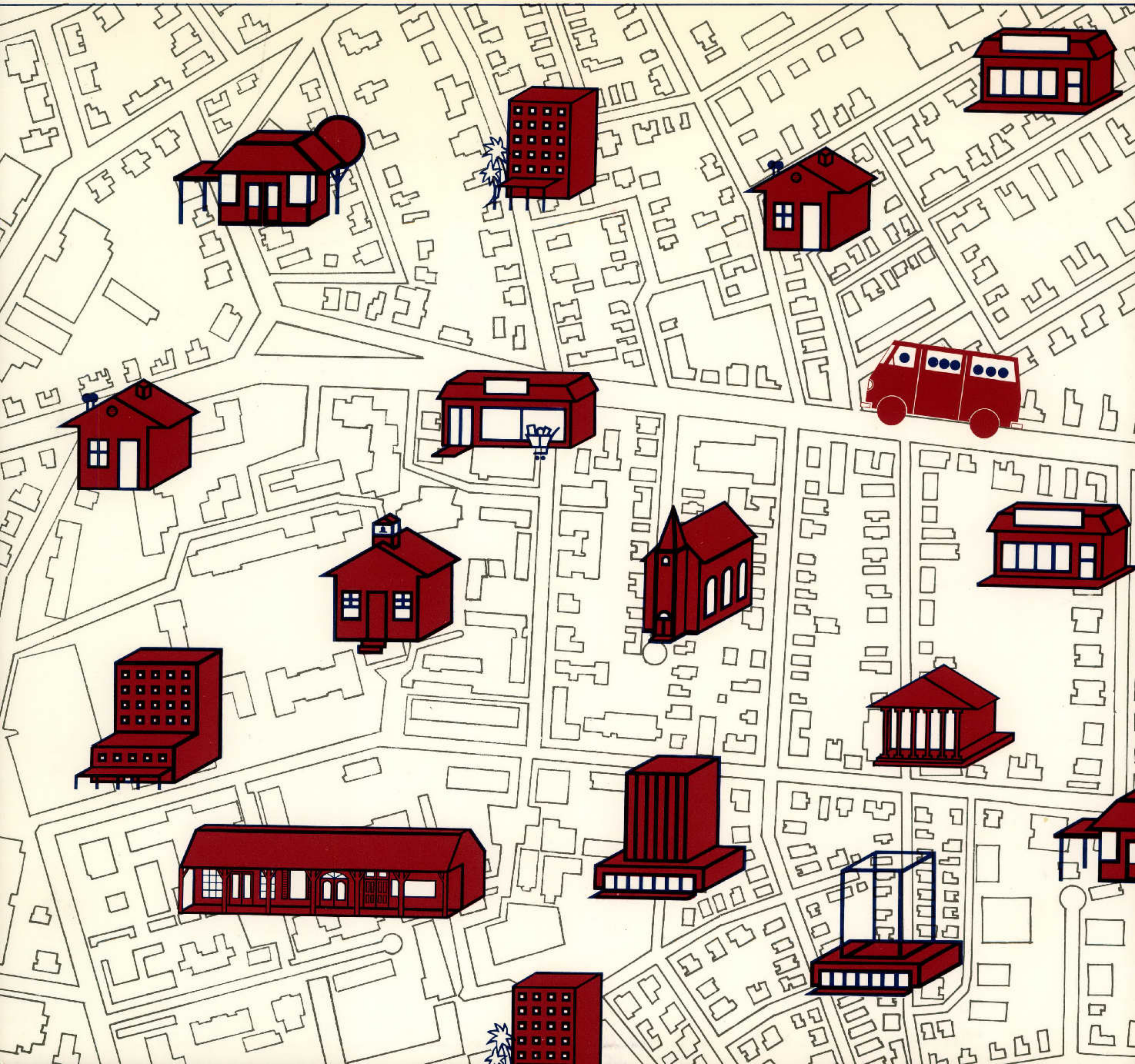
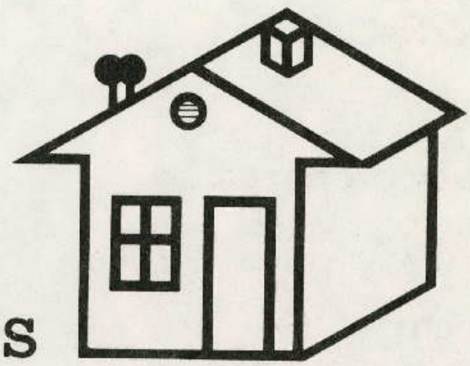
TEXAS ENERGY MANAGEMENT



1979 WORKSHOPS

TEXAS ENERGY MANAGEMENT

NEW RESIDENCES



WILLIAM P. CLEMENTS JR.
Governor, State of Texas

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

Government Documents
FEB 12 1980
Dallas Public Library

Staff Coordinators

Governor's Office of Energy Resources
7703 North Lamar Blvd. Austin, Texas 78752 (512) 475-5491

Tom Wright
Gloria DeLeon
Linda A. O'Neill

Materials prepared by

PLANERGY, Inc.
901 W. Martin Luther King, Jr. Blvd. Austin, Texas 78701 (512) 477-8012

Dennis Thomas
David McCandless, AIA
Jerry Matthews

Energy Management in new residences

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

This report was funded in part through a
grant from the Department of Energy.

