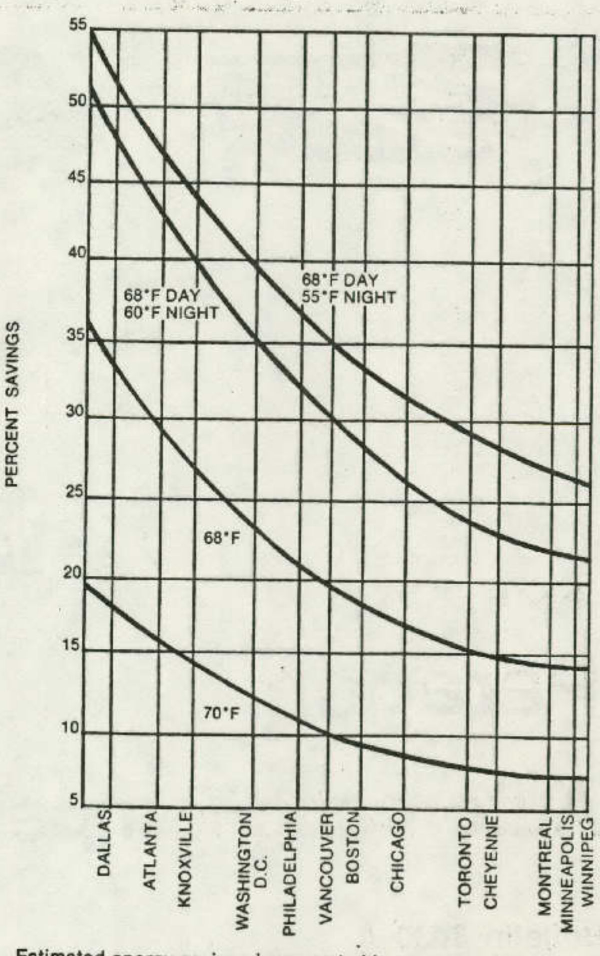
In recent studies, it was confirmed that the practice of turning down the thermostat is a very effective means of reducing fuel consumption in any type of heating system. Many people have the false notion that reducing their thermostat settings below sixty-eight degrees Fahrenheit at night will not save energy due to the increased consumption required to reheat the house to daytime levels.

Reducing thermostat settings from 72 to 68 degrees Fahrenheit in U.S. homes during the winter heating season could result in savings equivalent to more than 2.3 percent of the nation's total energy consumption. Night-time setbacks from 68 to 60 degrees Fahrenheit could increase the savings to 3.6 percent and setbacks to 55 degrees Fahrenheit would increase the savings to 4.1 percent.

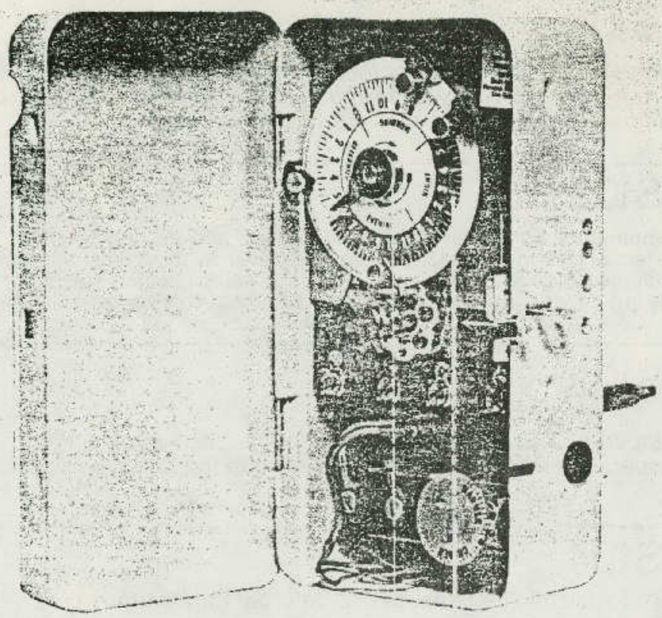
These figures and the following graph came from a recent study by Holifield National Laboratory. You can closely approximate your percent of savings by choosing the city closest to your location and selecting the desired setback temperature. Percent savings are greater in milder climates, however, dollar savings are greater in colder climates where fuel bills are higher.

Greater savings can be achieved by using the PARAGON TS Series with multiple setback capability. The above savings can be increased by programming an additional setback during periods when the building is unoccupied.

As fuel costs increase, the practice of night setback increases in popularity. Building temperatures can be lowered manually or automatically. Automatic scheduling with the PARAGON TS Series eliminates the human element of forgetting to lower the thermostat. By providing a warm house to wake up to, the PARAGON TS Series saves energy but doesn't sacrifice comfort.



Estimated energy savings in several cities resulting from temperature setback. Here 72 degrees (22 degrees C) is the reference setting; night setback is from 10:00 p.m. to 6:00 a.m.



WHY USE THE TS SERIES?

The PARAGON TS Series temperature schedulers offer programming flexibility not available on clock thermostats or thermostat "Fooler" models.

The TS Series has the following features:

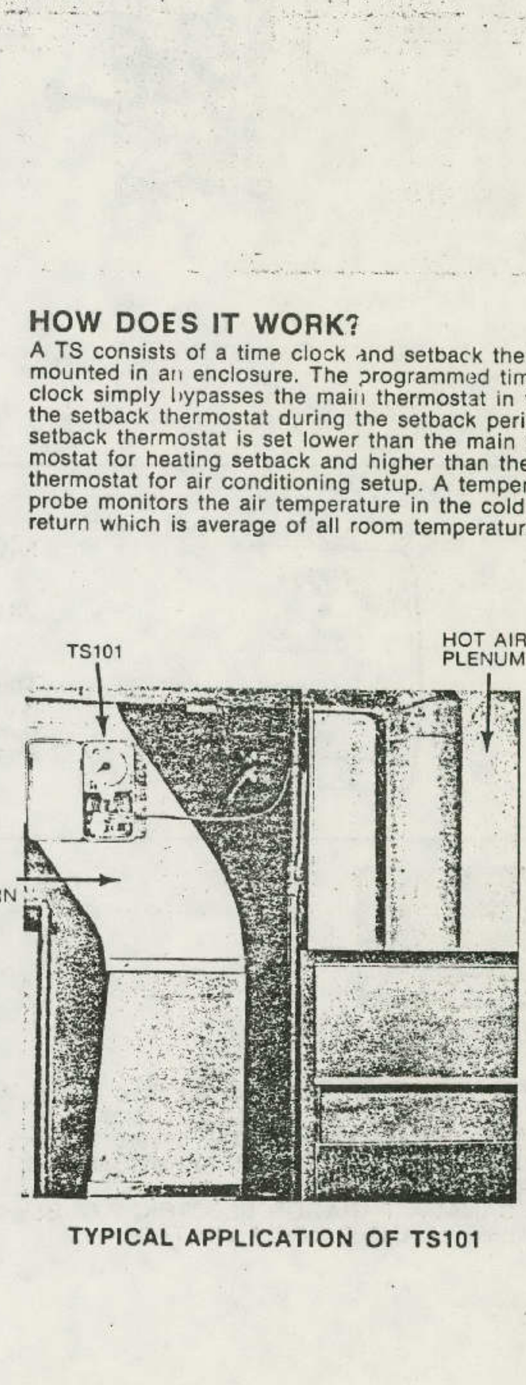
- **EXCLUSIVE** Skip-A-Day Feature. Unlike all other setback devices that operate under the same program seven days a week, the TS Series can be programmed for different needs. Few buildings have the same heating and cooling requirements seven days a week.

