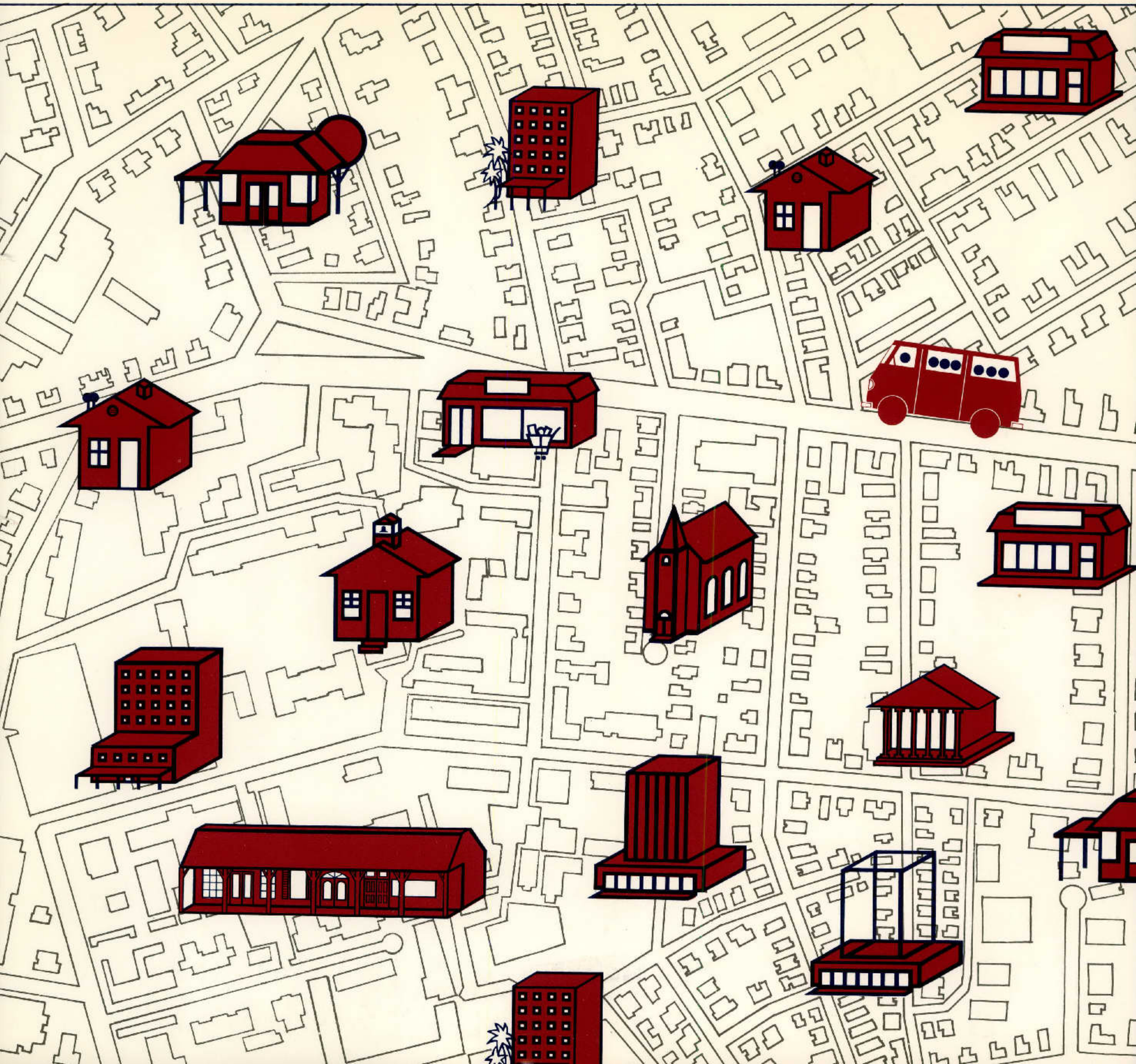
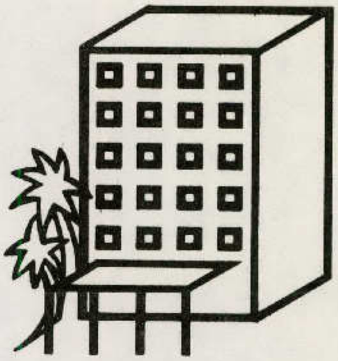
TEXAS
ENERGY MANAGEMENT



1979 WORKSHOPS

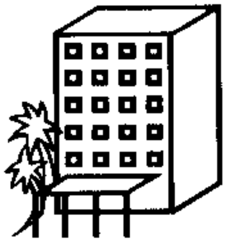
TEXAS ENERGY MANAGEMENT



HOTELS/MOTELS/RESTAURANTS

WILLIAM P. CLEMENTS JR.
Governor, State of Texas

David B. Marks
Director,
Governor's Office of Energy Resources



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Energy Management in Hotels/Motels/Restaurants

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

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Class A Energy Audits: Hotels, Motels, Restaurants, Oklahoma Department of Energy, 1978.

Energy Conservation Manual: Wisconsin Restaurants, Arnold & O'Sheridan, Inc., Consulting Engineers, for Wisconsin Office of State Planning and Energy, 1978.

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ENERGY FACTS

ENERGY FACTS

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ENERGY FACTS

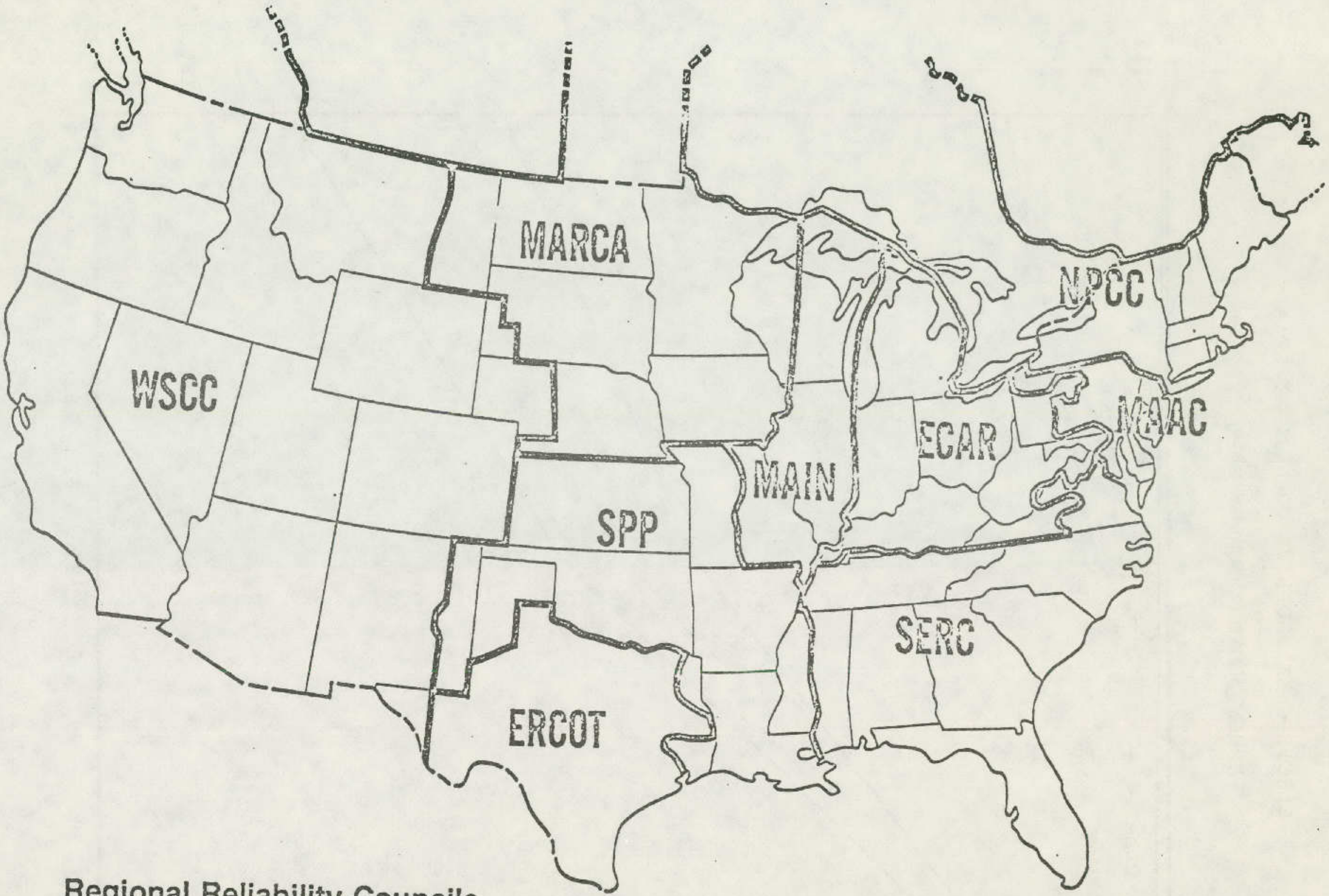
The subject of this workshop is energy conservation, or energy management as it is being referred to more frequently today; in this workshop then we will discuss how you may reduce your demand for energy.

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.

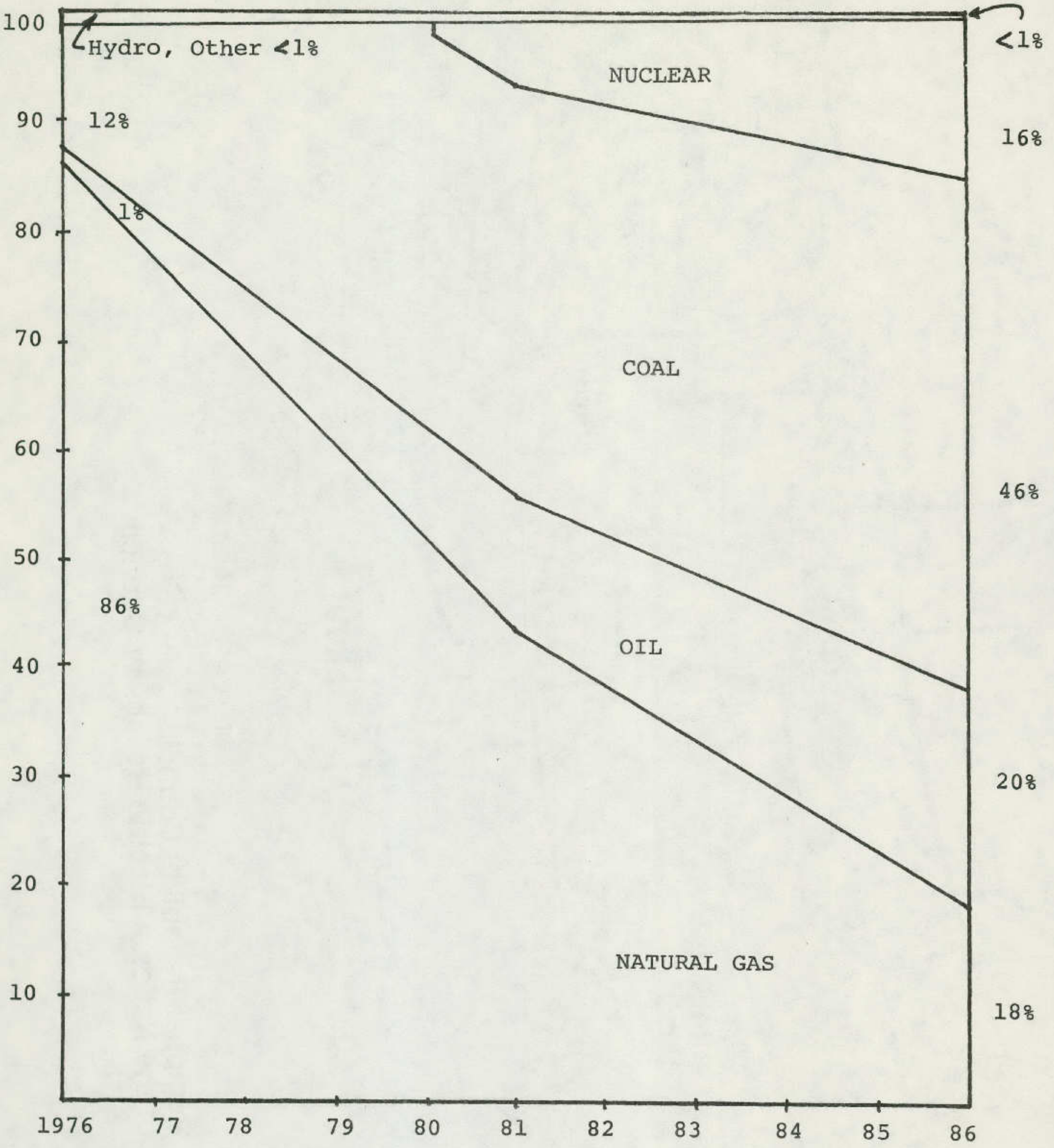
1978 WORLD OIL PRODUCTION

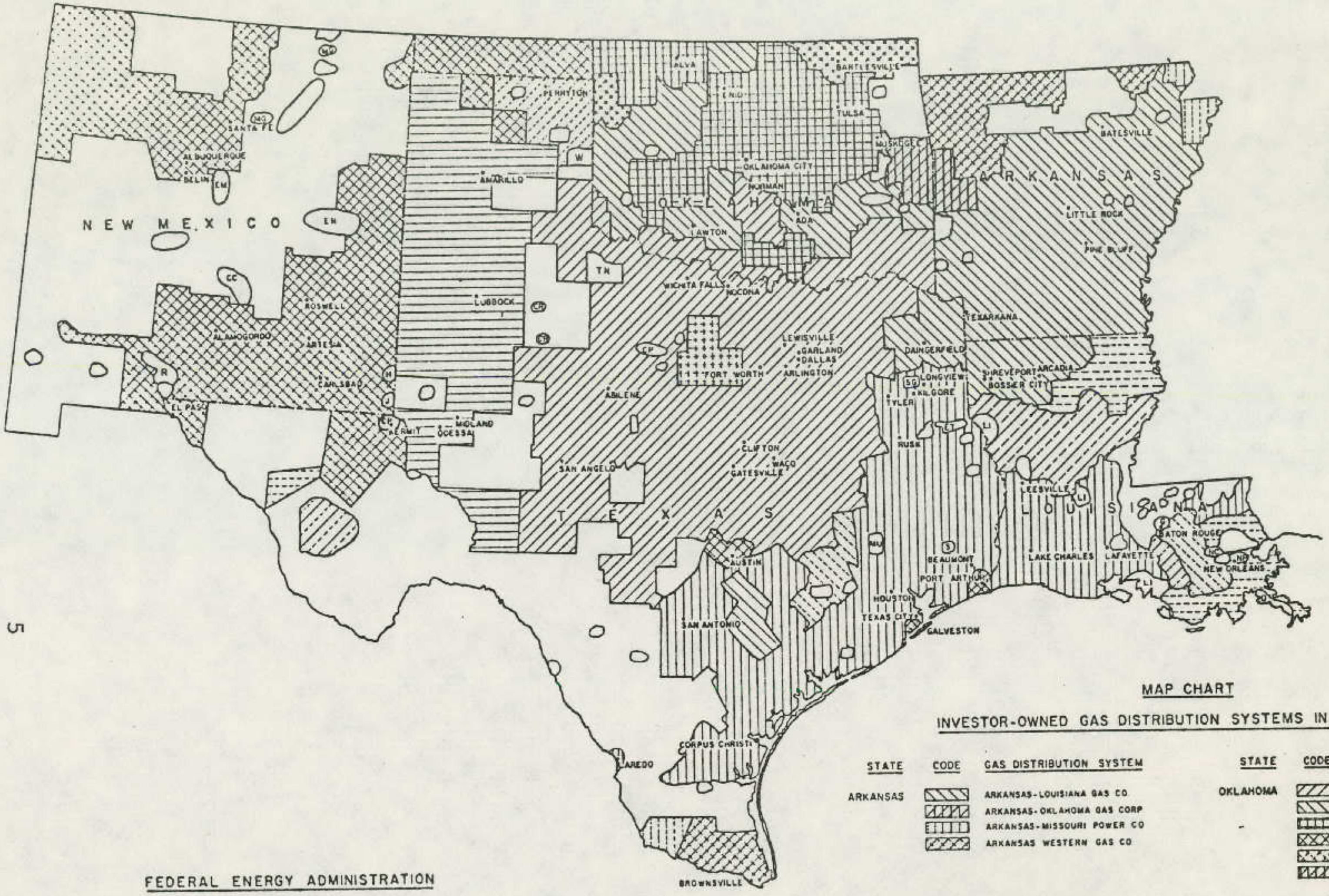
	MILLION BARRELS PER DAY
U.S.S.R.	11.40
UNITED STATES	8.66
SAUDI ARABIA	7.80
IRAN	5.25
IRAQ	2.50
VENEZUELA	2.15
LIBYA	2.05
CHINA	2.00
KUWAIT	1.90
NIGERIA	1.80
INDONESIA	1.65
ABU DHABI	1.45
CANADA	1.30
MEXICO	1.27
ALGERIA	1.26
UNITED KINGDOM	1.10



Regional Reliability Councils
of the National Electric Reliability Council

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





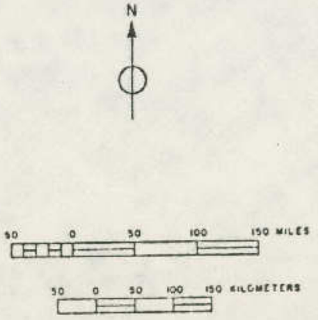
MAP CHART

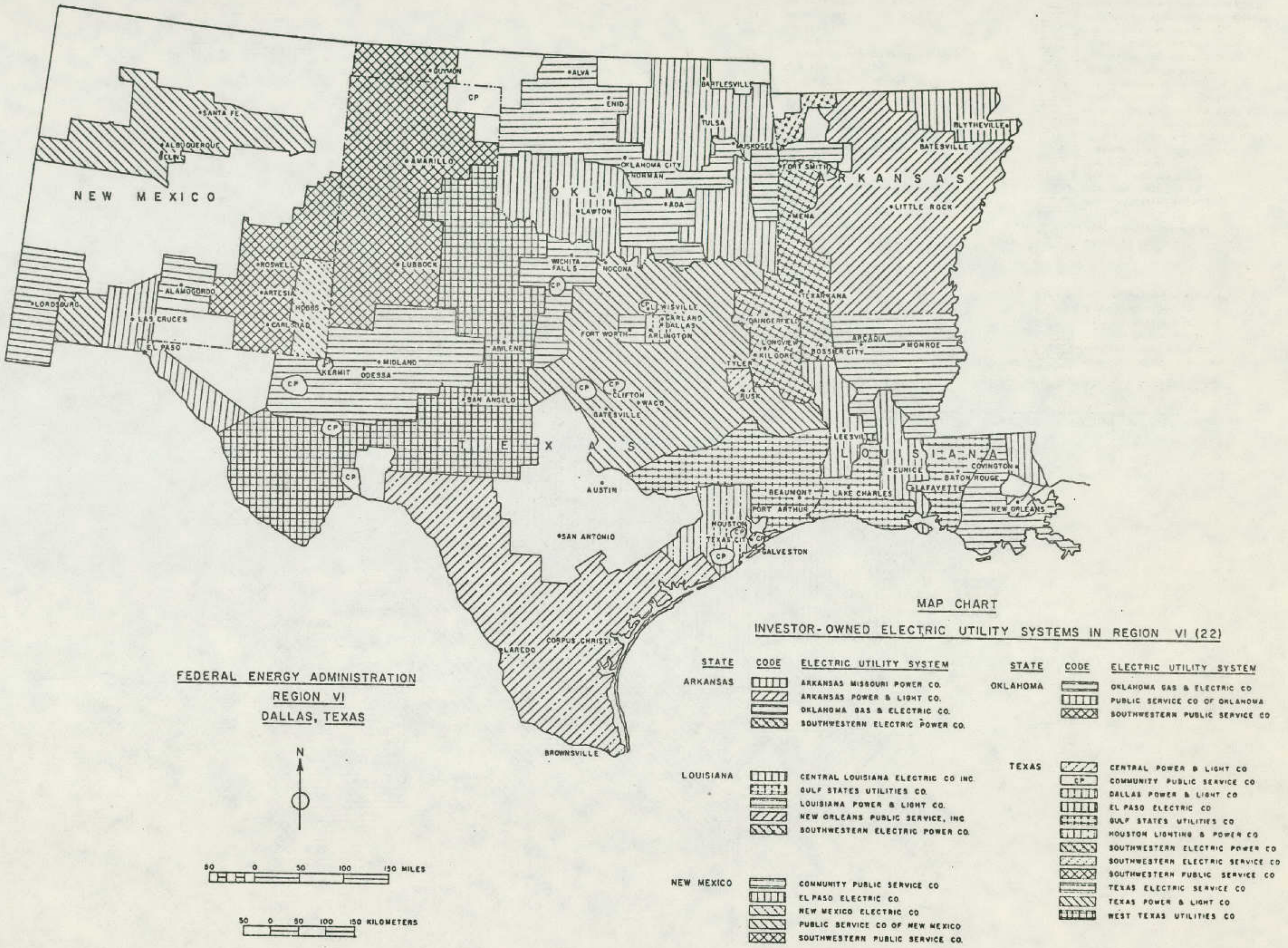
INVESTOR-OWNED GAS DISTRIBUTION SYSTEMS IN REGION VI (39)

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.
	N	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
	CR	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 CORP.
	▤	TEXAS WESTERN MUNICIPAL GAS CO.
	W	WHEELER GAS CO.

FEDERAL ENERGY ADMINISTRATION
REGION VI
DALLAS, TEXAS





FEDERAL ENERGY ADMINISTRATION
REGION VI
DALLAS, TEXAS

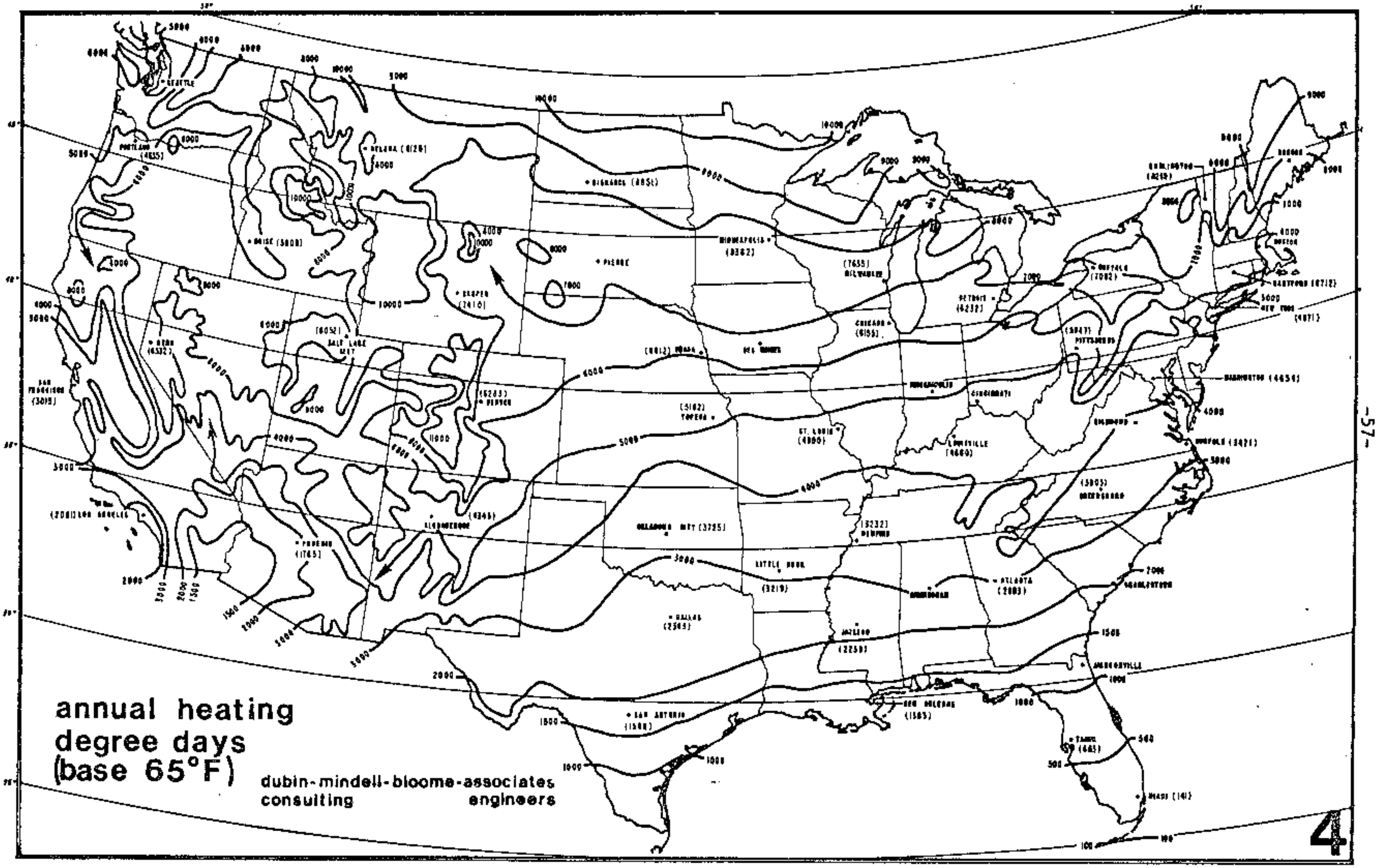
MAP CHART

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

STATE	CODE	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.

STATE	CODE	ELECTRIC UTILITY SYSTEM
OKLAHOMA	▤	OKLAHOMA GAS & ELECTRIC CO
	▥	PUBLIC SERVICE CO OF OKLAHOMA
	▩	SOUTHWESTERN PUBLIC SERVICE CO
TEXAS	▨	CENTRAL POWER & LIGHT CO
	CP	COMMUNITY PUBLIC SERVICE CO
	▥	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

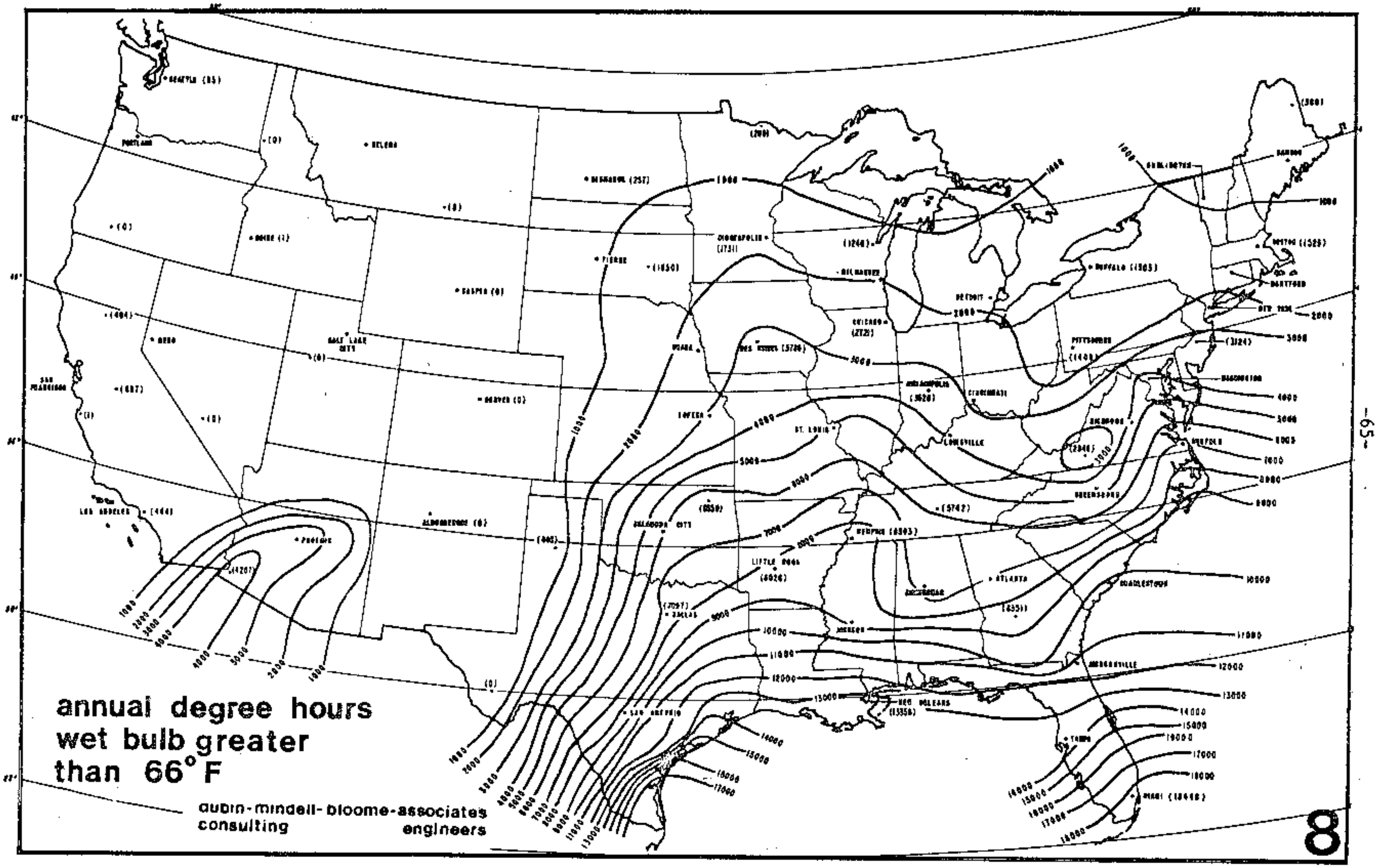
Extracted from: Guidelines for Saving Energy in Existing Buildings. Building Owners and Operators Manual: ECM 1 Vol.



annual heating degree days (base 65°F)

dubin-mindell-bloome-associates
consulting engineers

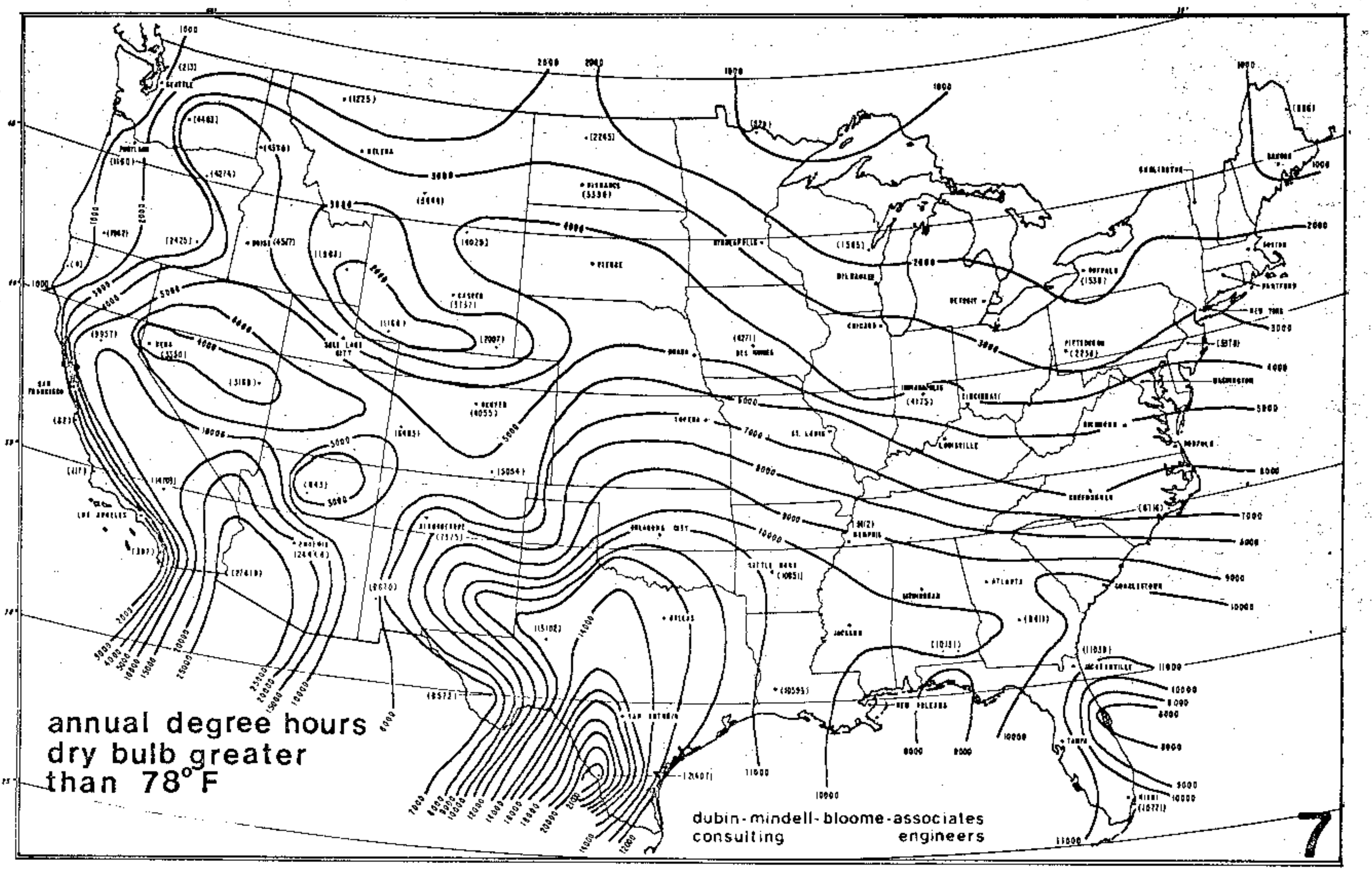
4



annual degree hours
wet bulb greater
than 66°F

dubin-mindell-bloome-associates
consulting engineers

8



annual degree hours
dry bulb greater
than 78°F

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TEXAS
ENERGY
ADVISORY
COUNCIL

TEAC
NEWS

VOLUME I, NO. 2

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Sheila Moritz, Editor

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.

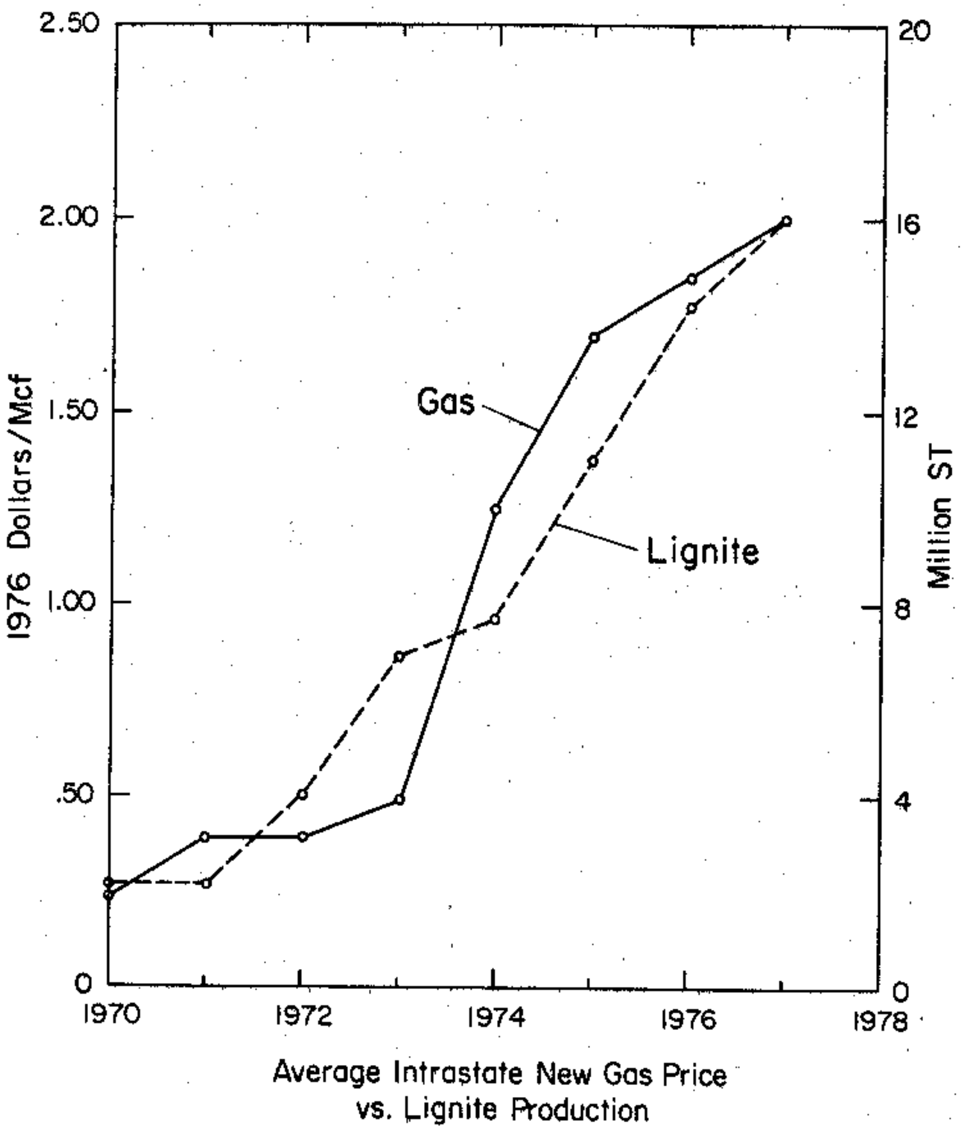


Figure 2. Correlation of rising intrastate gas price and increasing lignite production in Texas.