ACKNOWLEDGMENTS

The Governor's Office of Energy Resources is indebted to the many individuals and organizations who gave freely of their time and expertise in the development of these workshops. The success of the workshops is directly related to their willingness to share ideas, experience and materials in the hope that it would be easier for you to develop energy conservation programs. Among the individuals and institutions we would like to thank are:

The Texas Association of Home Builders and Their Local Chapters
The Investor Owned Electric Companies in Texas Through COMGOT
The Investor Owned Gas Companies in Texas Through Texas Gas Utilities Standards and Code Committee
Bureau of Business Research, University of Texas at Austin
Roy L. Wilson, Austin, Texas
The Burns Co., San Antonio, Texas
The Quinton Co., Beaumont, Texas
The Bill Milburn Co., Austin, Texas
Owens-Corning Fiberglas Corp.
Rockwool Industries, Inc.
HC Products Co.
Friedrich Air Conditioning and Refrigeration Co.
Carrier Corp.

These materials are intended to encourage an awareness of the wide range of ideas, products and services of potential assistance in the development of new residential conservation programs. References to specific ideas, products and services should not be construed as endorsements. It is hoped that the information provided through this workshop will be useful as you explore your many options and opportunities for encouraging energy conservation.

TABLE OF CONTENTS

6 INSULATION

A review of the various types of insulation materials, recommended R-values, and ASHRAE Tables of R-values for building materials.

7 INFILTRATION

A look at several problems and their solutions, being the most important energy conservation concern in the residential construction process.

8 MECHANICAL

Considerations of air conditioning equipment, smaller sizing, duct work, heat pumps, hot water heat exchangers, and evaporative coolers.

9 APPLIANCES

A review of energy-efficient appliances and lighting for new homes; rating methods, new developments and selection considerations.

10 CASE STUDIES

A selection of materials on actual cases from builders in Texas, including energy consumption and billings, and an energy efficiency rating form.

11 APPENDIX

Glossary and bibliography.

1

OVERVIEW

AN OVERVIEW

The goal of the 1979 New Residential Energy Conservation Seminars sponsored by the Governor's Office of Energy Resources, and conducted by PLANERGY, Inc., is to conserve 6.17 trillion BTU's of energy in 1980 (0.11% of Texas' projected consumption) by increasing the energy efficiency of new homes. These workshops, for which this text is written, are conceived as a means of informing and motivating builders, developers and the real estate field in the concepts of design, materials, construction techniques and marketing used in achieving real savings in energy and utility bills for the new home buyer.

Meaningful savings are possible. This is shown in actual billings included in the chapter on CASE STUDIES. The buying public is interested, and will become even more interested in such homes in the years ahead as discussed in the chapter on effective MARKETING techniques. Builders and sellers must respond positively to this trend toward the Energy Efficient Home because the residential market is moving in that direction throughout the United States. This workbook is written to provide the basic concepts of such homes for those who are interested in building and selling homes in Texas.

There are many builders, both individuals and large developers who are making real contributions toward the overall goal of energy conservation. They are working in Texas and other parts of our country. The National Association of Home Builders has been conducting relevant studies on various energy-specific construction concerns. And there are many other similar efforts by individuals, institutions, and state and federal agencies working toward this same end...energy conservation. We are seeing the patterns fall into place. The basic concepts are becoming clearer, and the individual successes in builiding an Energy Efficient Home are now being multiplied into large projects.

The field of energy concerns is now so broad, in fact, that it is necessary to define one's area of interest. This text, and the workshops for which it is written, are planned for builders and sellers of the majority of new homes being built. That majority is not yet the "solar home"; it is still the simple "box-with-pitch-roof" form, being variations on traditional and ranch style homes. The solar home, as it is generally interpreted, incorporates "active solar" systems and its design is usually influenced by the solar equipment used. The fact that "passive solar" considerations may affect its design also is not usually apparent. While "active solar" is still a few years away from inclusion in the new homes market some preparation for its advent is well advised.

Some "passive solar" concepts can and must be incorporated through orientation and design if the full potential for energy savings is to be achieved in new homes in Texas. The techniques of orientation and design which have always been available, and which were usually ignored during the "free energy" era, can be applied without much stylistic change in the present residential market. These passive solar techniques and some active solar considerations are discussed in this text, in the chapter on ORIENTATION AND DESIGN.

Conservation of heating and cooling energy involves, essentially, the control of the indoor environment with the least use of energy feasible. This means that the total building envelope must allow the least heat flow possible, into or out of the home according to seasons. Recent research and experience show conclusively that two major construction considerations must be applied to achieve the proper building envelope. These are (1) adequate INSULATION, or resistance to heat flow through the walls, roof-ceiling, floors, etc., and (2) thorough controls of INFILTRATION and its twin, exfiltration. These two factors are of such significance that they are treated in separate chapters in this text, following the chapter on HEAT FLOW.