  Example of residential application — If you entertain or sleep late on weekends, simply program the skip-a-day dial to skip the automatic setback operation.

  Example of commercial or industrial application — The TS Models can also be programmed to setback on week nights and the entire or partial weekend resulting in much greater savings than other setback devices.
- Multiple setback capability which increases savings potential. Unlike most setback devices the TS Series can be programmed for more than one setback period per day.
- Cost savings of 12 to 20 percent based on actual residential tests.
- Virtually tamper proof. Readily "accessible" setback devices are often re-adjusted for individual comforts — resulting in lesser savings. The TS is mounted in a "remote" location where constant re-adjusting or tampering is difficult. The device is programmed and forgotten.
- Manual by-pass which allows temporary omission of setback whenever desired. The scheduler returns to automatic function by itself.
- Flexibility, the scheduler can be used with forced air or hot water heating systems and also on multi-stage furnaces.
- Easy installation. Also, the TS Series is supplementary to existing thermostats, there are no modifications or replacements necessary.
- Setback thermostat range of 48 degrees.
- Low voltage for safety.

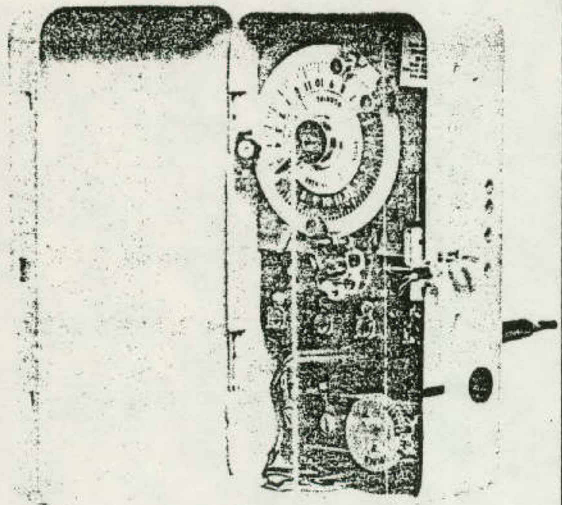
HOW DOES IT WORK?

A TS consists of a time clock and setback thermostat mounted in an enclosure. The programmed time clock simply bypasses the main thermostat in favor of the setback thermostat during the setback period. The setback thermostat is set lower than the main thermostat for heating setback and higher than the main thermostat for air conditioning setup. A temperature probe monitors the air temperature in the cold air return which is average of all room temperatures.



TYPICAL APPLICATION OF TS101

TS MODELS AVAILABLE



TS101

Temperature Scheduler for forced air heating systems. Skip-a-day, manual by-pass and multiple setback are standard. Temperature probe is inserted into cold air return.

TS102

Temperature Scheduler for central heating and air conditioning systems. This model has the same features as the TS101 with an additional capability of air conditioning "setup", which saves on heating/cooling costs in winter and summer. This model can also be wired to setback for the entire weekend.

TS103

Temperature Scheduler for hot water heating systems. The temperature probe is mounted external to the Scheduler case.

TS104

This device can be used for two different applications.

1. Commercial and Industrial application.
   The TS104 can be programmed to setback on week nights and all day Saturday and/or Sunday.
2. Vacation Home Application

   The TS104 can be programmed to have the vacation home or cottage at a desired temperature upon arrival. It simply raises the temperature from a low setting to a higher setting when occupancy is to occur. If the owner does not arrive by a specified time it automatically reverts to the low temperature condition until the following week.

MODEL A968

24V TRANSFORMER

The above models operate on 24 volt A.C. Voltage is usually obtained from the 24 volt heating system transformer. A separate 120/24 volt transformer Model **A968** can be obtained from the nearest PARAGON dealer.

AMF
Paragon

606 Parkway Blvd., P.O. Box 28, Two Rivers, WI 54241 U.S.A.

EXPORT SALES OFFICE: Two Rivers, Wisconsin 54241 U.S.A.
Cable: PECO Telex 26-3450 PARAGON TWOR

IN CANADA: PARAGON ELECTRIC P.O. Box 1030 Guelph, Ontario
Division of AMF CANADA LIMITED

Printed in U.S.A.

In addition, if the outside air dampers remain open at night or during other unoccupied periods, outside air is being heated and cooled unnecessarily since there are no occupants to require outside air.

Recommendations:

1. Reduce outside air to the minimum required to balance the exhaust requirements and maintain a slight positive pressure to retard infiltration; 5 CFM per person should be adequate.

2. Reduce exhaust air quantities as practical.

3. Check to see that the outside air dampers in each air handler close automatically when the air handler fan is turned off. If they do not, get them adjusted so that they do so. Turn off air handlers at nights and on Sundays if possible. If this is not possible, install time clocks which will override the air handler controls and close the dampers at night and on Sundays.

4. Close all outside air dampers when the building is cooled down or warmed up prior to an opening. With no one in the building, no fresh outside air is needed, and heating and cooling the additional air is wasteful of energy. If the automatic controls cannot be set to do this, it may be necessary for the building operator to make these changes manually each time.

5. Contact your installing contractor or the equipment manufacturer and get details of the air and outside air controls and settings and then write simple operating instructions for all who might operate the building systems to follow.

Section IV

Retrofit Recommendations

Primarily for Shopping Mall Management

IV-A Energy Management

Energy Manager

If the General Manager finds he does not have enough time to devote to energy management, it may be worthwhile to designate another employee as overall energy manager. In that case, some form of incentive system might prove worthwhile.

Meters

Reference to the graph for demand charges shows that the summer peak demand is establishing a minimum demand charge for the next twelve months such that demand charges are being paid for demand not actually used. As a means of making the mall operating staff more conscious of energy use, we recommend a daily meter-reading and cost computation system be established for the three KWH meters and the one graphical demand meter and that the resulting information be provided to the General Manager.