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	1971	2.7
			575	1972	2.7
Monticello	Monticello Titus Co.	Texas Utilities Co.	575	1974	2.9
			575	1975	2.9
			750	1978	3.8
Martin Lake	Tatum Rusk Co.	Texas Utilities Co.	750	1977	3.5
			750	1978	3.5
			750	1979	3.5
			750	1983	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	1980	2.7
			400	1985	2.7
Gibbons Creek	Carlos Grimes Co.	Texas Municipal Power Agency	400	1981	2.7
			400	1984	2.0+
Twin Oak	Bald Prairie Robertson Co.	Tx. Power & Light Co. and Alcoa	750	1984	3.5
			750	1985	3.5
Mill Creek	Oak Hill Rusk Co.	Texas Utilities Co.	750	1986	3.5
			750		
Undetermined	Harrison Co.	Southwestern Elec. Power Co.	640	mid-1980's	3.0
			640		
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

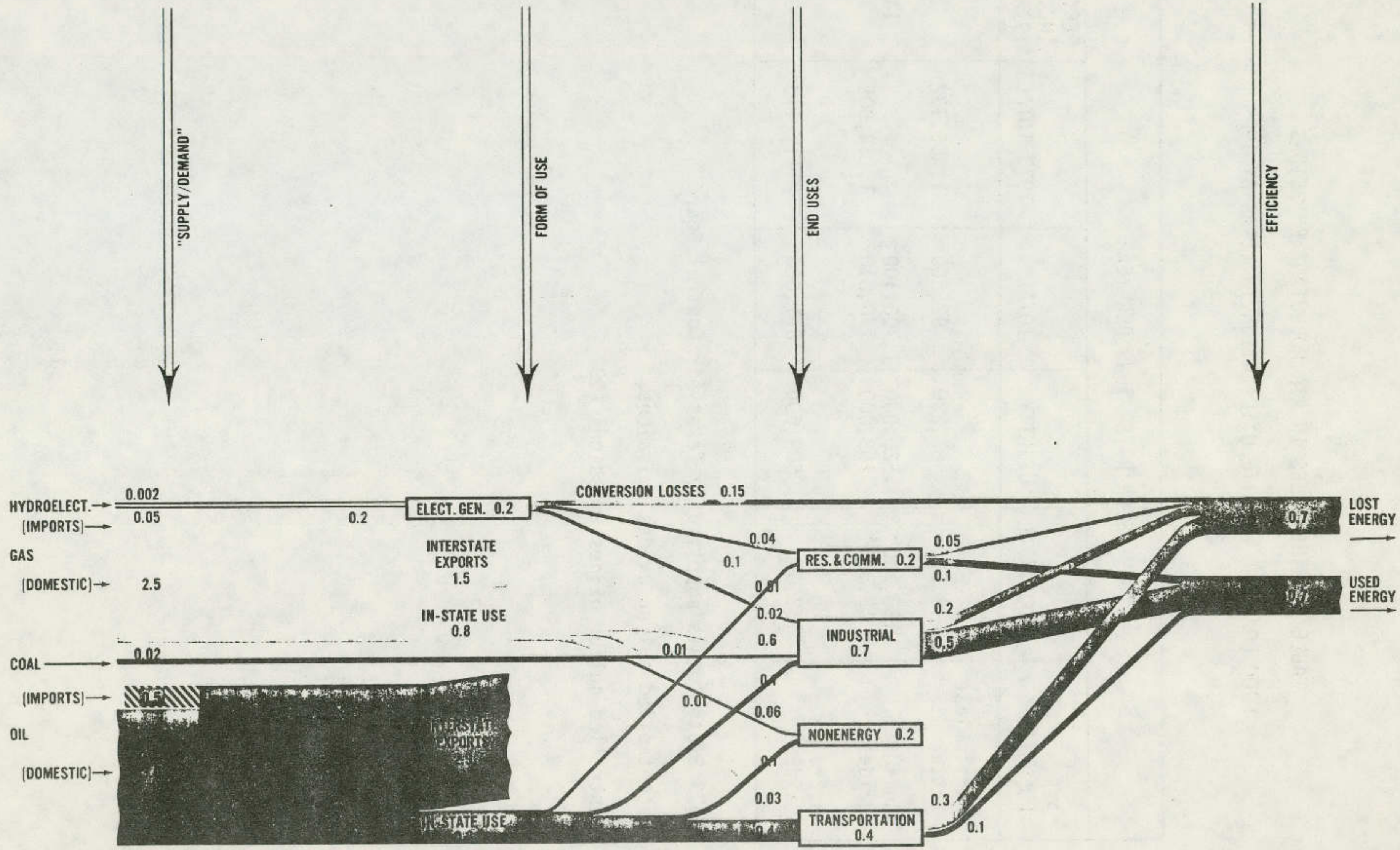
EMISSION RATE--TONS PER YEAR					
AIR POLLUTANT	INDUSTRIAL	UTILITY	TOTAL	1973 TOTAL[1]	PERCENT INC. OVER 1973 TOTAL
Particulate Matter	11,520	81,280	92,800	1,406,132	6.6
Sulfur Oxides	188,100[2] 18,810[3]	1,520,000[2] 152,000[3]	1,708,100[2] 170,810[3]	1,214,909	140.6[2] 14.1[3]
Nitrogen Oxides	162,000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

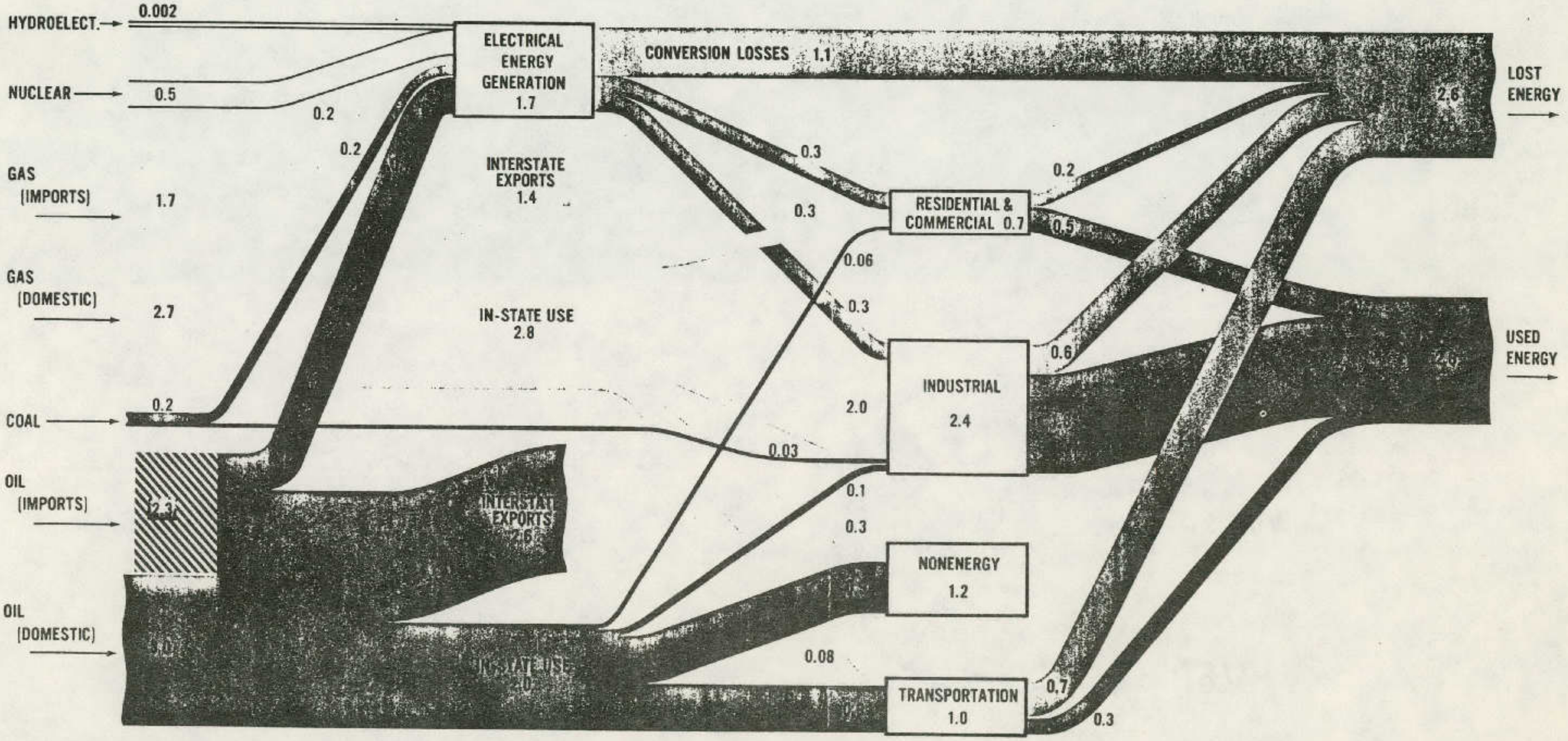
1960 A



(UNITS: MILLION BBLS IL EQUIVALENT)

FOLD-OUT "A"

1985

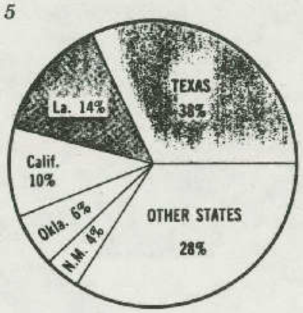


(UNITS: MILLION BBLS/DAY OIL <u>EQUIVALENT</u>)

FOLD-OUT "D"

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

Figure 5

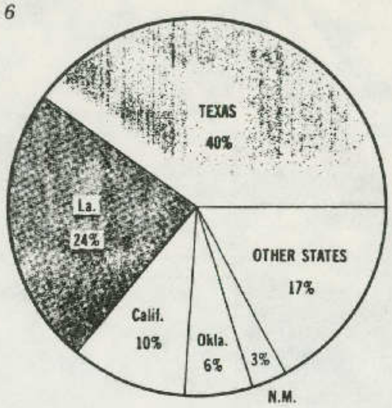


1960

U.S. 7.8*

TEXAS PROPORTION 3.0

Figure 6

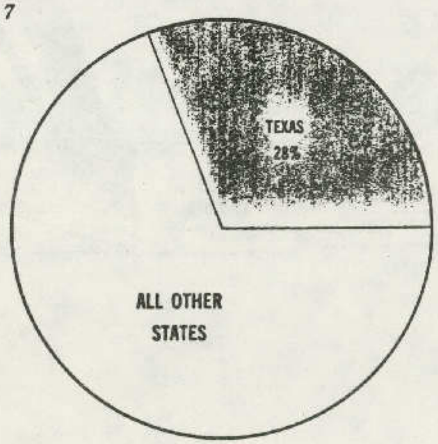


1970

U.S. 10.4

TEXAS PROPORTION 4.2

Figure 7

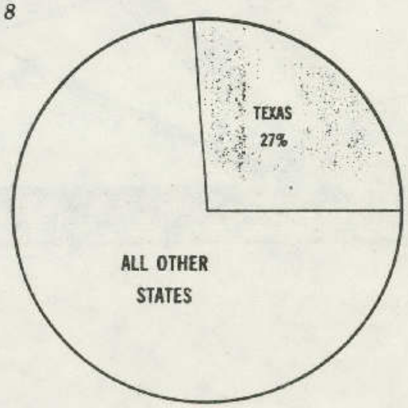


1980

U.S. 11.5

TEXAS PROPORTION 3.2

Figure 8



1985

U.S. 11.0

TEXAS PROPORTION 3.0

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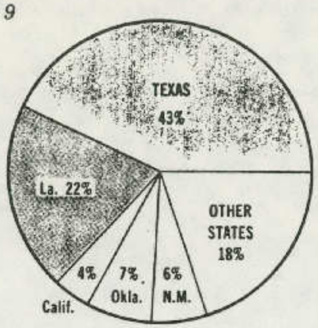
* All figures are Millions of Barrels per Day of Oil.
Size of the four graphs gives volumetric proportion.

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

Figure 9

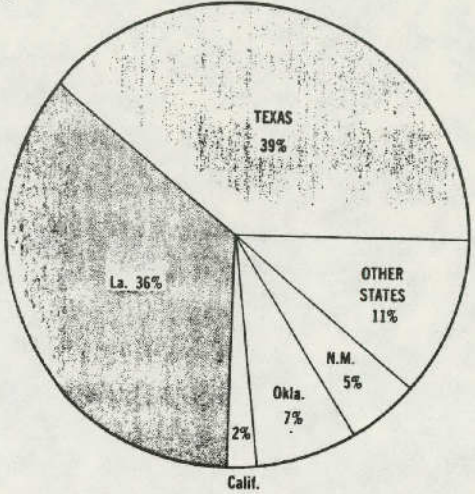


1960

U.S. 5.8*

**TEXAS
PROPORTION 2.5**

Figure 10

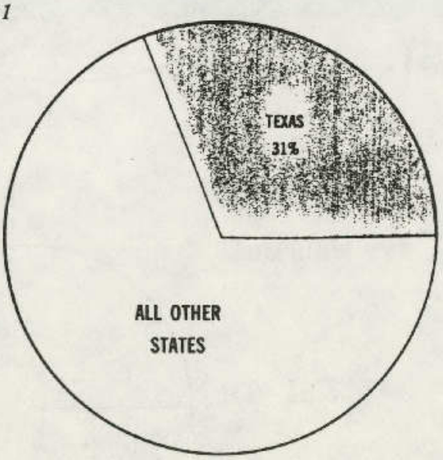


1970

U.S. 10.3

**TEXAS
PROPORTION 4.0**

Figure 11

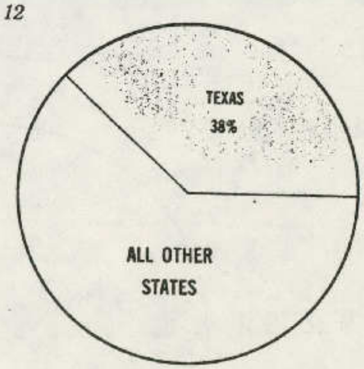


1980

U.S. 10.0

**TEXAS
PROPORTION 3.1**

Figure 12



1985

U.S. 7.1

**TEXAS
PROPORTION 2.7**

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

FOLD-OUT "I"

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

Figure 13

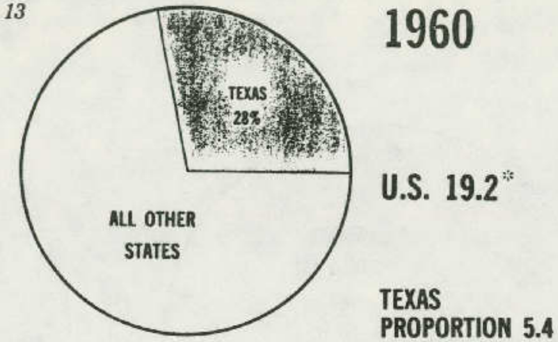


Figure 14

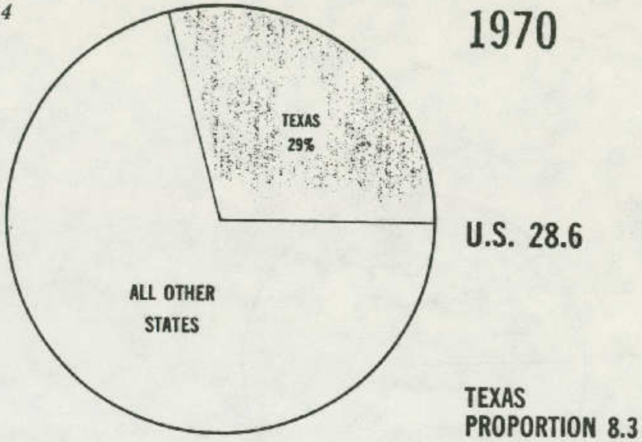


Figure 15

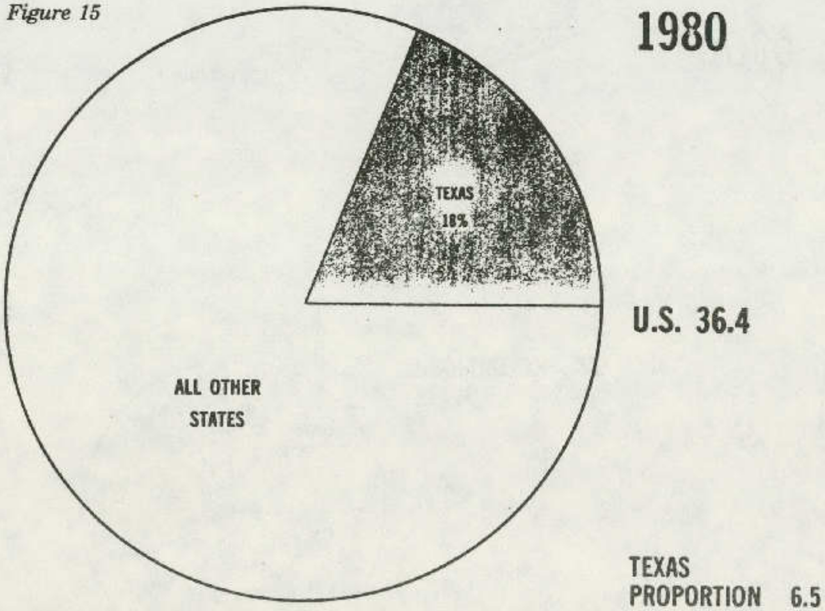
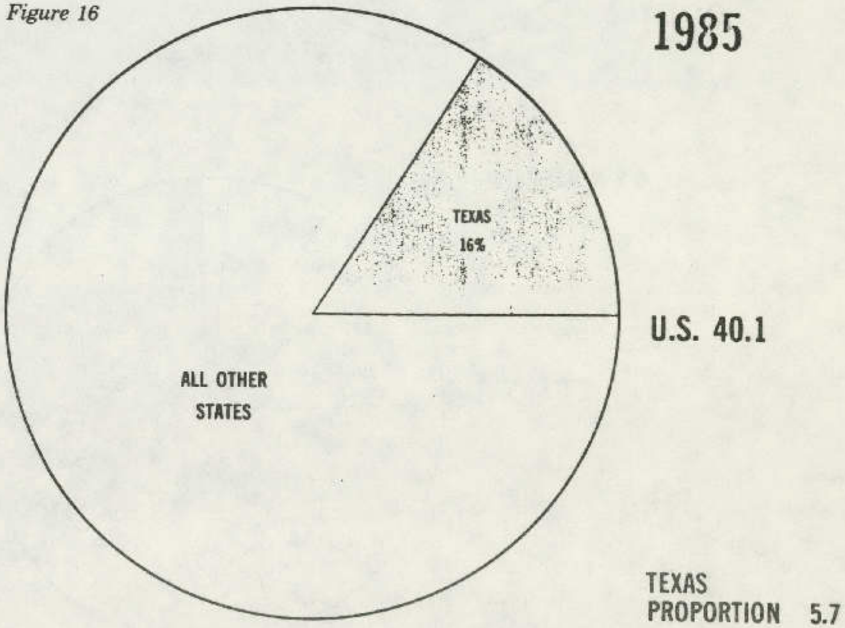


Figure 16



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

J

FOLD-OUT "J"

Texas Total Energy Production/Consumption, 1960-1985

Figure 17

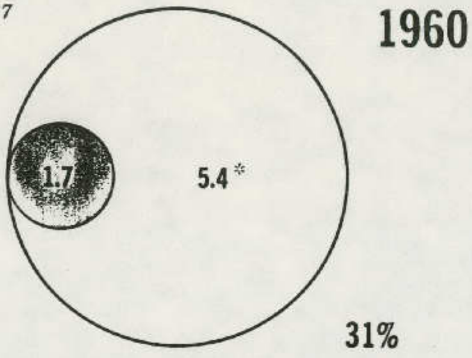


Figure 18

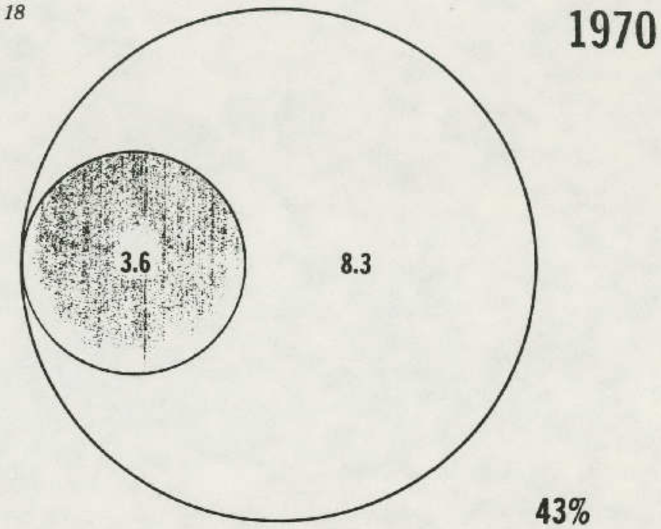


Figure 19

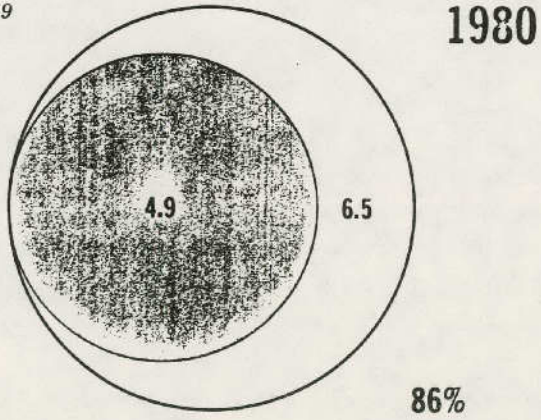
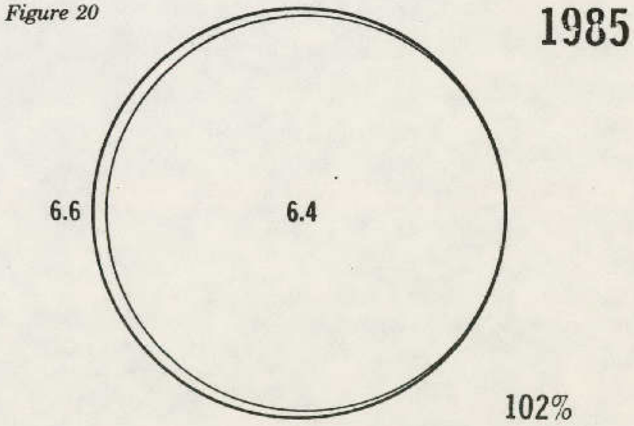


Figure 20



○ Production ▨ Consumption

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

2

ENERGY MANAGEMENT

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 BUILDINGS:				
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	58	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	23-242	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.

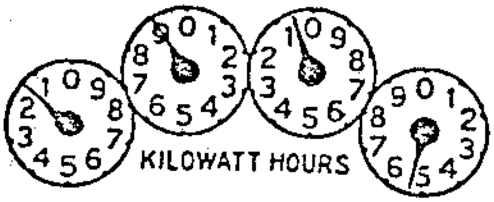
The kilowatthour demand meter may be separate from or be a component of the kilowatthour meter. Due to the many variations in demand meters and methods of reading each, you should consult with your utility company for instructions in reading your specific demand meter.

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.

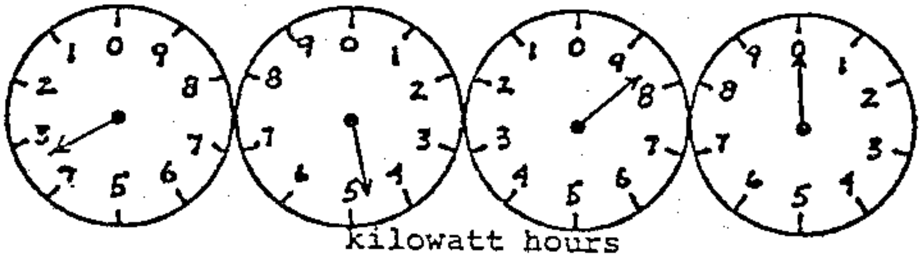
The sweep dial face meter records the maximum demand during the billing period. The pointers will indicate directly and hold the maximum KW demand during any period of the billing month. This indicated demand must be multiplied by the indicated dial face multipliers, if there is one, to obtain the correct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

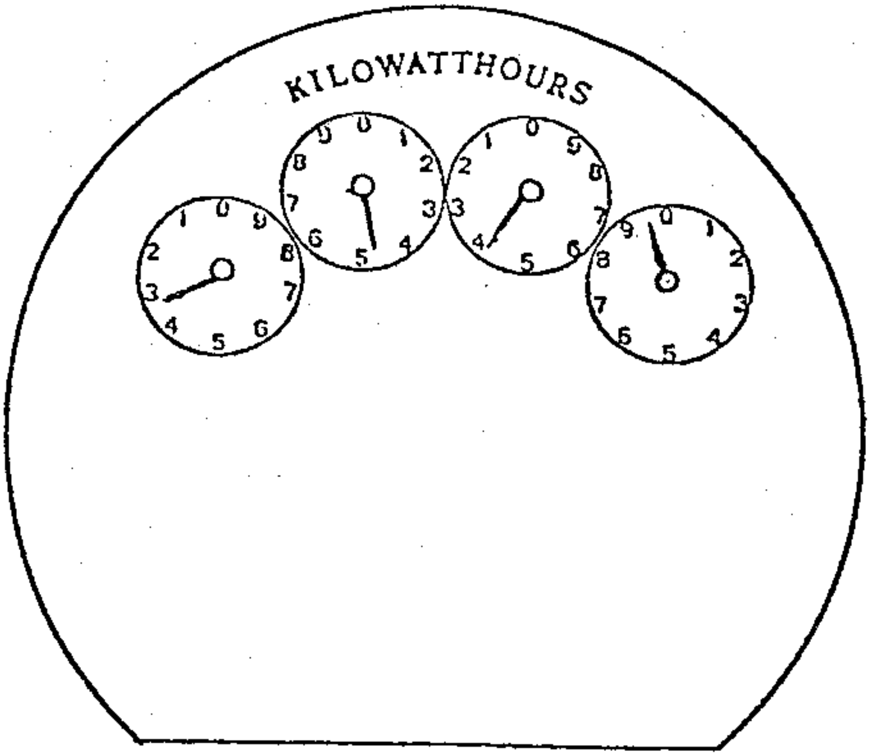
KILOWATTHOUR METERS



Reading = 1905 KWH

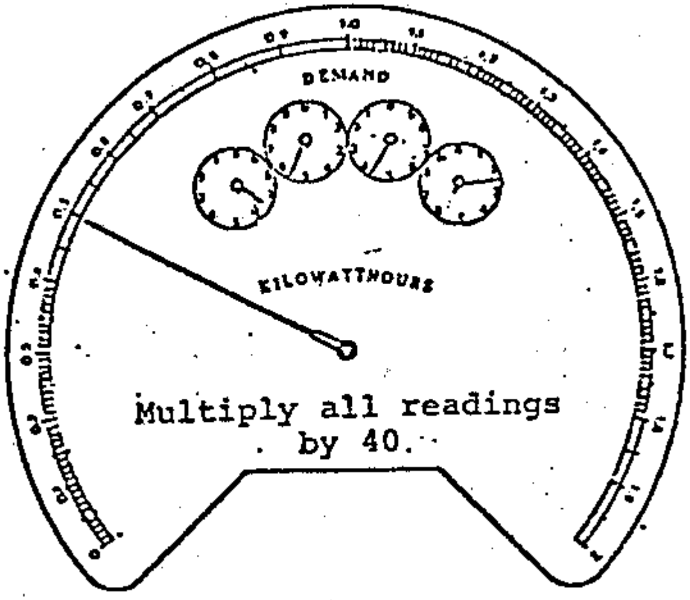


Reading = 3480 KWH



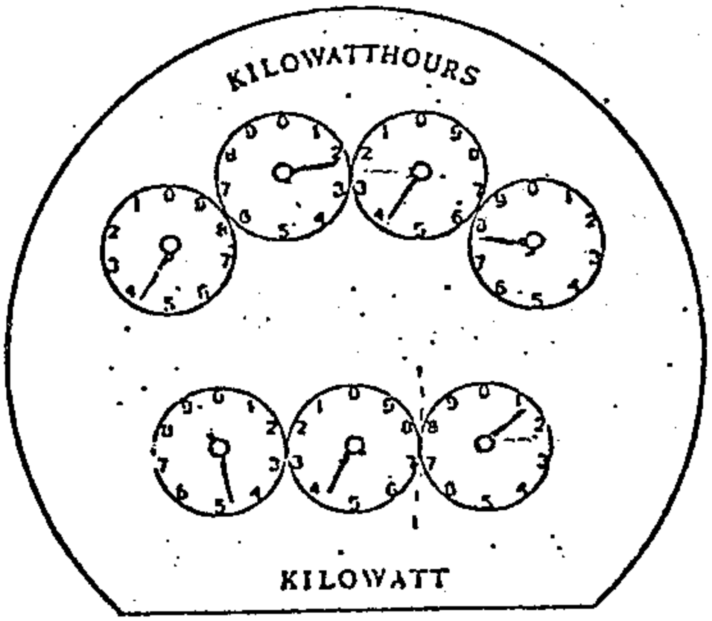
Reading = 3449 KWH

Kilowatthour Meters with Kilowatthour Demand Recorders



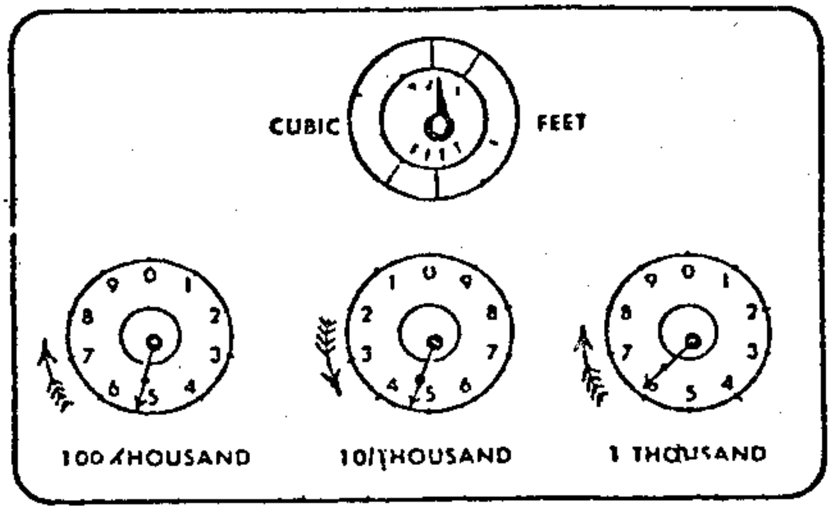
Multiply all readings by 40.

Reading 6542 KWH
.5 x 40 = 20 KW demand

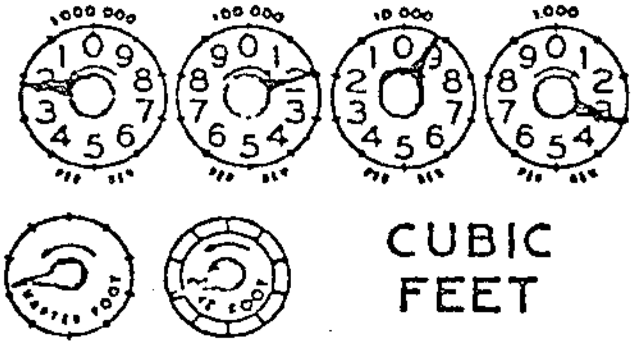


Reading 4247 KWHR
44.1 KW demand

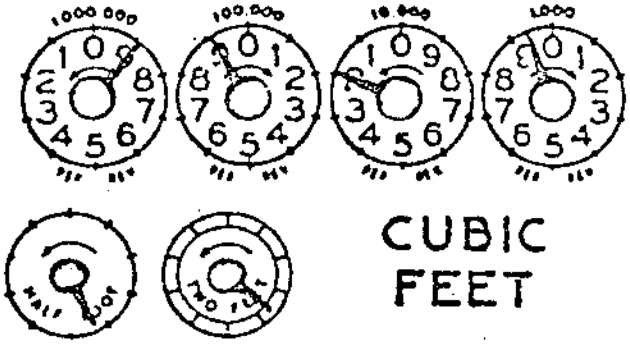
Gas Meters



Reading = 546,000 ft 3



Reading 2,193,000 ft.^{3}



Reading 8,929,000 ft.^{3}

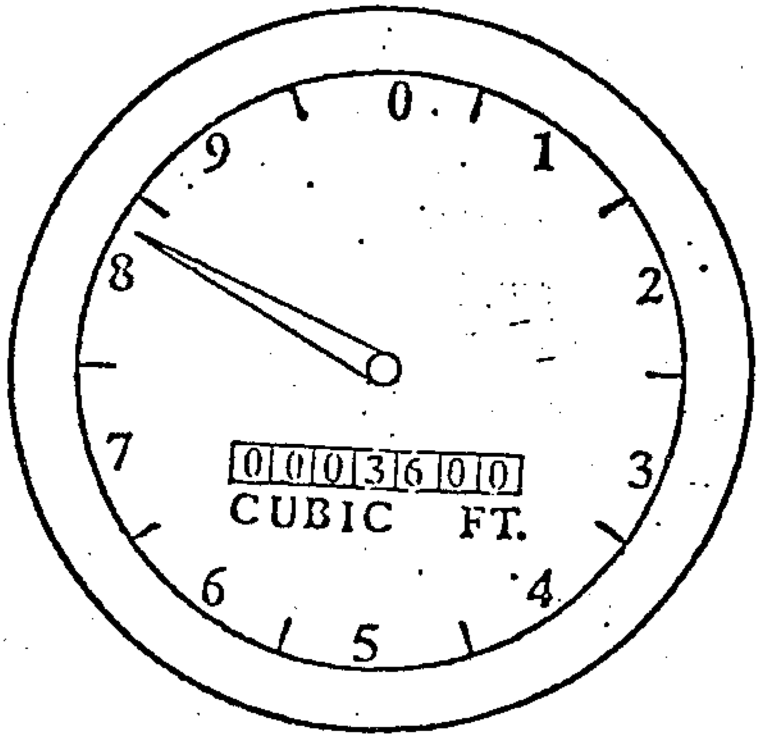
The above indicates different arrangements of gas meter faces. Others exist, however, are similar.

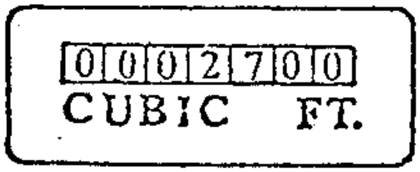
The low capacity, 1/4, 1/2, and 2 cubic feet dials are used to test the meter, as well as check gas consumption in the building under controlled gas usage.

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

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

Water Meters



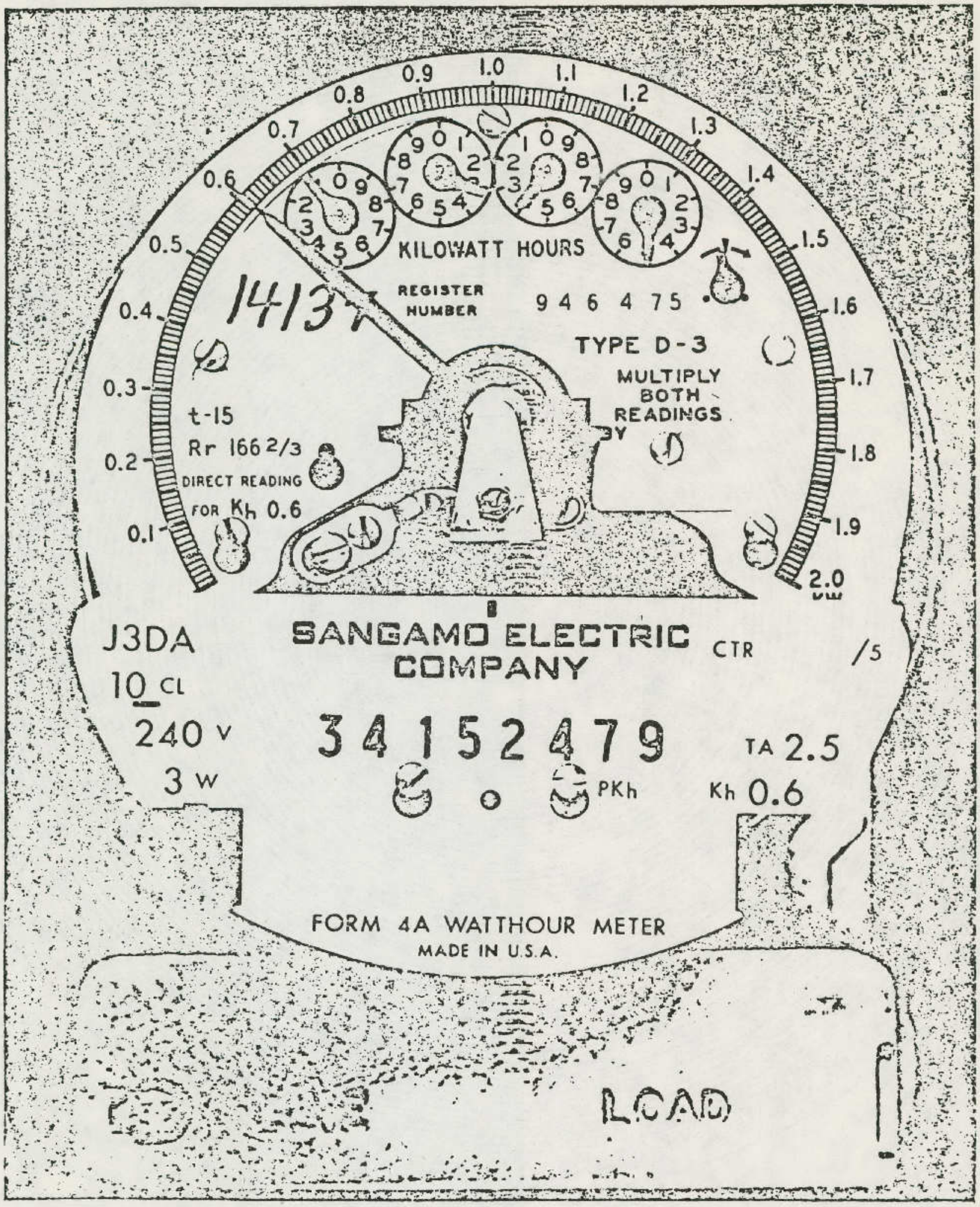


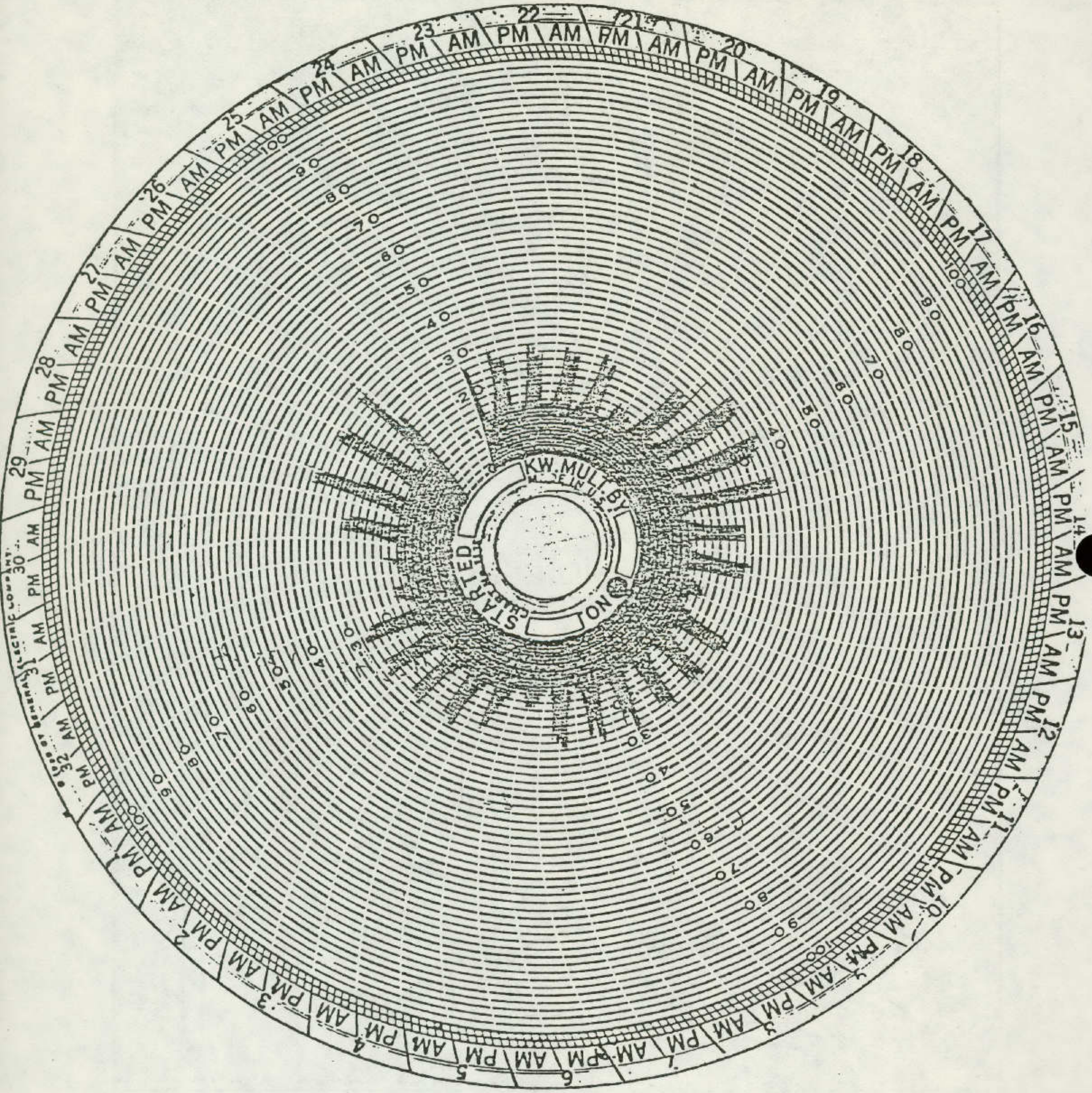
Water meter quantities are read directly as recorded on the meters as shown above. Meters may read in cubic feet, as shown, or in gallons. The type of measure will be shown on the meter face.