Research on infiltration is now proving that through leakage the "average" home allows about two air changes an hour in a 15 mile per-hour wind. This translates into 48 times the cubic volume of air in the house, which the owner pays to heat or cool as it moves through the house over a twenty-four hour period. Proper infiltration controls can reduce this leakage considerably. The potential for energy savings through good infiltration control is much greater than that afforded by the best insulation practices.

The experience of builders who are achieving good infiltration and exfiltration control, along with proper insulation installation, is rather dramatic. They are finding that in a home in which a four ton air conditioning system would ordinarily be required, the system can be reduced to about two and a half tons. This means that the installation cost is lower and the savings can often balance the added cost of the better insulation and infiltration controls. The major gain is threefold: (1) the new home owner has lower utility bills; (2) the builder therefore has a marketing advantage; and, (3) when multiplied by many, many houses there will be a meaningful reduction in overall energy use in Texas' homes.

One example of this approach to the Energy Efficient Home concept is shown in the work of Herman Quinton, The Quinton Company, Beaumont, Texas. Several years ago when Mr. Quinton was a contractor for insulation installations he realized that he was treating only one part of the building envelope problem. He then offered also the services of complete air infiltration and exfiltration control. This combination worked so well that it was obvious that smaller heating and cooling equipment could be used. Calculations of heat gain and heat loss confirmed his observations. But Mr. Quinton could not find a mechanical contractor willing to put in the smaller equipment. After some additional investigation he decided to include the mechanical systems also as part of his services. He gives written assurance to the home builder and owner that the system will function properly. Mr. Quinton was successful in this venture and his business has grown accordingly. To substantiate his efforts he has been monitoring the electrical usage and the utility bills of the families living in those homes which he has worked on. Some of his findings are presented in this text, in the CASE STUDIES chapter. They are proof that energy savings and dollar savings can be significant for the builder, the seller, and the new home owner.

There are many factors which must be considered in choosing the mechanical system for a home. The equipment for heating and cooling has been the major energy user, historically, and even if it can be reduced in size significantly, it must be chosen for its efficiency and for its appropriateness to the house plan configuration, including its duct (etc.) system design. While air conditioning systems should never be oversized, they must still provide adequate air movement for the size of the home. All these interrelated conditions are discussed in the chapter on MECHANICAL SYSTEMS.

When many energy conserving features are provided in one new construction they, of course, help each other. It becomes difficult to establish just how much savings can be attributed to any one feature, or what its pay-back period can be. One really has to look at the entire home and its savings over what has been standard consumption and cost. Buddy Burns, of the Burns Co., who builds and sells about 300 energy efficient homes a year in San Antonio, has worked with the National Association of Home Builders and Texas Power and Light Co. in analyzing both planning and construction techniques and the resulting savings. TP&L has done some significant testing of infiltration problems, and Mr. Burns is now using the same testing methods in his construction. Mr. Burns' estimate of the energy savings that can be achieved in new construction are based on (1) previous estimates from TP&L, NAHB, and other research literature; (2) the interrelation of all the necessary planning and construction techniques; (3) data from his own firms work; and (4) the life style, or "occupant attitude", of the new home buyer. Assuming that the new home owner appreciates the energy efficiency of his new home, Mr. Burns shows that the savings can amount to 33 to 50% of standard construction utility bills, according to the extent of the energy savings features built into the home. To achieve the most savings possible, Mr. Burns finds that there are five basic elements of planning and construction which must be properly handled. Their potential for energy savings over standard construction, as they related to each other and as applied in a new home are as follows:

Potential for Energy Savings

Orientation	=	16.67%
Design	=	21.33%
Thermal	=	12.0 %
Infiltration	=	33.33%
Equipment	=	16.67%
		100.00%

Seeing these elements of planning and construction in this perspective is very revealing. Note that 38% of the potential savings occurs before the ground is broken. Only 45% is attributable to the building envelope itself. It is especially revealing that thermal control through proper insulation and wall, roof, floor materials only contributes 12% of the savings that is actually possible. Air leakage is almost three times more critical than inadequate insulation.

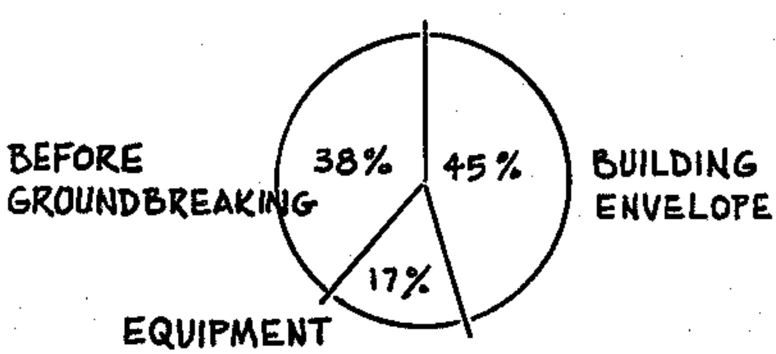
These five elements of planning and construction are the major concerns of most research and development on the Energy Efficient Home. It should not be surprising that they are also major chapter titles in this text. Mr. Burns has used these topics and many sub-topics under them to develop a "Power Saver" rating system for use on each house his company builds. His is not unlike other rating systems being developed and used by the industry, by federal and state agencies and by some utilities. It is expected that some such system may soon be used as an accepted method for identifying the particular characteristics of "energy efficient" homes as they come on the market in Texas. Mr. Burns' Energy Efficiency Rating forms are included in the CASE STUDIES chapter of this text. Additionally, some of the Burns Co. marketing materials and techniques are included in the chapter on MARKETING.