Master Meters versus Individual Meters

A look at the breakdown of the electricity bill reveals that the concept of major savings through master meters should be questioned. There is, for example, no declining block rate (i.e., the more you use the less it costs) for demand. All KWs of demand cost the same. In addition, the fuel cost per KWH is a flat rate and each KWH used costs the same in terms of fuel. Thus only about 25% of the total bill is left to be accounted for in the KWH declining block rate.

The other side of this coin is that the demand minimum bill for the next 12 months exempts only 30 KW from the monthly peak demand. If all 56 stores had their own demand meter, each meter would be able to exclude the first 30 KW, totaling 1680 KW; compared to only 30 KW now excluded with one demand meter.

The excess costs which are accruing this winter due to the peak demand of last summer are due in part ot the present arrangement with meters. The mall's central plant heats and cools Wards, but does not have the year-round base load of lights, air handlers, and appliances necessary to produce a favorable load factor. The summer peak will always be set when the cooling load is greatest. Without Wards wintertime electrical loads, it will be very difficult to avoid paying extra costs for minimum demand charges.

Accordingly, we recommend you explore two alternatives:

- first, eliminate Wards meter and add these loads to the mall master meter

- two, reduce the summer peak by providing a separate heating and cooling system for Wards, to include a separate demand meter, provided details of the tenant utility agreement can be worked out.

In this connection, you might wish to consider this problem area in any expansion plans for the mall. We recommend you study very closely the costs and benefits of such "split" arrangements when the mall provides heat and cooling from a central plant, but the tenants are metered separately for lighting and other loads. The demand "ratchet" or 12 month minimum demand bill clause makes the economics of this type of arrangement suspect.

IV-B Chiller Demand Reduction and Control

The demand "spikes" occurring throughout the year in just one fifteen minute interval appear to be the result of the second chiller and associated equipment coming on line. If it is brought on line, say with the demand limiter set at 60%, it could add an additional load of:

chiller (606 KW x .6)	364 KW
chilled water circulating pump	94 KW
condensor water circulating pump	37 KW
cooling tower fan	30 KW
Total	525 KW

We recommend that the mall investigate a system such as CHILLITROL II or York's Kilowatt Kontrol for automatic start, stop, and operation of the two chillers. A CHILLITOROL II installation will probably cost on the order of $10,000, but if it can cut 163 KW off the summer-time peak it will pay for itself in one year

163 KW x $5.13/KW x 12 mos. = $10,034

If it reduces that demand by 82 KW, it will pay for itself in two years.

Until such an automatic system is installed, we recommend you adopt the following manual procedures in order to minimize the demand peaks and spikes:

1. Do not start second chiller until first chiller is operating at about 80% load*

2. Before starting second chiller, set demand limiter on it at 40% and reduce demand limiter on the first to 40%

3. Wait for at least 15 minutes (demand meter interval) before raising demand limiters on both to higher settings.

* Note: In order to know that the chiller is at or near 80% load, we recommend the installation of two pressure sensors, one on either side of the evaporator, both connected to a pressure electric switch which would sound a bell alarm once the pressure differential reached the preset point corresponding to 80% load.

Notice in the attached CHILLITROL II literature that the manual procedures we recommend above, and many others, will be accomplished automatically.

IV-C Thermal Storage System for Demand Leveling

We recommend you investigate the use of the Thermaster (see attached literature) energy storage system both for reducing peak demand and for utilizing electricity at costs of 1.3¢/KWH during other than peak periods. By generating ice in the Thermaster in off-peak periods at night and in early morning, peak demands can be lowered. The use of this equipment effectively increases system capacity and is thus an alternative to added capacity. The largest unit manufactured is rated at 540 TON-HRS and is listed at $23,100.

A check of the demand graph for August of 1978 shows peak usage of chillers from about noon to 6 PM, or a period of 6 hours. One 540 Ton-HR unit would provide 540/6 or 90 tons of cooling equipment for six hours. A chiller requires about 1 KW of capacity for each ton of cooling, so 90 tons of chiller capacity not used would be 90 KW of demand not recorded. At $5.13/KW, that equates to $462 of cost for demand which would be avoided.

If that 90 KW were the peak demand for the year, then $5544 would be saved for that year, and the unit would pay for itself in about four years, not counting the KWH saving.

$462 X 12 = $5544

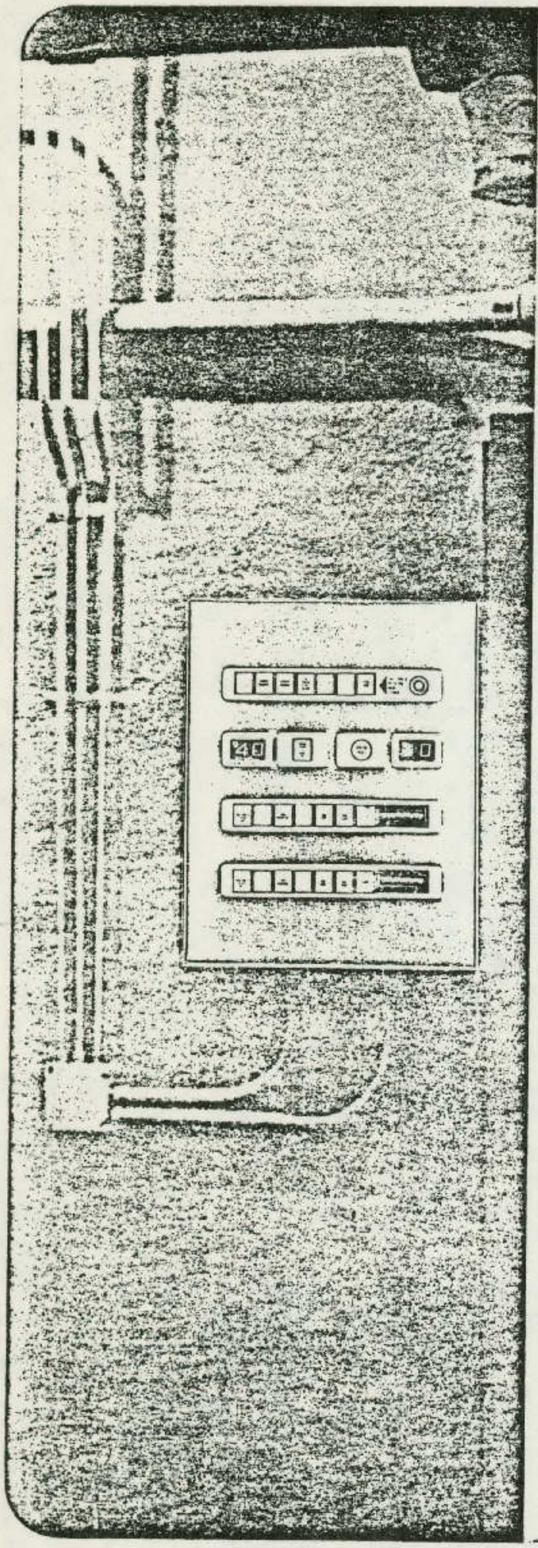
IV-D Tenant Agreement for Electric Energy

Because of the demand "ratchet" for the summer months, we recommend you keep all your check meters in use during those months so as to keep the 12-month minimum demand as low as possible.