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

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

ELECTRIC METER




KW. MULT. BY
STARTED
ON
MADE IN U.S.A.
GENERAL ELECTRIC COMPANY
AM
PM
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31
32
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20
30
40
50
60
70
80
90
100

Meter Readings Previous	Meter Readings 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 $0.0090660	Service Period DEC 27 To JAN 26	Past Due After FEB 15 1979
	Service Address		Your Account Number RATE G

TEXAS ELECTRIC SERVICE COMPANY

SP0911

TARIFF
FOR
ELECTRIC SERVICE

SECTION NO.	III	SHEET NO.	10
EFFECTIVE DATE	October 26, 1978		
REVISION	Second	PAGE	2 OF 2

SECTION TITLE	TARIFF NAME	APPLICABLE
Rate Schedules	Rate G General Service	Entire System except Ordinance Towns

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

<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)

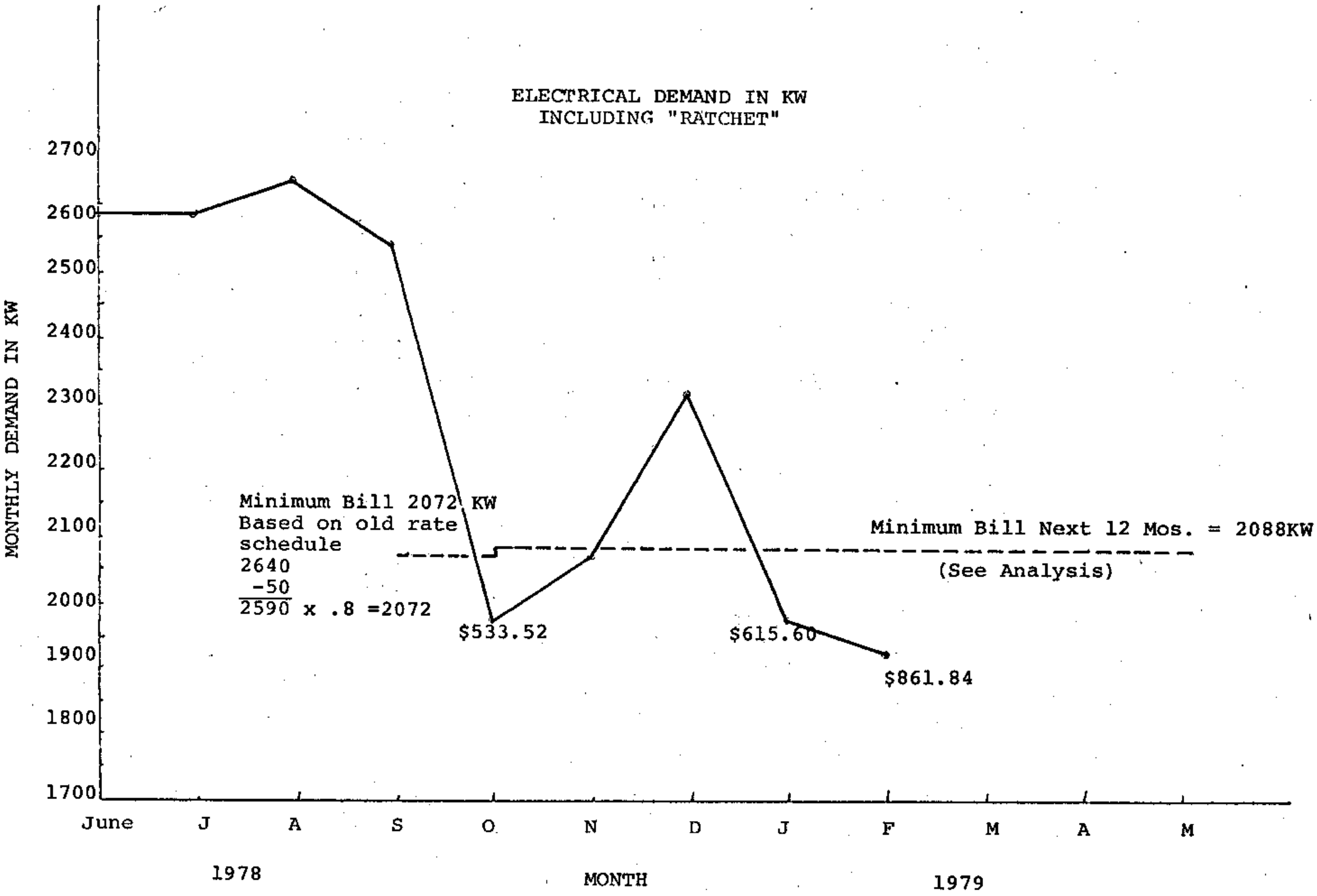
Identical to 1977 except "exceeds 50 KW" is changed to "exceeds 30 KW".

	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

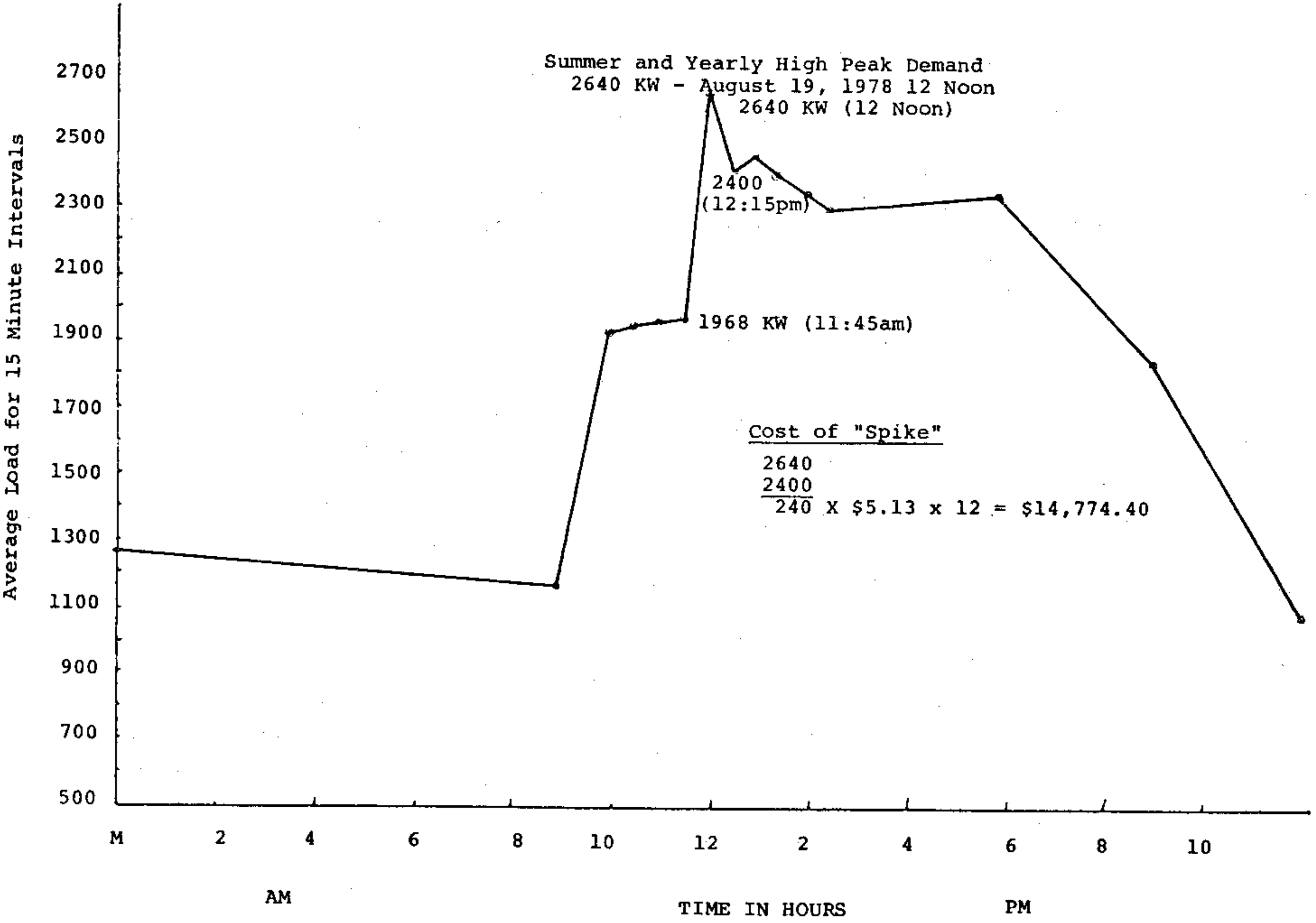
All winter months of 1979 will be billed for minimum of 2,088 KW

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"

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.

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
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

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
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

STATE OF TEXAS

COMPTROLLER OF PUBLIC ACCOUNTS

LIMITED SALES, EXCISE AND USE TAX RULES AND REGULATIONS

Rule .015 Natural Gas and Electricity (20.01(U), 20.021(B)(1), 20.021(C), 20.04(R)).

(a) Definitions:

(1) "Residential Use" means use in a family dwelling or in a multi-family apartment complex or housing complex or in a building or portion thereof occupied as a home or residence.

(2) "Commercial Use" means use by persons engaged in selling, warehousing or distributing a commodity or service, either professional or personal.

(3) "Manufacturing" means and includes every operation commencing with the first production stage of any article of tangible personal property and ending with the completion of tangible personal property having the physical properties (including packaging, if any) which it has when transferred by the manufacturer to another. For the purposes of this rule, direct use of natural gas or electricity in manufacturing will hereafter be referred to as "noncommercial use".

(4) "Processing" for the purpose of this rule means performing an operation in which a physical or chemical change in tangible personal property is brought about. The repair of tangible personal property by restoring it to its original condition is not considered processing of that property. The property being processed may belong either to the processor or to his customer, the only tests being whether the property is "processed" and whether it will ultimately be sold. The mere packing, unpacking or shelving of a product to be sold will not be considered processing of that product. Direct use of natural gas or electricity in processing will hereafter be referred to as "noncommercial use".

(5) Other "Noncommercial uses" include:

(A) Exploration for or production or transportation of material extracted from the earth;

(B) Agriculture, including dairy or poultry operations and pumping water for farm and ranch irrigation; or

(C) Electrical processes such as electroplating, electrolysis, and cathode protection.

(b) Sales Tax applicable. For the purpose of this rule, the furnishing of natural gas or electricity shall be considered to be the furnishing of tangible personal property. All the provisions in TEX. TAX.—GEN. ANN. ch. 20 applying to the sale of tangible personal property shall apply to the sale of natural gas or electricity.

(c) "Commercial Uses" taxable; "noncommercial uses" exempt. The tax imposed by TEX. TAX.—GEN. ANN. ch. 20 shall be collected on the sale of natural gas or electricity for commercial use. The sale of natural gas or electricity for residential use or for use directly in manufacturing, processing or for other noncommercial uses is exempt.

(d) Predominant Use; Exemption Certificates.

(1) Natural gas or electricity used during a regular monthly billing period for both exempt and nonexempt purposes under a single meter shall be totally exempt or nonexempt for the billing period based upon the predominant use of such natural gas or electricity measured by that meter. The person claiming the exemption must make a determination that the predominant use of the natural gas or electricity is for an exempt use and must issue an exemption certificate to the utility company. Refer to Rule 026.02.20.007 for further information on exemption certificates.

(2) Persons whose use of natural gas or electricity is solely in family dwellings will not be required to furnish exemption certificates.

(3) Persons whose use is in multi-family apartment complexes, housing complexes or other residential buildings may be required to issue exemption certificates if one is necessary for the utility company to distinguish exempt residential use from nonexempt commercial use.

(4) Manufacturers, processers and other noncommercial users will be required to issue exemption certificates to establish their exemption

(e) Effect of Billing Periods. The tax imposed by TEX. TAX.—GEN. ANN. ch. 20 will apply to sales of natural gas or electricity for residential use made during a customer's regular monthly billing period which begins before the October 1, 1978, effective date of the exemption. The tax shall not apply to regular monthly billing periods beginning on or after the effective date of the exemption.

Effective Date: October 25, 1978
Filed with Secretary of State: August 23, 1978
Texas Register No. 026.02.20.015

BOB BULLOCK
Comptroller of Public Accounts

STATE OF TEXAS

COMPTROLLER OF PUBLIC ACCOUNTS

LIMITED SALES, EXCISE AND USE TAX RULES AND REGULATIONS

Rule .007 Exemption Certificates - [20.04(B)].

An exemption certificate may be issued only by an organization which is itself exempt or by a person purchasing an item which is exempt under Article 20.04 of the Limited Sales, Excise and Use Tax Act. "Exemption numbers" or "tax exempt numbers" do not exist for the purposes of this Act.

It will be presumed under the Limited Sales, Excise and Use Tax Act that gross receipts of retailers are subject to the sales tax until the contrary is established. The burden of proving that a sale is exempt is upon the seller, unless he requires the purchaser to issue an exemption certificate. However, the exemption certificate relieves the seller from this burden of proof only if taken in good faith.

Any person who issues an exemption certificate in regard to the purchase of taxable items which he knows, at the time of purchase, will be used in a manner other than that expressed in the certificate is guilty of a misdemeanor.

This exemption certificate must be substantially in the form set out below:

EXEMPTION CERTIFICATE

The undersigned hereby claims an exemption from payment of taxes under Chapter 20, Title 122A, for the purchase of the taxable items described below or on attached order or invoice which is made a part hereof, and will be purchased from ______________________________

____

The reason that said purchaser is claiming this exemption is: ______________________

____

____

The purchaser will be liable for payment of the Limited Sales and Use Tax if he uses the items in some manner other than the reason listed above, he shall be liable for the tax based on the price paid for the taxable items. It is a misdemeanor to give an exemption certificate to the seller for taxable items which I know at the time of purchase will be used in a manner other than that expressed in this certificate, and upon conviction I may be fined not more than $500 per offense.

Executed this the __________day of ______________________________________, 19 ______

Purchaser ______________________________

Agency Purchased for ____________________

Address ________________________________

The tax status of any specific item may be determined by obtaining the sales tax ruling dealing with that specific property or by contacting the Comptroller's Office.

Effective Date: December 31, 1975
Filed with Secretary of State: December 31, 1975
Texas Register No. 026.02.20.007

BOB BULLOCK
Comptroller of Public Accounts

EXEMPTION CERTIFICATE

The undersigned claims exemption from payment of taxes under the Limited Sales, Excise and Use Tax Act (TEX. TAX.-GEN. ANN. art. 20.01 *et. seq.*) for the purchase of taxable items described below or on the attached order or invoice, which will be purchased from:

Supplier's Name

Supplier's Address

City State

Purchaser claims this exemption for the following reason:

I understand that I will be liable for payment of the Limited Sales, Excise and Use Tax if I fail to comply with the applicable provisions of the Limited Sales, Excise and Use Tax Act and Comptroller Rules regarding exempt purchases. Liability for the tax shall be based on the price paid for the taxable items.

IT IS A MISDEMEANOR to give an exemption certificate to the seller for taxable items which I know at the time of purchase will be used in a manner other than that expressed in this certificate, and upon conviction I understand I may be fined up to $500 per offense.

Name of Purchaser

Address

Purchaser's Signature

Date

This certificate should be furnished to the supplier. Do *not* send the completed certificate to the Comptroller of Public Accounts.

Form 2A95-13.03

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

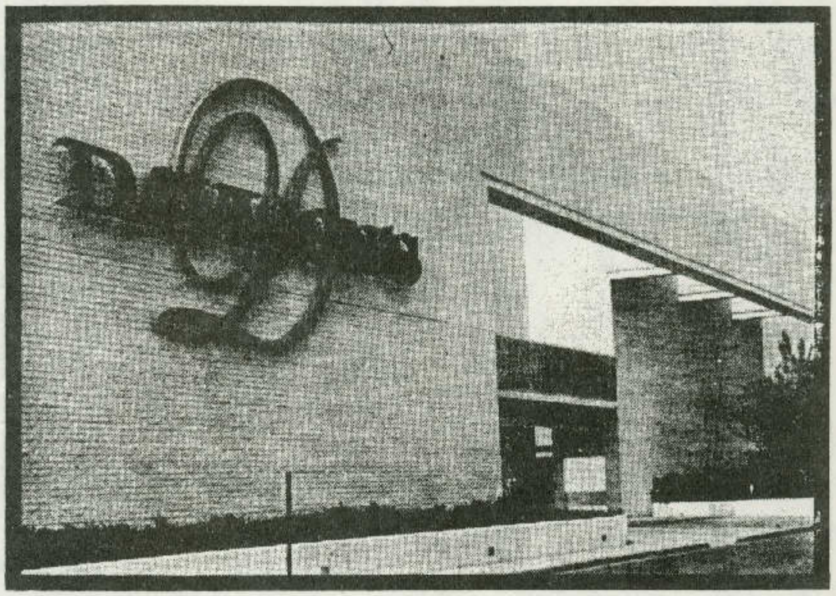
MINICOMPUTERS/MICROPROCESSORS

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

Case history Davison's department store CH3

Davison's Stores
$82,000 annual savings—6 month payback

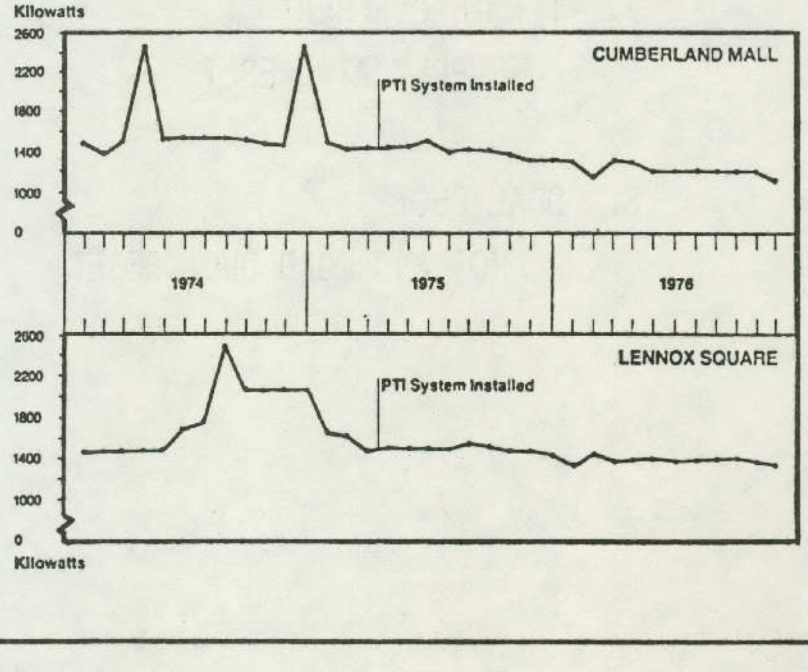
ATLANTA, GEORGIA. In April, 1975, two Model 414 Power Demand Controllers manufactured by Pacific Technology, Inc. were installed; one system in each of the Davison's Department Stores located in the Cumberland Mall and Lennox Square. These two systems were installed by Honeywell for use with their BOSS (building operation supervisory systems) Centers.



In each store, the PTI system controls four fans, one chiller (in two stages), four lighting circuits, a steam boiler and numerous duct heaters. In addition, the BOSS Center regulates environmental control of dampers on a time-shared basis for energy management service.

Gradually, a constant and increased reduction in demand resulted without customer discomfort. Both stores realized a combined savings of $82,000 during the first 12 months. Because of this tremendous savings, both systems and all installation costs were paid for within six months.

The two graphs show the monthly billed demand in kW for each store, both before and after the PTI systems were installed.



Equipment data sheet

Power demand controller

Model 414

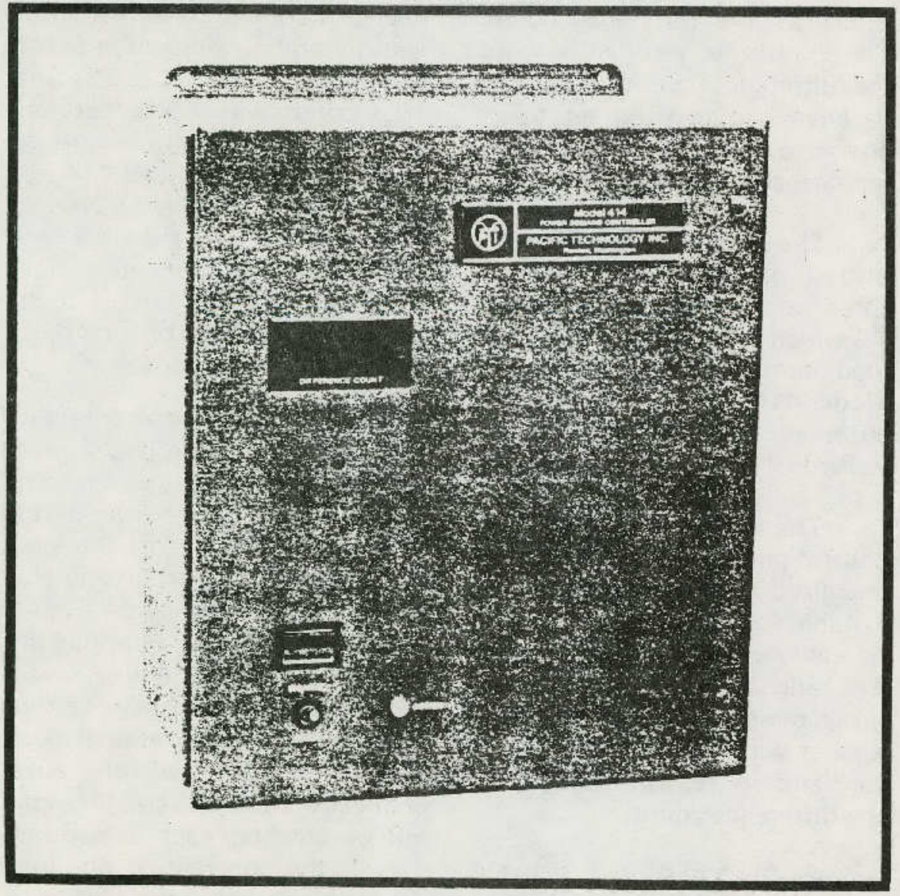
FEATURES

- ☐ Low cost, automatic control of one to 20 loads
- ☐ Load priority easily changed
- ☐ Compatible with utility pulse metering
- ☐ May be used when internal reset pulse is not available

APPLICATIONS

- ☐ HVAC systems in buildings and malls
- ☐ Furnaces and melters for metal reduction and forming
- ☐ Controls resistive heating, electric water boilers, heaters and motors
- ☐ Colleges, factories, hospitals, hotels, offices and schools

Model 414 AS/5 with difference count display option



The Model 414 Power Demand Controller is a digital control system designed to limit peak electrical demand through automatic control of preselected loads. This system finds application in commercial buildings or industrial plants where the total connected load is 300 kW or greater.

The Model 414 operates on the Ideal Curve concept. In this technique, the kilowatt-hour metering pulses are compared with pulses generated at an ideal rate which has been operator selected. Throughout each demand interval, the difference between the utility metering pulses and the internally generated pulses is continuously calculated and presented on an optional digital front panel display. (See figure 1, over.)

An initial offset in the ideal curve prevents crossover early in

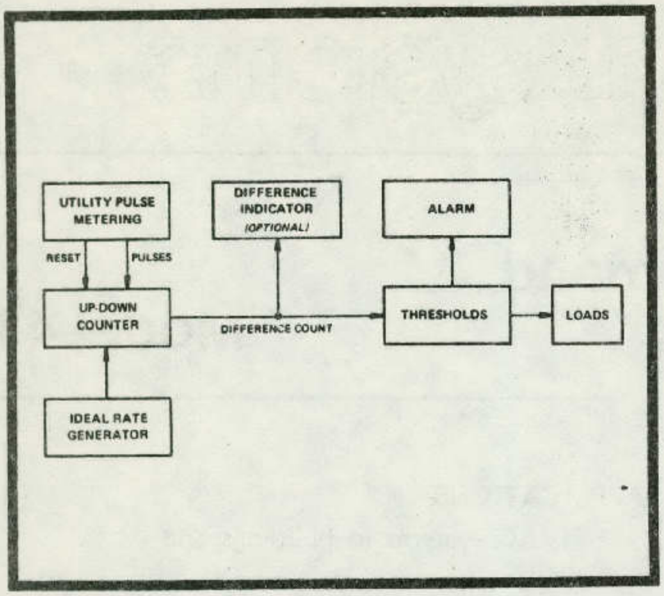


Figure 1

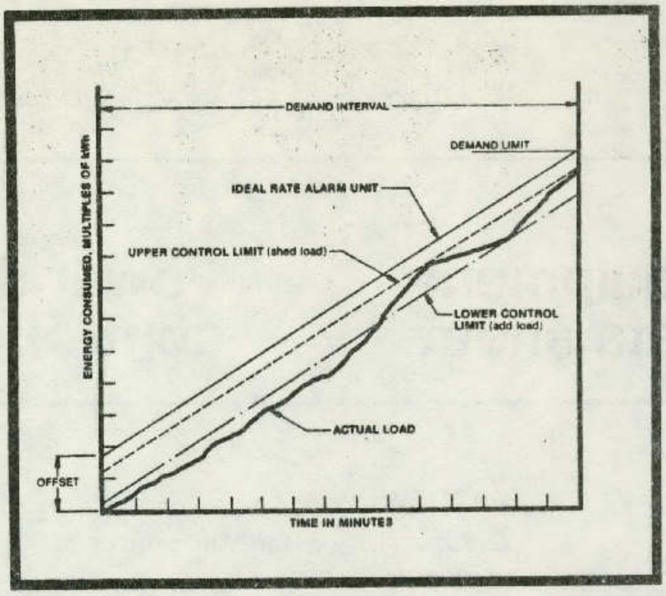


Figure 2

the demand interval before load trends have been established. The operating set point for the reference generator and the initial offset are selected by means of front panel digital thumbwheel switches. The demand limit is equal to the total of the offset and reference settings (see figure 2).

If the difference count were to decrease until it passed through zero (indicating crossover of the actual load curve), an alarm circuit is activated to alert the operator that the preset demand limit will be exceeded if the rate of energy consumption is not decreased.

Control of loads may be accomplished automatically by one of three basic configurations of the Model 414.

The Model 414 AN develops a linear analog output voltage ranging between 0 and 10 volts dc. This voltage is proportional to the difference count. The output is zero volts when the difference count is zero or negative and may be set to increase to 10 volts dc at any difference count greater than five.

The Model 414 AS has relay output, on/off control. There are three versions of the Model 414 AS which offer either 5, 10 or 20 load control circuits. Thus the Model 414 AS/20 can be used to automatically control up to 20 individual control circuits.

The threshold at which each control circuit is energized or deenergized is independently adjustable so that load priority can be easily established or changed. The add or shed setpoints are programmed (see figure 3) by jumper wires on the logic control card and are set as a function of the difference count.

At the end of each demand interval, all loads that have been turned off during the interval are re-energized. To prevent simultaneously adding all loads, a selectable time interval of 1, 2½, 5 or 10 seconds will elapse between the addition of each load. As an option, either the Model 414 AS/10 or 414 AS/20 may be ordered with manual over-ride switches and load status indicators. This allows any control circuit to be manually switched on or off, or left on automatic control.

Many applications require that all the controllable loads equally share the load shedding responsibility rather than having the lowest priority off the longest time. This is particularly true when interfacing with HVAC systems in building as undue discomfort might otherwise result. The Model 414 AS may be purchased with an optional load cycler circuit which automatically advances the first load off by one step each demand interval, thus preventing one load from always being the first to be

Patent number 3,514,713 applies to some of the above equipment.

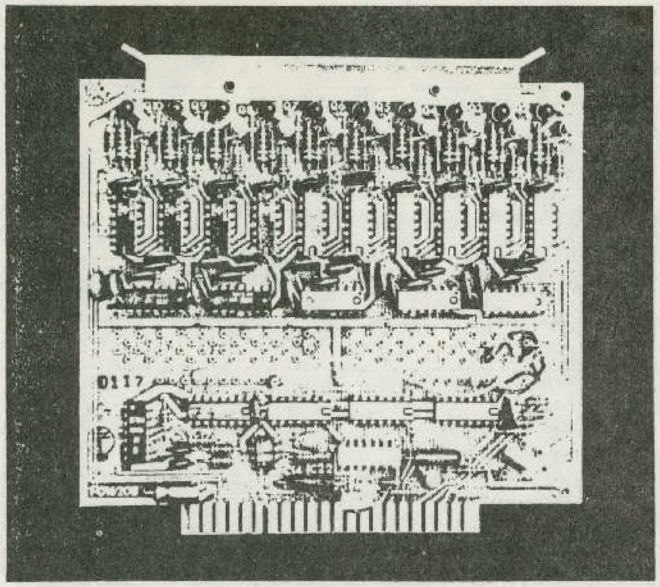
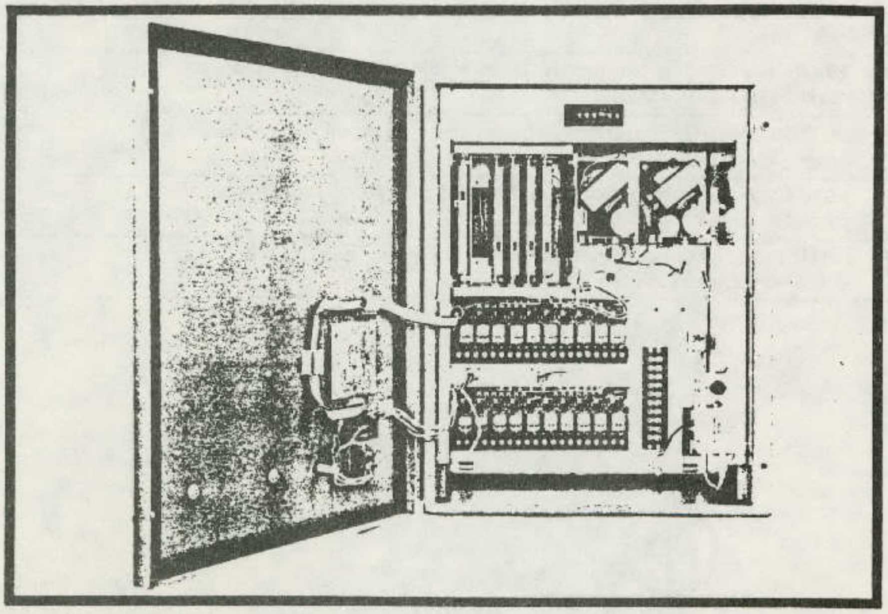


Figure 3

shed. The load cycler may also be used to rotate all loads one step with a selectable time base. These two features are independent and may be used separately or together. These options insure more equal distribution of the load shedding responsibility.

In some installations the utility metering may provide only the kWh pulses without the demand interval reset pulse. This may typically occur in smaller installations where a demand register has been fitted with a pulse generator for kWh pulses only.

Model 414 AS/20



A special version of this system, the Model 414R, is available for these applications. The 414-020 option (no additional cost) should be specified at the time of order. All of the standard system configurations listed are available with the model 414R as well as the standard Model 414.

The model 414R operates in an Ideal Rate mode. Loads are automatically controlled so that the rate of energy consumption is maintained at a predetermined level.

SYSTEM CONFIGURATIONS

414 AL	Alarm only
414 AN	Analog output, 0-10V dc
414 AS/5	Relay output with five control circuits
414 AS/10	Relay output with ten control circuits
414 AS/20	Relay output with twenty control circuits

Specifications

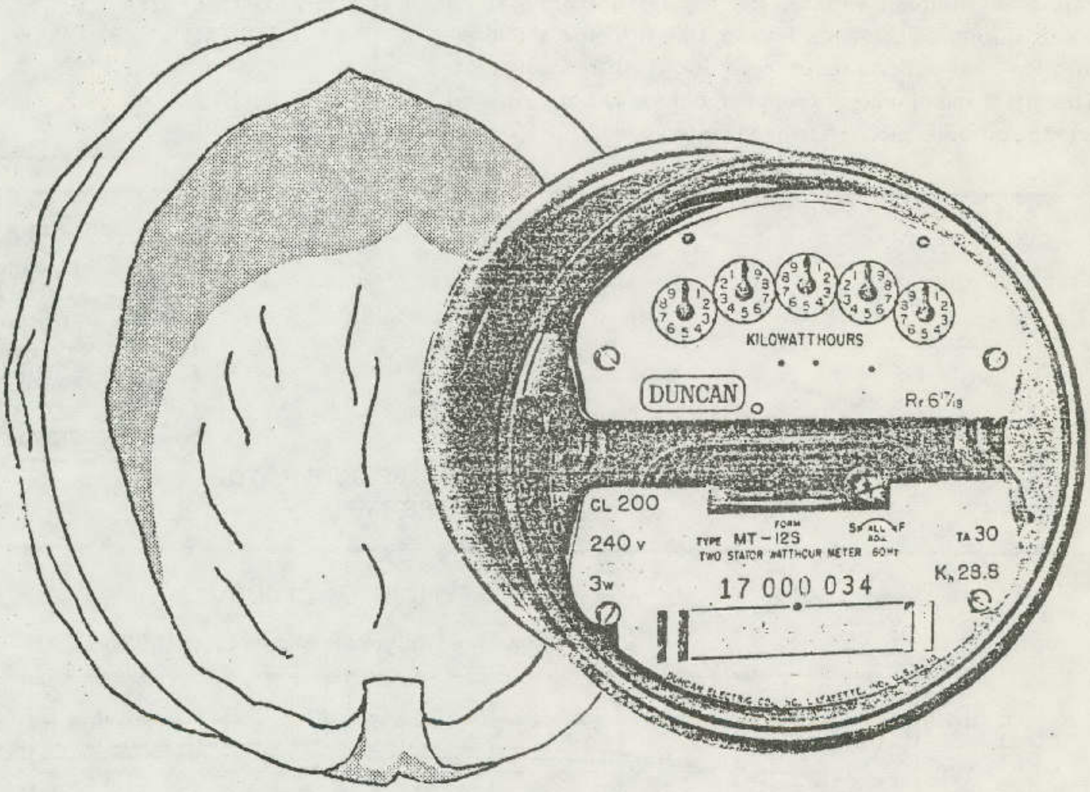
Maximum Pulse Count	999 (4999 Available as option)	
AC Pulse Input	Standard 3-wire metering circuit, 115V ac, 60 Hz at 3600Ω nominal input impedance.	
Maximum Rate	20 per second	
Period Reset	2-wire, contact closure for 0.05 seconds minimum, 115V ac, 60 Hz at 3600Ω nominal input impedance.	
DC Pulse Input	Standard 3-wire metering circuit, 24V dc at 500Ω nominal input impedance.	
Maximum Rate	20 per second	
Period Reset	2-wire, contact closure for 0.05 seconds minimum, 24V dc at 500Ω nominal input impedance.	
Metering Period	15, 30 or 60 minutes	
Displays	Alarm Alarm Disabled Load Status	
Outputs		
Control	Isolated relay contacts, 5A resistive for each control circuit except in 414 AN which has 0 - 10V dc output, 5 mA maximum @ +10V.	
Alarm	Isolated relay contacts, 5A resistive	
Input Power	105V to 125V ac, 60 Hz, 50W nominal	
Ambient Temperature	0^{o}C to 50^{o}C	
Weight	414 AL, 414 AN, 414 AS/5	Approx. 30 lb.
	414 AS/10, 414 AS/20	Approx. 45 lb.
Dimensions (in inches)	414 AL, 414 AN, 414 AS/5	14(H) x 12(W) x 9(D)
	414 AS/10, 414 AS/20	20(H) x 16(W) x 9(D)

Options

414-001	Adds 4th digit to reference set point (4999 max.)
414-005	2-digit difference count display
414-010	Pulse-to-kilowatt converter
414-020	Adapts 414 to utility metering which does not have a period reset pulse.
414-021	10 ON/AUTO/OFF override switches and load status indicators on cover (414 AS/10 Only).
414-022	20 ON/AUTO/OFF override switches and load status indicators on cover (414 AS/20 Only).
414-025	Load Cycler to automatically advance load shedding sequence and/or to rotate all loads on timed basis.
414-030	50 Hz modification. Adapts unit to 50 Hz power but requires 2:1 step down transformer if used on 230V ac line voltage.

DUNCAN

MT METER . . .



in a nutshell

DUNCAN ELECTRIC COMPANY, INC. P. O. BOX 180 LAFAYETTE, INDIANA 47902

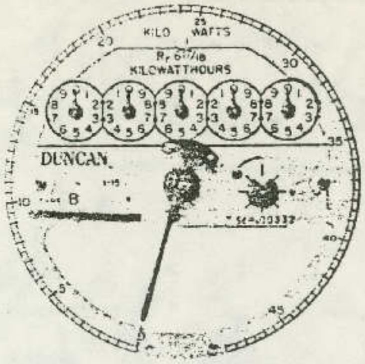
COMPATIBLE ACCESSORY PRODUCTS

Meters with mechanical demand registers, and watthour-thermal watt demand meters are available. An electronic pulse generator, Type PG-6MT or PG-6MTL, can be mounted on any of these meters, as well as on standard type MT watthour meters.

All meter features necessary to operate a pulse generator are standard on transformer rated meters, and are optional on self-contained. These features include:

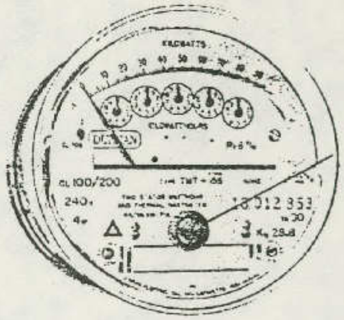
1. pulse generator drive pinion on rotor spindle
2. P. G. power winding in left stator potential coil
3. KYZ terminals in baseplate (on 13 terminal types pre-wired from center terminals to side terminals).

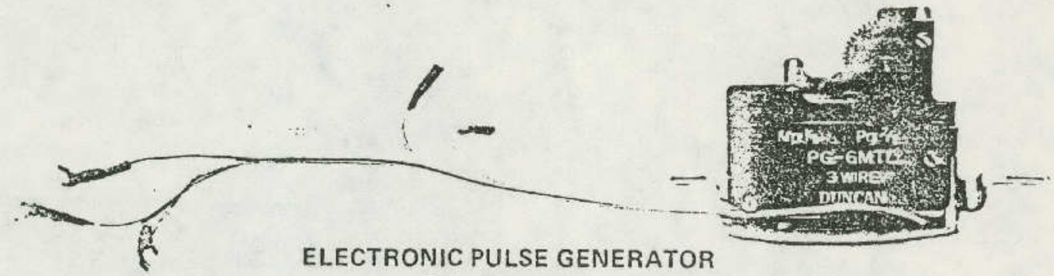
Mechanical demand registers are mounted to the meter by an intermediate gear unit which includes the first reduction (worm) gear. This makes it possible to accurately adjust worm mesh without the register obscuring visual access during adjustment. The register fits onto the intermediate gear unit without need for further adjustment. Thermal demand units are supplied only as factory installed on the appropriate KWH-demand meter.