Occupant attitude, which is "half the battle" according to Mr. Burns, may seem like a force over which the builder and the real estate agent have no control. They can influence the life style of the new home buyer more than they realize, however, through the marketing techniques and materials which they choose to use. There is no greater educational force than that which is inherent in advertising, especially where a mans pocketbook is concerned. Occupant attitude is discussed in detail, therefore, in the chapter on MARKETING.

Another way that the builder can have some influence on the energy uses of the home owner is through the choice and installation of the appliances he can provide. A chapter on APPLIANCES is, therefore, included in this text. There are several energy conservation factors which should influence the purchase and the installation techniques for a number of home appliances and fixtures which the builder and the selling agent should understand. Put in proper focus this material can also be used in marketing and thus have a further influence on the new home owner's energy use.

Energy conservation in Texas varies from other states in many ways because of its differnet climates. Actually, Texas is made up of several geographic, demographic, and historic areas as well as climatic regions, and they all combine to influence both energy consumption and how we build our homes. It is our intention that this text be as "Texas specific" as is possible. Most recommendations will apply to all regions, while for other points, explanations and examples for particular climatic conditions will be presented. It is obviously not possible in a text this size, in Texas, to present a specific set of guidelines for each reader's home area. The reader is urged to interpret the recommendations with the variables presented to apply to his own region.

POTENTIAL FOR ENERGY SAVINGS



2

MARKETING

MARKETING

The energy efficient home is taking its place more and more clearly in the new residential market in the United States. The energy crisis which came upon us in 1973, and which may well hit us again even harder, gave the impetus to research, construction and marketing in the field. During the intervening years much has been learned and the buying public has become aware of home energy conservation. While some folks may not now be as fearful of fuel shortages as they used to be, inflation and the cost of fuels have become a big concern. So now we can also show that it is cheaper to live in an energy efficient home than a standard one, that a real savings in dollars as well as energy is possible, and in a new energy saving home the dollar savings can begin practically as soon as the new home buyer moves in.

There is one major point that makes buying a new energy efficient home very attractive, economically. There are four other points that follow in obvious order. Taken altogether one wonders that the bankers would lend money on anything but the energy efficient home:

1. Put it in the Mortgage-- The savings created by putting the cost of the "energy savings package" (ESP) in the mortgage is substantially higher than the increase in the monthly mortgage payment for doing it.

2. Savings through Tax Deduction -- In the beginning years of the mortgage, the major part of that extra cost for the ESP is deductible as interest paid for income taxes.

3. The Savings Increases Yearly -- As energy costs climb each year, the difference in utility bills for the ESP home compared to the standard home increases, indicating a greater savings per month (1, above). It is a hedge against inflation.

4. Potential Resale Profit Grows -- When principal, interest, taxes, insurance and utilities are added up in Life Cycle Costing, the energy efficient home will cost progressively less to own and thus will be more attractive to buy than the same age standard home.

5. No Better Investment -- The $1,500 for the ESP would have to be invested in something else earning 27% the first year on up to 63% in the 10th year to equal the savings it will create in utility bills.

Understanding these five points is essential to developing a marketing approach based on dollars saved by the homeowner. Each builder or real estate salesman must know the potential for savings for the home he is marketing, then he can apply these principals in his "pitch".

Put it in the Mortgage

It is obvious that any basic materials and labor put into new home construction will be included in the cost and thus in the owners mortgage, whether they are standard items or part of the Energy Savings Package. We are so used to viewing the individual items of the ESP in terms of individual payback that we sometimes forget that they are already "paid for" in the new home through its mortgage. Since all items in the ESP work together with the whole house to achieve real energy conservation it is questionable if you can isolate their contributions, or their "payback". In total they are causing immediate savings in energy and in utility bills, and this savings is invariably much more than any increase in the mortgage. One item, a small increase in the down payment on the house, due to the ESP cost, might occur, but it should be quickly paid off.

A good example of the dollars and sense involved in this marketing point is made in the booklet A New Home Buyer's Guide to Energy Efficient Homes*, available through the Governor's Office of Energy Resources. We quote from page 4 of that booklet here:

The Economics of Energy Efficiency

Let's take a look at a hypothetical example:

Suppose that you wanted to buy a 1,600 square foot home in Dallas. The price for a "standard" construction package is $55,000, while the same house with a special "energy efficient" package costs approximately $1,500 more. The question is whether the additional cost is justified.

The "standard" package has single glazed windows, solid core wood exterior doors, R-11 wall insulation, R-19 ceiling insulation, standard weatherstripping and a central air unit with an Energy Efficiency Ratio (EER) of 7.5.