In addition, we believe it would be in the best interests of all involved to revise the tenant agreements to permit: (1) installation of night set-back or set-up times as discussed in Section III and (2) duty cycling of air handlers. The 236 KW load of air handlers can be reduced by 10-25% without lowering comfort levels by turning off air handlers for so many minutes each hour. A reduction of 59 KW would produce savings of

Demand	59 KW @ $5.13 x 12	$3,656
Energy 59 KW x 24 hrs/day x 6 days/wk x 52 wks x $.0128793 = $5690		$5,690
	Total	$9,326

Here's how Chillitrol II™ works to simplify your day to day chiller operation.



1. Automatically starts chiller
2. Unloads first chiller at peak load
3. Eliminates surge problems
4. Stabilizes the system
5. Dials in chiller capacity to match system reaction time.
6. Provides for manually loading or unloading chillers from any Chillitrol II™ location.
7. Provides only the actual cooling needed by resetting the chilled water according to the air conditioning requirements.
8. Provision for manual control of chiller during service.

Chillitrol II™ frees you from tedious monitoring of complicated controls by automatically controlling your chillers with programmed logic.

What Chillitrol II™ Does	How Chillitrol II™ Works
1 Existing chiller controls always function as safety limits.	**1** Chillitrol only takes over after chiller is safe to run by controlling load signal between temperature and vane motor.
2 Loads, unloads, starts, and stops chillers automatically, without expensive power surges.	**2** After chiller first starts, Chillitrol opens vanes and loads chiller to 32%. Automatically steps up if needed in 2% increments on a time-system.
3 Automatically resets suction temperature by sensing load requirements.	**3** Suction temperature can be elevated as a function of vane opening and is automatically controlled by the load conditions.
4 Remotely monitors and displays vane position in percentages.	**4** Chillitrol tracks the vàne and displays its position.
5 Starts up only when needed and positively prevents overshooting.	**5** A patented stabilization system that is compatible with any existing control system is utilized to perform this function.
6 Automatically maintains load while chiller is being serviced.	**6** Bypass switch permits operation of serviced chiller, under its own control, and automatically programs start of second chiller.
7 Automatic daily selection of lead lag chillers.	**7** An external alternator switch added to the built in circuit within the Chillitrol unit, can select automatic operation; also, the smaller of unmatched chillers can automatially be selected from external source if required.
8 Manual override provisions for engineer takeover.	**8** Bypass switch in "manual" position automatically returns control to operator.
9 Any Chillitrol failure allows transfer of operations back to original chiller controls.	**9** Unit is fail safe. Failure is visually displayed and alerts operator to manually control chiller operation.
10 Automatic changeover if one chiller fails.	**10** Failure circuits in chillers are monitored and upon failure sequence functions are automatically changed.
11 Chillitrol operates chillers with less KW per ton of refrigeration required during light load conditions.	**11** Direct sensing system reacts to actual load requirements instead of anticipating load.
12 Programmed usage of stand-by chiller, only when needed.	**12** Stand by chiller is started automatically when first chiller reaches 86% vane position. First chiller is brought down to 40% and waits for second chiller to match load; then both chillers automatically alternate up in 2% increments using higher water temperatures.

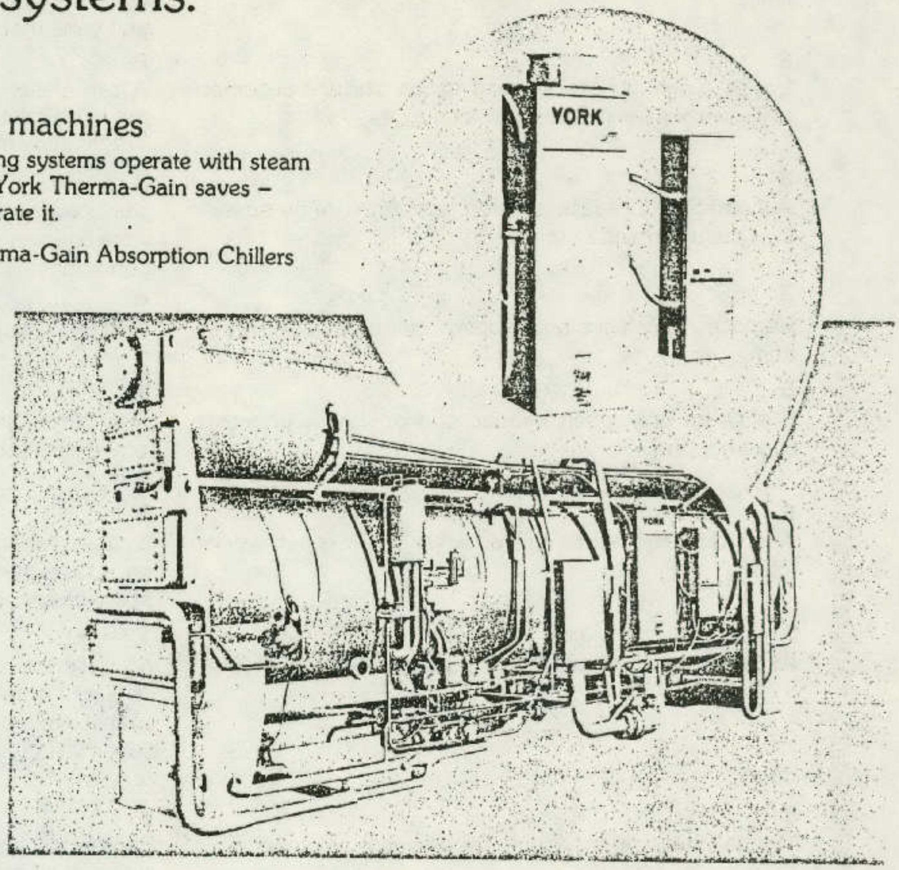
Patent pending

New energy-saving technology . . .
York innovations save countless energy dollars in big building systems.