BLOCK
INTERVAL
DEMAND
REGISTER
TYPE B

WATTHOUR
THERMAL WATT
DEMAND METER
TYPE TMT

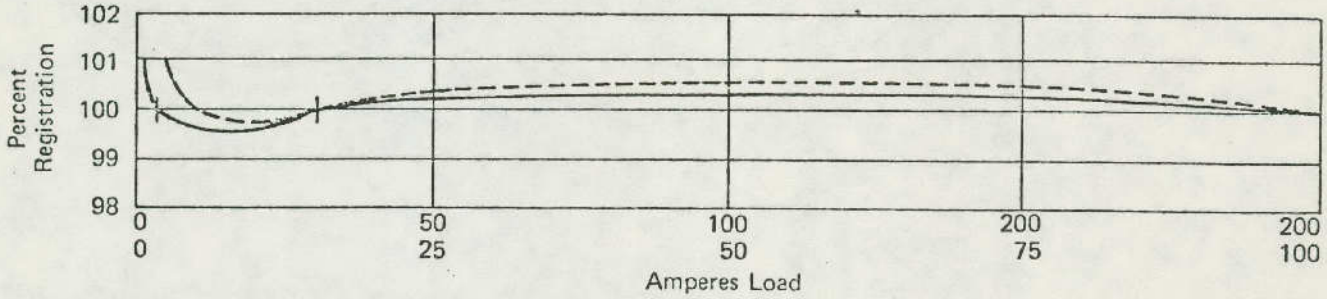




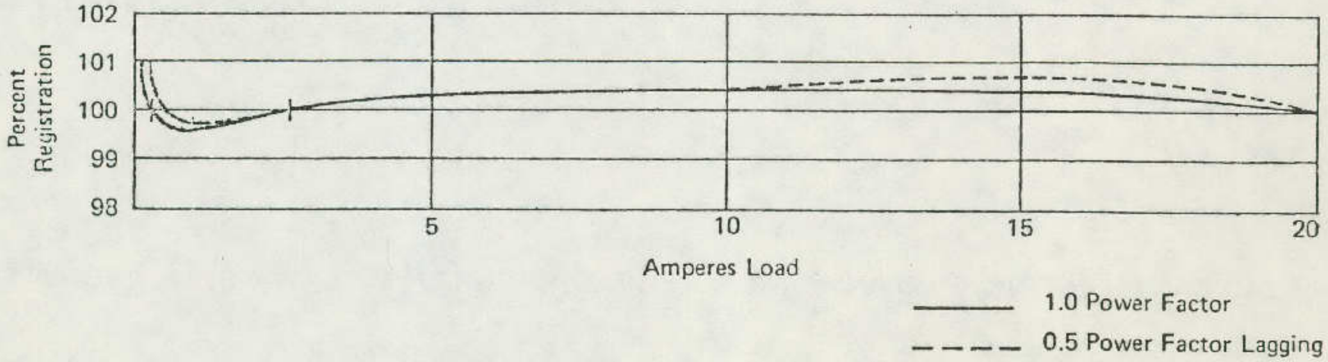
ELECTRONIC PULSE GENERATOR
TYPE PG-6MTL

TYPICAL LOAD CURVES

Self-Contained Polyphase Meters Class 100 and 200



Transformer-Rated Polyphase Meters



3

AUDITS AND COSTS

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

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

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 = $\dfrac{P_{OHP}}{\text{nameplate HP}}$.

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

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

$$= .11 \times 20 \text{ HP}$$

$$= 2.2 \text{ HP}$$

e. Eff = .50

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

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

$$= 3.28 \text{ KW}$$

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

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

$$= 2.10 \text{ KW}$$

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

$$= 1.18 \text{ KW (reduction)}$$

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 ____________

____
(Area Identification)

Floor ________

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
Fluorescent: = .0012

Motors: Column 3 ÷ 1,000

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft of area ____________

____________________________ (Area Identification)

Floor ________

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
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	ELECTRICITY 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.

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

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

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

the percent return on investment can be calculated using

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

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

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

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.

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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	New	Used	Life years
		$	$	$	

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

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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)

(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

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:

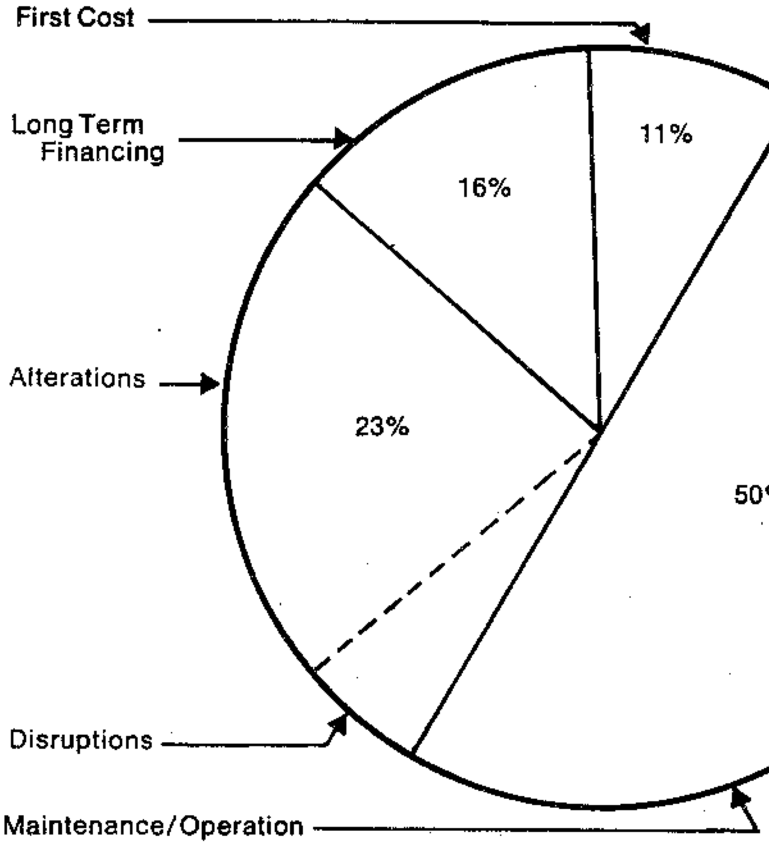
1. Consult your tax specialist to find out if this system qualifies for the regular investment tax credit of 10%. If it does, enter $50,000 on line 1(c) of Form 3468

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:

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

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

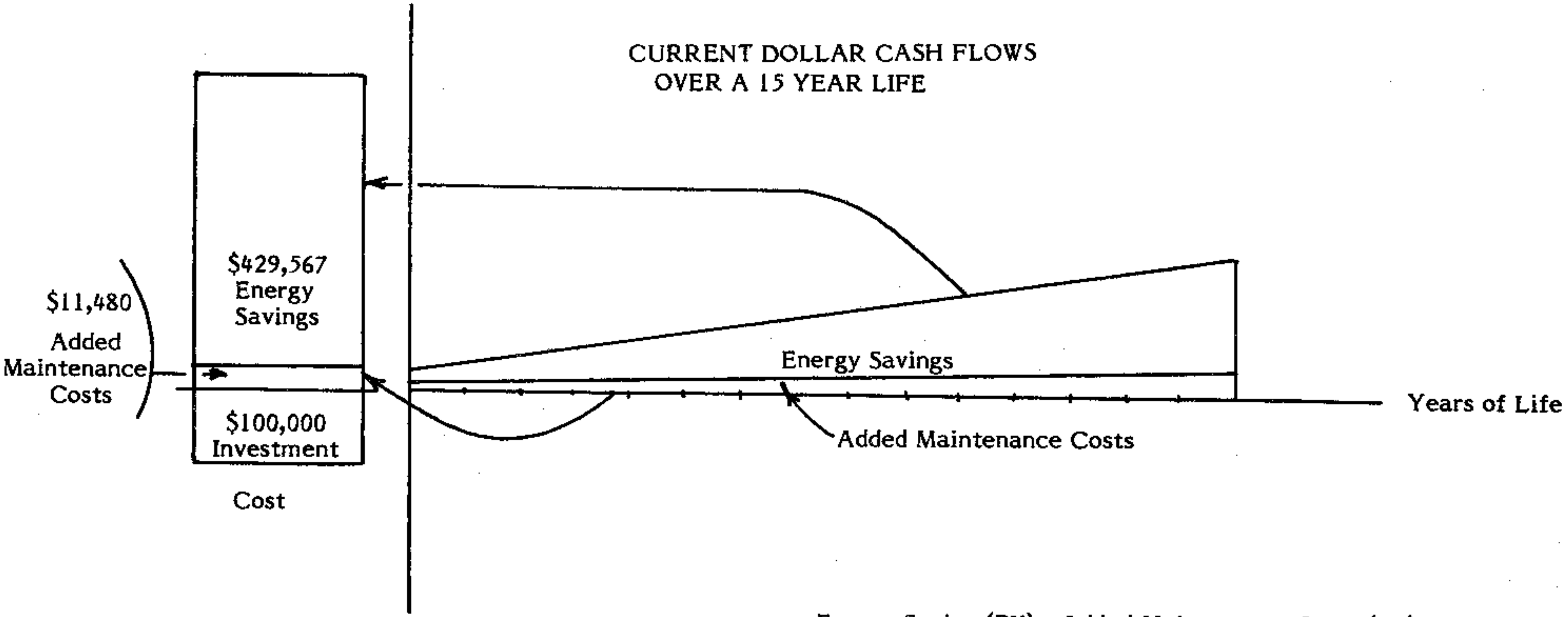
The effect of escalating energy prices on this analysis is unmistakable, and points out that this factor should be included in all computations for all such energy decisions.

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

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

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

DOLLAR SAVINGS OPPORTUNITY (DSO) NO. ________

DESCRIPTION:

FIRM/BUSINESS: ____________________
TYPE OF FIRM/BUSINESS: ____________________
FACILITY: ____________________
LOCATION: ____________________
ADDRESS: ____________________
DATE OF AUDIT: ____________________
AUDITORS: ____________________
____
____

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:

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

SAVINGS/INVESTMENT RATIO ________
SIMPLE PAYBACK PERIOD ________

SIR =
SPB =

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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:

4

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

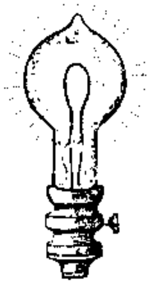
Total Lighting Represents About 5% Of The Total Fuels Consumed

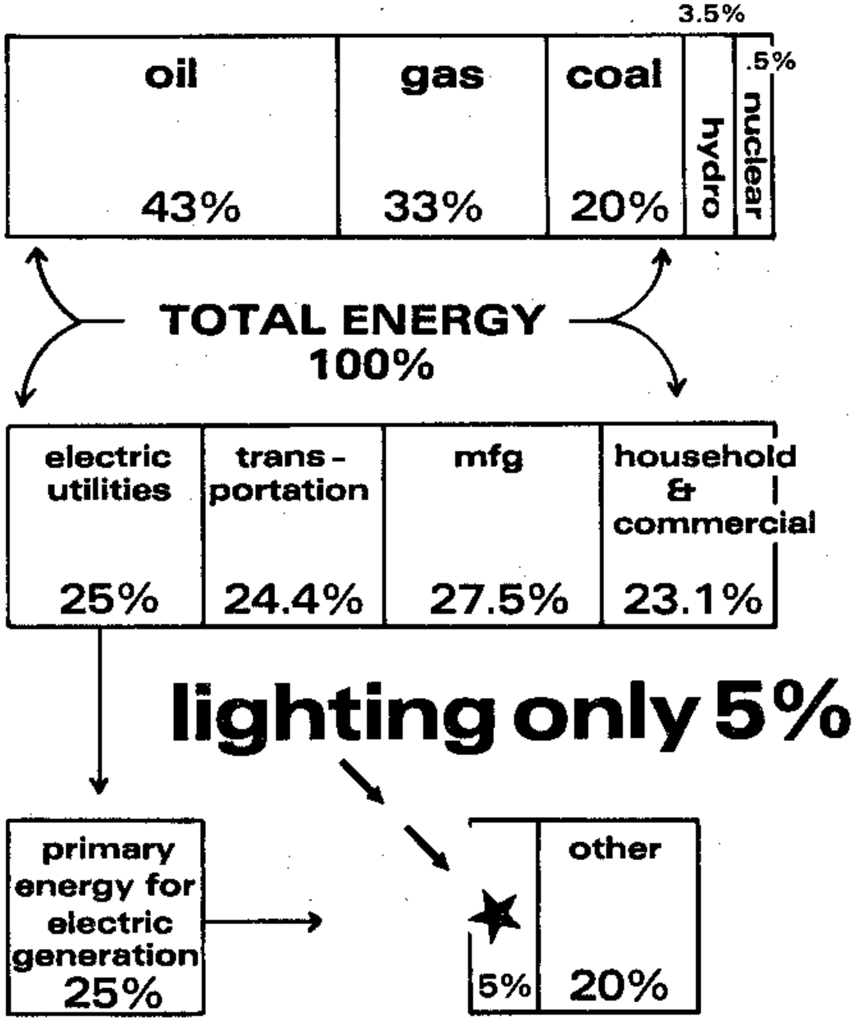
U.S.A. Heat Energy Consumption

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

Relamping with Lower Wattage Lamps

Preparation of a relamping schedule to reduce the wattage used for lighting can be done with two different approaches. The simplest is to merely replace the lamps with standard lamps of lower wattage. In using this approach, each case should be reviewed carefully to ascertain that the new lighting level is acceptable. This method of reducing wattage only applies to incandescent lamps. The approximate change in lumen output for a reduction of one standard lamp size is indicated in the table on Page VIh2.

As an illustration of the use of the table, consider a corridor with a lighting level of 20 foot candles which has fixtures with 60 watt lamps. By replacing the lamps with 40 watt bulbs, the resulting lighting level will be about 52% of 20 or 10.5 foot candles. If a lighting level in a corridor of 10 foot candles will not distract from guest and employee comfort and safety, (See Page VIf1), then this substitution may be possible.

The second approach is to replace lamps with special bulbs which have a slightly lower wattage than a standard lamp. The various manufacturers of these lamps may use trade names which imply that they save watts. They often do reduce the wattage used, but the lamp cost may be higher than for a standard lamp. The use of these lamps should be guided by an analysis of lamp cost, lamp life and potential for savings in electrical power. Lamps of a few manufacturers are tabulated on Pages VIh3 and VIh4.

Relamping with Lower Wattage Lamps

Incandescent Lamps

Standard Lamp				Replacement Lamp					
Watts	Lamp Description	Lumens	Hours Life	Watts	Lamp Description	Lumens	Hours Life	Lumen Output	Watts Saved
40	40A	455	1500	25	25A	235	2500	51.6%	15
60	60A	870	1000	40	40A	455	1500	52.3%	20
75	75A	1190	750	60	60A	870	1000	73.1%	15
100	100A	1750	750	75	75A	1190	750	68.0%	25
150	150A	2880	750	100	100A	1750	750	60.8%	50
200	200A	4010	750	150	150A	2880	750	71.8%	50
300	300M	6360	750	200	200A	4010	750	63.0%	100
500	500/IF	10850	1000	300	300M	6360	750	58.6%	200

NOTES:
1. This table shows the effects of relamping with the next lower wattage lamp, as an energy saving possibility.
2. The Lumen Output column shows the ratio of the replacement lamp lumens to present lamp lumens.

Relamping with Lower Wattage Lamps

Incandescent Lamps

Standard Lamp				Energy-Saving Lamp					
Watts	Lamp Description	Lumens	Hours Life	Watts	Lamp Description	Lumens	Hours Life	Lumen Output	Watts Saved
40	40A	460	1500	34	34A/SS	420	2500	91.3%	6
60	60A	890	1000	54	54A/SS	760	2500	85.4%	6
		890	1000	54	54/99IF	645	2500	72.3%	6
75	75A	1210	750	69	69A/SS	970	2500	80.2%	6
100	100A	1740	750	93	93A/SS	1460	2500	83.9%	7
		1710	750	90	90/99IF	1230	2500	71.9%	10
150	150A	2850	750	143	143A/SS	2380	2500	83.5%	7
		2850	750	135	135A/SS	1990	2500	69.8%	15

NOTES:
1. This table shows the effects of relamping with energy-saving lamps of two manufacturers. No representation concerning the acceptability of these lamps versus those of other manufacturers is implied.
2. The Lumen Output column shows the ratio of the energy-saving lamp lumens to the standard lamp lumens.

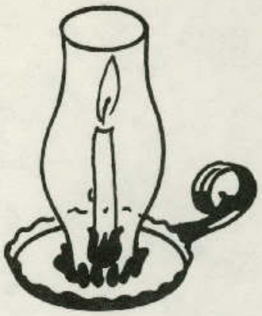
Relamping with Lower Wattage Lamps

Fluorescent Lamps

Standard Lamp			Energy-Saving Lamp				
Watts	Lamp Description	Lumens	Watts	Lamp Description	Lumens	Lumen Output	Watts Saved
40	F40CW	3150	35	F40/CW/RS/SS	2850	90.5%	5
			34	F40/CW/RS/EW	2800	88.9%	6
			35	F40/CW/RS/WM	2850	90.5%	5
40	F40WW	3200	35	F40/WW/RS/SS	2900	90.6%	5
			34	F40/WW/RS/EW	2900	90.6%	6
			35	F40/WW/RS/WM	2850	89.1%	5
75	F96T12/CW	6300	60	F96T12/CW/SS	5600	88.9%	15
	Slimline		60	F96T12/CW/EW	5220	82.9%	15
			60	F96T12/CW/WM	5600	88.9%	15
75	F96T12/WW	6400	60	F96T12/WW/SS	5600	87.5%	15
	Slimline		60	F96T12/WW/EW	5340	83.4%	15
			60	F96T12/WW/WM	5600	87.5%	15

NOTES:
1. This table shows the effects of relamping with energy-saving lamps of three manufacturers. No representation concerning the acceptability of these lamps versus those of other manufacturers is implied.
2. The Lumen Output column shows the ratio of the energy-saving lamp lumens to the standard lamp lumens.

Lighting



Energy Conservation Opportunities involving lighting are found in every room normally occupied by Engineering and Maintenance Department personnel as well as almost everywhere else throughout the property.

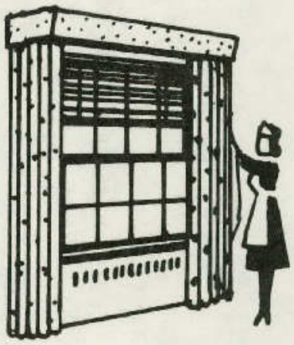
Operating Procedures

- **Turn off lights in unoccupied mechanical equipment rooms, shops, storage rooms, and other spaces when lights are not essential for safety or security reasons.** (But insure exit lights and hazard lights always meet safety and fire codes.)

- **Instruct operators and maintenance personnel to use minimum lights when operating or maintaining equipment and facilities, and to turn off lights when they leave spaces.**

- **Mark or color code individual switches in multiple installations to identify lights each one controls, and to show which lights are to be turned on when not all are needed.**

- **When adequate natural light from windows is available, open draperies and raise shades to perform maintenance and other activities involving temporary occupancy of spaces.**
  Close draperies and shades when maintenance is completed or space is vacated.



Maintenance Procedures

- **Clean windows and skylights and remove window obstructions to increase natural light from windows.**

- **Schedule maintenance during daylight hours, when possible, to reduce use of lights.**
  Example: One 100 watt lamp burning for 10 hours uses one kilowatt hour of electricity. If the lamp burned 12

hours a day for a year, 438 kilowatt hours of electricity would be used. The cost of energy wasted would be $21.90 at a rate of 5 cents per kilowatt hour.

- **Review lighting levels in all engineering and maintenance spaces.**
  Prepare new standard lamping plans which use the minimum numbers and sizes of lamps to light Mechanical and Electrical Equipment Rooms, Boiler Rooms, Shops, Storage Rooms, etc. without adversely affecting safety. (See Part VI for minimum lighting levels, and Part VI for How To Use a Light Meter to measure lighting levels.)

- **Replace lamps with lamps of smaller sizes, and remove excess lamps in accordance with the new standard lamping plan.**

- **Assist other department heads to review lighting levels, prepare new standard lamping plans, replace lamps with lamps of smaller sizes, and remove excess in their assigned spaces.**
  Example: Remove Both Lamps of a Two-Lamp Fluorescent Fixture. When removing both lamps, disconnect the black and white ballast power leads from the power supply. In addition to the wattage saved from the lamp removal, there will be savings in ballast wattage as follows:

Lamp Type		Two Lamp Ballast Watts Saved
40W	F40 - Rapid Start	12
40W F48T12	Slimline	20
60W F48T12/HO	High Output (800 ma.)	30
110W F48PG17	Power Grooves (1,500 ma.)	15

Remove Two Lamps In a Four Lamp Fluorescent Fixture Or One Lamp In Three Lamp Fixtures. In a four-lamp fixture, remove both inside lamps and disconnect power wiring to their associated ballast. (Savings will be lamp wattage plus ballast wattage.) In a 3-lamp fixture remove the middle lamp.

For each pair of 40 watt rapid start lamps removed (and associated ballast disconnected), there would be an energy savings of 403 kilowatt hours per year, based on 12 hours of use per day. At 5 cents per kilowatt hour, $20.15 per year would be saved for each such lamp combination removed from service.

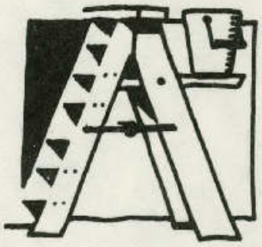
Do Not Remove One Lamp In a Two Lamp High Intensity Discharge Fixture. It is not possible to operate one lamp if the ballast is a series type. In fixtures which do not use a series type ballast, one lamp left in operation should not be adversely affected. However, the ballast may overheat, and this will reduce its life.

Remove Lamp From a Single Lamp Mercury or Metal-Halide Fixture. Generally, there would be no adverse effect on the ballast. However, there will be a current flow consuming as much as 40 watts in a 400 watt ballast or 80 watts in 1000 watt lamp ballast. Disconnect the power leads to the ballast to save energy.

Remove Lamp From a Single Lamp High Pressure Sodium Fixture. Removing a lamp for more than a short period of time will damage the starting circuit in the ballast because the circuit will operate continuously with the lamp removed. A failed lamp can cause the same type of damage. Remove the lamp and disconnect power leads to the ballast.

For each 400 watt lamp removed (and associated ballast disconnected), there would be an energy savings of 1927 kilowatt hours per year, based on 12 hours of use per day. At 5 cents per kilowatt hour, $96.35 per year would be saved for each such lamp removed from service.

- **Clean and wash walls, ceilings, and floors.**
  Cleaned surfaces reflect light better, so that less artificial lighting is needed.

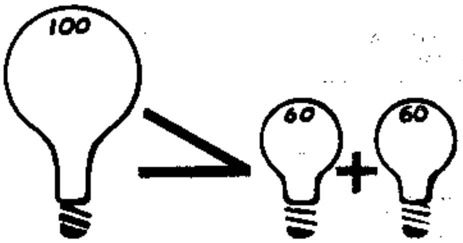


- **Consider using fluorescent lamps where practicable.**
  According to manufacturers' data, they require about one-third the electric energy to match the lighting level of incandescent lamps.

- **Consider using general service incandescent lamps.**
  For the same wattage, according to manufacturers' data, general service lamps with 750 to 1000 hour life are more efficient than extended service lamps with 2500 hour life. To provide the same level of lighting, therefore, extended service lamps must be larger, so they would use about 17 percent more energy. A typical 100 watt extended service lamp provides only 85 percent of the light provided by a typical 100 watt general service lamp. Many studies indicate that extended service lamps are economical only in hard to reach places.

- **Relamp with lower wattage lamps.**
  When relamping, make use of lower wattage lamps whenever practicable. See Part VI for a listing of relamping changed to reduce lighting wattage without the need to modify luminaires (light fixtures).

- **Use more efficient ballasts.**
  When ballasts burn out, replace with the following: For fluorescent lights, 430 milliampere, replace low power factor high-watt ballasts with high power factor (90% or more), low-watt ballasts. (Circuits with 50% power factor ballasts have 240% more energy losses in wiring than those with 90% power facctor ballasts.)



- **Consider using single, larger incandescent lamps instead of two or more smaller lamps, where the fixtures permit.**
  One 100 watt lamp (at 1750 lumens output) produces more light than two 60 watt lamps (at 2 X 860 or 1720 lumens output), with a 20% saving in energy, according to manufacturers' data.

- **Initiate and follow routine cleaning schedules for lighting fixtures.**
  All fixtures become dirty with use, and produce more light when cleaned. Energy will be saved if fewer lights are required, or smaller lamps can be used to provide satisfactory lighting.

- **Wherever possible, replace 150 watt incandescent lamps with 75 watt lamps in hi-hat down lights.**

Information on Minimal Lighting Levels

NOTE CAREFULLY: This information was developed by the Illuminating Engineering Society as one criterion to use in lighting design. For the proper application of these levels, see the IES Lighting Handbook, 1972. While for convenience of use the table sometimes lists locations rather than tasks, the authors indicated that footcandle values have been arrived at for specific visual tasks, and the tasks selected for this purpose have been the more difficult ones which commonly occur in the various areas. We emphasize that particular lighting situations (e.g., on stairs and walkways) may require greater illumination levels than those listed to meet safety and security needs and/or the specific requirements of federal, state and local laws and regulations, such as federal Occupational Safety and Health Act standards and building codes.

AREA	FOOTCANDLES ON TASKS*
AUDITORIUMS	
Assembly only	15
Exhibitions	30
Social activities	5
CENTRAL STATION (Boiler Room)	
Air-conditioning equipment, air preheater and fan floor, ash sluicing	10
Auxiliaries, battery rooms, boiler feed pumps, tanks, compressors, gauge area	20
Boiler platforms	10
Burner platforms	20
FOODSERVICE FACILITIES	
Dining Areas	
Cashier	50
Intimate type	
Light environment	10
Subdued environment	3
For cleaning	20
Leisure type	
Light environment	30
Subdued environment	15
Quick Service type	
Bright surroundings	100
Normal surroundings	50
Food displays-twice the general levels but not under	50
Kitchen, commercial	
Inspection, checking, preparation, and pricing	70
Entrance foyer	30
Marquee	
Dark surroundings	30
Bright surroundings	50
HOTELS	
Bathrooms	
Mirror	30 [g]
General	10
Bedrooms	
Reading	30
Inkwriting	30 [h]
Make-up	30 [i]
General	10
HOTELS (Cont'd)	
Corridors, elevators, and stairs	20
Entrance foyer	30
Front office	50
Linen room	
Sewing	100
General	20
Lobby	
General lighting	10
Reading and working areas	30
Marquee	
Dark surroundings	30
Bright surroundings	50
LAUNDRIES	
Washing	30
Flat work ironing, weighing, listing, marking	50
Machine and press finishing, sorting	70
Fine hand ironing	100
OFFICES	
Accounting offices	
Auditing, tabulating, bookkeeping, business machine operation, computer operation	150+
General offices	
Reading poor reproductions, business machine operation, computer operation	150+
Reading handwriting in hard pencil or on poor paper, reading fair reproductions, active filing, mail sorting	100*
Reading handwriting in ink or medium pencil on good quality paper, intermittent filing	70+
BUILDING EXTERIORS	
Entrances	
Active (pedestrian and/or conveyance)	5
Inactive (normally locked, infrequently used)	1
Vital locations or structures	5
Building surrounds	1
PARKING AREAS	
Self-parking area	1
Attendant-parking area	2

* Minimum, maintained.

\+ Equivalent sphere illumination.

[g] For close inspection, 50 footcandles (54 dekalux).

[h] Pencil handwriting, reading of reproductions and poor copies require 70 footcandles (75 dekalux).

[i] For close inspection, 50 footcandles (54 dekalux). This may be done in the bathroom, but if a dressing table is provided, local lighting should provide the level recommended.

Source: IES Lighting Handbook, 1972

THERE IS MORE TO LIGHTING THAN

FOOTCANDLES!

DEFINITION

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

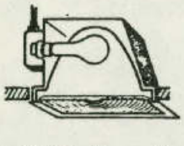
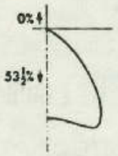
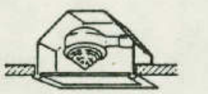
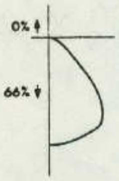
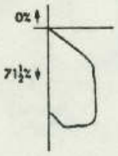
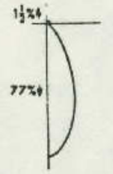
LIGHT REQUIRED: 100 FOOTCANDLES OVER
50,000 SQUARE FEET

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.)

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

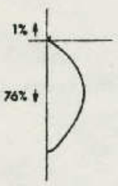
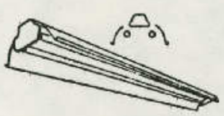
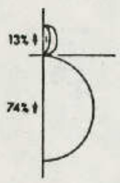
TABLES OF COEFFICIENTS OF UTILIZATION

Typical Luminaire	Typical Distribution and Per Cent Lamp Lumens		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)																
10  Wide distribution unit with lens plate and inside frost lamp	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
			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
			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
			8	.30	.26	.23	.30	.26	.23	.29	.26	.23	.28	.25	.23	.28	.25	.23	.22	.10
			9	.27	.23	.21	.27	.23	.21	.26	.23	.21	.26	.23	.20	.25	.22	.20	.19	.09
			10	.25	.21	.18	.25	.21	.18	.24	.21	.18	.24	.20	.18	.23	.20	.18	.17	.09
11  Recessed unit with dropped diffusing glass	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
			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
			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
			9	.21	.17	.14	.21	.16	.14	.20	.16	.13	.19	.16	.13	.19	.15	.13	.12	.11
			10	.19	.15	.12	.19	.15	.12	.18	.14	.12	.18	.14	.12	.17	.14	.12	.11	.10
12  Clear HID lamp and glass refractor above plastic lens panel	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
			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
			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
			8	.38	.33	.30	.38	.33	.30	.37	.33	.30	.36	.32	.29	.35	.32	.29	.28	.12
			9	.35	.30	.27	.34	.30	.27	.34	.29	.26	.33	.29	.26	.32	.29	.26	.25	.11
			10	.32	.27	.24	.31	.27	.24	.31	.27	.24	.30	.26	.24	.30	.26	.23	.22	.11
13  Enclosed reflector with an incandescent lamp	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
			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
			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
			9	.37	.31	.28	.36	.31	.28	.36	.31	.28	.35	.31	.28	.34	.30	.27	.26	.13
			10	.33	.28	.25	.33	.28	.25	.32	.28	.25	.32	.28	.25	.31	.27	.24	.23	.12
14  Narrow distribution ventilated reflector with clear HID lamp	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
			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
			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
			8	.58	.54	.51	.58	.54	.51	.57	.53	.51	.56	.53	.51	.55	.52	.50	.49	.09
			9	.55	.51	.48	.55	.51	.48	.54	.50	.48	.53	.50	.48	.53	.50	.48	.47	.08
			10	.53	.49	.46	.52	.48	.46	.52	.48	.46	.51	.48	.45	.50	.47	.45	.44	.08

[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

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 ventilated reflector with clear HID lamp			8	.45	.40	.36	.45	.40	.36	.44	.39	.36	.43	.39	.35	.42	.38	.35	.34	.13
			9	.41	.36	.32	.41	.36	.32	.40	.35	.32	.39	.35	.32	.38	.35	.32	.30	.13
			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 reflector with clear HID lamp			8	.41	.35	.31	.41	.35	.31	.40	.34	.31	.39	.34	.30	.38	.33	.30	.29	.15
			9	.37	.31	.27	.37	.31	.27	.36	.30	.27	.35	.30	.27	.34	.30	.26	.25	.15
			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 ventilated reflector with phosphor coated HID lamp			8	.52	.47	.43	.51	.46	.43	.50	.45	.42	.48	.44	.41	.47	.43	.41	.40	.11
			9	.48	.43	.39	.47	.42	.39	.46	.42	.39	.45	.41	.38	.44	.40	.38	.36	.11
			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 reflector with phosphor coated HID lamp			8	.45	.39	.35	.44	.38	.35	.42	.37	.34	.40	.36	.33	.38	.35	.32	.31	.12
			9	.41	.35	.31	.40	.34	.31	.38	.33	.30	.36	.32	.29	.35	.31	.28	.27	.12
			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	.41	.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 with 14°CW shielding			9	.35	.28	.23	.34	.27	.23	.32	.26	.22	.30	.25	.21	.28	.24	.20	.19	.15
			10	.32	.25	.20	.31	.24	.20	.29	.23	.19	.28	.22	.19	.26	.21	.18	.17	.14

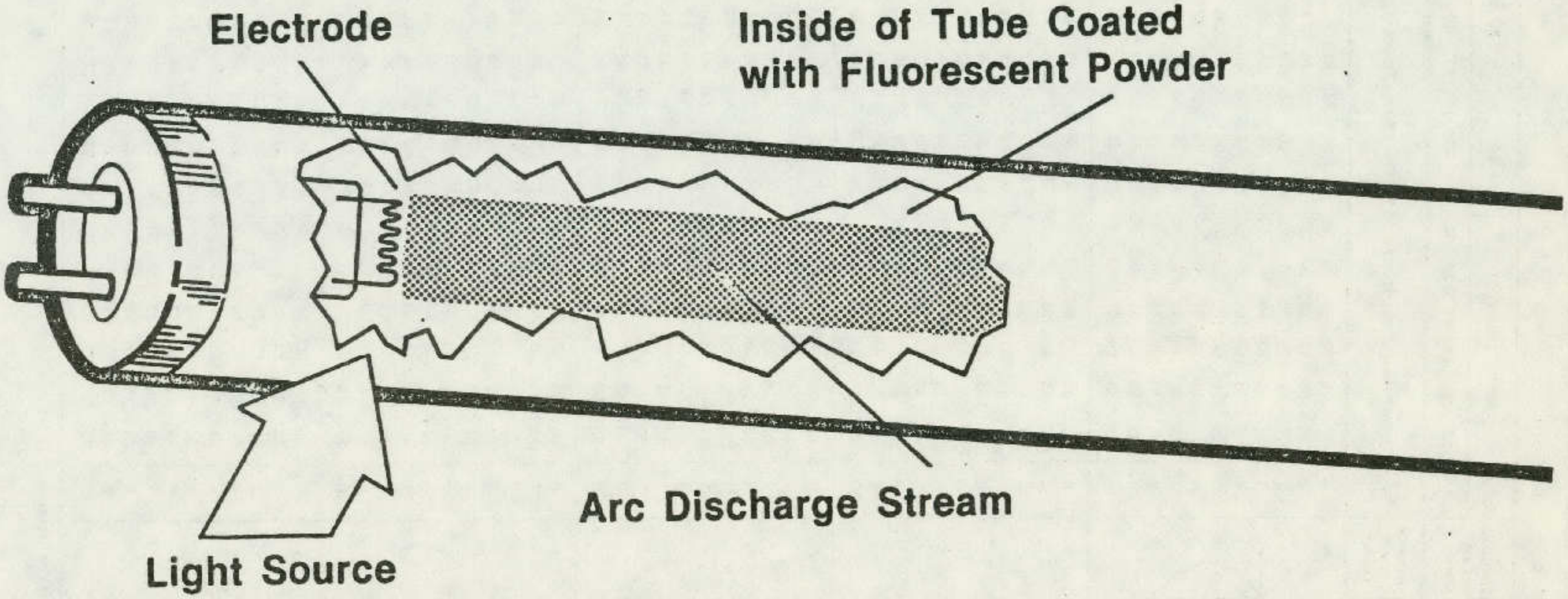
[a] ρ_{cc} = per cent effective ceiling cavity reflectance.

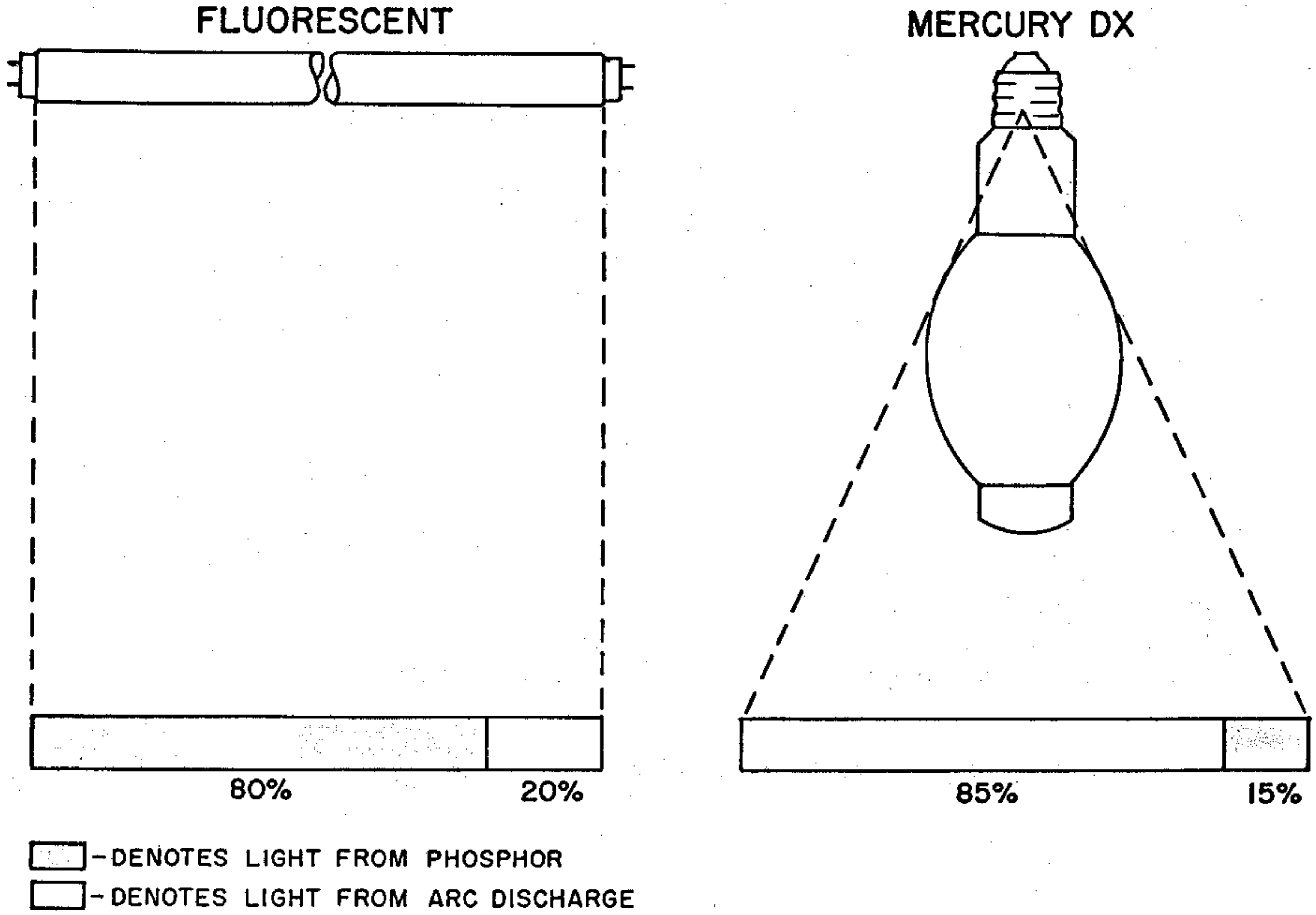
[b] ρ_w = per cent wall reflectance.