The typical "energy efficient" package features double glazed windows, storm doors, R-19 wall insulation, R-26 ceiling insulation, superior weatherstripping, thorough air infiltration controls, and a high efficiency heat pump central air unit of smaller size with an EER of 8.5.

Your purchase of the "energy efficient" package could result in an average monthly savings of approximately $33.58 ($403 per year) on your heating and cooling bills (assuming 5.5¢/KWH summer and 5¢/KWH winter). On the other hand, the energy efficient package would cost you an additional $150 in the down payment and an extra $11.61 each month (for principal and interest, assuming a 30-year loan @ 9-3/4 percent with 10 percent down).

How long before you would reach the point of being money ahead due to the energy efficient home package? The answer may surprise you: only about seven months.

You would save approximately $22 each month due to the energy efficient package (the difference between $33.58 and $11.61). In seven months you would have saved approximately $150, which would be equal to the additional down payment you had to make when you purchased the home.

Beginning in the eighth month from date of purchase, you would reap actual savings averaging $22 per month....for as long as you own your home. That's assuming that utility costs remain constant. If they continue to go up as experts predict they will, your average monthly savings would also grow.

There may not be a better investment.

The Tax Deduction

The second point to consider is the tax advantage which goes with putting the ESP in the mortgage. The interest portion of each monthly mortgage payment can be claimed as a tax deduction, and a little of this will be due to that slight increase in the mortgage payment for payment for

---

* For copies of A New Home Buyer's Guide to Energy Efficient Homes, contact your local real estate association, your local builders association, or the Governor's Office of Energy Resources, 7703 North Lamar, Austin, Texas 78752, (512) 475-5407.

the ESP. Since the cost of utilities is not deductable, the owner will be trading a nondeductable expense for one that has some tax deduction advantage.

To see what this might amount to, let us use the numbers from the mortgage example quoted above. The savings in the utility bills was $33.58 and the extra mortgage cost was $11.61 per month indicating an actual savings of about $22 per month; $11.61 for 12 months equals $139.32 per year on the mortgage for the ESP. Of this, about $125 would be deductable as interest in the early years (this amount of course, varies with the amortization schedule). Assuming a family taxable income after deductions of about $22,000 per year, an actual tax reduction of about $36 would result from the $125 deduction. This would be $3 per month, and with the $22 savings for putting the ESP in the mortgage the owner would realize a savings of about $25 per month.

While we are looking at taxes we should also consider the new federal tax credits for energy applications. These credits do not apply to new homes except for the installation of "renewable energy sources" such as "solar, wind-powered, or geothermal property for your home." Today's new home builder may want to plan his homes to be able to market them so the new home owner can more easily adapt a future solar system to the home and thus be able to apply for that tax credit. This would involve at least the proper solar orientation, roof slope, and structure for the house. It might also include some of the piping and wring roughed in, and space for equipment. Such consideration could be marketed as a "SOLAR CONVERSION PACKAGE."

The Increasing Savings

Of course the tax savings through deductions for the energy package would decrease through the years with the amortization schedule, but the basic savings in dollars for less energy use in the home would increase much more dramatically. If, as is predicted, the cost of energy increases at a rate of 10% per year, the $33.58 per month savings in the example above would increase to a monthly savings of about $49 or $50 in only five years. On a yearly basis that is an increase in savings from $403 to about $590 or $600 in only five years. In the tenth year that savings would be about $950. If the ESP home owner pays $950 less than the standard home owner imagine what the standard house energy bill is in the tenth year...about $2,500. If the "standard" home is an energy hog its owner may be paying about $300 in the heavy months.

Life Cycle Cost and Potential

All this leads us to considering the "Life Cycle Costs" of the home, that is: the total for the major cost items for owning the home over a period of time. For many years the real estate brokers and the builders have considered these costs by the initials "P-I-T-I" to include principal, interest, taxes and insurance. Now the term P-I-T-I-U has been adopted to include the utilities costs. When we consider these costs over a period of ten years for example, the principal and interest remain the same (P-I), the taxes and insurance (T-I) will probably go up the same amount for comparable "standard" and "energy saving" homes, and the utilities costs (U) will be quite different. The energy savings of $403 the first year plus the increasing savings the next nine years will amount to a total savings of $6,422 in energy costs for the ESP home, assuming energy costs climb at a rate of only 10% per year.

One must not forget the mortgage and taxes over the ten year period. The income taxes saved may amount to $450 depending on the owners income bracket. The additional mortgage cost of $11.61 per month is $139.32 per year, which is $1,393.20 over the ten years. Adding the $450 for taxes to the $6,422 saved on energy, and subtracting the $1,393, we see a Life Cycle Cost savings in ten years of about $5,479 for investing in the energy savings package.

We know, of course, that in the long run all homes cost a lot more than the original base price because of the continuing interest payments in the loan. What we have tried to show above is that the energy savings accumulate to a dramatic advantage for the ESP home owner, and the total costs reflected in P.I.T.I.U. make the ESP home eventually much less expensive.