Therma-Gain absorption machines

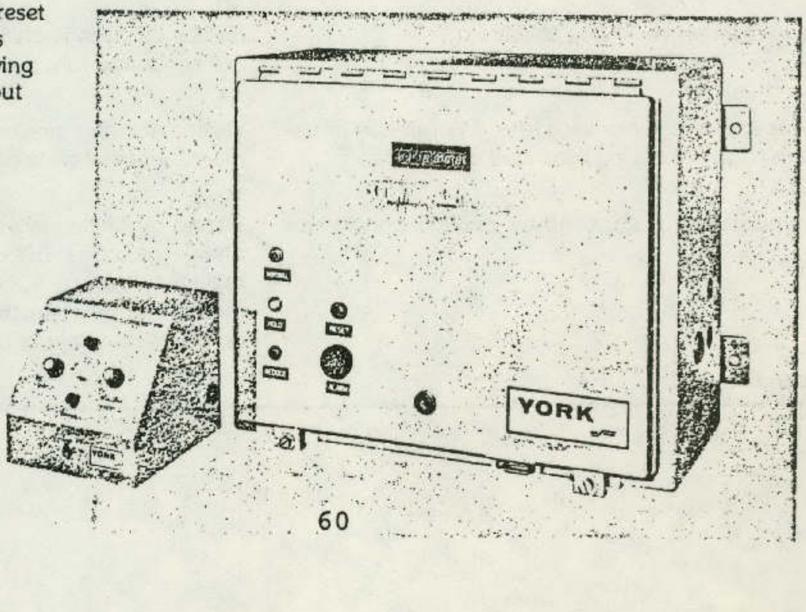
Almost all absorption air conditioning systems operate with steam as their power source, and this is what York Therma-Gain saves – steam, and the energy required to generate it.

During the cooling off-season, Therma-Gain Absorption Chillers provide up to 60% of the absorption system's cooling capacity, using only 2% of the steam required for that much cooling. Building owners save up to 30% in annual cooling costs. Another energy-saving "first" from York.



Kilowatt Kontrol demand limiter

Applied with York's centrifugal water chillers, Kilowatt Kontrol can reduce a building's electrical demand by as much as 20 percent. The building's electrical demand is monitored, and if it exceeds a preset limit, Kilowatt Kontrol modulates the chiller's cooling capacity, saving the building owner money without sacrificing occupant comfort.



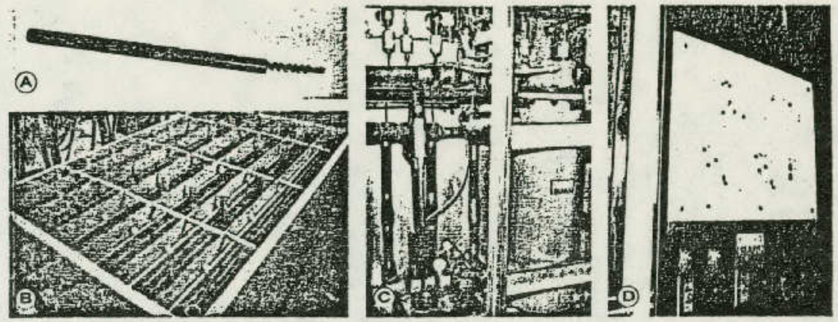
Now you can enjoy the economy of off-peak cooling and heating

CALOSKILLS

Thermaster™

Thermal Energy Storage Systems

Shown at right — (A) Expanded view shows section of a refrigerant coil with internal spiral and oil return insert. (B) In-plant construction view of top section of the THERMASTER before installation of insulated top, showing refrigerant coils, coil plates and baffles. (C) View of THERMASTER controls compartment with doors open, showing refrigerant piping, thermal expansion valves and driers, resistance heating elements and circulator. (D) View of graphic control panel, typical of the custom designed control packages available.



Key to effective energy management in space conditioning

A MULTI-FEATURE MULTI-BENEFIT SYSTEM

1. **Heating & Cooling Storage** — The basic energy storage capabilities of the THERMASTER provide the means for lowering ever increasing electric demand charges and for taking advantage of time-of-use rates.

2. **Wide Range of Capacities** — There are 20 different models in the THERMASTER line. Rated capacities range from 48 to 540 ton-hours cooling effect and over 8-million Btu heat storage in increments to satisfy most any facility requirement.

3. **Multi-Unit Adaptability** — For large capacity requirements, THERMASTER units are fully adaptable for installation in multiples, in either series or parallel flow, depending on the need.

4. **Versatility** — While THERMASTER cannot be instantaneously shifted back and forth between heating and cooling, it can be converted seasonally. In a 3-unit multiple installation for example, we may have all 3 on cool; 2 on cool, 1 on heat; 2 on heat, 1 on cool; or all 3 on heat.

   In Spring-Summer or Summer-Fall transition periods, a THERMASTER system is typically fitted with low capacity resistance heaters to supply auxiliary heat for that occasional cool morning while the THERMASTER remains available for cooling.

5. **Retrofit** — The THERMASTER is a great capacity expander. It can effectively double the capacity of existing systems. Take a conventional cooling system as an example — it does nothing during nighttime hours. To expand it, the installation of a THERMASTER is the answer — simply repipe refrigerant and water to the THERMASTER. The compressor can then work around the clock, storing its effect at night, instead of running only during the day.

   When existing system is DX instead of hydronic, the air handlers must be converted for water use.

6. **Heavy Duty Industrial Type Construction** — Full weight steel pipe and heavy gauge sheet steel are used for refrigerant coil and vessel, respectively. The construction is all welded for rugged, leak-proof service far beyond the life expectancy of normal commercial equipment.

7. **Polyurethane Insulation** — 6" of low density polyurethane insulation on side, rear, top and bottom (2" all around the front controls compartment) means low radiation losses, even at internal temperatures of 32°F. in summer and 190°F. in winter. This feature provides protection for unit installation indoors or outdoors.

8. **Controlled Water Passage** — A controlled water flow through the unit means no chance of inaccessible blocks of ice forming. All the water contacts all the ice for complete cooling. In the heating mode, this feature minimizes stratification.

9. **Internal Baffling** — Fixed internal baffles jut into the water flow path, agitating the water as it passes through the THERMASTER for efficient heat transfer between water and ice. This "scrubbing action" is a must.

   The baffle system eliminates the need for such power-consuming auxiliaries as motor-driven propellers or air-compressors. Where such devices are used, you pay for the power to run them and then pay again for refrigeration to take this same energy out of the water — paying twice for this effect.

   This feature also helps to reduce stratification in the heating mode.

10. **Attractive Appearance** — Embossed aluminum exterior sheathing is both attractive and functional, providing a protective outer covering for the THERMASTER insulation.

11. **Internally Spiraled Refrigerant Coils** — Wound wire helixes within the refrigeration coils continually keep liquid refrigerant in contact with coil walls — keeping them wetted and more effective.