[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

NEW

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.	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.

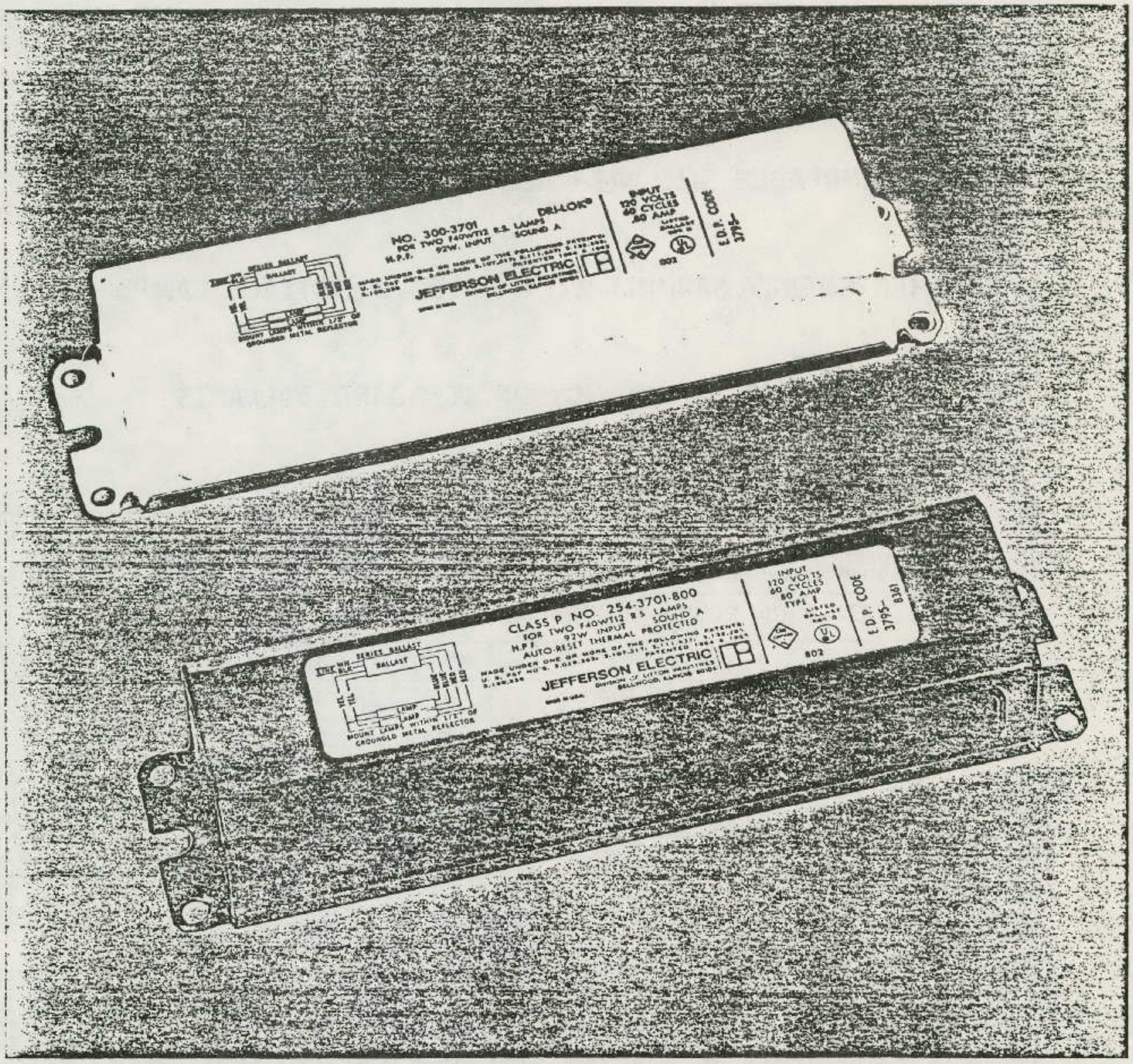
[3] Indicates length of lamp plus two standard lampholders.

[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.

Fluorescent Ballasts



Litton
JEFFERSON ELECTRIC

ENERGY-LOK™

ENERGY SAVING BALLASTS

- SAME LIGHT OUTPUT AS STANDARD BALLASTS
  ....WHILE REDUCING ENERGY DEMAND.

- INTERCHANGEABLE SIZE WITH ALL STANDARD SIZE BALLASTS

- FURTHER ENERGY SAVINGS WITH REDUCED WATTAGE LAMPS

- DOUBLE THE LIFE EXPECTANCY OF STANDARD BALLASTS

LAMP TYPE	NOM. RELATIVE LIGHT OUTPUT	LAMP CUR. AMPS	LINE VOLT.	CATALOG NUMBER	C B M	MIN. START. TEMP.	LINE CUR. AMPS	INPUT WATTS*			SOUND RATING	WIR. DIAG.	DIMEN.	LEAD LGTH. CHART
								CBM TEST PROC.	OPEN FIXT.	ENCL. FIXT.				
RAPID START—HIGH POWER FACTOR—60 HERTZ														
	Full		120	254-4701-800	▲	+50°F	.73	84	78	75	A	2	B-1	3
	Full		277	244-4708-800	▲	+50°F	.30	84	78	75	A	2	B-1	3
2F40T12	Full	.430	120	300-4701-800	▲	+50°F	.73	84	78	75	A	2	B-1	3
	Full		277	300-4708-800	▲	+50°F	.30	84	78	75	A	2	B-1	3
	80%		120	255-501		+50°F	.70	76	70	68	A	2	A-1	4
4 Lamp open, recessed fixture 4 Lamp enclosed, recessed fixture												Charts on p. 11		
SLIMLINE AND INSTANT START—HIGH POWER FACTOR—60 HERTZ														
	Full		120	254-4791-800	▲	+50°F	1.35	159	151	141	C	3	A-1	9
2F72T12	Full		277	254-4798-800	▲	+50°F	.58	159	151	141	C	3	A-1	9
OR	Full	.425	120	300-4791-800	▲	+50°F	1.35	159	151	141	C	3	A-1	9
2F96T12	Full		277	300-3798-800	▲	+50°F	.58	159	151	141	C	3	A-1	9
	60W		120	255-3541		+50°F	1.07	90-115	112	108	C	3	A-4	12

Charts on p. 19

*Input watts for standard lamps
Input watts reduced approx. 12.5% for energy saving lamps
2 Lamp open, surface mounted fixture
2 Lamp enclosed, surface mounted fixture

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

		118 Volts[1]			277 Volts[2]		
			Two — Lamp			Two — Lamp	
Lamp Designation	Nominal Watts	Single Lamp	Series	Lead-Lag	Single Lamp	Series	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

	Initial			End of Life**		Rated
		Lumens Per Watt			Lumens	Average
Lamp Type	Lumens	Lamp	Lamp/Ballast	Lumens	per Watt*	Life
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.

CHARACTERISTICS OF SYLVANIA LAMPS(1)

	TUNGSTEN HALOGEN INCANDESCENT	FLUORESCENT	MERCURY	METALARC	LUMALUX	LOW PRESSURE SODIUM
LUMENS PER WATT	6-23	150 25-84	30-63	68-125	77-140	180 137-183
LUMENS	40-33,600	96-15,000	1,200-63,000	12,000-155,000	5,400-140,000	1,800 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	18 35-180
LIFE	750-8,000	9,000-20,000	16,000-24,000+	3000 20,000 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	Medium 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.

Interchangeability of Lamps and Ballasts

LAMP TYPES

Ballast Types	Lumalux	Unalux	Metalarc	Metalarc Swingline	Super Metalarc	Mercury
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 autotransformer	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.

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

Hotel and Motel Lighting Case Studies

Interior Hallways

Existing Lighting System: 26 recessed ceiling fixtures each with a 100 watt incandescent lamp.

Replacement Lighting System: 26 surface mounted hight quality vandal proof fixtures each with a 32 watt circline fluorescent lamp using the existing outlet box.

Annual Operating Savings:	Energy (kilowatthours)	$676
	Lamp Replacement	26
Capitol Cost:	Fixtures cost	702
	Lamp cost	116
Payback:	1.16 years at current energy cost	
Air Conditioning:	.74 ton reduction due to less heat produced by the 32 watt fluorescent lamp	

Exterior Lighting

Existing Lighting System: 7-500 watt quartz floodlights, and 72-150 watt PAR spotlights. Total lumens - 201,930 and total watts - 14,300.

Replacement Lighting System: 3-135 watt, 4-90 watt, and 24-55 watt high pressure sodium lamps. Total lumens - 313,500 and 2,954 total watts.

Annual Operating Savings:	Energy (Kilowatthours)	$1,188
	Lamp Replacement	482
Capitol Cost	Fixture & Lamp Cost	5,590
Payback:	3.34 years at current energy cost	

5

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:

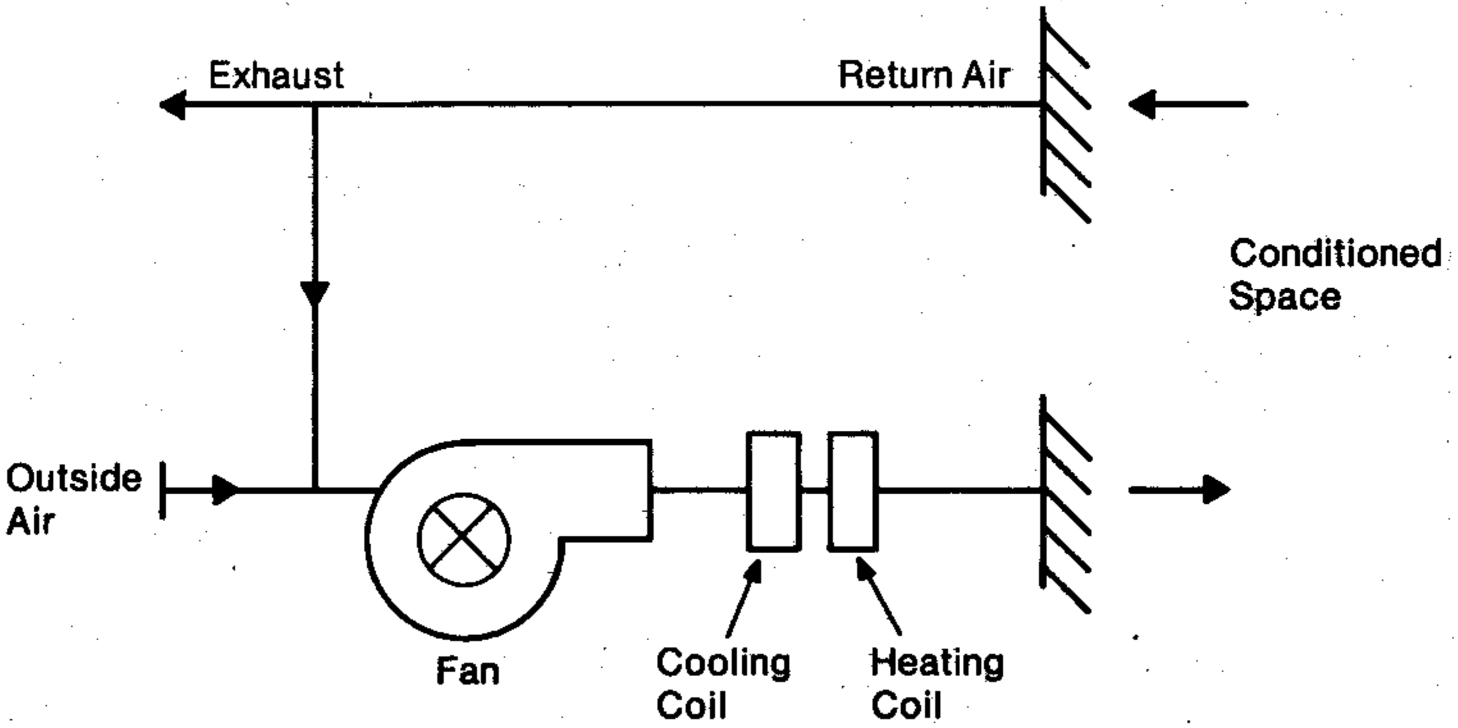
Single Zone System

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

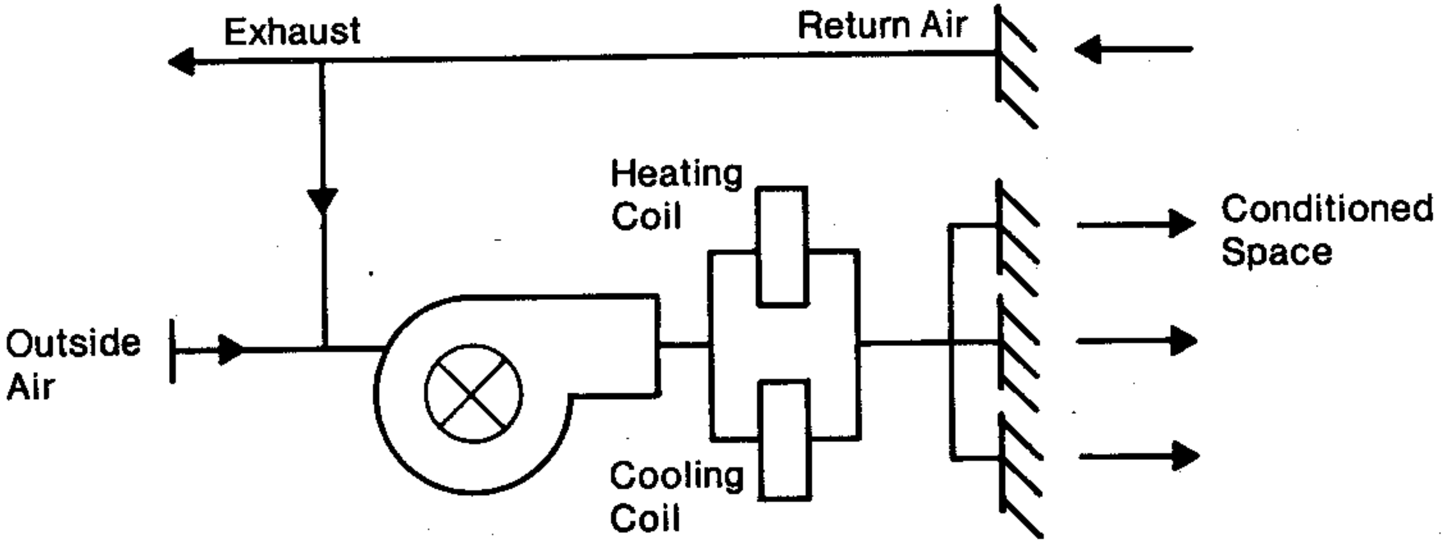
A multizone system heats and cools several zones -- each with different load requirements -- from a single, central unit. A thermostat in each zone controls dampers at the unit which mix the hot and cold air to meet the varying load requirements of the zone involved. Steps which can be taken to improve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

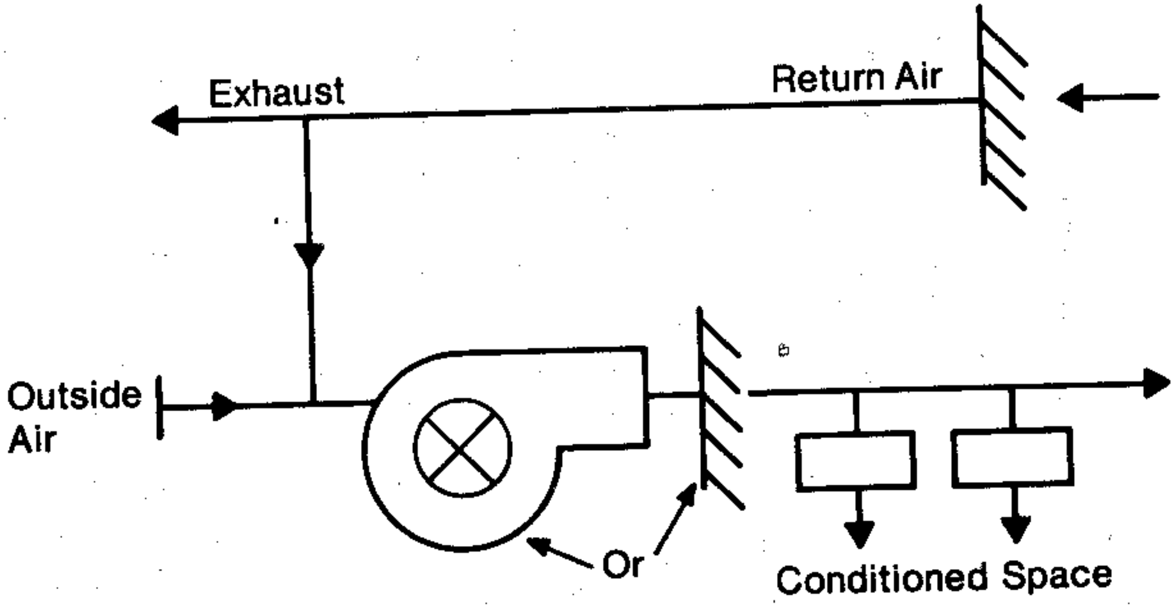
- Determine the minimum amount of airflow which is satisfactory and reset the constant volume device accordingly.

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

Induction Systems

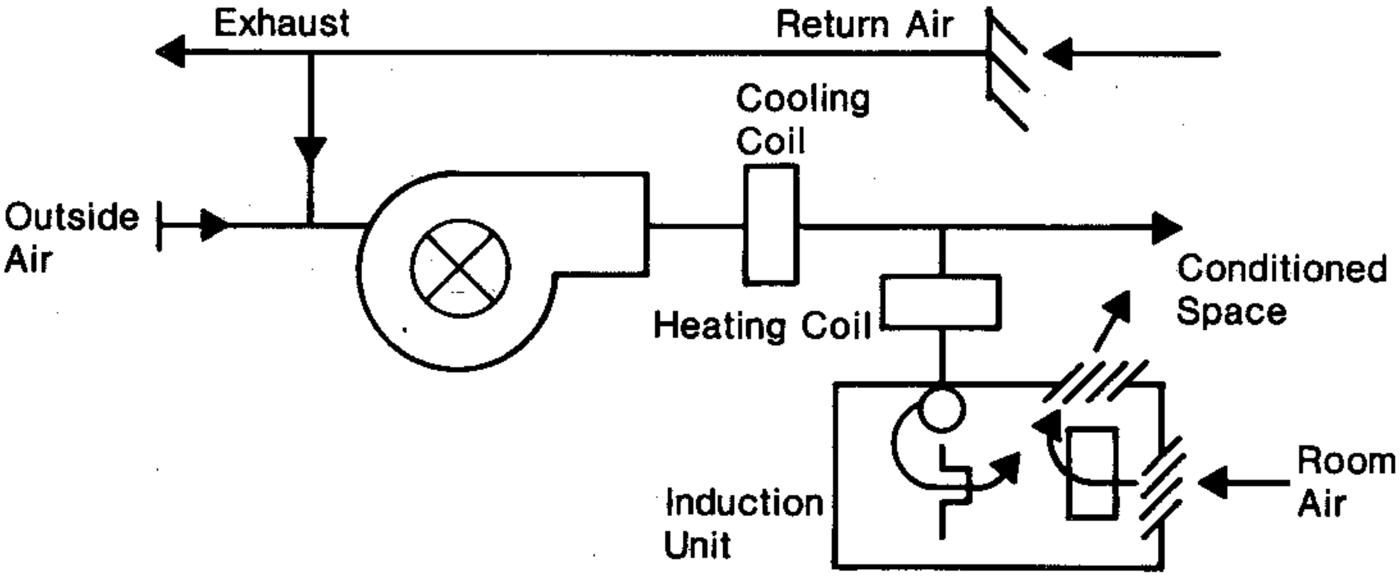
Induction systems comprise an air handling unit which supplies heated or cooled primary air at high pressure to induction units located on the outside walls of each

Variable Volume



- Generally A Very Efficient System
- Inlet Vanes Or Discharge Dampers At 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

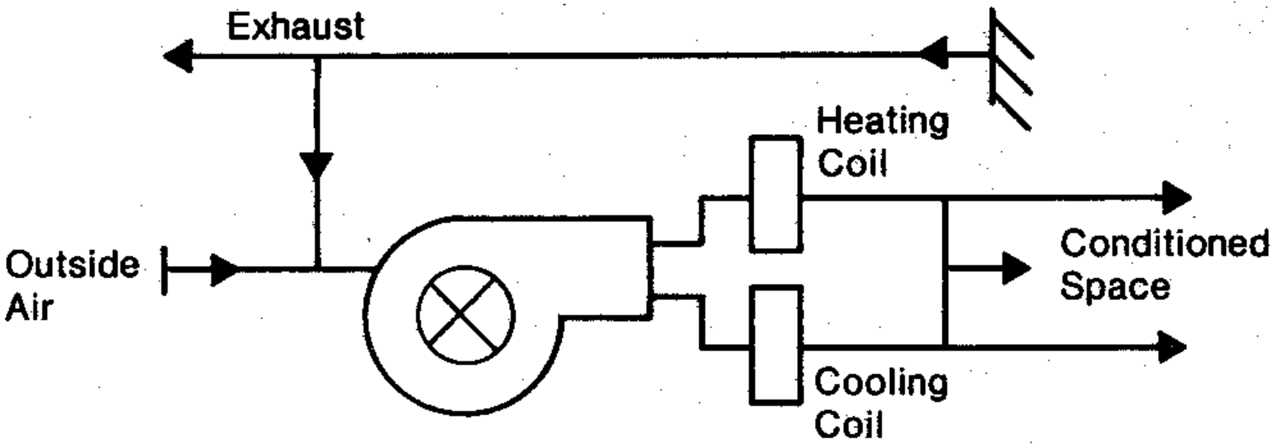
space served. The high pressure primary air is discharged within the unit through nozzles inducing room air through a cooling or heating coil in the unit. The resulting mixture of primary air and induced air is discharged to the room at a temperature dependent upon the cooling and heating load of the 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.

Fan Coil System

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.

Refrigeration Equipment

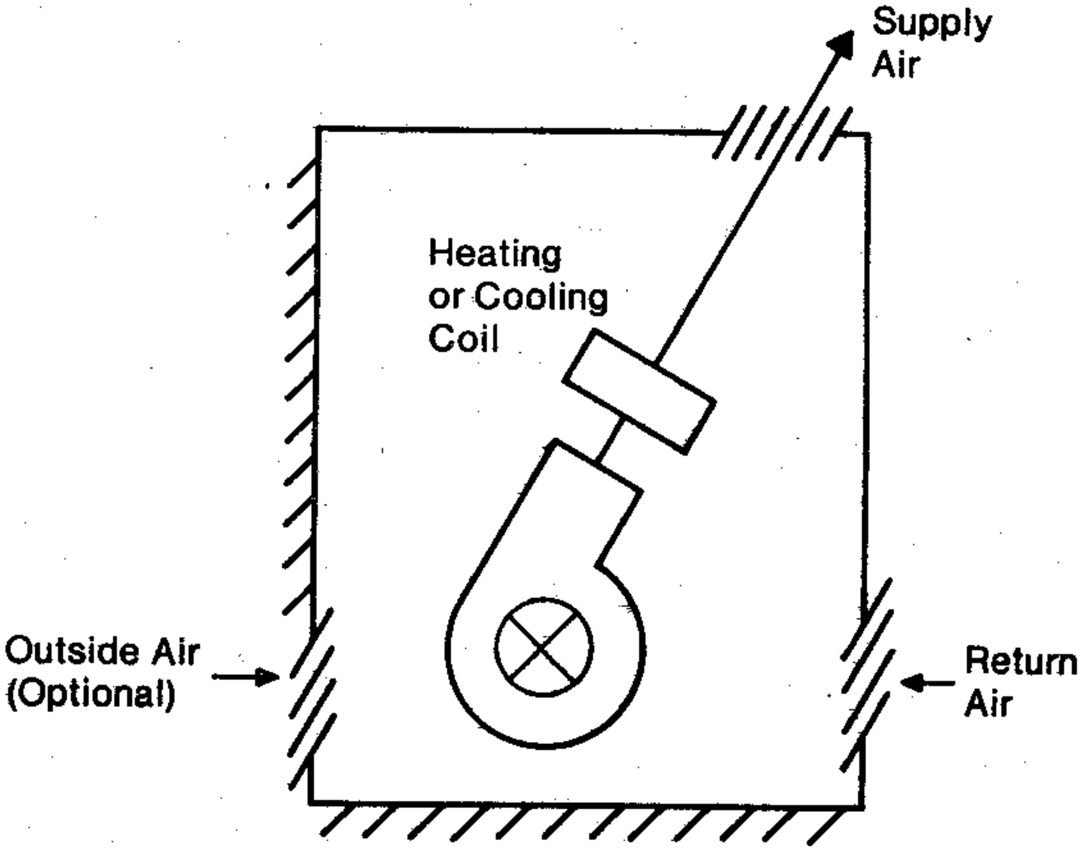
* Circuit and Controls

  -- 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.

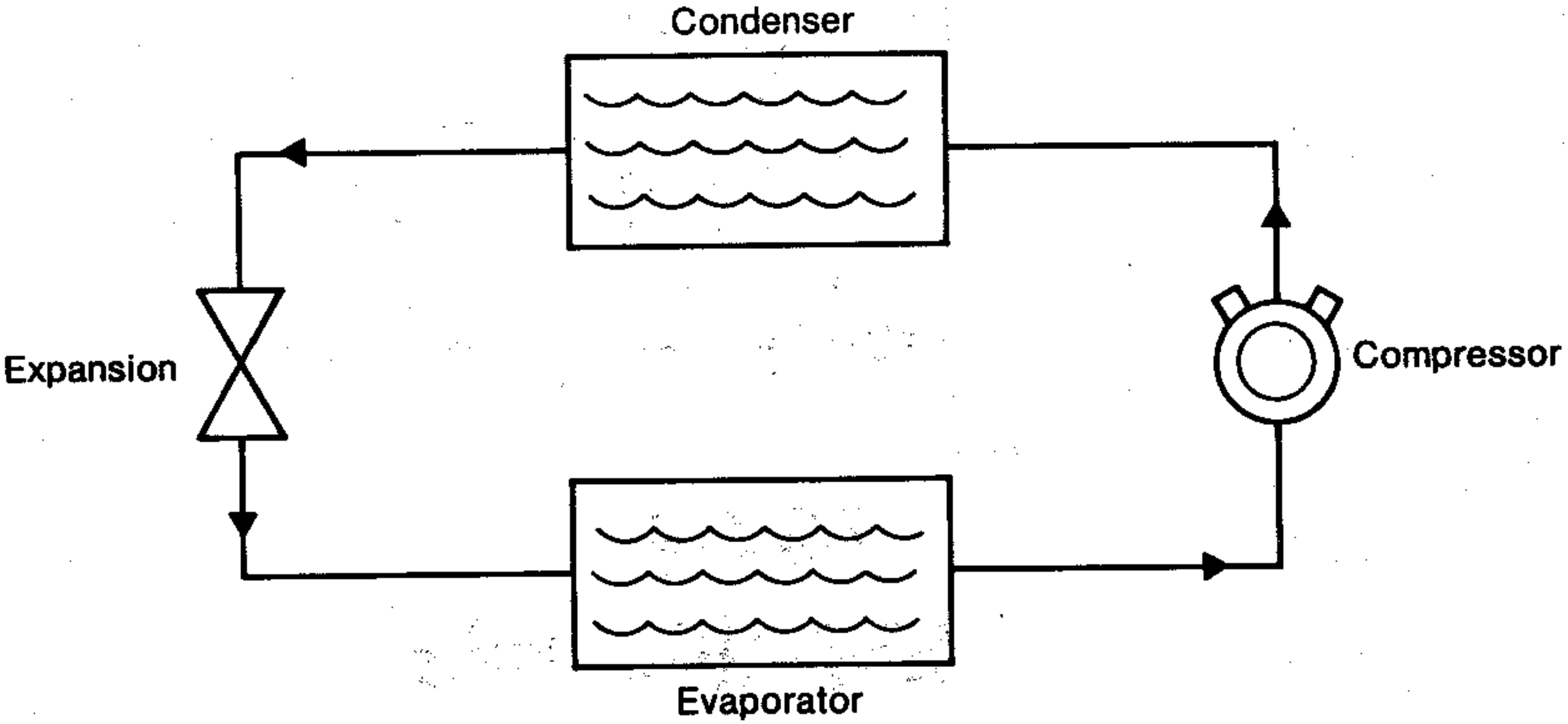
  -- Use a leak detector to check for refrigerant and oil leaks around shaft seal, sight glasses, valve bonnets, flanges, flare connections, relief valve on the condenser assembly and at pipe joints to equipment, valves and instrumentation.

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

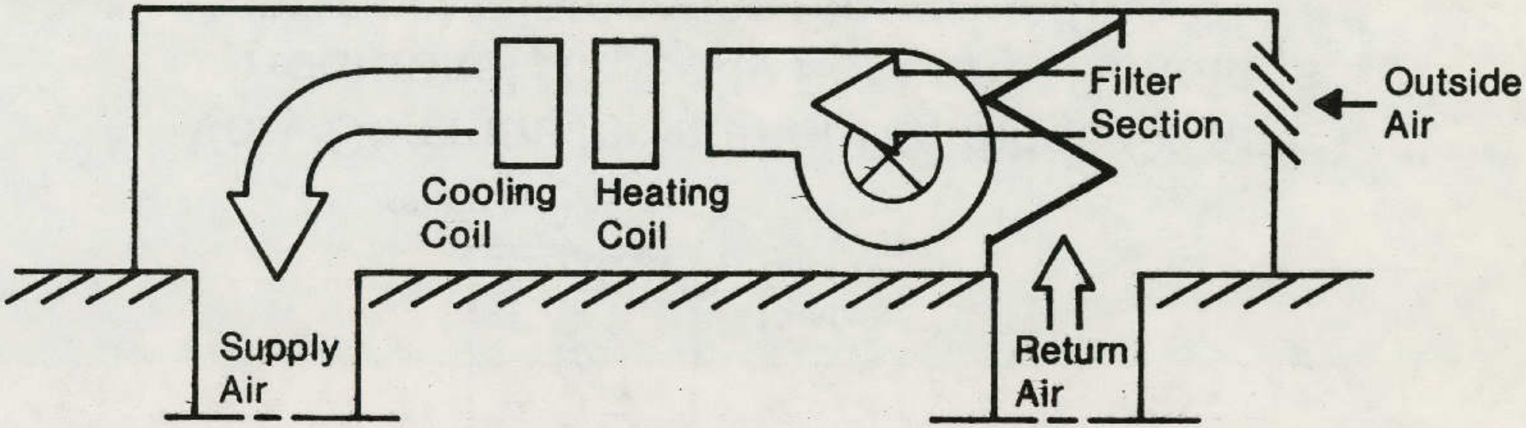
Fan Coil Unit
(2-Pipe)



Refrigeration Diagram:

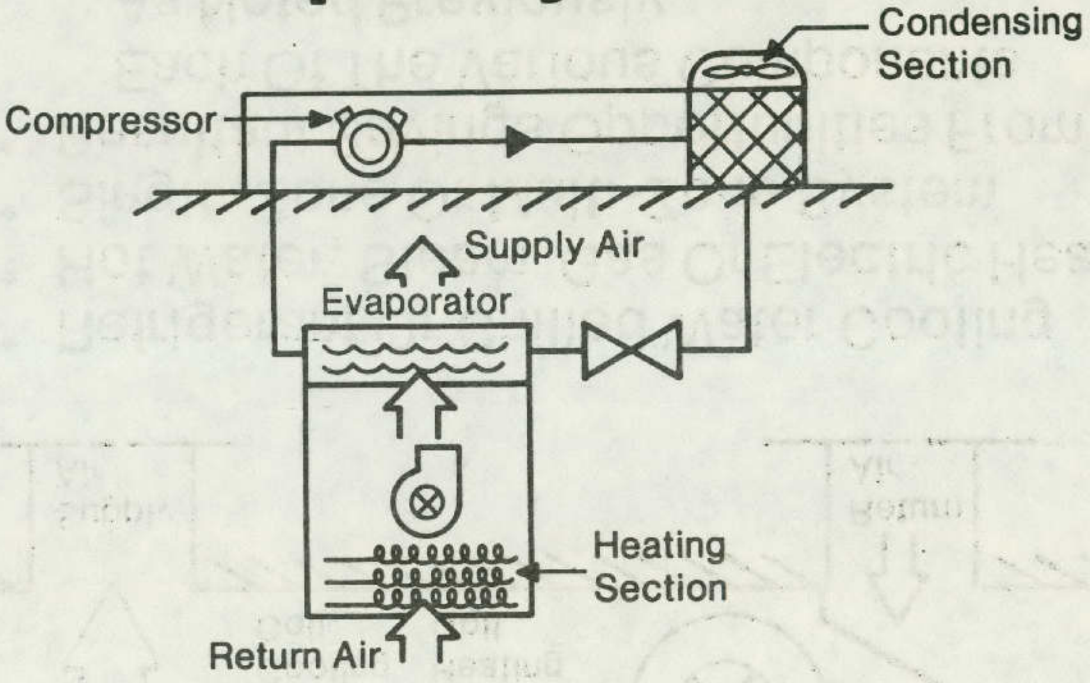


Rooftop Unit:



* 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

-- 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.

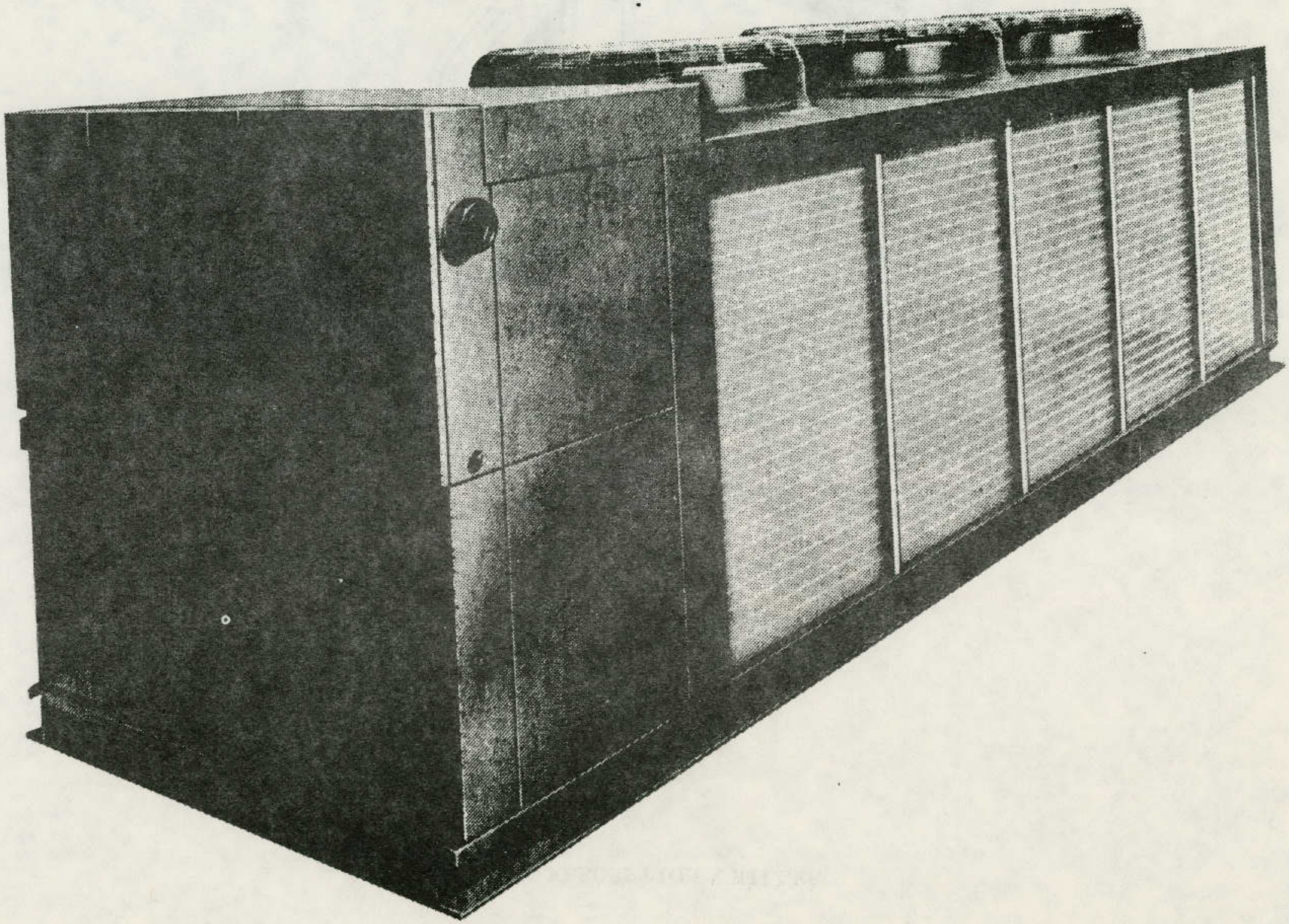
* Self-Contained Units (Windows and through-the-wall units; heat pump,etc.)

-- Clean evaporator and condenser coils.