This type of dollar reasoning can be used as a marketing technique. Each builder and seller will have to apply his own numbers to the example he wishes to present in his publicity and advertising. A good example of this which has been used effectively in San Antonio is included in the reprinted Marketing materials at the end of this chapter. Look for the heading "LIFE CYCLE COSTING" by the Burns Co. in San Antonio. Note, at the end, that Mr. Burns claims that a buyer qualified for an 80% loan on a $60,000 home built to "Builder Standards" should "also qualify for an 80% loan on a $68,150 Burns Co. "Power Savers V" home, considering that the total cost over 10 years is actually the same." Burns challenges the home buyer to "show this ad to your bank or lending institution" and ask them about qualifying for the higher priced energy efficient home. "If their answer is anything but 'yes', ask them to call me," he says, providing his telephone number for added emphasis.

The home owner who keeps a record of his utility bills, and uses his ESP home properly will be able to compile convincing evidence of how his house "saves money". After a period of several years he will have proof of its Life Cycle costs. There is every expectation, with the threatening shortages of oil for energy generation, that energy consumption records in BTU per SQ. FT. per YEAR will have a marked effect on the resale value of all homes.

Even though we have had a first "energy crunch", this concern for conservation at the time of resale has not proven a meaningful force. That is because the buying public seems complacent, but that attitude will probably change. In the first place, Americans' access to world oil sources is very questionable at this writing, and another, longer oil emergency may soon occur. Secondly, with the introduction of Building Energy Performance Standards (BEPS) and the techniques of energy audit analyses, the term "BTU per SQ.FT. per YEAR" may become quite a common measure of energy use. When we all learn the differnece between, say, 42,000 BTU per square foot per year* compared to 80,000 BTU for the same season there will be a new factor in real estate sales considerations. It may take a few years for this to come about...probably just long enough to enhance the resale value of the new ESP homes of those buyers who may need to move again.

A Better Investment for $1,500?

One of the most dramatic "pitches" you can put in your marketing approach is to ask your home buyer where he can get a 27% return on a one year investment. Your answer is in buying your energy efficient home. The explanation is this: if he doesn't invest the $1,500 for the ESP in your house to save $403 in the first year's utility bills he will have to invest it in something else that will pay 27% interest income so that he can afford the difference between the utility bills for your house and for the standard one he may buy instead.

The real clincher is that in the tenth year that investment of $1,500 would have to be in something paying a 63% return to match the difference in utility bills, if energy costs go up by only 10% per year.

---

* Based on a 1,500 Sq. Ft. home in Austin which uses only 20,800,000 BTU for heating and 42,200,000 BTU for cooling.

Let us assume that in our earlier example (mortgage, taxes, etc.) the Standard Home's average monthly utility bill is $90.52 and the ESP home's bill is $56.94, for which the difference is $33.58. If two-thirds of the standard home's bill is for heating and cooling, then by the billing for the ESP home we see that its costs for heating and cooling was reduced by about 50% which is reasonable for a good quality ESP project. The rest of the cost accounts for other energy uses such as water heating, lights, refrigerator, etc. Additional savings in dollars can be found by choosing appliances properly, and the reader is therefore urged to study the chapters on Mechanical Systems and Appliances.

A "No Cost" Energy Package?

So far we have tried to use dollars saved to justify dollars spent in a way that might be used for a marketing effort. Let's look at the energy saving package and the whole design concept, and ask, "Is the work on energy conservation really going to make the house cost more?"

Some builders have said that their extra costs on a simple but effective program have been balanced by the reduction in mechanical equipment size and cost, which results from good control over heat gain and loss. If we assume that the Energy Savings Package costs $1,500, as in our earlier example, the point is hard to prove. One must remember, however, that each project has its own peculiarities; the marketing ideas and construction accounting for one developer seldom work for another.

The chapters of this text which follow give much information on developing an effective energy program before construction starts. Much can be achieved for energy conservation on a relatively small scale effort. Lets make the following assumptions for a project of several homes:

1. The lots are developed for proper orientation and design (winter solar heat gain; no solar gain thru glass in summer; good cross ventilation possible; shading against summer heat gain on walls).

2. Once you are in the attic, walls, etc. to install the basic insulation, it is only the materials that add to the costs if you increase the R-value.

3. Plan and achieve a very good control over infiltration and exfiltration: partly through doing the normal things carefully (vapor barriers, attic ventilation, weatherstripping, good carpentry and trim work, good subcontractors, etc.) and partly by having a straight forward and thorough caulking job done with one of the expanding urethane foam sealants.

4. Design the house and its ductwork for simple flow patterns of the supply and return air.

These items can all be considered standard cost, not energy-cost, items, except for the extra insulation and the urethane foam caulking, if quality of construction and design concept are important to the developers reputation. Through these efforts, the heat gain and loss could be reduced to the point where a 2½ ton heating and cooling system can be used in lieu of the usual 4 tons. At $500 per ton, estimated, a $750 savings is indicated. There may however, be some attendant conditions, such as assuring adequate air movement, which may reduce this savings. But even $400-to-$500 will go a long way in providing some extra insulation thickness in the ceiling and good infiltration control.