12. **Oil Return from Refrigerant Coils** — The THERMASTER incorporates a reduction in cross-section of the bottom portion of each coil to assure oil return to the compressor. This reduction, effected by inserts within the vapor helixes, assures that the coils do not become oil-logged and less effective.

13. **Individual Coil Valving** — Each refrigerant coil is fitted with its own thermal expansion valve and drier to allow that coil to work at the optimum level as dictated by the pattern of the ice field.

14. **Progressive Ice Melt-Off** — In the cooling mode, controlled water flow results in ice melt-off from the coils on the warm water return side of the THERMASTER first. With reduced ice thickness on these first coils, the compressor capacity can be more effectively used in a load-leveling application during the load cycle.

15. **Externally Adjustable Ice Thickness Control** — Since it is less efficient to store more ice than is required for the anticipated load, a readily adjustable ice thickness control is supplied as standard to easily permit periodic changes in its setting. (Fall and spring usage will be less than mid-summer.) Some reserve should be allowed to handle the occasional above-normal day during intermediate times.

16. **Complete Package Economy** — THERMASTER thermal energy storage units are available as factory-packaged assemblies, if desired, to simplify installation and to reduce installation costs. A condensing unit can be mounted on top or at the rear of the THERMASTER and a resistance heater within the front controls compartment. The complete package is then piped, wired (including the automatic ice thickness control), charged with refrigerant and test run at the factory.

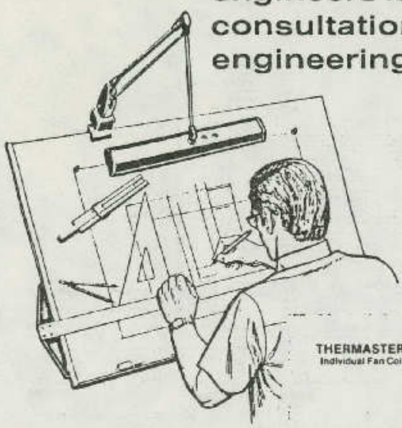
    Space is available in the controls compartment for the installation of the water supply pump to the air handlers.

    A separate pre-wired graphic control panel can be supplied to satisfy any degree of control and/or monitoring.

17. **Over 30 Years' Experience** — Caloskills has the technology to do the job right . . . the first time . . . from a background of over 30 years of experience in thermal energy storage. The THERMASTER design has proven sound. Manufacturing techniques developed over the years approach zero-defect construction. Testing procedures are used at various contruction stages to assure reliability.

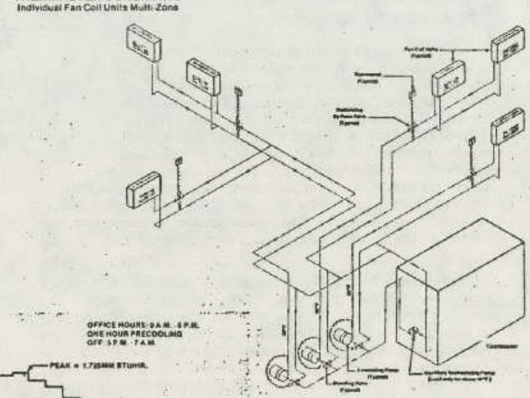
18. **Thousands of Operating Installations** — Caloskills and its parent organization have a history of over 7,000 installations in a surprising variety of applications. Our applications ability and know-how are unmatched in the industry. There are few situations which we have not encountered. Caloskills knows when it can satisfy a customer's requirement and, more importantly — we know when we can't!

CALOSKILLS™ . . . a staff of skilled, experienced, professionally-trained designers and engineers is at your service for consultation, complete systems engineering and installation



A Thermaster can be applied to practically any type of hydronic space conditioning system — be it central or remote air handlers, single or multi-use, cooling or heating/cooling combinations. Thermasters may be applied in multiples for large installations.

THERMASTER SCHEMATIC
Individual Fan Coil Units Multi-Zone



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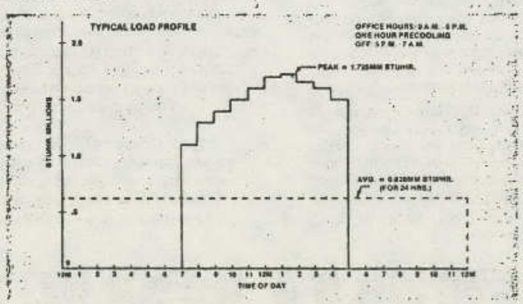
Load leveling of space conditioning will typically reduce the required tonnage by two-thirds with the use of Thermaster storage capabilities. The space conditioning load may also be fully shifted to operate in off-peak hours or when other building loads are not on-line. This results in still lower demand charges and increased savings on time-of-use rate structures.

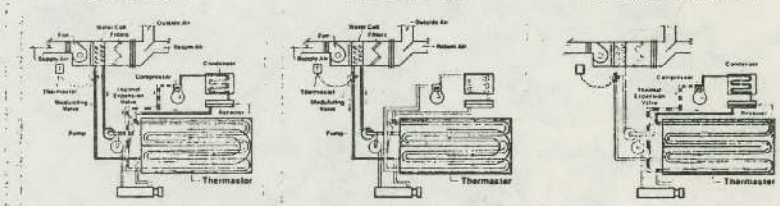


Let us help you implement effective energy management to capitalize on the economy of off-peak power for your space conditioning.

The key to effective energy management is nighttime production and storage of static ice and hot water during off-peak periods for more economical hydronic cooling and heating . . .

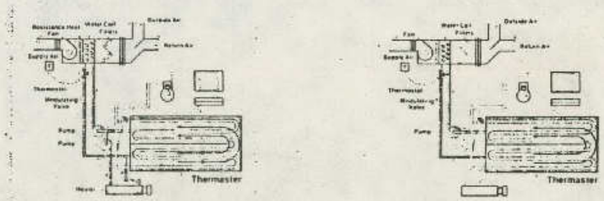
COOLING

ON-PEAK LOAD LEVELING | ON-PEAK LOAD SHIFTING | OFF-PEAK LOAD LEVEL & LOAD SHIFT



HEATING

OFF-PEAK LOAD LEVEL & LOAD SHIFT | ON-PEAK LOAD SHIFTING



We are ready to package and deliver a complete turn-key Thermal Energy Storage System that's right for your requirements — and are happy to work with your architect, consulting or mechanical engineer, contractor and all members of the HVAC community to employ our specialty to your advantage.

CALOSKILLS™

Thermaster™...the ke

Thermaster — the heart of Caloskills' Thermal Energy Storage System — a heavily insulated water vessel with internal refrigeration coils.