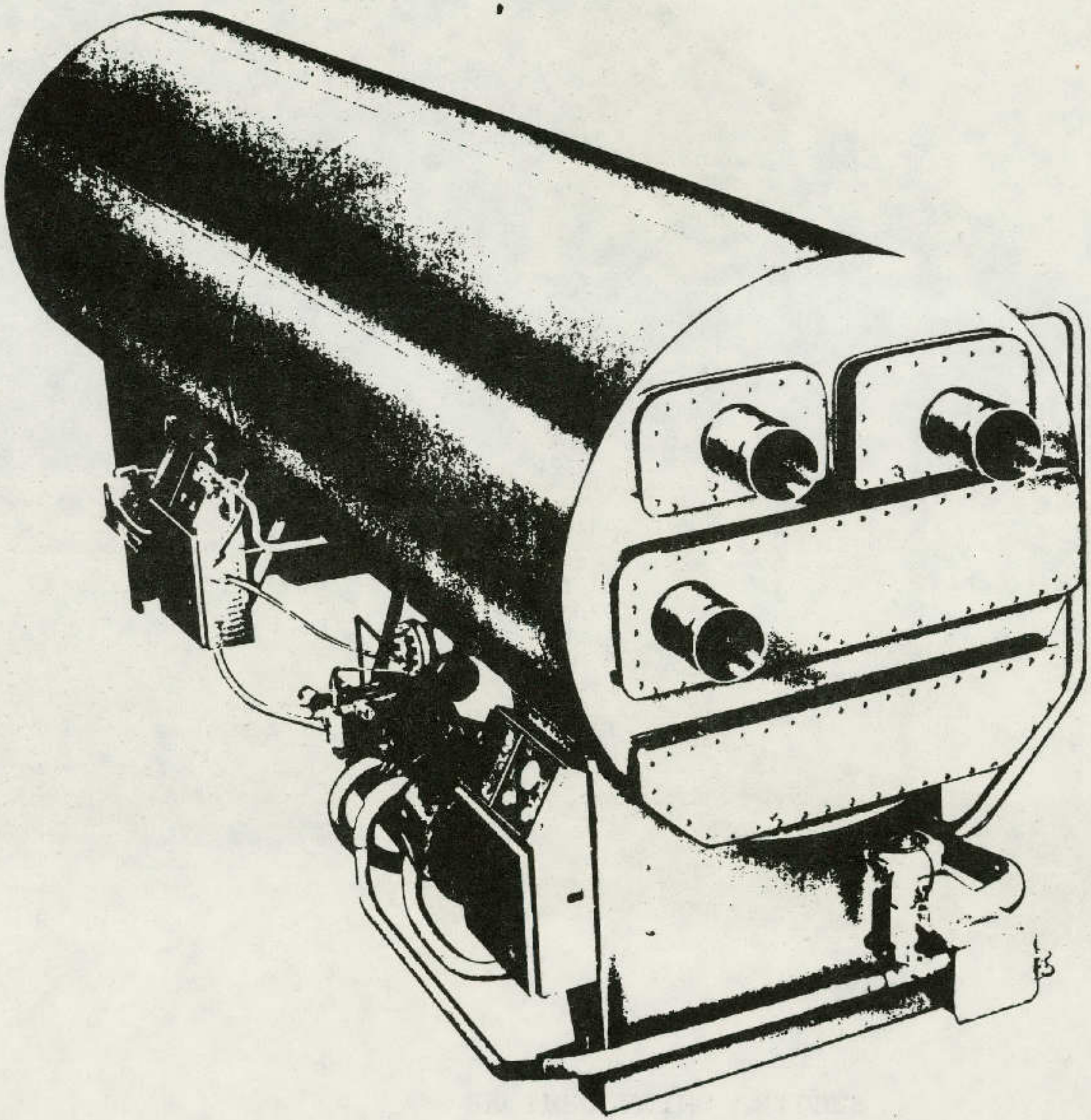
-- Keep air intake louvers, filters and controls clean.

-- Keep air flow from units unrestricted.

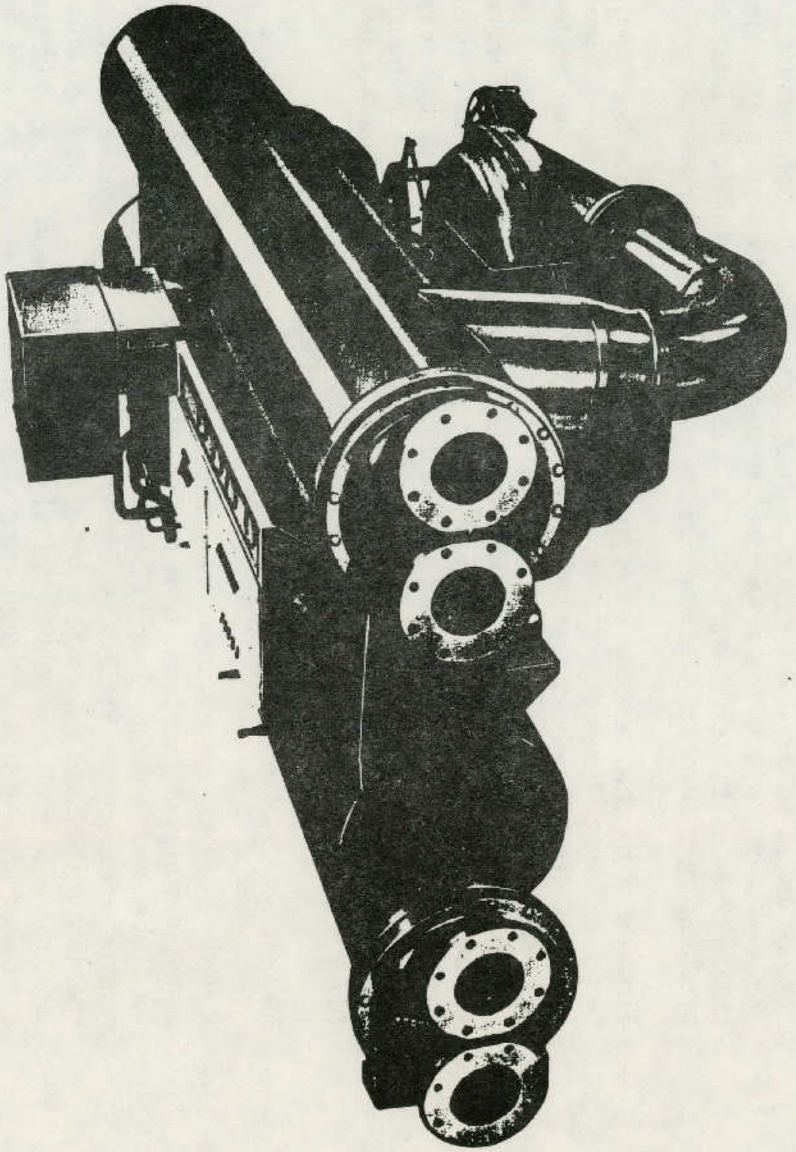
RECIPROCATING CHILLER



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.

Heating Equipment

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.)

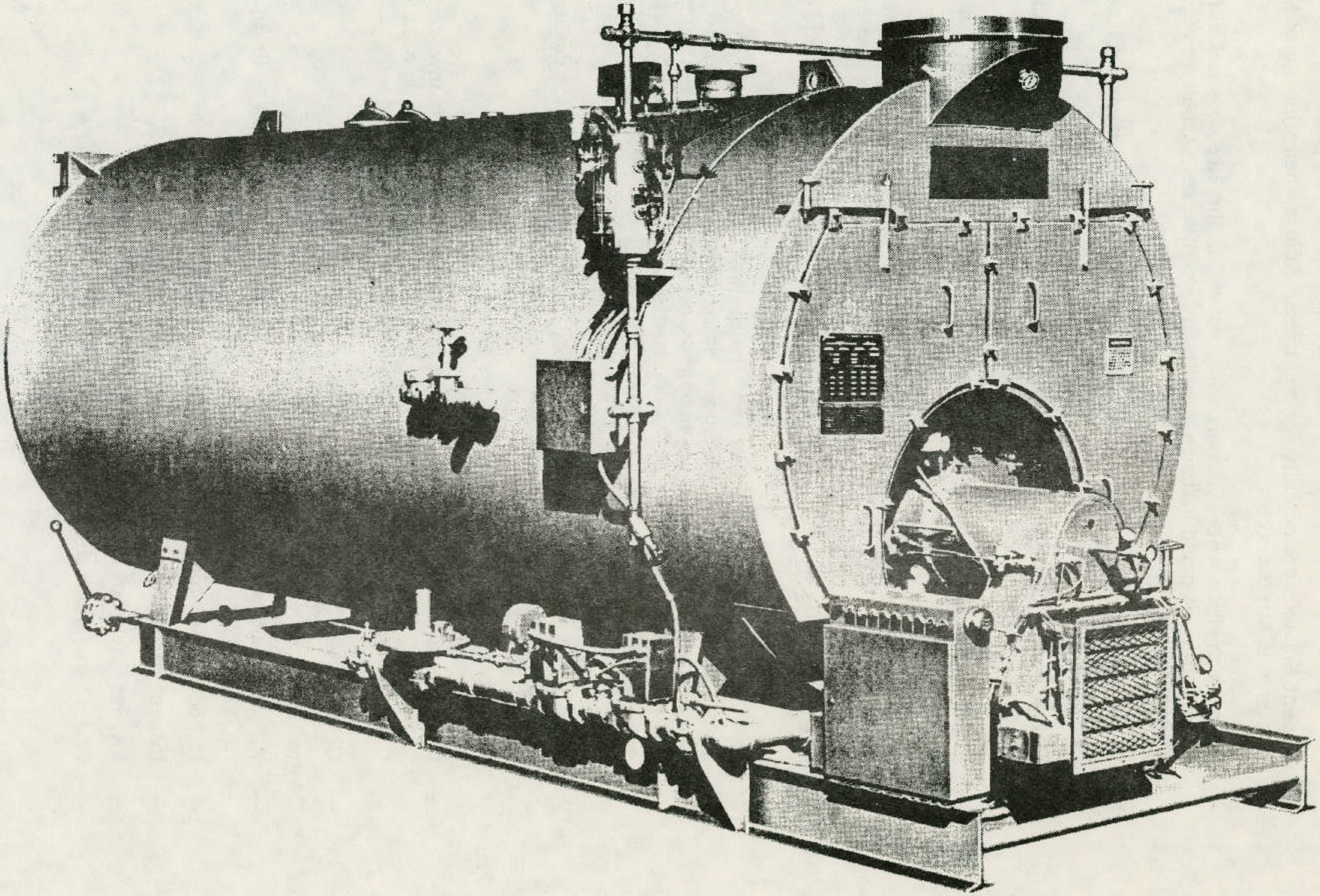
-- Fireside of the furnace and tubes must be inspected for deposits of soot, flyash and slag. Fireside refractory surface also must be observed. Soot on tubes decreases heat transfer and lowers efficiency. (If your boiler does not now have one, consider installation of a thermometer in the vent outlet. 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°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.

Hot and Chilled Water Piping

* 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.

Steam Piping

* 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.

Disribution 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.

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.

6

BUILDING SHELL

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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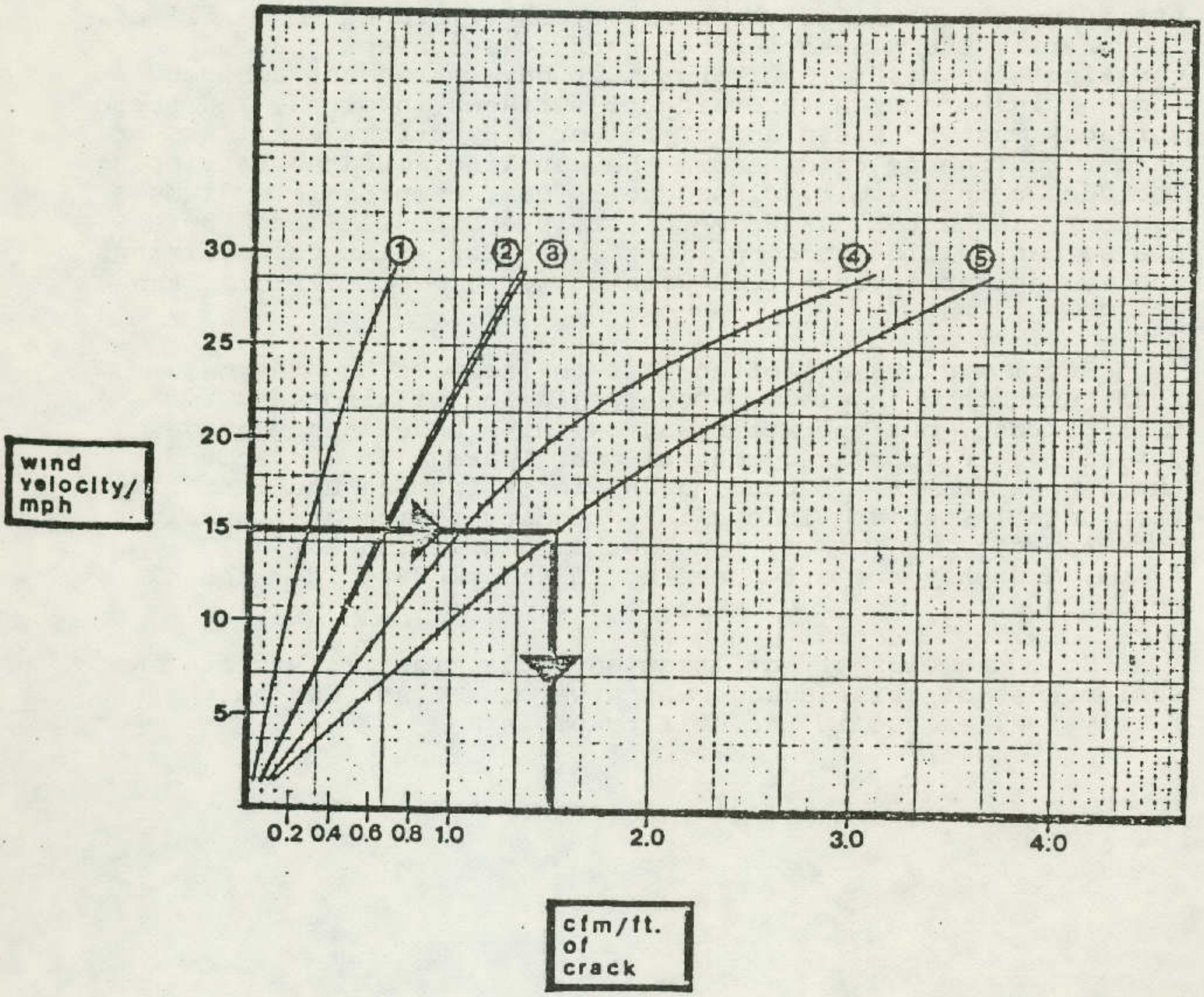
key to window infiltration chart

(leakage between sash & frame)

type	material	weatherstripped?	fit
① all hinged	wood	yes	avg.
	metal	yes	avg.
② all hinged	wood	no	avg.
	metal	no	avg.
dbl. hung	steel	no	avg.
③ all	wood	yes	loose
dbl. hung	steel	yes	avg.
④ casement	steel	no	avg.
⑤ all hinged	wood	no	loose



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	26,375	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

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fig. 48

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. wall	inside = gypsumboard insulation = R-17 exterior = sheathing plus wood panel, painted	.055 U-value

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

				HEAT LOSS THROUGH WALLS BTU/FT.^{2} YEAR											
				NORTH				EAST & WEST				SOUTH			
		SOLAR RADIATION	DEGREE	U=0.39		U=0.1		U=0.39		U=0.1		U=0.39		U=0.1	
CITY	LATITUDE	LANGLEY'S	DAYS	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	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
DENVER	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
CHICAGO	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. LOUIS	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 YORK	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 FRANCISCO	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
ATLANTA	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 ANGELES	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
PHOENIX	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
HOUSTON	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

fig 40

YEARLY HEAT GAIN/SQUARE FOOT THROUGH WALLS

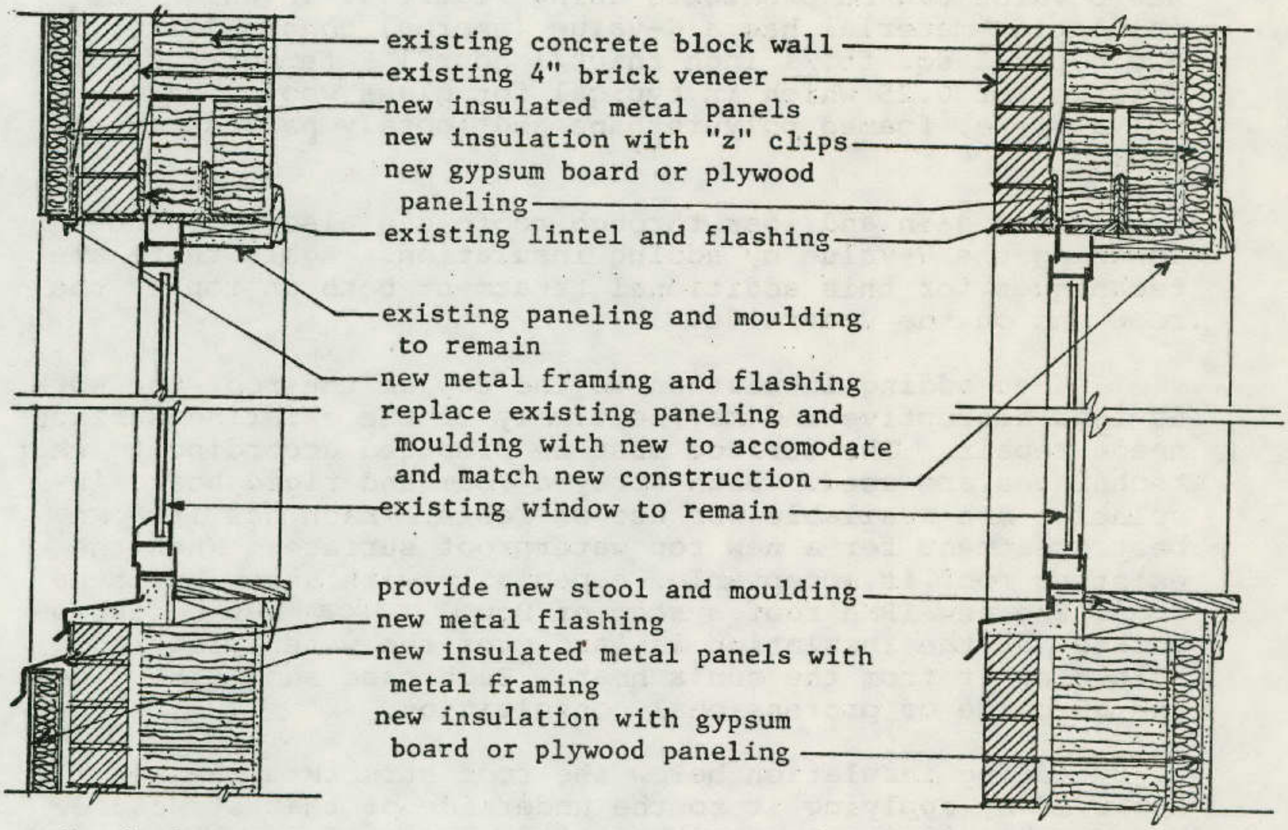
				HEAT GAIN THROUGH WALLS BTU/FT.^{2} YEAR											
				NORTH				EAST & WEST				SOUTH			
		SOLAR RADIATION	D.B. DEGREE HOURS ABOVE	U=0.39		U=0.1		U=0.39		U=0.1		U=0.39		U=0.1	
CITY	LATITUDE	LANGLEY'S	78°F	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	2,500	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

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

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.

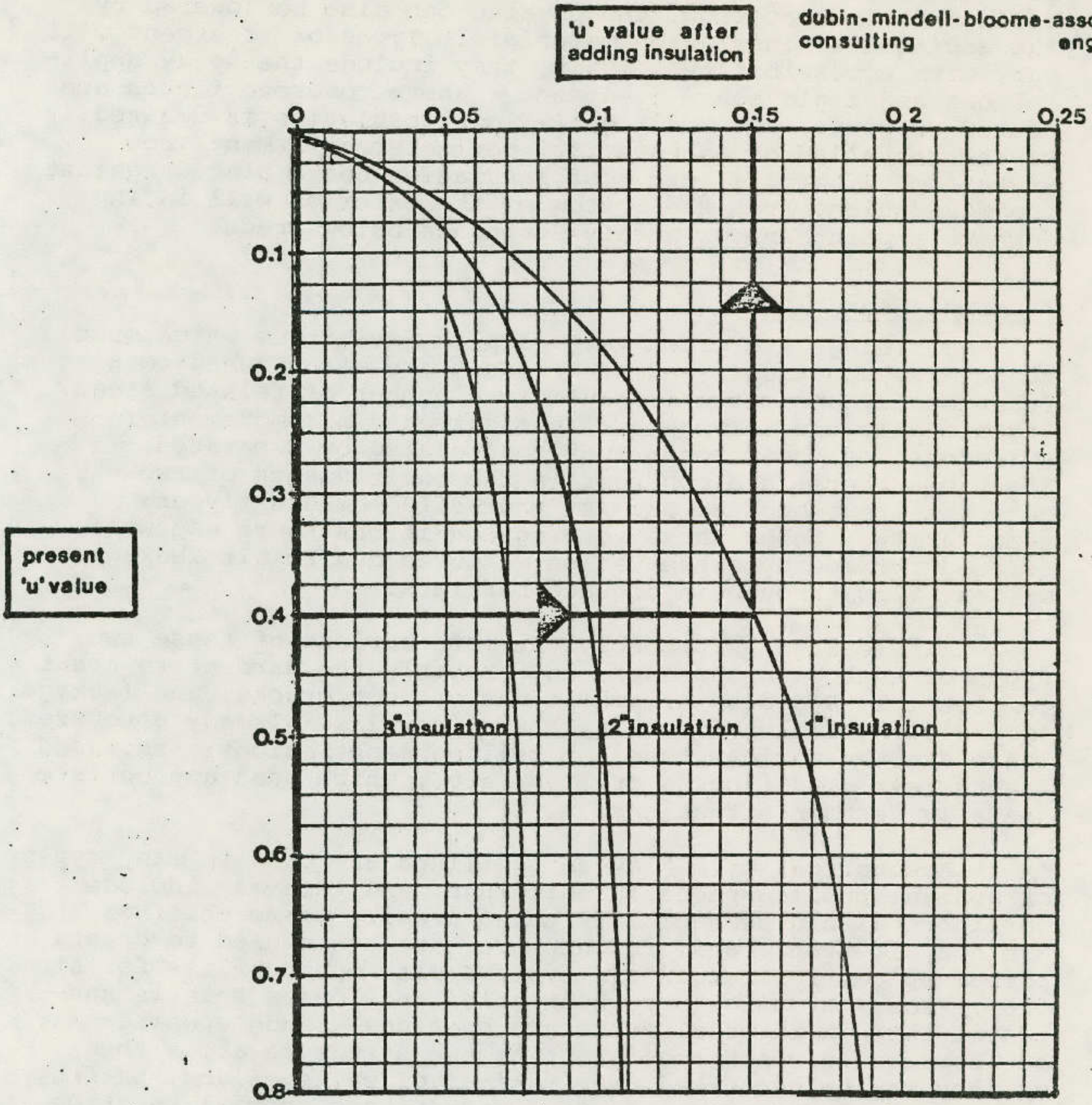
As a rule of thumb, the inches of duct insulation required is one fifteenth of the temperature difference between the conditioned air inside the duct and the unconditioned air in the attic space.

heating

effect of insulation
on 'u' value

fig. 37

dubin-mindell-bloome-associates
consulting engineers



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.($^\circ$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.

$Q = U \cdot A \cdot \Delta T$

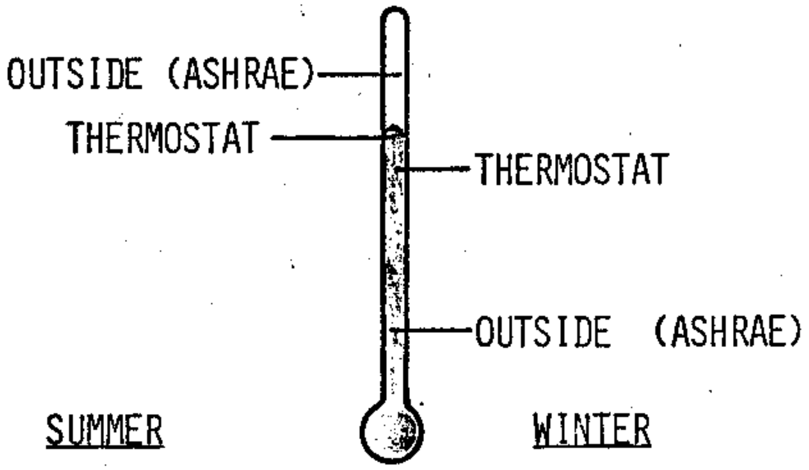
Q IS BTUH: HEAT FLOW PER HOUR

U = U-VALUE, FOR EACH TYPE OF WALL, GLASS, CEILING, ETC.

$$\text{U-VALUE} = \frac{1}{\text{R TOTAL}}$$

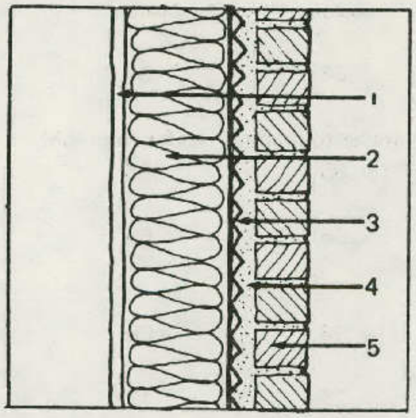
A = SQ. FT. AREA OF WALL, ETC.

ΔT = "DELTA-T" = DIFFERENCE IN THE DESIGN TEMPERATURES



TYPICAL WALL SECTIONS

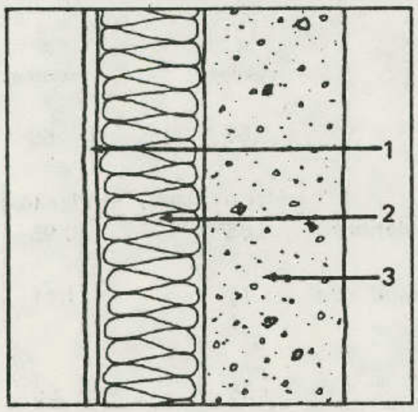
HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



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

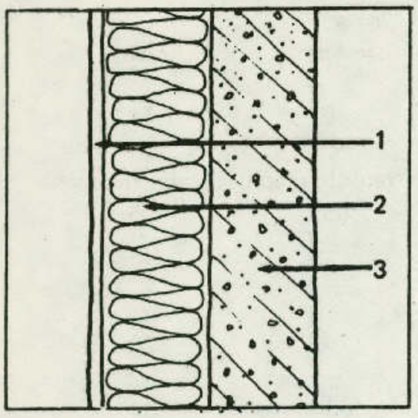


WEIGHT 95.5 lb./ft^2

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

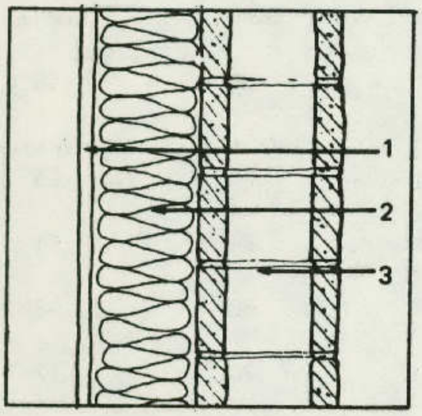
HEAT TRANSFER COEFFICIENT WALL CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation	(refer to graph)	(refer to graph)
	1½" Furring Space (without insulation)	.85	.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	(refer to graph)	(refer to graph)
	1½" Furring Space (without insulation)	0.85	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

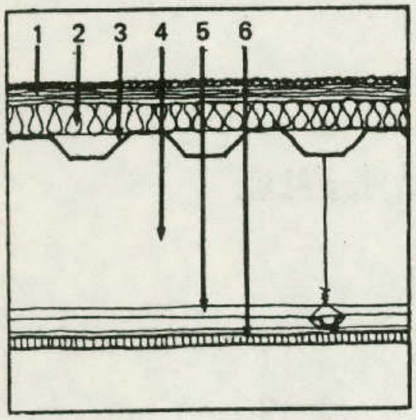
TYPICAL INSULATION MATERIALS

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

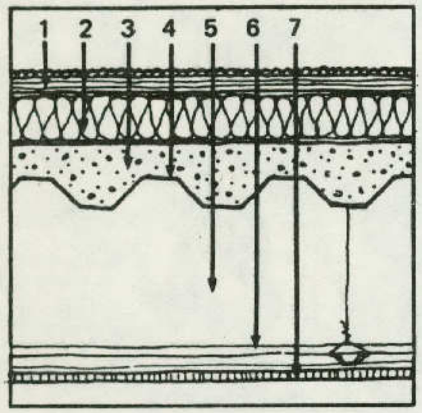
HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



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



	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

WEIGHT 26.7 lb./ft^2

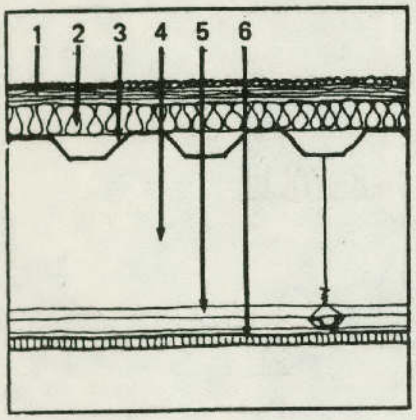
TYPICAL INSULATION MATERIALS

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

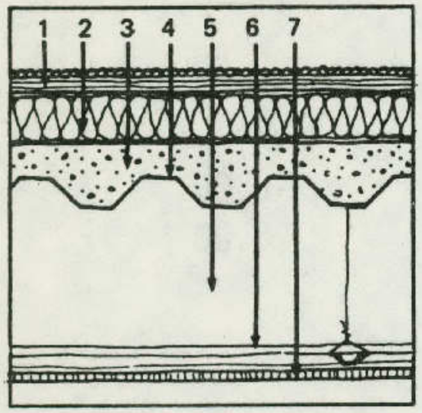
HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



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

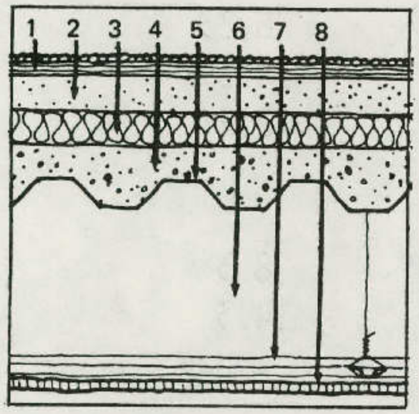


WEIGHT 26.7 lb./ft^2

	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



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

WEIGHT 31.7 lb./ft^2

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./°F
(U-VALUE)

WINDOWS	HIGH	LOW
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.

7

RESTAURANTS/COFFEE SHOPS

Restaurants

Table of Contents

Food and Beverage Department

This department contains many heavy energy users, so the opportunities to reduce your energy consumption significantly are excellent—if you are willing to tighten up the operation. The opportunities for energy conservation can be separated, in general, into those relating to food preparation (kitchen areas) and food service (dining areas). Consequently, this section has been organized along these lines to enable the Manager and Department Head to follow the recommendations more easily.

A 1974 national study on the distribution of the restaurant utility dollar indicates the following ranking:

	Table Service Restaurant	Fast Food Service
Food preparation	45.1%	27%
Sanitation	12.6%	-
Electrical	8.2%	26%
Refrigeration	2.0%	6%
Heating, ventilating, and air conditioning	32.1%	36%
Miscellaneous	-	5%

Note: Energy costs have increased markedly since 1974.

Here are some figures to give you a better idea of how the energy which is delivered to your kitchen is used. The terms Kilowatt Hour, Cubic Feet and BTU may still not mean much to some of you, so they have been converted to dollars and cents in order to make the point perfectly clear.

- Griddles cost 22 cents to 33 cents per hour to run.
- Fryers cost 15 cents to 33 cents per hour to run.
- Broilers cost 22 cents to 44 cents per hour to run.

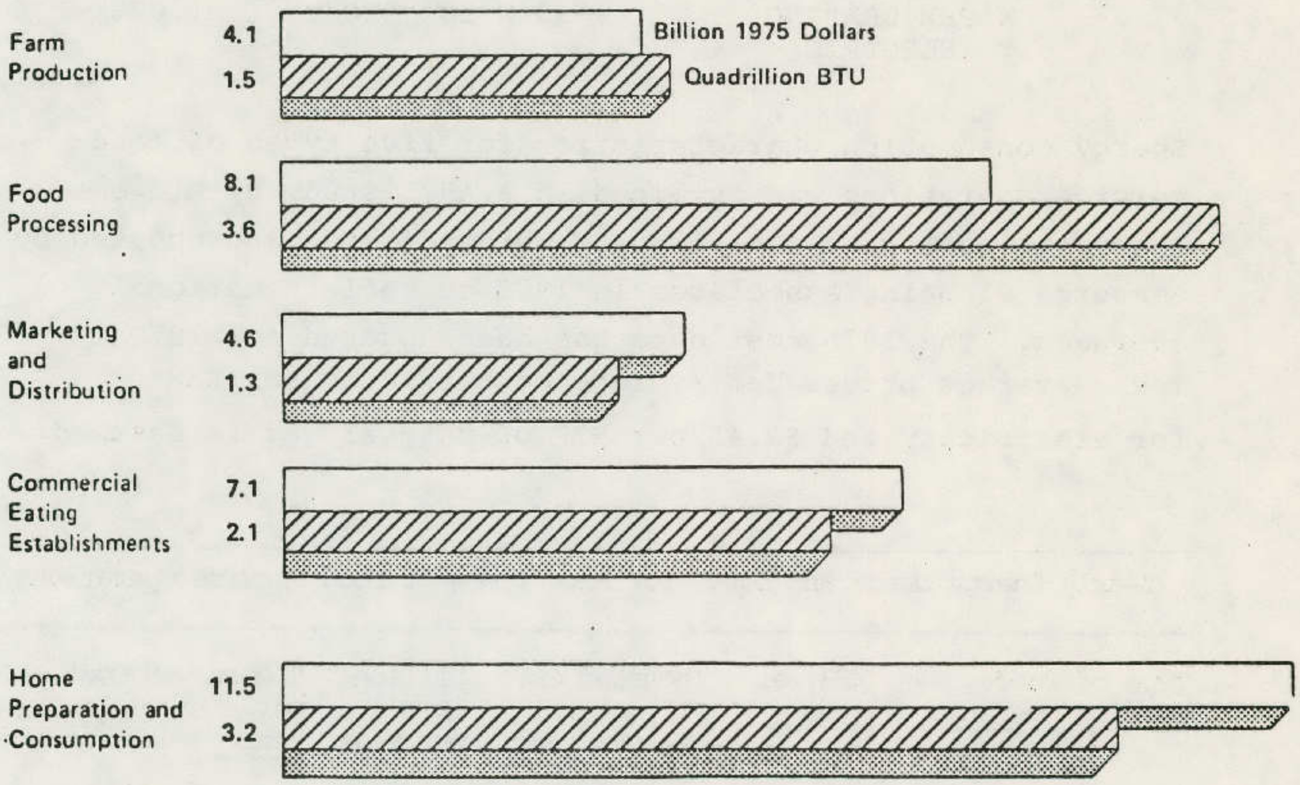
- Ovens cost 22 cents to 45 cents per hour to run.
- Ranges cost 50 cents to $1.00 per hour to run.
- Dishwashers cost 45 cents to $2.50 per hour to run.

These are average values, and they will vary with utility rates and appliance sizes. Nevertheless, it is easy enough to see that cutting down the running time of these appliances and using them only when they are actually needed should really make a big difference not only in the cost to you, but in the amount of energy which is used.

Remember, too, that no energy conservation program can succeed unless your equipment receives proper cleaning and maintenance care. Regular schedules of cleaning and maintenance will extend the life of the equipment, keep it operating at top efficiency, and conserve energy.

According to a U.S. Department of Agriculture report*, commercial eating establishments spent over $7 billion in 1975 on energy costs alone. Expenditures in 1979 will be in excess of $10 billion.

ENERGY IN U.S. FOOD SYSTEM, 1975



The 2.1 quadrillion BTUs consumed by commercial food service operations represents almost 3% of national energy consumption.

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*Energy Policies: Price Impacts on the U.S. Food System. Thomas Van Arsdale and Patricia J. Devlin, U.S. Department of Agricultural Economic Report No. 407, July 1978, p. 3.

Consumption by different components is illustrated by the following table:

COMMERCIAL FOOD SERVICE ACCOUNTS
FOR 3% OF U.S. ENERGY USE

COOKING	150 X 10^{9} BTU/YR.	(.2%)
SPACE HEATING	1200 X 10^{0} BTU/YR.	(1.6%)
REFRIGERATION	50 X 10^{9} BTU/YR.	(.07%)
AIR CONDITIONING	300 X 10^{9} BTU/YR.	(.4%)
WATER HEATING (ELECTRIC)	50 X 10^{9} BTU/YR.	(.07%)

Energy consumption characteristics for five types of food service operations was outlined in a 1973 study by Midwest Research Institute. The figures were adjusted and updated by Resource Planning Associates in 1975 to reflect national averages. The 1975 cost data has been updated for 1979 Texas average prices (an average cost of 4.5¢ per KWH for electricity and $2.45 per MCF of natural gas is assumed).

Yearly Energy Usage and Costs for Five Types of Food Service Operations

Type of food service operation	KWH per year	Thousand Cu. Ft. natural gas per year	Million BTU's per year	$ Cost per year	$ Cost/Yr. Tx. 1979*
Fast food	216,000	1,500	2,237	7,320	13,395
Coffee Shop	249,821	1,826	2,679	8,648	15,716
Table Service	284,000	2,500	3,469	10,680	18,905
Cafeteria	473,850	4,754	6,371	18,985	32,971
Hotel/Motel	852,974	5,666	8,577	28,391	52,266

Sources: 1973 sample data compiled by Midwest Research Institute. Adjusted and updated to reflect 1975 national averages by Resource Planning Associates.

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*PLANERGY estimates, using natural gas cost of $2.45/MCF and electricity costs of 4.5¢/KWH.

Southwestern Public Service Company

P.O. BOX 631 • LUBBOCK, TEXAS 79408

COMMERCIAL ELECTRIC COOKING

OPERATING COST ANALYSIS

To determine the operating cost of commercial cooking appliances, there are two factors which must be considered. First is the amount of energy consumed, second is the demand established.

KWH (energy requirements): The energy required can be determined, to a fair degree of accuracy, by determining the input necessary to maintain operating temperature of the appliance, and the energy required to cook a given amount of products.

To show the method of calculating energy requirements, the following example is used:

PROBLEM: A restaurant has a Mark 313 Fryer (which has a fat capacity of 28 pounds). It is operated an average of ten hours, and during this time is used to french fry one hundred pounds of potatoes. How much energy is required for the day's production?

In a fry kettle, an average of thirty watts per hour, per pound of fat, is required in order to maintain an average temperature of 350° Fahrenheit in the fat (but not the product cooking). Therefore, the energy required to idle the fryer would be energy per hour, per pound, times the number of hours, times the number of pounds. 30 W x 10 hrs. x 28 lbs = 8,400. Since 8,400 is the product of watts times hours, it will be expressed as watt hours, and can be further reduced to KWH by dividing by 1,000 (the number of watts in a kilowatt).

$\frac{8,400}{1,000}$ WH = 8.4 KWH = The energy required to maintain operating temperature in fry kettle for ten hours.

The approximate energy requirements to cook a product can be calculated by the BTU (British Thermal Unit) method.

One BTU is the amount of heat required to raise one pound of water one degree Fahrenheit (1° F). All food have a conversion factor with reference to water.

Example: Factor for a potato is .78, i.e., it required 78% as much heat to raise any given number pounds of potatoes a given number of degrees, as would be required to raise the same number of pounds of water the same number of degrees.

The next step of our problem is to determine the amount of energy required to cook one pound of potatoes from room temperature (approximately 70° F.) until they are done.

Since potatoes, like all vegetables, are considered done when internal temperature of 200° F. is reached, a temperature rise of 130° F. (200° minus 70° F.) is required. This formula is expressed as:

BTU's Required = °F. temperature rise x number pounds product x conversion factor
BTU's Required = 130° F. x 1 x .78
BTU's Required = 101.4

Heat units (BTU's) can be translated into terms of energy (watts) by dividing by 3.412 (number of BTU's in one watt), or can be expressed as a formula: $W = \frac{BTU}{3.412}$

In the example above: $W = \frac{101.4}{3.412}$ = 29.7 watts per pound

For all practical purposes, we can say that it required 30 W per pound to cook potatoes. Since 100 pounds of potatoes were cooked, requiring 30 watts per pound, it is determined that 3,000 watts, or 3 KWH, were required (30W/Lb. x 100 Lb.).