A Different Incentive

Dollars are not the only incentive which should be used in marketing the energy efficient home. By contrast consider human comfort. A home that is truly energy efficient has an environment which is more comfortable to live in because it has been designed and built to reduce heat gain in the summer and heat loss in the winter. The inside surface temperatures are also more moderate. These is less heat radiated inward from the ceiling, the walls and windows in the summer. Similarly, in the winter those ceilings, walls and windows are not so cold, and the human body does not loose so much heat to them. The cold drafts and warm air flow patterns due to convection currents which we all have experienced in older uninsulated and leaky structures, do not occur in an energy efficient home. Furthermore, if the mechanical system is properly designed for air flow, and if it is properly sized (not oversized) it will run more efficiently with less temperature contrasts in its cycles and air circulation, and it will, therefore, provide a more even, comfortable environment. Herman Quinton of Beaumont quotes one of his home owner's experiences regarding his energy efficient home. The story says a lot about comfort as well as energy conservation. It seems that this family went away from home from July 2nd to July 5th, turning off the air-conditioning as they left. During those three days the weather stayed at about 95°F temperature and 95% relative humidity. When they came back to the house the inside temperature had gone up only from 76° to 78°.

Owner's Attitude

There is one very important aspect of building and selling energy efficient homes which the builders and developers should understand quite clearly. It is the owner's attitude toward living in an energy efficient home, and how he uses it and enjoys it. The builder who ignores this concern may find that he has a few customers who do not understand what they have bought. On the other hand, a discussion of the owners life style in the energy efficient home can be used as a marketing technique.

The importances of the owners understanding of his home and the possibility of achieving real savings is evident in an experience of Buddy Burns, a San Antonio Builder. He tells of a family who bought one of his "Power Saver" homes and who were happily saving energy and dollars for a couple of years. When they had to leave San Antonio they sold it to a second family who bought it because of the Burns Co. reputation. After several months the second family complained to Mr. Burns about the high electric bills, so he reviewed with them their lifestyle in the home. He pointed out that the first owners got lower bills because they were probably more careful about closing exterior doors and windows and turning off unnecessary lights, using appropriate temperature settings and the night set back for the thermostat, establishing reasonable water temperatures and shower usage, and non-wasteful patterns generally. The house obviously had the potential for savings, but it had to be used appropriately to achieve its possibilities.

That is true of all energy efficient homes. They have the potential but they are not more efficient than the folks who live in them. Marketing techniques should play up the "ways by which the family can make the house save dollars for them."

R.B. Fitch of Fitch Creations in North Carolina, who set out to build "the most energy efficient moderately priced house in the United States," provides home buyers with information on how lifestyles affect energy consumption. "You've got to show people how to live in their house properly because buyers have more effect on energy consumption than anything we can build into the house." Since most builders and realtors depend upon referrals, keeping customers satisfied is an important consideration.

Another advertising approach used by Fitch that reinforces his good energy habits theme is a contest called the "Polks Landing Challenge." Singles, couples and couples with children make up the three categories of contestants vying for the lowest utility bills. Fitch pays the lowest bill in each category every month. "The contest costs me $60 to $70 a month, and I think it's the best money I ever spent for advertising," he said.

A final point that needs to be made in your initial marketing effort is an assurance that energy conserving homes can be as attractively designed as any conventional construction home. Many consumers have the mistaken idea that an energy conserving home resembles a windowless box. Bill Milburn is careful to point out in his ads that "We believe a home can be energy-efficient and still win awards for design...Because a dull interior has nothing to do with energy savings. It's just a poor excuse for poor design."

And Buddy Burns says, "People still want a good looking home, and that's what we try to provide...and all things being equal, and I have energy too, I'll sell."

Energy conserving homes are here to stay. There is not a builder or realtor who can afford to ignore this new trend. The sooner you build your reputation, the less it will cost you in the long-run. A carefully planned and executed merchandising campaign is the key to successful entry into this new market. Many builders of energy efficient homes have already reached the point where they can boast waiting lists for their homes. These frontrunners know what they're talking about. You should too.

The Energy Story: Foreword

The purpose of this brochure is to **inform** you, not alarm you. It deals with a very real problem—the energy crisis. It exposes a very real danger—that your home, no matter how new, may soon be obsolete. And it offers a very real solution—a six-part remedy with an established track record of success in combatting and controlling the problem.

If you are one of the 20% of American families who have gotten serious enough about energy conservation to look for an energy efficient home, take the time to read this brochure carefully.

Fred E. "Buddy" Burns,
President
The Burns Co.

The Problem
Is there really an energy crisis?

The Danger
Your home may be obsolete.

The Solution
Six steps to energy efficient construction.

Attitude: Are you willing to do your part?

Design: Two stories are better than one.

Orientation: Follow the sun.

Thermal Protection: Keep the heat from moving.

Weatherization: Extra insulation isn't the answer.

Equipment: Using existing technology and proven systems in new combinations.

The Energy Story.

The Energy Story: The Problem.

I'm Buddy Burns.