It can be tailored to the requirements of the installation with air or water cooled condensing units, electric resistance heaters, automatic ice thickness controls and complete control packages — for THE ULTIMATE IN THERMAL ENERGY STORAGE and new cooling/heating economy.

COOLING . . .

The refrigeration is turned on automatically or manually during the appropriate hours. Up to 50% of the water in the unit is turned into ice — formed in large sheets over the coils. When cooling is called for, a water circulating pump sends the chilled water to the coil in an air-handling unit and then back to the Thermaster where it is re-cooled.

The refrigeration compressor may be off during this period, relying only on the ice for cooling. This provides for a load-shift condition. As an alternative, the refrigeration can be left on to combine the cooling effect of the ice with that of the condensing unit for increased cooling capacity and decreased equipment size. This load-leveling condition provides for greatest utilization of the cooling equipment.

HEATING . . .

The heating elements are turned on automatically or manually and water is recirculated over these elements continuously by a small low-head, high volume circulator to gradually increase the water temperature within the Thermaster. Under normal conditions, this occurs during the hours of peak space heating demand. At the same time, the unit is providing hot water for this peak load through the main circulating pump, over to the air-handling unit coil and back. During the day, the heating elements may be either on or off as desired, but in most cases their use is not required.

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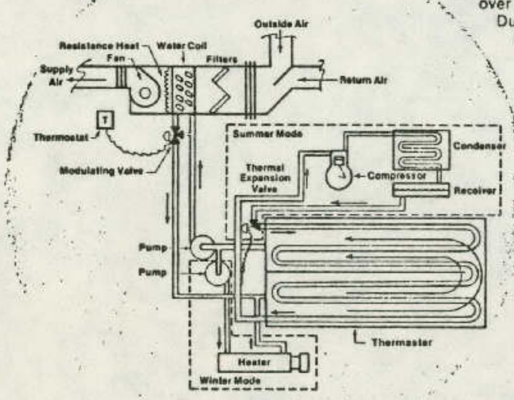
THERMASTER SCHEMATIC
Central System

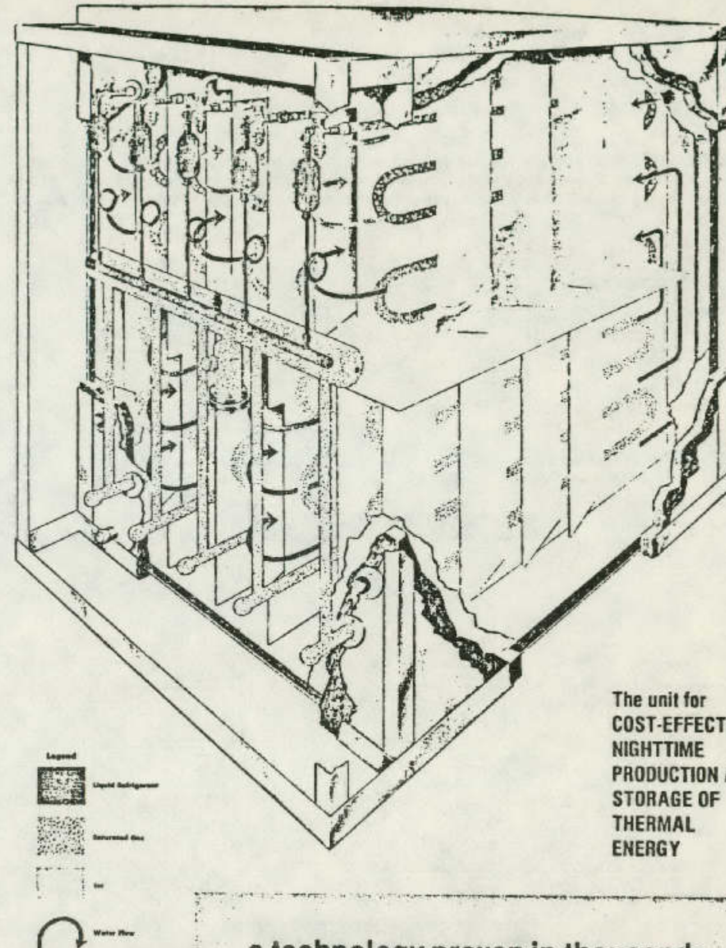


TRANSITIONAL PERIODS

During periods of seasonal change, while the Thermaster is still in cooling mode, the occasional heating requirement may be satisfied by the use of small in-duct resistance heaters. Outside air economizers can also be quite effective at times when ambient conditions are right.

AUTOMATION - ACCESSORIES

All operations of the system — in both heating and cooling modes — may be controlled manually, automatically or semi-automatically. The complete package can include timed circuits, inside-outside thermal sensors, anticipators, economizer cycles, supplemental heat cycles, ice thickness controls and heat recovery systems — to give you the ultimate in energy management.



Front controls compartment paneling and doors are not shown in the above cut-away view.

The unit for COST-EFFECTIVE, NIGHTTIME PRODUCTION AND STORAGE OF THERMAL ENERGY

a technology proven in thousands of our parent firm's refrigeration and air conditioning installations over the past thirty years.

"This thermal storage cooling system will provide a reduction of approximately 70 % in on-peak demands . . ."

— as reported in an article in **Electrical Consultant** *magazir*

Thermal Energy Storage is the key to effective energy management in space conditioning

THE CONCEPT OF THERMAL ENERGY STORAGE

Thermal Energy Storage is a proven means of storing heat energy (Btu) effect produced during one period of time for use during a different period. It may be positive (heat) or negative (absence of heat, e.g. cold) and the cycle may be hourly, daily, weekly or yearly.

The storage medium may be a gas, liquid or solid. The storage may be in the form of latent concealed or potential heat (result of the material's change of state) or sensible heat (temperature in the storage medium).

The concept is not new. It began before the days of mechanical refrigeration, when ice was cut from lakes and ponds in winter and stored for use in the summer. A standard domestic hot water heater is an example of an hourly-daily cycle of storing of sensible heat.

A wide variety of process industries have used the energy storage concept for years. In food and dairy process plants, where reliability is of the utmost importance, it is accepted as the standard for product cooling.

THE APPLICATION

Thermal Energy Storage may be used effectively in any service not having a flat load profile. This includes an endless variety of industrial process loads.

It is also applied in space conditioning loads in commercial, industrial or institutional facilities, both winter and summer. Churches are excellent examples of weekly cycle facilities. Offices, health care facilities, retail stores, theatres, schools and many other type structures can make effective use of the daily cycle.