This 3 KWH added to 8.4 KWH (energy to idle fryer ten hours) gives the total KWH's used to french fry 100 pounds of potatoes during the ten hour period.

3.0 KWH	Required to cook 100 pounds.
8.4 KWH	Required to maintain fryer temperature
11.4 KWH	Total used in cooking 100 pounds of potatoes over a ten hour period

By using the method as outlined, the energy requirements for cooking any food product, by any cooking method, can be determined. It is not necessary to go through the full procedure. This procedure was outlined only to show how the following charts were developed.

We will have two charts. Chart number one lists the different types of cooking equipment with the energy requirement to maintain operating temperature expressed in watts per hour. Chart number two lists the different foods with the energy requirement to cook product expressed in watts per pound.

By using the factors from these two charts, a simple formula of energy required is written, where:

Total KWH = (energy to maintain operating temperature, times operating hours) plus (energy to finish one pound of product, times number of pounds of product) all divided by 1,000

Example: Roast oven operating four hours and used to roast fifteen pounds of fresh beef. How much energy is required?

Solution: $\text{KWH} = \frac{(840 \times 4) + (20 \times 15)}{1{,}000} = 3.66 \text{ KWH}$

CHART #1

TYPE EQUIPMENT	ENERGY TO MAINTAIN OPERATING TEMPERATURE (IN WATTS PER HOUR)
Fryer	30 Lb.
Oven (Bake)	750 Section
Oven (Roast)	840 Section
Griddle	330 Sq. Ft. of Area
Broiler	*
Range	**

The broiler is a constant input appliance. Therefore, operation should be figured only on imput rating. The product should be disregarded except as it effects operating time.

Example: Hotpoint HBG 18 Broiler has four controls, each one governing one-fourth of total input.

Rated Input:	Full On	12.0 KW
	3/4 On	9.0 KW
	1/2 On	6.0 KW
	1/4 On	3.0 KW

KWH usage will then be figured on basis of input, multiplied by time in hours.

Example: HBG Broiler on 3/4 used 45 minutes. 9.0 KW x .75 hours = 6.75 KWH.

** The commercial electric range is a combination appliance. The oven requirements can be figured as any other roast oven. The griddle, or slab top range, using a thermostatic control, can be figured on the same basis as the griddle. Where a three heat switch is used, energy to maintain operating temperature of cooking surface must be figured on basis of input.

Example: One grid section of Hotpoint hot top range with three heat switch has input of 5,300 W or 5.3 KW of high heat. Medium heat is 1/2 or 2.65 KW. Low heat is 1/4 or 1.3 + KW. Calrod units and french plates are figured on the same basis.

CHART #2

FOOD PRODUCT	ENERGY REQUIRED TO FINISH PRODUCT (IN WATTS PER POUND)
Beef (Fresh)	20
Beef (Frozen)	34
Bread or Rolls (Dough)	28
Bread or Rolls (Brown & Serve)	12
Fish & Seafoods (Fresh)	30
Fish & Seafoods (Iced or Frozen)	35
Pork (Fresh or Smoked)	22
Pork (Frozen)	37
Potatoes (Raw)	30
Potatoes (Pre-Blanched & Frozen)	45
Poultry (Fresh)	22
Poultry (Frozen)	26
Pies (Average of all types)	35
Vegetables (Raw)	42*
Vegetables (Frozen)	50*
Vegetables (Dried)**	18*

* Average of most commonly used.

** Factor for dried vegetables based on premise that product is soaked before cooking.

Food Preparation — Kitchens

General

- **Set up schedule of preheating times for kitchen appliances and stick to it.**
  Equipment should be turned on at a specific time to a specific temperature, and turned off at times when it is not needed. A 10 to 15 minute preheat period is sufficient for solid-top gas ranges. A deep fat fryer requires only 7 to 15 minutes for preheating. Consult manufacturer's instructions for individual appliances.

- **Cook in the largest volume possible.**
  Most food service operators find they can cook some items partially or completely in advance, thus making more efficient use of energy.

- **Set thermostats to the lowest temperature that still gives satisfactory results.**
  Dialing higher does not reduce preheating time, while a lower temperature results in lower energy consumption because less energy will be lost to the surrounding air.

- **Reduce "peak loading."**
  Your electricity bill is determined by two factors: (1) a demand charge, the highest (or peak) kilowatt use for any short time period during the month (usually 15 or 30 minute period); and (2) an energy charge based on your total consumption in kilowatt hours. Some rules to follow in reducing peak use and demand charges are:
    - Schedule energy-intensive cooking, such as baking and roasting, during non-peak demand hours (periods in which the least amount of electric energy is being used in the kitchen and in other departments).
    - Set a limit on the number of electric appliances which may be used at the same time.

- **Replace all defective parts and broken equipment promptly.**

- **Keep records of breakdowns, parts replacements, and regular maintenance checks on all equipment.**
  Poorly functioning equipment, and worn or dirty parts, waste energy.

- **Plan menus to minimize energy usage.**
  Meals which require less cooking time to prepare will use less energy, and can still be appealing.

Surface Cooking Units

- **Place foil under range and griddle burners.**
  The operating efficiency will improve, and the equipment will be easier to clean. (But don't block air inlet openings for gas burners.)

- **Cover pots and pans with lids.**
  They will keep the heated air in and decrease cooking time.

- **Turn down heat as soon as food begins to boil, and maintain liquids at a simmer.**
  Keeping the heat higher than the boiling temperature does not cook food any faster, and it uses more energy.

- **Keep all cooking surfaces clean.**
  Build-up of grease and other encrusted matter reduces cooking efficiency.

- **Place weight on bacon and sausage to quicken cooking time.**
  (But note that this may alter the characteristics of the product.)

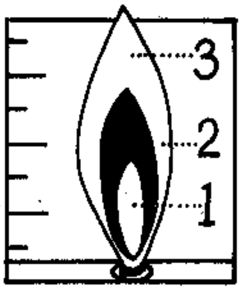
- **Regularly check all gas units for uneven or yellow flames.**
  To correct the condition, clean the burners, pilot lights, and orifices with a stiff wire brush. If the flame is still yellow or uneven, have your serviceman correct the gas-to-air mixture by adjusting the air shutters.

- **Ask the utility company to check regularly that adequate gas pressure is being supplied.**

RANGETOPS

- **Group kettles and pots on closed-top ranges.**
  By using as little surface area as possible, and adjusting heating elements to desired levels, heat loss will be decreased.

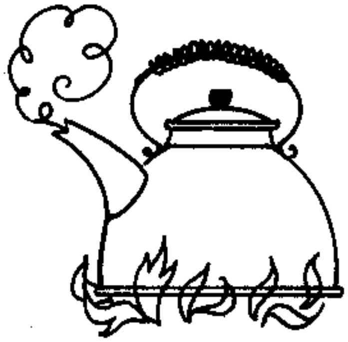
- **Do not turn gas burners on until you are ready to cook.**



- **Regulate gas burners for optimum heating and energy efficiency.**
  Adjust the flame until it is entirely blue and has a firm center cone. The tips of the flame should just touch the utensil bottom.

- **If you must keep electric burners on for short periods when they are not actually in use, reduce the temperature until you are ready to cook.**
  This will not only conserve energy, but it will also prolong the life of the burners. Only a few minutes are required to bring the surface of a solid top range up to cooking temperature.

- **Burners should always be smaller than the kettle or pot placed on them.**
  The diameter of the pot should be about 1" larger than the diameter of the electric coils or plates.



- **Use flat bottom pots and pans to maximize heat transfer.**

- **Clean off build-up of spilled food.**
  Review manufacturers' recommendations for cleaning rangetops and develop a schedule to have it done daily or even more frequently.

GRIDDLES

- **Use a low or medium flame for light griddling.**

- Remove water or ice from product before frying to eliminate temperature fluctuation and fat breakdown.
- **Turn the burners down during slack periods.** Use thermostatic control when possible to avoid continuously high or excessive heat.
- **Place food being cooked close together and heat only that portion of the griddle being cooked on.**
- Griddles will cook different foods simultaneously at different temperatures.
- **Scrape off excessive food and fat particles after each cooking use.**
- **At least daily, clean and wipe out the grease troughs and remove any stuck-on food.**
- Place a weight on meat to force good contact with cooking surface or place a deep pot lid over product to allow steam to speed cooking.
- Filter fat at least once a day. More often with high volume cooking.
- **Regularly use a reliable commercial thermometer to check surface temperature against the control dial reading.** If the readings do not match, your thermostat may need recalibrating. Many utilities and commercial maintenance companies offer this service.
- Recalibrate thermostats twice a year.

BROILERS

- Gas broilers heat quickly. Turn the flame low between operations. During slack periods, turn the broiler off.
- Clean grate of carbonized grease daily.
- Clean baffles, drip pans, and grease troughs daily.
- If equipped with heat reflector, clean and polish daily.

- **Keep briquets clean.**

- **Turn char-broiler heat to medium after briquets are hot.**

- **When practical, load heated broilers to capacity to utilize the entire surface area.**

- **Use infrared broilers to advantage.**
  These can be turned off when not in use and quickly reheated.

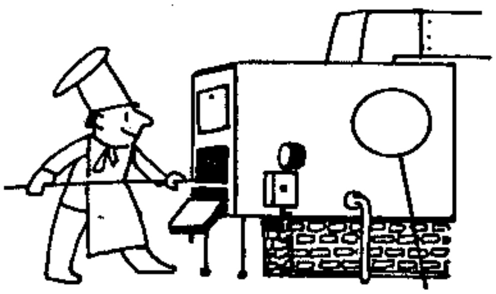
- **Correct faulty operation of burners.**
  A blue flame with a distinct inner cone is best. Flames should never float or strike directly on refractor elements but should just wipe the surface. To accomplish this:

    - **Clean burners and be sure openings as well as air shutters are clear.**
      (Handle ceramic refractor units carefully.)

- **Replace damaged refractory ceramics as needed.**

- **Have gas burners checked semi-annually by an experienced service representative.**

Ovens



- **Use warm-up time to begin cooking food** (except for food which will dry out or overcook).
  Start the day's baking with foods that require the lowest oven temperature. Use other electrical appliances sparingly while preheating electric ovens to avoid excessive demand charges.

- Stagger preheat of oven sections. Use a minimum of other electrical appliances while preheating. This will keep the instantaneous electrical demand down.

- **Plan baking and roasting to use ovens to capacity.** This eliminates bringing the oven to full heat more than once or twice a day. Energy is wasted when all of the available cooking heat is not used. In standard ovens, allow at least a 2-inch clearance for air to circulate around pans. Convection ovens may require less circulation space.

- **In roasting, save energy by using lowest practical temperature.**

- Deck ovens can be used simultaneously at different temperatures.

- Operators bake potatoes in aluminum foil. This makes for an attractive product. But it's a steamed potato. And that shiny foil covering can reduce oven effectiveness by as much as 75 degrees F. which only adds cooking time, temperature, and energy. If you feel you must bake in foil, turn the dull side out as it absorbs more heat.

- **Load and unload quickly to avoid unnecessary heat loss, and avoid opening doors to look at food.**
  For every second an oven is open, the interior temperature can drop as much as 10°F.

- **Remove boil-overs and spill-overs promptly to avoid buildup of carbon deposits which can adversely affect efficiency of the unit.**

- **Repair broken door hinges and cracks that allow heat to escape.**
  Clean all crumbs and encrusted matter from around the door opening. Don't slam or stand on oven doors.

- **Every few months have a qualified service representative calibrate the oven thermostat.**
  If your oven is not heating normally, have it checked immediately. Higher than necessary temperatures waste energy.

- Consider using heavy duty broiler for roasting or baking in lieu of oven.
- During late afternoon, when electric utility demand peaks, augment heavy-duty equipment with convection, microwave or warming ovens.
- Clean lower edges of doors of any charred food on a regular basis.
- Regularly clean decks of carbonized food particles.
- **Once or twice a year check the level of ovens.**
  Look for warped oven sides or bottom which can contribute to improper door closing and thus to energy waste. Re-level ovens as necessary.
- **Have gas service company representative check burners, thermostats, door closings, and insulation annually.**

CONVECTION OVENS

- **Follow manufacturer's instructions for cleaning fan blades.**
  The accumulation of foreign material can restrict the amount of air delivered and waste energy.
- **Have the motor checked annually.**
  Proper performance is essential to peak efficiency.
- Both deck and forced-convection ovens cook at lower temperatures than conventional ovens.
- Forced-convection ovens preheat much more quickly than conventional and standard deck ovens. However, they will quickly dry out food if not used properly.

MICROWAVE OVENS

Microwave ovens have been widely used for their ability to thaw food and reducing the energy needed to complete the cooking. Managers have successfully found ways to batch-cook products and reheat in the microwave oven when ordered. Menus can be extended as a result of the fast cooking of the microwave oven. Major companies are available to assist food service managers in making appropriate menu choices for microwave application, based on size of the establishment, extensiveness of menu, and food product.

- **Consider using microwave ovens for reheating and reconstituting.**
  According to manufacturers' data, microwave ovens may use less energy than conventional ovens by doing the job in less time.

- **Carefully follow instructions in the user's guide.**
  Use only recommended utensils to avoid damaging the interior surface door seals.

- **Wipe up spills frequently, and keep interior surfaces clean.**
  Never use abrasives which may scar or nick the oven surface and eventually reduce efficiency.

- **Have the timer professionally checked at least once a year.**
  (While the serviceman is there have him check for radiation leakage.)

Fryers

- **Turn thermostat up only as high as required to reach frying temperatures (310-360°F).**
  Preheat time from room temperature to 350°F is only about 5 minutes.

- **Do not load beyond manufacturer's stated capacity.**
  Normally, baskets are loaded to one-half to two-thirds capacity. Crowded food takes longer to cook and wastes energy.

- **Check cooking oil level frequently.**
  Food must be covered with oil to cook correctly. Add fresh oil if level drops below marker. Cooking without sufficient covering oil wastes energy.

- **Clean fryers regularly.**
  They perform better and use less energy. Be sure procedures are carried out as recommended by manufacturers.

- **Drain fryer daily.**

- **Regularly inspect and clean interiors of fixed-well fryers for grease or carbon deposits.**

- **Check the temperature of cooking oil often to be certain heating elements and thermostat controls are working correctly.**
  Use a reliable commercial thermometer.

- **Clean heating elements at least weekly.**
  This should be done daily if you do high-volume frying. Remove all traces of burned food, grease, or carbon.

- Consider a method of insulating the fry kettle. Military facilities have cut cooking time by 25% by an application of exterior insulation to fryers.

Food Warmers & Hot Plates

- **Turn on only as needed.**
  Do not let them operate when not in use, and make certain they are turned off at night.

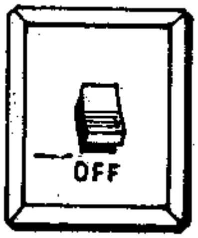
- **Operate at the lowest temperature which is permissible for safe food handling.**

- Cut back the number of active heat lamps to the immediate needs of meal service periods.

Toasters

- **Turn off rotary toasters when not in use.**

- **Clean regularly.**
  Clean equipment performs more efficiently and uses less energy.



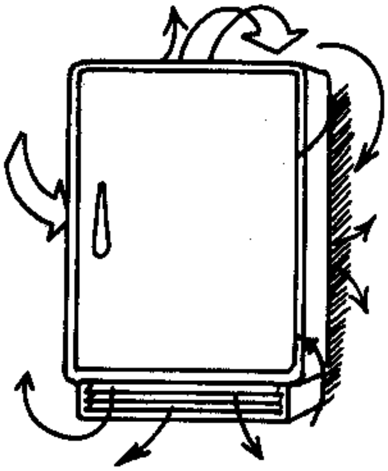
Steam Cookers and Tables

- **Insure thermostatic controls are operating properly.**
  Maintenance of higher than necessary temperatures wastes energy.

- **Fill cooking vessels according to manufacturer's recommmendations, and to capacity, if possible.**
  The amount of steam used is almost the same whether cooking a small or large amount of food.
- **Where possible, begin cooking food in a steamer.**
  Then finish it as necessary in the desired manner.
- **When practical, consider using steam cookers for such items as vegetables, rice and pasta to speed up cooking time.**
  Only small amounts of energy are required to maintain the cooking temperature once it has been reached.
- **Maintain the temperatue control on steam tables at a level that will keep food warm without allowing clouds of steam to escape.**
  Clouds of steam indicate unnecessarily high temperatures which waste energy.
- The more jobs you can do by steam, the less energy you'll use. In deep fat frying or griddling, save energy by first cooking the product in steam and then finishing it off to the desired brown and crust in the fryer, frypan, or oven.
- Thaw frozen foods in steam vessels rather than boiling water. Racks of frozen food may be thawed in volume.
- **Keep equipment and door seals free of debris to prevent steam leakage and energy waste.**
- **Repair all steam leaks, no matter how small.**
- **Check steam traps for steam leakage.**
  Steam passing through a trap indicates a defective trap that should be repaired or replaced. When steam, instead of liquid condensate, passes through a trap, significant energy is wasted.

<u>*Example:*</u> A steam trap with a 3/8 orifice on a 100 psi line when passing steam will waste 470,000 lbs. per month. At $5.00 per thousand pounds, the cost would be $2,350 per month or $28,200 per year for each such trap.

- **Have damaged steam line insulation repaired promptly.**
  Uninsulated steam lines waste energy and require additional steam to accomplish the cooking. This condition also adds unwanted heat to the kitchen area and may result in a need for more cooling and ventilation than would otherwise be necessary. Light-gauge sheet metal may be used to protect insulation where steam lines are exposed to the possibility of damage.



Refrigerators and Freezers

- **Thaw frozen food in the refrigerator.**
  As food thaws, the surrounding air is cooled, and the energy used by the refrigerator will be reduced.

- **Allow hot food a few minutes to cool before placing it in refrigerator or freezer.**
  Air cooling reduces the amount of work the refrigerator or freezer must do.

- **Do not store products in front of coils in a manner that restricts air flow.**

- **Set up procedures to reduce the frequency and length of time refrigerator and freezer doors are opened.**
  Frequent and lengthy openings are extremely wasteful of energy.
    - Plan ahead to take out or replace several items at one time.
    - Clearly label stored items.
    - Prepare schedules for use of walk-ins.

- **Turn off lights in walk-ins when leaving.**
  Unneeded lights waste energy and also add heat which wastes cooling energy.

- **Equip walk-ins with pilot lights on light switches.** This will make it easy to see whether lights have been left on.

- **Consolidate foods stored in refrigeration and freezer space where possible.**
  Full refrigerators and freezers use energy more efficiently than partially full units. When possible, empty units through consolidation and turn them off.

- **Be sure that items do not jam against closing doors.** They can damage the door gaskets and cause air leaks, thus wasting energy.

- **Schedule fan and condenser cleaning and compressor check-up as a regular maintenance item.**
  The frequency with which this job is done will vary with local conditions, so the schedule should be determined at each property. Clean fans and condensers and properly working compressors are more energy efficient.

- **Do not store anything within 4 feet of the compressor.** It needs free space to remove the heat from the unit most efficiently.

- **Frequently clean fins and plates of condensers which are located in areas where there is a rapid build-up of grease or other problem causing materials.**
  Such conditions cause the units to work overtime and waste energy.

- **Keep blower coil free of ice build-up and dust.**
  Such conditions cause units to operate longer and waste energy.

- **Keep thermometers properly calibrated to insure that desired temperature is maintained.**
  Lower than necessary temperature wastes energy.

- **Be sure units are leveled periodically.**
  Doors should fit correctly and close automatically from an open position. Air leakage wastes energy.

- **Check for short cycling and loss of temperature control periodically.**
  Check refrigerant level if abnormal operation exists. Such conditions result in excessive running time and waste energy.

- **Feel the outside walls for cold spots. Do this frequently for a new unit.**
  A cold spot indicates that the insulation has shifted or is waterlogged. Contact the manufacturer if you find this problem. Improper insulation wastes energy.

- **Maintain defroster.**
  If the unit has an automatic defrost cycle, have it adjusted periodically by a trained refrigeration service technician. If the unit does not have an automatic defroster, defrost as recommended by the manufacturer. Excessive frost build-up reduces the efficiency of units and wastes energy. Note, however, that more frequent defrosting than necessary also wastes energy.

- **Keep all door gaskets and seals in good condition.** A piece of paper inserted between the gasket and door frame should resist withdrawal when the door is closed. Make this test around all sides of the door, including the hinge side. Damaged gaskets permit air leakage and waste energy.

- **Maintain proper tension on refrigerator compressor belts and replace those that are worn or damaged.** Excessive down periods for unscheduled repair require energy to reestablish proper temperatures and can result in food spoilage as well as wasted energy.

- **Schedule food deliveries, where possible, to avoid overloading refrigeration facilities, or under-capacity utilization.**
  Be sure foods requiring freezer or refrigerator storage are promptly placed in storage. Recooling such foods wastes energy.

- **Close ice-maker storage bins after each use.**

DISHWASHERS

Very seldom is there a situation where a food service establishment has a dishwashing system that is too large. Generally, the situation is reversed. The dishwashing system can operate the same way as other equipment, and that is to have full loads running through the machine during the busy times of the day, turning off the machine in "less productive" times. If appropriate racks and shelving are available, sorting of soiled dishes could be done. When a rack is full, operate the dishwasher.

- Provide a pressure reducing valve on the hot water supply line to reduce the water pressure to 20 psi flowing. This will consume less hot water.
- Do not heat water over 180°F.
- Check, clean, and adjust as required the rinse arms and nozzles at regular intervals.
- Replace faulty thermostats controlling tank water temperatures.
- Check drain valve for tight seal and keep it free of debris.
- Using a deliming solution regularly to remove scale from inside of machine and from heating elements, for efficient operation.
- Consider installing a power pre-wash if your requirement dictates a rack conveyor machine. This reuses the heated wash water and spent detergent, thus not requiring extra water and heat for the pre-wash.
- Turn off machine and pumps when not in service.
- Locate the hot water booster heater as close to the machine as is possible and insulate hot water line.
- **Turn off booster heater until it is needed.**

In addition to the conservation measures mentioned above, there is another method suitable for non-conveyer type dishwashing operations. A chemical solution can be used in lieu of 180° water to meet sanitation requirements. Some of the smaller dishwashers can be equipped at the factory or in the field with a special injector which dispenses a measured amount of 5.2% solution of sodium hypochlorite into the wash and/or rinse water. With this chlorine sanitizer, standard water temperature (120-140°) can be used. With such a machine, temperatures above 140° are neither required nor desirable. Kits are available for some existing dishwashers. Check with the Department of Health and consult with your dishwasher manufacturer.

Hot Water

A 125-seat restaurant with a daily seat turnover of 1.8 uses about 200,000 gallons of water per year. Since a large percentage of this usage is hot water, any effort to conserve will reduce heating costs as well as the water bill. A realistic goal of 15% reduction in hot water use (approximately 50 gallons per day) would result in $50 savings in water and energy costs at an average restaurant.

A savings of 200 gallons of water a day would save over 73,000 gallons per year. If 135 gallons of that were hot water heated from 50 degrees to 140 degrees Farenheit, the annual savings for heating would be $110 per year. The annual saving for water, based on $.53/1,000 gallons would amount to an additional $39 savings per year.

SAVINGS FROM REDUCED HOT WATER USE

Daily Hot Water Reduction	Reduced Hot Water Consumption gal/yr	Reduced Water Cost	Energy Savings 30¢/Therm
100	36,500	$19	$ 80
200	73,000	$39	$160
400	146,000	$78	$320

Other opportunities are:

- Where hot water for hand washing is provided, heat to 110°F instead of 140°F. Do not reduce temperature of water serving the dishwasher.
- Install flow restricting orifices or aerators in piping or on faucets. These can reduce flow by approximately 50%. (This can also be accomplished by partially closing valves in the faucet supplies.

- If renovating, consider installing self-closing faucets on water taps, particularly the hot water. These can cut water consumption approximately 60%.
- Insulate new piping and insulate and/or repair existing hot water piping and tanks. In a system with about 200 feet of piping, good insulation will save approximately $15-$25 per year.
- If a domestic hot water circulating pump is used, provide a time switch to shut off the pump when the building is unoccupied.
- Replace seals or repack packing glands of hot water circulating pumps, as leaks develop.
- Flush water heaters every six months to remove solids settled on bottom of tank. This will maintain heater efficiency.
- Repair leaky faucets. A hot water faucet dripping at a rate of 1 gallon an hour would consume 9,000 gallons per year, or $20 in energy.
- With immersion type domestic hot water heater installed into boiler shell, remove and clean scale build-up from interior and exterior coil surfaces at least once a year.
- Remove exterior scale build-up from electric hot water heater coils at least once a year.

MAINTENANCE SCHEDULE
FOOD SERVICE

	Schedule				
Maintenance Item:	Daily	Weekly	3 Mo.	6 Mo.	Yearly
Kitchen food preparation equipment	*				
Leaks, faucets, piping, equipment	*				
Refrigeration pilot lights	*				
Door gaskets: refrigerator, freezer, etc.		*			
Condenser Coils: refrigerator, freezer, etc.		*			
Dishwasher drain valve		*			
Filters: Kitchen hoods	*	*			
Defrost cycle: refrigerator, freezer, etc.		*			
Adjust gas burners			*		
Check dishwasher temperature			*		
Clean dishwasher rinse arms and nozzles			*		
Check disposal operation			*		
Check steam traps			*		
Check oven blower fans and motors				*	
Check all thermostats for calibration				*	
Lubricate burner gas valves				*	
Check hot water booster heat coils				*	
Clean light fixtures				*	
Check H & V unit operation				*	
Check exhaust air quantity				*	

Maintenance Item	Daily	Weekly	3 Mo.	6 Mo.	Yearly
Check steam cookers for lime deposits				*	
Check micro-wave ovens for operation					*
Clean walls and ceilings					*
Lubricate all equipment	Frequency as required by manufacturer				

ENERGY CONSERVATION OPPORTUNITIES (major cost)

Most restaurant owners and managers who will be using the information contained in this manual will find that their facilities were, no doubt, built prior to our awareness of the extent of the depletion of the world's natural resources. Energy costs were comparatively low, hence, the major attention in the construction industry was focused on holding down the initial construction costs. Now we realize that our fuel supplies are neither inexhaustable, nor are they absolutely dependable. Our only alternative is to explore every possible means of reducing energy consumption even when they require additional major capital investments.

This section presents selected major cost energy conservation opportunities. You need to keep in mind that some items discussed in this section will require capital expenditures that may not be economically justified on the basis of current energy costs. They may, however, become cost effective if energy cost increases escalate (or, if government controls set maximums on energy consumption of individual businesses).

The energy conservation opportunities presented in this section should be considered when you plan a major renovation of your restaurant. Please remember that anytime you introduce new energy systems or alter existing systems, you need to check with permit granting state agencies. We strongly recommend that qualified engineers or architects be involved in the analysis, planning, and supervision of any major work that you may consider for your facility. Also, each item under consideration should be justified by an economic analysis.

There are two energy conservation opportunities listed in this section that should be investigated for your operation at this time. If you do not currently have a vestibule which provides double entry doors, you should consider installing one. The initial cost of this investment can be recovered in approximately four years through energy savings.

Secondly, a double-wall hood system appears to have significant potential for saving energy. The initial cost of retrofitting an existing hood requires a relatively large investment ($7,000 - $10,000 for a 4x8 hood which exhausts 3,200 cfm). However, the heating energy savings could easily approach cost recovery within two years.

Building

- Consider adding insulation to the attic (if you have one) and walls. A 3,000 sq. ft. frame building with 15% window area, uninsulated walls, and R-11 attic insulation has a heat loss of about 100,000 BTU/hour under design temperatures. Increasing attic insulation to R-38 (12" of fiberglass batts or better), insulating the walls to R-11, and double glazing the windows would reduce heat loss by 2½ times. The savings in heating costs would approximate $300 over the heating season.

- Add a second pane to single pane windows. This can be done by installing a properly sealed storm panel to the outside of existing windows. You will save energy by reducing heat loss through windows in half.

- During major renovation, consider light colored roofing materials to reduce solar roof load.

- Consider installing vestibules at exterior entries. A vestibule, which provides double entry doors, could cost up to $3,000 to install. Energy savings, assuming a 1/16" crack (with 1 cfm per lineal foot of crack), 65° indoor temperature, 5 mph winds could approximate $800/year.

Hot Water

- During major renovation, consider providing separate hot water heaters and piping systems for kitchen and general building use. This will allow for two different water temperatures, with a low temperature (110°F) for general use.

Electrical

- In larger areas, rewire lights to multiple switching allowing the use of only part of the lights when full lighting is not required.

- Install dimming controls for spaces requiring more than one level of control.

- Replace existing fixture lenses with lenses that have special light distribution patterns to increase lighting effectiveness.

- For parking lots, consider replacing mercury-vapor lamps with high pressure sodium lamps. Annual savings in electricity will approximate $35 per lamp (after accounting for the higher cost of the high pressure sodium lamps).

Heating, Ventilating and Air Conditioning

- A constant volume terminal reheat system is not energy efficient. Consider retrofitting such systems to variable air volume (VAV). This can be accomplished by the addition of a VAV valve behind the terminal reheat coil to relieve the constant volume air supply to the ceiling plenum. This valve will modulate the cool air supply from 100% to minimum as room conditions vary. At minimum air supply, the reheat coil will be activated if the heating balance between the air supply and space is insufficient. This system may require modifications to the return air duct system. It does not require air volume controls at the fan. Cost should approximate $1,000 per terminal unit retrofitted. Complete balancing of the air system will be required after this retrofit. Energy savings will depend on the specifics of your system.

- Consider installing an economy cycle to your present heating, ventilation, and air conditioning system.

  This cycle will use outdoor air for cooling whenever the equipment is in a cooling mode and outside air is cool enough to accomplish the necessary cooling.

  The outdoor air and return air duct system, at the main air handling equipment, will require extensive modification. Also, the addition of an exhaust air system, to the outside, will be required. The return air system will have a fan added to it for a positive return of the air, as well as positive exhaust, when operating in the economizer mode. In some cases, oversized return and exhaust ducts may substitute for the return or exhaust fan.

  The controls will activate the economize cycle through air temperature or enthalpy sensing and deactivate it and start the refrigeration system as the outdoor air warms up to a point that it no longer is capable of cooling.

  Costs for this system renovation will vary considerably depending upon building, space, existing system, etc. However, $20,000 is an initial thinking point until your system is analyzed as to its specific conditions.

- Consider replacing standard kitchen hood tempered air make-up units with double wall hood system. This can reduce the kitchen energy load up to 80%. You need DILHR approval prior to this type of modification.

  To accomplish this, the hood is modified by the installation of an insulated air passage to the hood skirt. Air is supplied through this passage to an air nozzle at the base of the hood skirt and directed into the hood. The air tempering unit is deactivated and only the fan and filter system is used to supply the air to the hood air passages. The exhaust fan is adjusted only to required air flow.

To retrofit an existing 4x8 hood which exhausts 3,200 cfm could cost $7,000 to $10,000. Annual heating energy savings for a twelve hour day, seven day week, five month year, could easily approach a two year payback.

- Consider heat reclaim. There is available heat in almost every building exhaust system that exhausts air to the out of doors. All heat reclaim methods are major cost items and should only be investigated further if planning major renovation. The following items must be analyzed on a one to one basis to determine costs and economic justification:
  - Building exhaust air
  - Kitchen and food service hood exhaust
  - Laundry dryer exhaust
  - Internal lighting
  - Dishwasher and laundry waste water
  - Heat from refrigeration condensing units

Methods of heat reclaim - type of heat exchanger

	Effective efficiency:
Rotary wheel	65-80%
Fixed plate	40-60%
Single tube or heat pipe	55-70%
Run-around	55-70%
Shell & tube	50-70%
Double-bundle	60-75%

Rotary wheel: A rotating wheel passes through two ducts or air streams (½ of wheel in each) and transfers heat and moisture from one air stream to the other.

Fixed plate: Large, box-shaped heat transfer unit with separate passages to carry two different air streams without mixing. Heat is transferred from one air stream to the other through the passage walls.

Single tube: A bundle of tubes which project into adjoining ducts or air streams, each tube charged with refrigerant and a wick. The wick carries the liquid refrigerant by capillary action to the warm end where it evaporates and absorbs heat from the warmer air. The evaporated refrigerant, being a gas and under a higher pressure, flows back through the hollow center of the wick to the cold end of the tube, where it condenses and gives up its heat to the cooler air. The cycle is continuous.

Run-around: Standard finned coils or heat exchangers, located in remote areas of the building connected to a closed piping circuit. Heat is absorbed by the coils or heat exchangers, transferred to the medium, circulated through the piping systems to another coil, where the heat is released.

Shell and tube: A style of heat exchanger used with liquid or gaseous heat recovery. Can be used in the run-around system or for waste water, steam, or condensate reclaim.

Double-bundle: Refrigeration condenses, coils or heat exchanger with two piping circuits running through it. Each piping circuit can circulate a different medium, thereby, allowing the transfer of heat from one circuit to the other.

Others:

- Solar: Clean, safe, non-polluting. This has uses in many areas, however, the present high cost has restricted its use. When technology develops efficient equipment capable of being mass produced, this will become an active area for future energy demands. Climatic factors effect solar collection, however, the future economic feasibility of solar energy will be closely related to future fuel costs.
- Wind: In experimental stages with cost and storage, the major problems requiring technological breakthrough.
- Geothermal: In research and development.

8

CASE STUDIES

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Section II

SECTION I

A. Total Energy Management

The energy audit is an important step in establishing an energy management program which results in real dollar savings. But is only one of many steps which are necessary if these cost savings are to 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 max-audit

5. Establish tough and measurable energy use goals, using energy tracking system for measurement.

   *implement all no-cost actions
   *implement selected capital improvememt retrofit projects and measure energy savings

6. Report the results in both energy and dollar terms.

B. Demand Audit

The March 1978 bill for this building is shown in detail below, followed by City of Austin electric rate schedule GS-Multiple Service. This tabulation is necessary and will be used for computing savings in Section II and in terms of both KW demand and KWH of consumption.

From the tabulation it can be seen that the various parts make up the total bill as follows:

Typical Electricity Computation

March 1979

30400	KWH
64	KW
$.02723	Fuel Adjustment
$1418.17	Total Bill

		Energy Charge	Demand Charge
a.	30400 @ $.012	364.80	
b.	30400 @ $.02723	827.79	
c.	64 @ $3.22		206.08

Energy Charge	364.80	26%
Fuel Charge	827.79	58%
Demand Charge	206.08	15%
Customer Charge	19.50	1%
	1418.17	100%

$$\text{Cost per KWH} = \frac{\$364.80 + 827.79}{30400} = .03923/\text{KWH}$$

Cost per KW = $3.22*

---

*See C. above and rate schedule, following page.
Demand charge from May through October would have averaged $4.81/KW ($5.78/KW for 1st 30 KW; 3.95/KW for all over 30)

Character of Service:

Alternating current, 60 cycles, single phase, (or three phase) service in accordance with the Installation Rules and Standards for Electric Service prescribed by the City of Austin from time to time.

Rate:

	Billing Months of November through April	Billing Months of May through October
Customer Charge	$3.50	$3.50
Energy Charge	*.66¢ per KWH all KWH	*.66¢ per KWH all KWH
Capacity Charge	NONE	2.5¢ per KWH first 500 KWH 1.275¢ per KWH all additional KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

GENERAL SERVICE
Multiple Fuels

Application:

This rate is applicable to all electric service required by any customer to whom no other specific rate applies and when the electricity provided by the City of Austin is used in conjunction with other forms of energy.

Electric service of one standard character will be delivered to one point of service on the customer's premises and is measured through one meter.

Character of Service:

Alternating current, 60 cycles, single phase or three phase in accordance with the Installation Rules and Standards for Electric Service prescribed by the City of Austin from time to time.

Rate:

Applicable to a customer whose electric service meets or exceeds 30 kilowatts per month for any two months within the most recent six summer billing months or as determined by the City of Austin. This rate shall be applied for a term of not less than one year (twelve months).

	Billing Months of November through April	Billing Months of May through October
Customer Charge	** $4.50	** $4.50
Energy Charge	* 1.2¢ per KWH all KWH	* 1.2¢ per KWH all KWH
Capacity Charge	$3.22 per KW all KW	$5.78 per KW first 30 KW $3.95 per KW all additional KW

The kilowatt (KW) for the current billing month shall be the maximum indicated or recorded by metering equipment installed by the City of Austin. When the power factor is less than 85%, kilowatt (KW) shall be determined by multiplying the indicated KW by 85% and dividing by such lower peak power factor.

Rate:

Applicable to a customer whose electric service does not meet or exceed 30 kilowatts per month for any two months within the most recent six summer billing months or as determined by the City of Austin.

	Billing Months of November through April	Billing Months of May through October
Customer Charge	** $4.50	** $4.50
Energy Charge	* 1.2¢ per KWH all KWH	* 1.2¢ per KWH all KWH
Capacity Charge	NONE	2.5¢ per KWH first 1,000 KWH 1.85¢ per KWH all additional KWH

* Plus an adjustment for fuel cost calculated according to the formula set forth in Part 2 of this ordinance.

** Plus an additional $15.00 per month for customers whose KWH billed in any month within the last 12 months exceeded 10,000 KWH.

GENERAL SERVICE
Single Fuel

Application:

This rate is applicable to all electric service required by any customer to whom no other specific rate applies and where the electricity provided by the City of Austin is the only source of energy used on the premises. The primary use of this energy must be for space comfort conditioning.

Electricity Bill Analysis

The electricity bill for March 1979 has been calculated by increments as described in City of Austin in electric rate schedule for General Service, Multiple Fuel. The calculation and a copy of the rate schedule are referred to earlier.

As long as this rate schedule is in effect, savings in energy will result in cost savings as follows:

$3.22 per KW of demand
3.923¢ per KWH
(1.2¢ energy charge
2.723¢ fuel adjustment charge
3.923¢)

Demand

Electricity is used in the building for four major uses: kitchen equipment, lighting, air-handlers and other equipment run by motors, and the cooling system.

Lighting

Lighting was inventoried by actual count and inspection and is itemized in Appendix A. Total installed capacity of lighting is 9.7 KW (5.1 KW incandescent; 4.6 KW fluorescent).

Kitchen Equipment

Kitchen equipment is divided into the categories of Cooking/Processing (83.1 KW), Holding/Serving (15.55 KW), Storage (5.8 KW), and Fabrication and Preparation (3.11 KW) for a total of 73.96 KW. An itemized list of equipment by category, as well as the percentage of total KW represented by each category, is given in Appendix A.

HVAC

Gas heating (the only gas use on the property) and electric air conditioning are employed. Total KW for compressors, condensers, fans, and vent hood exhaust is 47.7 KW

Total Winter Demand
December 1978
(76 KW Billed)

The peak demand for December (76 KW) is broken out into the following probable load distribution.

	KW	
Lighting Demand	3.62	Incandescent
	4.408	Fluorescent
	8.028	Sub-Total
Cooking/Processing	5.3	Stove (1 Hot Plate)
	12	Fryers (2)
	21.6	Griddles (2)
	38.9	Sub-Total
Holding/Serving	6.6	(11 Total KW @ 60% load)
Storage	3.48	(5.8 KW @ 60% load)
Fabrication & Preparation	.9	(1.5 KW @ 60% load)
Sub-Total	57.908	
Heating	3.18	(5.3 KW for 3 fans @ 60% load)
Exhaust Fans (3)	1.17	(1.96 KW for 3 fans @ 60% load)
Sub-Total	4.35	
TOTAL	62.258*	

*This total is almost 14 KW below billed demand. The difference may likely be accounted for if the air conditioning units were turned on at any time during the month. If 2 AC units came on, the additional KW load would be 13.51 (19.3 KW @ .7 load factor = 13.51). If the heating units were also on, total KW demand would be 75.738. The possibility of both heating and air conditioning being on simultaneously is quite real. At the time of the audit March 20, one dining room thermostat was set on heating; the other four feet away was set on cooling.