THE BENEFITS

Thermal Energy Storage results in lower power bills by the technique of load management — by leveling or shifting the energy load. Power usage may be shifted to periods when time-of-day rate differentials are in effect. Reduced horsepower requirements mean lower demand charges. Both factors contribute to lower operating expenses. Load Management reduces electric utilities' need for additional generating capacity, a contributing factor toward increasing utility rates.

The principle of working from an energy reserve reduces the chances of loss of capacity from system failure or power outages. This means a more reliable system.

CALOSKILLS™ offers you a practical, complete systems approach for dependable, automatic operation

Space Conditioning . . .

Heating and cooling loads offer the greatest opportunity for load management by Thermal Energy Storage. Commercial, light industrial and institutional facilities show the best cost effectiveness.

Daily and Weekly Cycles . . .

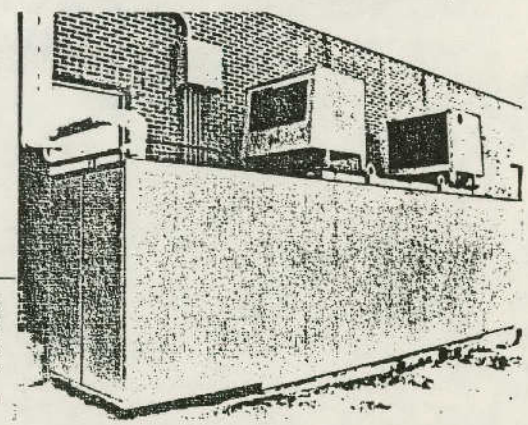
Space conditioning involves the daily cycle, except in the case of church or similar facilities which could be considered as weekly. Yearly cycles could be effective but are substantially hampered by the excessive storage volumes required. Hourly cycles are only applicable to intermittent process loads.

Liquid Storage Medium . . .

Liquid is the easiest medium to handle and water, the most common, is readily available and cheap. Alternatives are gases and solids, both of which have extreme limitations due to their physical properties.

Latent and Sensible Heat . . .

Utilizing a water base provides the ability to freeze it in the cooling mode and thereby use the latent heat effect which substantially reduces the storag volume requirements for a giv application. Additional capaci may be realized by also utilizi some sensible heat effect. In t heating mode, sensible heat relied on exclusively. Genera a unit sized for the cooling lo will have sufficient capacity handle the heating load (1 200° F. heated water).



At right — Installation of THERMASTER at an office facility has factory mounted dual air-cooled condensing units. Heating elements for winter service and circulating pumps are mounted within the front control compartment.

—Photo courtesy of Metropolitan Edison Company

Appendix A

Attached to and made a part of
the Lease by and between
, Landlord and

____

As Tenant, Dated ____________

ELECTRIC ENERGY

Sec. 1: Landlord shall furnish the electric energy that Tenant shall require in the Demised Premises for $_________ per month, which Tenant agrees to pay commencing on the 1st day of the month following delivery of the premises to Tenant. Landlord shall not be liable in any way to Tenant for any failure or defect in the supply or character of electric energy furnished in the Demised Premises by reason of any requirement, act or omission of the public utility serving the building with electricity or for any other reason not attributable to Landlord, Tenant shall furnish and install and replace lighting tubes, lamps, bulbs and ballasts required in the Demised Premises.

Sec. 2: Tenant's use of electric energy in the Demised Premises shall not at any time exceed the capacity of any of the electrical conductors and equipment in or otherwise serving the Demised Premises. In order to insure that such capacity is not exceeded and to avert possible adverse effect upon the building electric service, Tenant shall not, without Landlord's prior written consent in each instance (which shall not be unreasonably withheld), connect any heating or cooking equipment or any additional fixtures, appliances or equipment (other than lamps, typewriters and similar small office machines) to the building electric distribution system or make any alteration or addition to the electric system of the Demised Premises as compared to the circumstances existing on the Commencement Date. Should Landlord grant such consent, all additional risers or other equipment required therefore shall be provided by Landlord and the reasonable cost thereof shall be paid by Tenant upon Landlord's demand. As a condition to granting such consent, Landlord may require Tenant to agree to an increase in the fixed rent by an amount which will reflect the value to Tenant of the additional service to be furnished by Landlord, that is, the potential additional electrical energy to be made available to Tenant based upon the estimated additional capacity of such additional risers or other equipment. If Landlord and Tenant cannot agree thereon, such amount shall be determined by a reputable, independent electrical engineer, to be selected by Landlord and paid equally by both parties.

Sec. 3: If the public utility rate schedule for the supply of electric current to the building shall be increased or decreased during the term of this lease, the fixed charges herein reserved shall be equitably adjusted to reflect the resulting increase or decrease in Landlord's cost of furnishing electric service to the Demised Premises, and the amount set forth in Section 1 shall also be adjusted accordingly. If Landlord and Tenant cannot agree thereon, the amount of such adjustments shall be determined by a reputable, independent electrical engineer, to be selected by Landlord and paid equally by both parties. When the amount of such adjustment is so determined, the parties shall execute an agreement supplementary hereto to reflect such adjustments in the amount of the fixed charges stated in this Exhibit and in the amount set forth in Section 1, effective from the effective date of such increase or decrease in the public utility rate schedule; but such adjustments shall be effective from such date whether or not a supplementary agreement is executed.

Sec. 4: Landlord reserves the right to discontinue furnishing electric energy to Tenant in the Demised Premises at any time upon not less than thirty (30) days notice to Tenant. If Landlord exercises such right of termination, this lease shall continue in full force and effect and shall be unaffected thereby, except only that, from and after the effective date of such termination, Landlord shall not be obligated to furnish electric energy to Tenant and the Tenant shall be relieved of its obligation to pay the charges set forth in Section 1. If Landlord so discontinues furnishing electric energy to Tenant, Tenant shall arrange to obtain electric energy directly from the public utility company furnishing electric service to the building. Such electric energy may be furnished to Tenant by means of the then existing building system feeders, risers and wiring to the extent that the same are available, suitable and safe for such purposes. All meters and additional panel boards, feeders, risers, wiring and other conductors and equipment which may be required to obtain electric energy directly from such public utility company shall be installed by Landlord at its expense before discontinuance of service.

Sec. 5: The Landlord shall have the right to install a check meter on Tenant's electrical service at the point of entry into the Demised Premises or at any other mutually agreeable location for the purpose of determining the Tenant's maximum demand for electric current. If the demand load exceeds _______ KW for any thirty (30) minute period, then the Tenant will pay to Landlord an additional $_________ per month for each KW of such excess demand. If Tenant requires the use of a substantial amount of power for more than _________ hours per week, then the Tenant will pay to Landlord an additional amount equal to _________ times the amount stated in Section 1 for each hour of such excess per week. Five per cent or more of normal operating requirements shall be deemed to be substantial.

EXHIBIT C

Presented by the
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