Total Summer Demand
June 1978
(80 KW Billed)

	KW	
Lighting Demand	3.62	Incandescent
	4.408	Fluorescent
Sub-Total	8.028	
Cooking/Processing	5.3	Stove
	12	Fryers (2)
	21.6	Griddles (2)
Sub-Total	38.9	

Holding/Serving	6.6	(All equipment on at 60% load factor except water heater)
Storage	3.48	(All on @ 60% load factor)
Fabrication & Preparation	.9	(Griddle compressors & food wells)
Sub-Total Kitchen	57.908	
HVAC (3)	25.5	(Load factor of 60% assumed)
Exhaust Fans (3)	1.14	(Load factor of 60% assumed)
Sub-Total	26.64	
TOTAL	84.548*KW	

*The variation of the calculated total KW (84.548) from the billed total KW (80) is only 4.548 KW and can be accounted for by a variation of lighting load, the load factor for some or all of the motors, or other variables of kitchen equipment in use, etc.

C. Energy Utilization Index

We have analyzed the gas and electricity bill information provided. The calculations and a graphical display of these calculations are attached. Our analysis shows energy use of 593,969 BTU/Sq.Ft./Yr. for the last 12 months of this building. Since utility bills for May are not available at the time of this report, we have used an average of the monthly consumption for the 11 previous months. This figure might be compared with:

1. The proposed Building Energy Performance Standards being considered by the Department of Energy suggest that design characteristics for the median restaurant in the Dallas zone allow for a yearly consumption of 80,000 BTUs/sq.foot. This consumption does not include energy needs for hot water and kitchen equipment. (See following "Energy Use in Commercial Building.")

2. A table service restaurant in the same general area, operated 18 hours per day, and serving breakfast, lunch, and dinner, has an Energy Utilization index of 284,220 BTU/S.F./Yr. (gross consumption of 1532.8 MBTU/yr ÷ 5393 S.F.).

3. Another hamburger restaurant in the same general area with identical operating hours, having an EUI of 392,019 BTU/Sq.Ft./Yr.

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	31-93	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	26
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

	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%
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	
Newark zone	69	22-93	48-80	
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	41-83	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."

ENERGY USE IN BTUs PER SQUARE FOOT

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST				
1978	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	35840	122.3	80	370.90	1695.33	.047					122.3	1695.33	53,640
JUL	33040	112.8	80	370.90	1647.90	.05					112.8	1647.90	49,474
AUG	30480	104	80	370.90	1487.78	.049					104	1487.98	45,614
SEP	30720	104.8	76	355.10	1458.71	.047					104.8	1458.71	45,965
OCT	23200	79.2	76	355.10	1227.46	.053					79.2	1227.46	34,736
NOV	23280	79.5	76	244.72	1077.16	.046	22	22.7	66.67	3.03	102.2	1143.83	44,825
DEC	24480	83.6	76	244.72	1049.78	.043	85	87.6	281.08	3.31	171.2	1330.86	75,088
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 ____________

ENERGY USE IN BTUs PER SQUARE FOOT

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST				
1979	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	21600	73.7	68	218.96	1017.14	.047	84	86.5	286.68	3.41	160.2	1303.82	70,263
FEB	11200	38.2	68	218.96	642.89	.057	38	39.1	138.00	3.63	77.3	780.89	33,903
MAR	30400	103.8	64	206.08	1418.17	.047	33	34	138.00	4.18	137.8	1556.17	60,438
APR	204000	69.6	68	218.96	949.48	.047					69.6	949.48	30,526
MAY													
JUN													
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													
TOTAL	286,640	971.5		3175.30	13671.80	.0477	262	269.9	910.43	3.47	1241.4	14,582.23	593,969

Column 3 = Column 2 x .003413

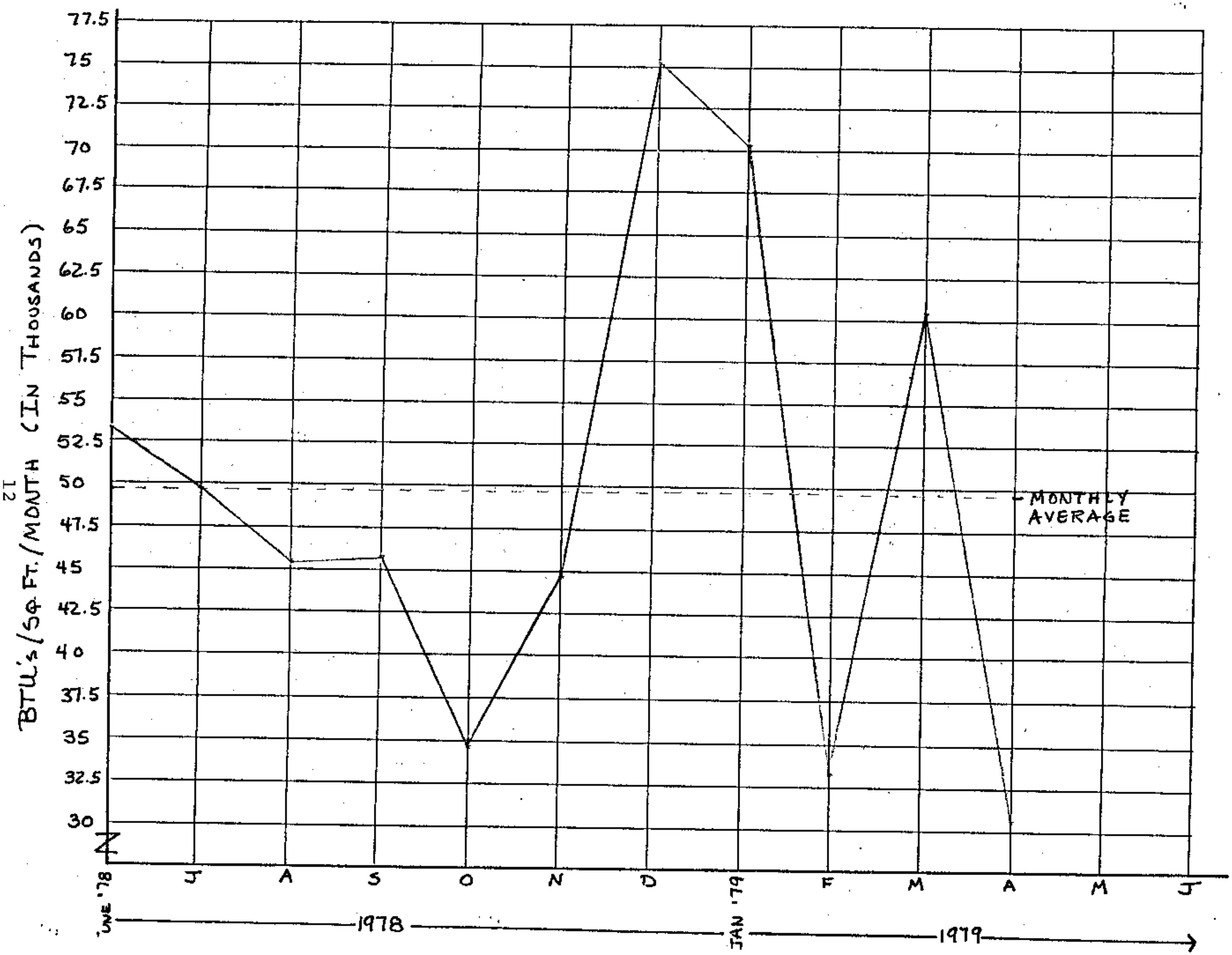
Column 9 = Column 8 x 1.03

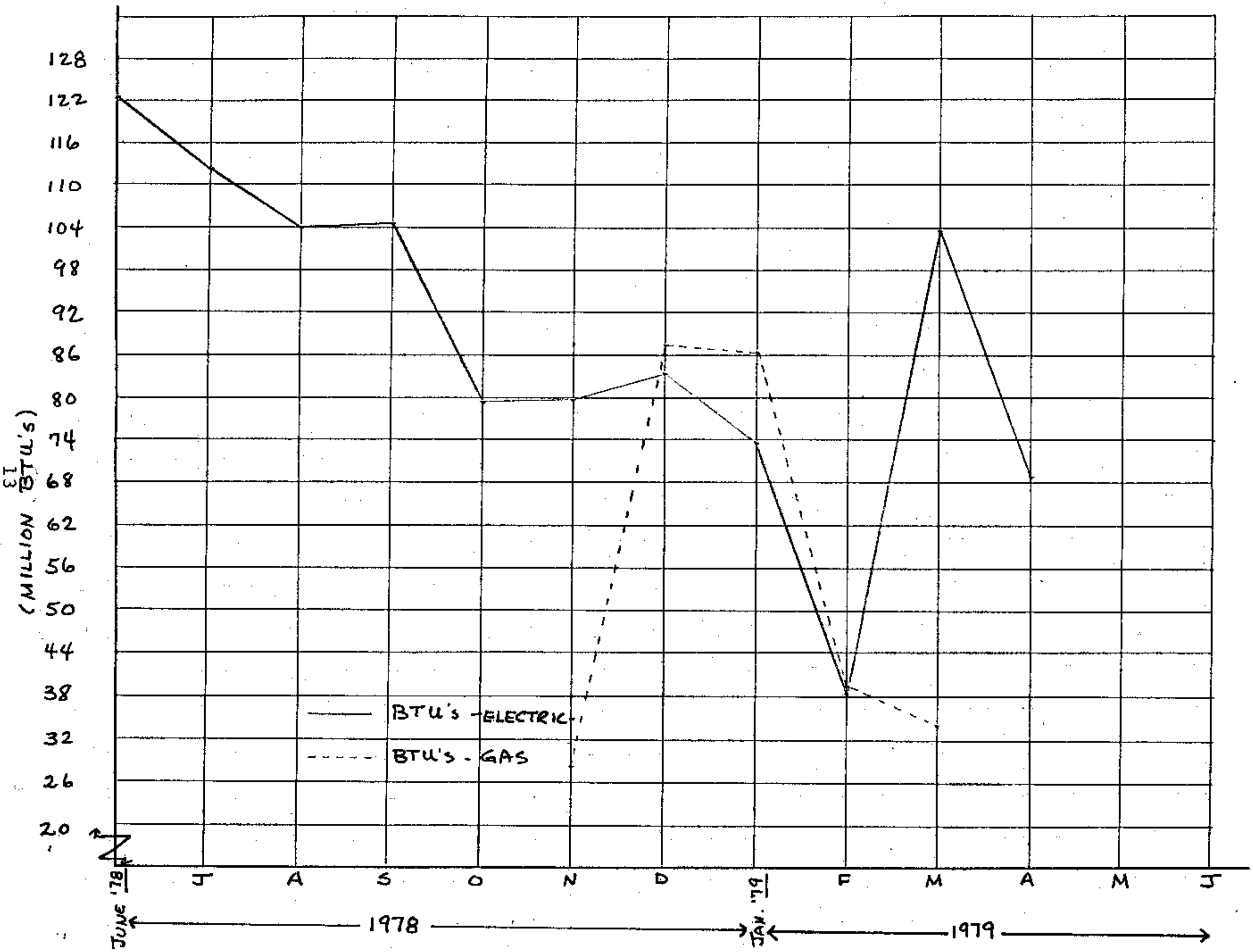
Column 12 = Column 3 + Column 9

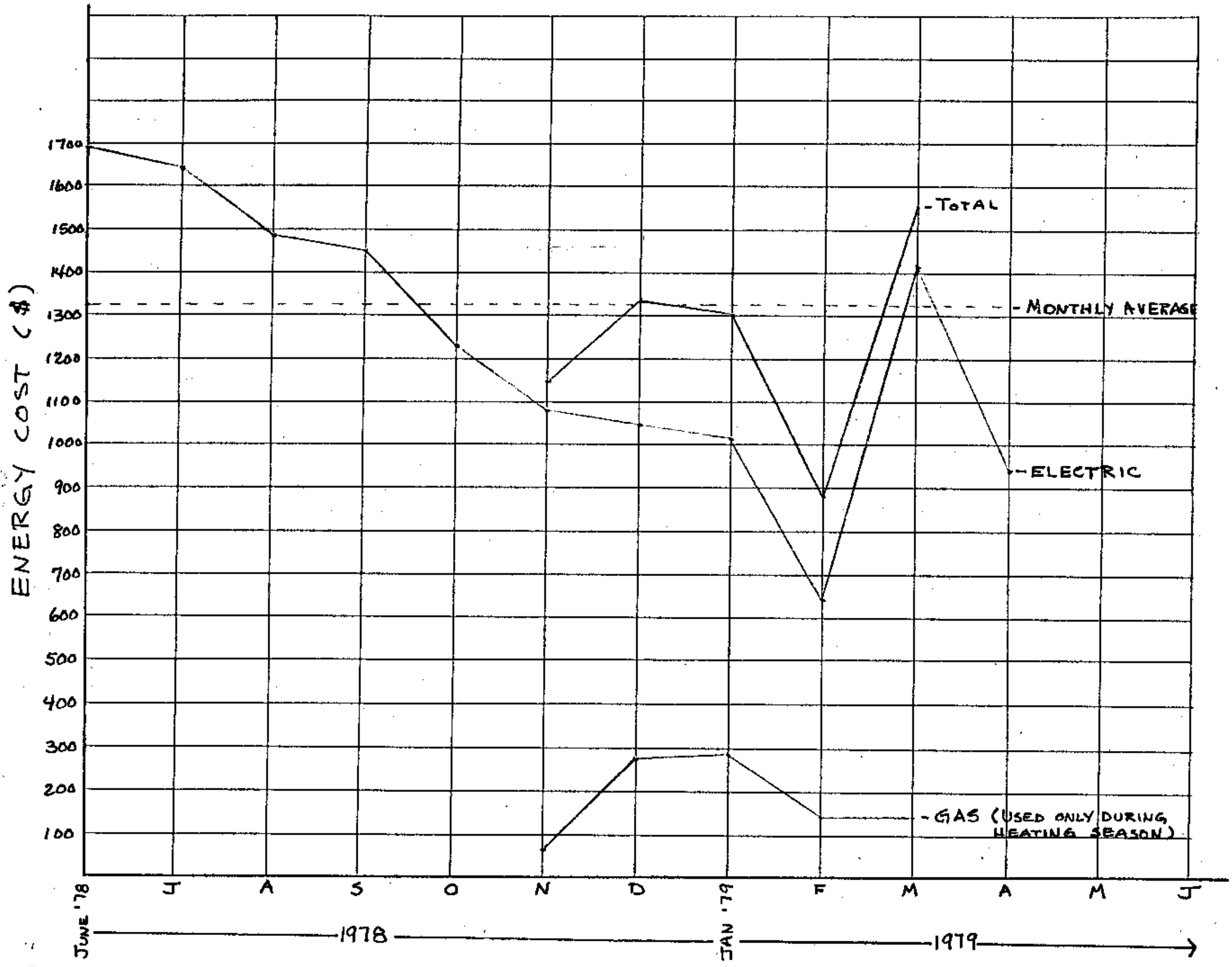
Column 13 = Column 6 + 10

* 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.

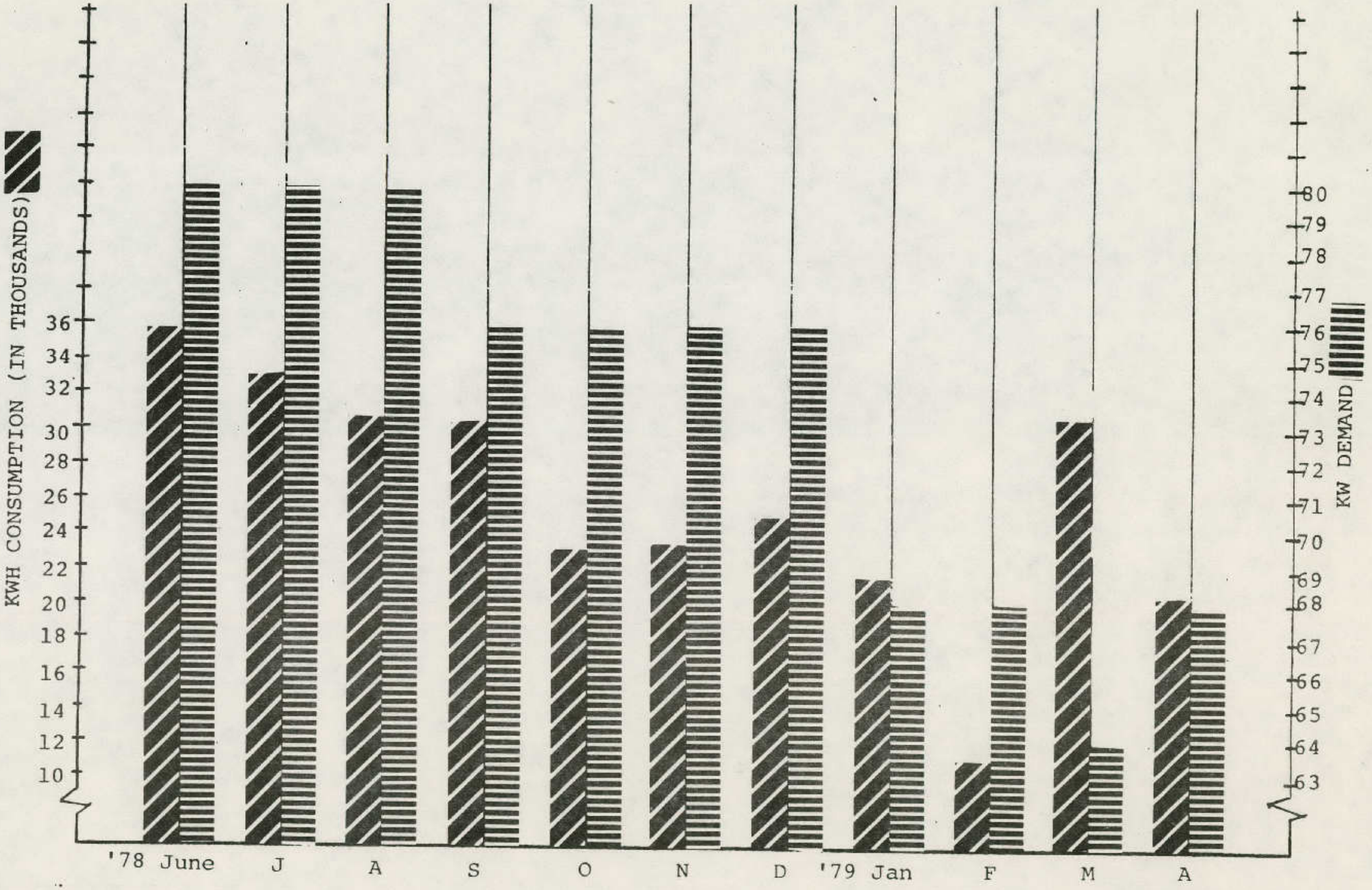
Total Square Feet 2280


77.5
75
72.5
70
67.5
65
62.5
60
57.5
55
52.5
50
47.5
45
42.5
40
37.5
35
32.5
30
BTU's/SQ FT./MONTH (IN THOUSANDS)
12
MONTHLY AVERAGE
JUNE '78
J
A
S
O
N
D
JAN '79
F
M
A
M
J
1978
1979


(MILLION BTU's)
128
122
116
110
104
98
92
86
80
74
68
62
56
50
44
38
32
26
20
BTU's - ELECTRIC
BTU's - GAS
JUNE '78
J
A
S
O
N
D
JAN. '79
F
M
A
M
J
1978
1979


ENERGY COST ($)
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
- TOTAL
- MONTHLY AVERAGE
- ELECTRIC
- GAS (USED ONLY DURING HEATING SEASON)
JUNE '78
J
A
S
O
N
D
JAN '79
F
M
A
M
J
1978
1979

ELECTRICITY
USAGE AND DEMAND



D. EXTRA FORMS

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

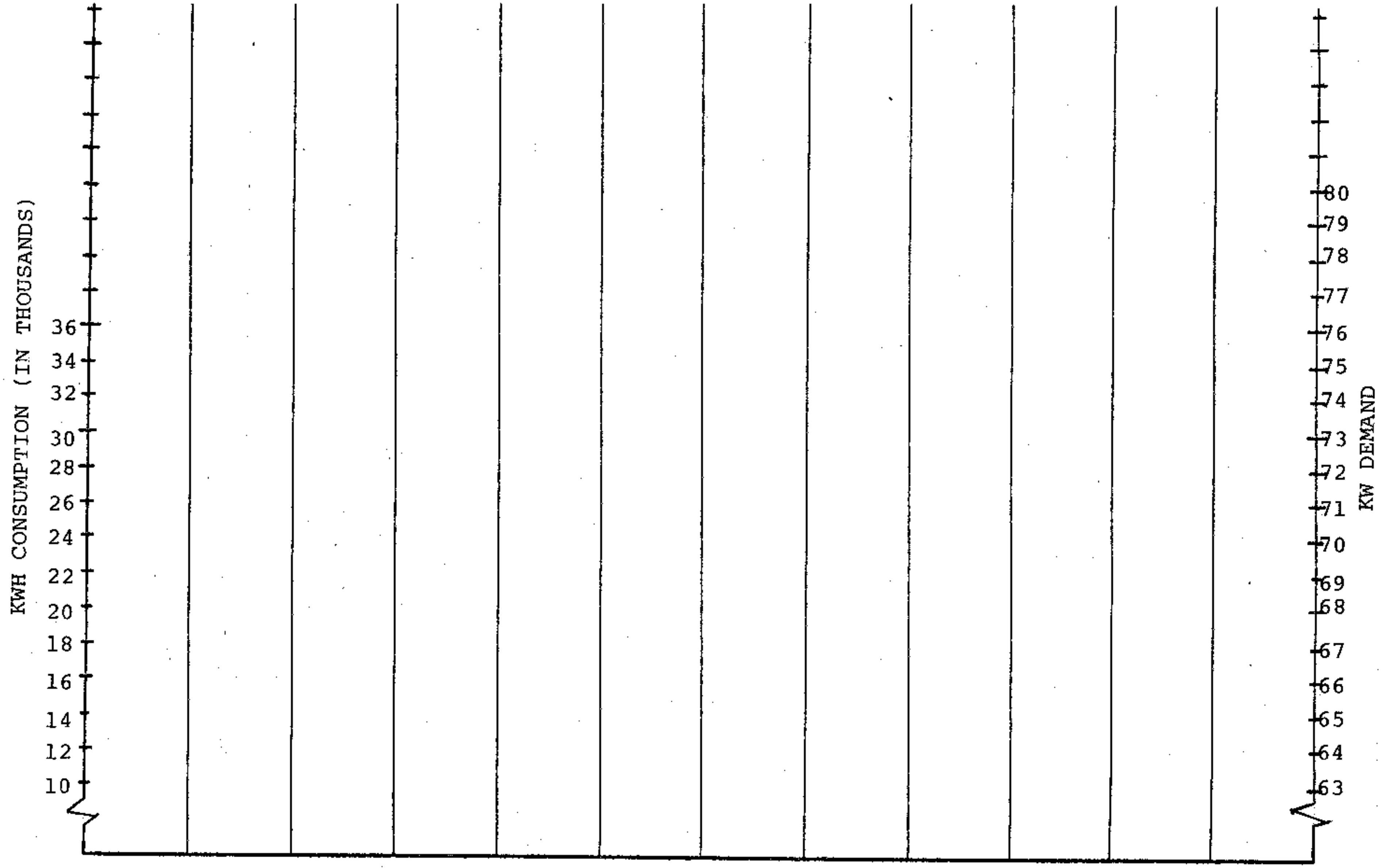
Column 12 = Column 3 + Column 9

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 ____________

ELECTRICITY
USAGE AND DEMAND



EQUIPMENT SCHEDULE

	8am	9	10	11	12	1pm	2	3	4	5	6	7	8	9	10	11	12
HVAC																	
KITCHEN LIGHTS																	
DINING ROOM LIGHTS																	
FRYERS (1) 5 min. preheat																	
(2) " "																	
GRIDDLES (1) 7 min. preheat																	
(2) " "																	
BUN WARMERS																	
CHILI WARMER																	

Section II

No and Low Cost Recommendations

Lighting

1. Do not turn on dining room, bathroom and serving area lights until first customers arrive at 11:00 a.m.

   Cost: $0 Annual Savings: $156.38
   3258 KWH

2. Replace 40 watt bulbs in Tiffany lamps with 15 watt. (Lamps are decorative and have negligible contribution to light level in dining room.)

   Cost: $9.00 Annual Savings: $85.15
   1774 KWH

   Payback: 1.2 months.

3. Spot relamp all 40 watt fluorescent fixtures with watt-miser lamps and ballasts.

Cost:	$110.00	Lamps	Annual Savings:	$134.59
	$162.00	Ballasts		2804 KWH
	$272.00	Total		

   Payback: 24 months.

   The calculations are based on group relamping. If lamps and ballasts are replaced on a spot basis as regular maintenance, the additional cost for energy-saver lamps and ballasts are only marginally greater than cost for existing lamps and ballasts.

4. Consider leaving dining room fluorescents off during day. At 10:00 a.m. on day of audit, footcandle readings were in excess of 100 with dining room lights off.

   Cost: $0 Annual Savings: $266.89
   5560 KWH

Building Shell

The building is in very good structural condition. Large glass areas on the E (180 S.F.), N (204 S.F.), and S (204 S.F.) faces of the building allow significant amounts of heat transmission.

Consider installation of solar shades, screens, or film to reduce heat loss in winter and heat gain in summer.

The following table of solar heat gain through glass areas is derived from Guidelines for Saving Energy in Existing Buildings - ECM 2, pp. 127-129. Figures have been adjusted upward by 40% to reflect 7 day operating week rather than 5 day.

Solar Heat Gain

North	31,416,000	BTU/Yr.	-	204	S.F. Glass
East & West	65,688,000	BTU/Yr.	-	180	S.F. Glass
South	59,220,000	BTU/Yr.	-	204	S.F. Glass
Total	156,324,000	BTU/Yr.	-	588	S.F. Total

Heat Loss

Heat loss estimates for glass area have been taken from ECM 2 , p. 29.

	Heat loss/BTU/S.F./Yr. x	S.F. Window Area =	Total Heat Loss
South	15×10^3	204	3060×10^3
East & West	20×10^3	180	3600×10^3
North	22×10^3	204	4488×10^3

Total Heat Loss = 2217×10^3 BTU/Yr. or 2.2×10^6

Sun control film (shades, or screen) with a shading coefficient of .50 for summer and a heat loss reduction of up to 20% in winter will reduce heat gain by up to 78×10^6 BTU/Yr. in summer ($.50 \times 156,324,000 = 78 \times 10^6$) and heat loss by up to $.44 \times 10^6$ BTU/Yr. in winter ($.20 \times 2.2 \times 10^6$).

Savings for heating are calculated by the formula

$$\frac{\text{MBTU} \times \$\ \text{MBTU}}{\text{Equipment Efficiency}}$$

$$\frac{.44 \times 3.37}{.6} = \$2.47 \text{ Saved, Heating Season}$$

Gas = \$0.48/KWH
Electricity = 3.37/MBTU (Derived from EUI sheet)

Costs for gas and electricity are average costs from June 1978 through March 1979. Actual costs (and savings) will be higher (March gas bill is \$4.18/MCF) as utility rates increase.

Savings for cooling are calculated by the formula:

$$\frac{\text{BTU/YR saved}}{\text{EER X 1000}} \quad \text{x} \quad \text{cost/KWH}$$

$$\text{or} \quad \frac{74{,}000{,}000}{7.0 \text{ x } 1000} \quad \text{x} \quad .048 \quad = \quad \$507.43$$

Cost to install solar film = $970.20
(At average installed cost of $1.65/S.F.)

Annual Savings = $2.47 + 507.43 = $509.9

$$\text{Payback} = \frac{\text{First Cost}}{\text{Annual Savings}} \text{ x } 12 \quad \frac{970.20}{509.9} \text{ x } 12 = 22.83 \text{ months}$$

HVAC

HVAC system had apparently been recently serviced and was in good operating condition. Filters were clean. Vent rain cap was missing from rooftop unit located closest to front of building. Cap should be replaced as soon as possible.

The potential savings as a result of implementing any or all of the preceding recommendations are not additive. For example, if solar film were installed to reduce solar heat gain, solar lumination is also reduced and dining room fluorescents would perhaps need to be turned on.

Kitchen

All of the kitchen equipment is relatively new and is kept in good working order. Kitchen and equipment are clean and well-maintained. While the manager apparently staggers the start up of cooking equipment, there is no actual start up schedule for equipment. In an effort to control demand, it is advisable to establish a fixed schedule for equipment start up and a policy of idling equipment during slack times. Reasons for start-up schedules should be fully explained to all restaurant managers in the franchise in order to get full support and cooperation.

The second line of cooking equipment should be called into service only as absolutely necessary. The annual cost for operating the back up griddle and fryer (4 and 3 hours per day respectively) is $2,126.83. The griddle exhaust hood annual operating cost is $152.91. The additional uncalculated load on the space conditioning systems would increase the annual cost even more.

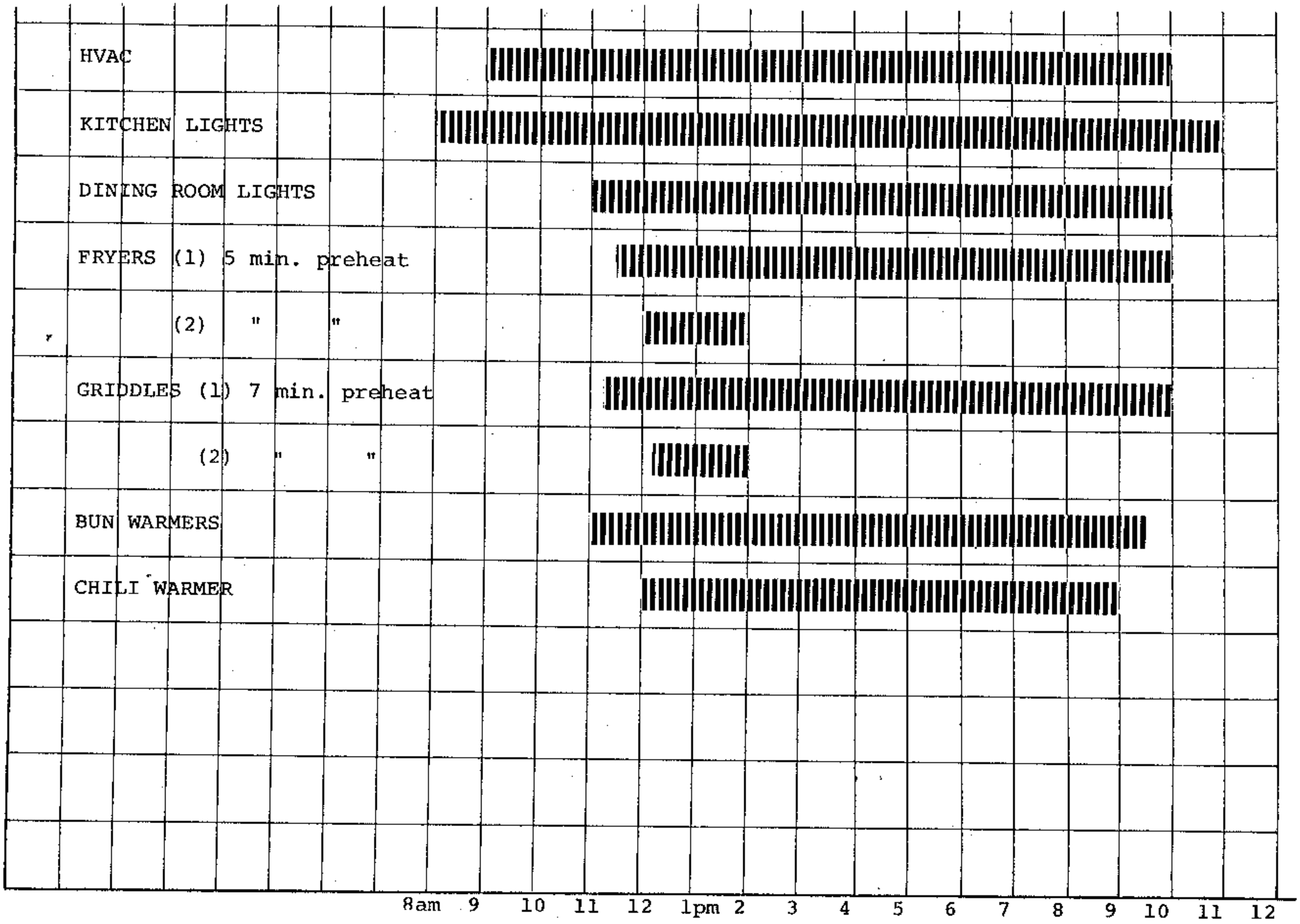
Operating Cost Per Hour

	$/Hour
Fryer	0.58
Griddle	1.04
Stove (1 element)	0.25
Large Ice Maker	0.10
Bun Warmer	0.14
Frosty Machine	0.18
Chili Warmer	.05

Characteristics of Electric Equipment

Equipment	Name Plate KW	Time to Preheat	Energy to Maintain 350°F
Fryer	5.5	5 min.	485 watts
Fryer	12	5 min.	770 watts
Griddle	12	7 min.	1,880 watts
Deck Oven-2 pan	6	20-30 min.	650 watts
Convection Ovens	11	9-10 min.	1,880 watts
Range Top	15.3	20-30 min.	690 watts/section
Range Oven	6	20 min.	600 watts/section

EQUIPMENT SCHEDULE



APPENDIX A

ELECTRICAL REQUIREMENT

Gross sq ft
of area 2280

(Area Identification)

Floor

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								
TIFFANY-DINING	14	40	560	.56	14	362	2838	
" -SERVING	3	40	120	.12	14	↓	608	
BATHROOMS	4	100	400	.4	14		2027	
VENT HOODS	5	40	200	.2	8		579	
WALK-INS	2	60	120	.12	2		87	
OUTSIDE	17	40	680	.68	4		985	
PARKING	2	250	500	.5	4		724	
OUTSIDE SIGN	1	1430	1430	1.43	4		2071	
INFR. FOOD WARM	6	250	1500	1.5	6		3258	
			SUBTOTAL	5.1		SUBTOTAL	13177	3%
Fluorescent								
DINING RM.	10	4X40	1600	1.92	14	362	9730	
KITCHEN	12	4X40	1920	2.30	14	↓	11656	
STORAGE	2	2X40	160	.192	1		70	
OFFICE	1	4X40	160	.192	14		973	
			SUBTOTAL	4.6		SUBTOTAL	22429	2.7%
TOTAL				9.7			35606	5.7%

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

Motors: Column 3 ÷ 1,000

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft of area ____________ ______________________ (Area Identification) Floor ________

Electrical Equipment	1 No.	2 Volts	3 Amps	4* Phase	5 Watts	6 Tot. Watts (Col. 1 x Col. 5)	7 Tot. Kw: See below	8 Number Hours per day	9 Number Days per year	10 Kwh Annual Requirements	11 Percent
Kitchen (cont.)											
Cooking/											
Processing											
FRYER	1						12	10	362	43440	
"	1						12	3		13032	
GRIDDLE	1						21.6	10		78192	
	1						21.6	.4		31277	
STOVE	1						15.9	10		57558	
						SUBTOTAL	83.1		SUBTOTAL	223499	49.3
HVAC											
-COMP.	2	208	21	3	7557	15114	15				
-COND. FAN	2	208	3.7	1	770	1540	1.5				
-EVAP. BLOW	2	208	6.7	1	1394	2788	2.8				
-COMP.	2	230	27	3	10743	21486	21.5				
-COND FAN	2	230	3.6	1	828	1656	1.7				
HEATING											
-CIRC. FAN	1	230	6.2	3	2467	2467	2.5				
EXHAUST	3	208	2	3	720	2160	2.2				
	1	115	4.4	1	506	506	.5				
Subtotal							47.7				28.3

*Three Phase: Column 5 x 1.73
Motors: Column 6 ÷ 1,000

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft of area ____________ ________________________ (Area Identification) Floor ________

Electrical Equipment	1 No.	2 Volts	3 Amps	4* Phase	5 Watts	6 Tot. Watts (Col. 1 x Col. 5)	7 Tot. Kw: See below	8 Number Hours per day	9 Number Days per year	10 Kwh Annual Requirements	11 Percent
Kitchen:											
Storage											
WALK-IN	1							24	365		
-DOOR HEATER	1	120			394	394	.394			3451	
-EVAPORATER	1	(4500 BTU @ 38°F)			437	437	.437			3828	
-CONDENSER	1	(5100 BTU @ 25°F)			971	971	.971			8506	
FREEZER-CON.	1	230	7.5	(2½HP)	1725	1725	1.725			15111	
-EVAPORATER	1	230	2.4		552	552	.552			4835	
-COIL	1	230	6.3		1440	1440	1.44			12614	
-PAN HEATER	1	230	1.2		280	280	.28			2458	
Subtotal						SUBTOTAL	5.799		SUBTOTAL	50803	3.4
Fabrication &											
Preparation											
BURGER MAKER	1	115	14			1610	1.61	1	362	583	
GRID/COMPRESSOR	2	120					.5	24		4344	
-FOOD WELL	2	208					1	24		8688	
						SUBTOTAL	3.11		SUBTOTAL	13615	1.8
Subtotal							8.91			64418	5.3

*Three Phase: Column 5 x 1.73
Motors: Column 6 ÷ 1,000

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft of area ____________ ______________________ (Area Identification) Floor ______

Electrical Equipment	1 No.	2 Volts	3 Amps	4* Phase	5 Watts	6 Tot. Watts (Col. 1 x Col. 5)	7 Tot. Kw: See below	8 Number Hours per day	9 Number Days per year	10 Kwh Annual Requirements	11 Percent
Kitchen (con .)											
Holding/CHILL	2	(MFGR. DATA ... ONLY 1 USED REGULARLY)					1.0	8	362	2896	
Serving FROSTY	2										
-COMPRESSOR	1	230	6.0			1380	1.38	12		5995	
"	1	230	6.0			1380	1.38	10		4996	
- BEATER	1	230	6.2			1490	1.49	8		4315	
"	1	230	6.2			1490	1.49	.2		1079	
- OTHER MOTOR	1	230	3.5			800	.8	4		1158	
" "	1	230	3.5			800	.8	1		290	
ICE MAKER	2	120	.8			192	.192	24		1668	
" "	1	208	10.5			2184	2.18	24		18940	
- DRIVE	1	115	2			230	.23	6		500	
DRINK MACHINE	2	120	.8		96	192	.192	24		1668	
BUN WARMER	2	120	12		1440	2880	2.88	12		12511	
									SUBT.	56016	
CASH REGISTER	2	115			50	100	.1	7		253	
WATER COOLER	1	115	5.3			610	.61	24		5300	
WATER HEATER	1	240	18.5			4500	4.5	12		19548	
									SUBTOTAL	25101	
Subtotal							19.224			81117	11.4

*Three Phase: Column 5 x 1.73
Motors: Column 6 ÷ 1,000

168.634 TOTAL KW

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