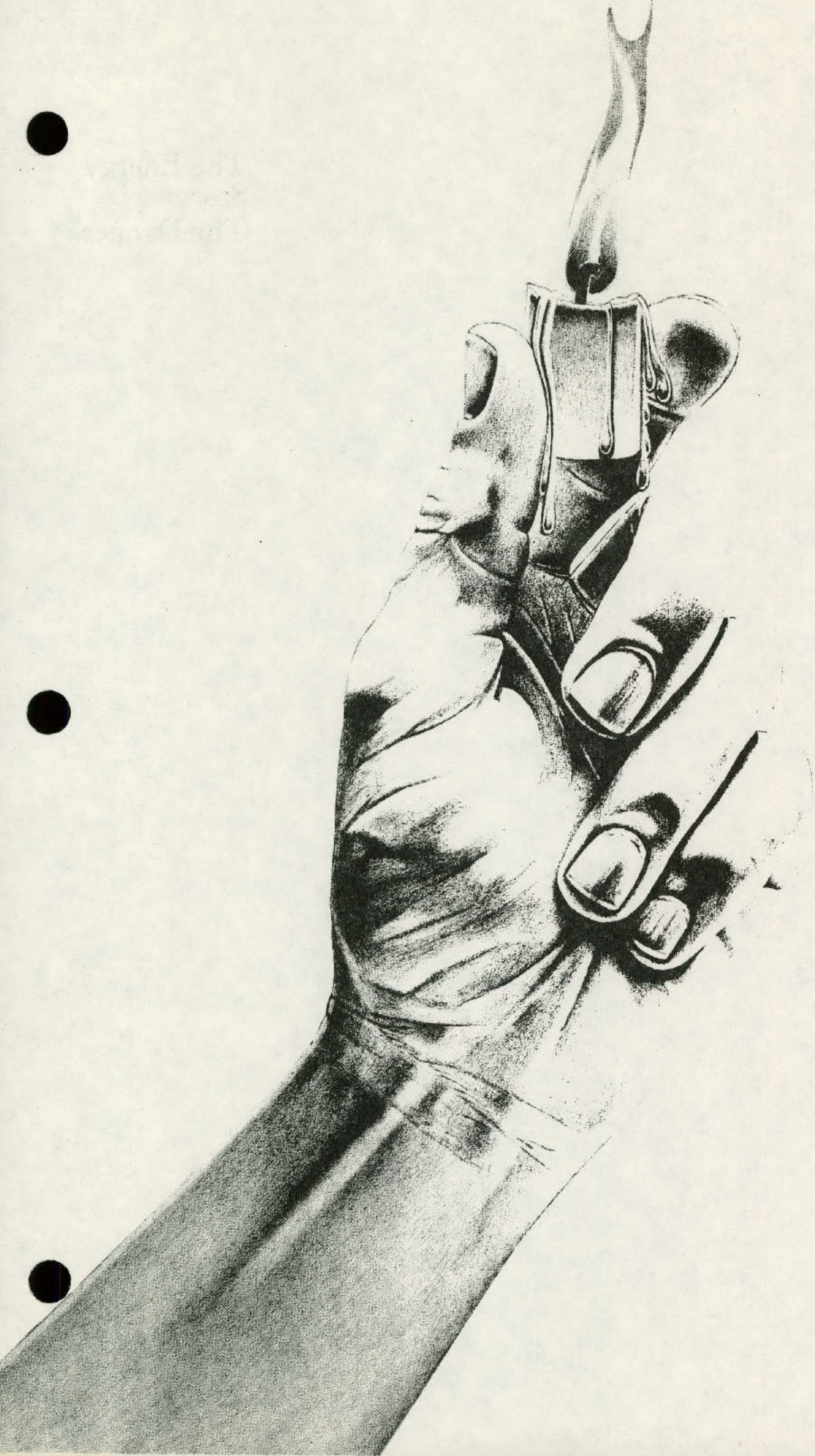
And since 1973, when I began building San Antonio's first energy efficient homes, there's been a lot of talk about the so-called "energy crisis." We've all noticed a steady rise in our utility bills, but all too often we blamed our natural gas supplier or common inflation for what we hoped was an overpublicized, temporary condition.

Well, it's not. The energy crisis is *real*, and it's permanent. Yet, if I told you that your utility bills will probably *double* in six years, *triple* in ten, I doubt if you'd believe me. And if I told you that your present home may soon be *obsolete*, you'd probably laugh.

Don't Laugh.

As of 1975, the U.S. had proved recoverable reserves of about 228 trillion cubic feet of gas and 34 billion barrels of oil. But, our production of easily accessible reserves keeps falling nearly 3% a year, while low domestic prices discourage investment in the extremely high cost of drilling rigs, exploration, etc. to develop the critically needed new production. Our consumption continues to increase at record pace, further widening the gap between supply and demand. Almost *no* progress has been made to convert our present generation systems to coal or nuclear power, America's two most abundant energy resources *potentially* capable of providing more energy than all the Mid-East oil fields. And we all know you can't "leap frog" into new energy production overnight, it takes years. For example, from original planning to *projected* first production, San Antonio's nuclear plant will take nine years—1971 to 1980.

In the meantime, we're at the mercy of foreign oil suppliers, now importing one-half all our oil consumption. And while the government has made no "official statement" of what's going to happen to energy prices in the future, the conservative consensus of economic analysts indicates an average rise of 10–12% per year. Compounded, this *doubles the cost of utilities in six years, triples the cost in less than ten!*

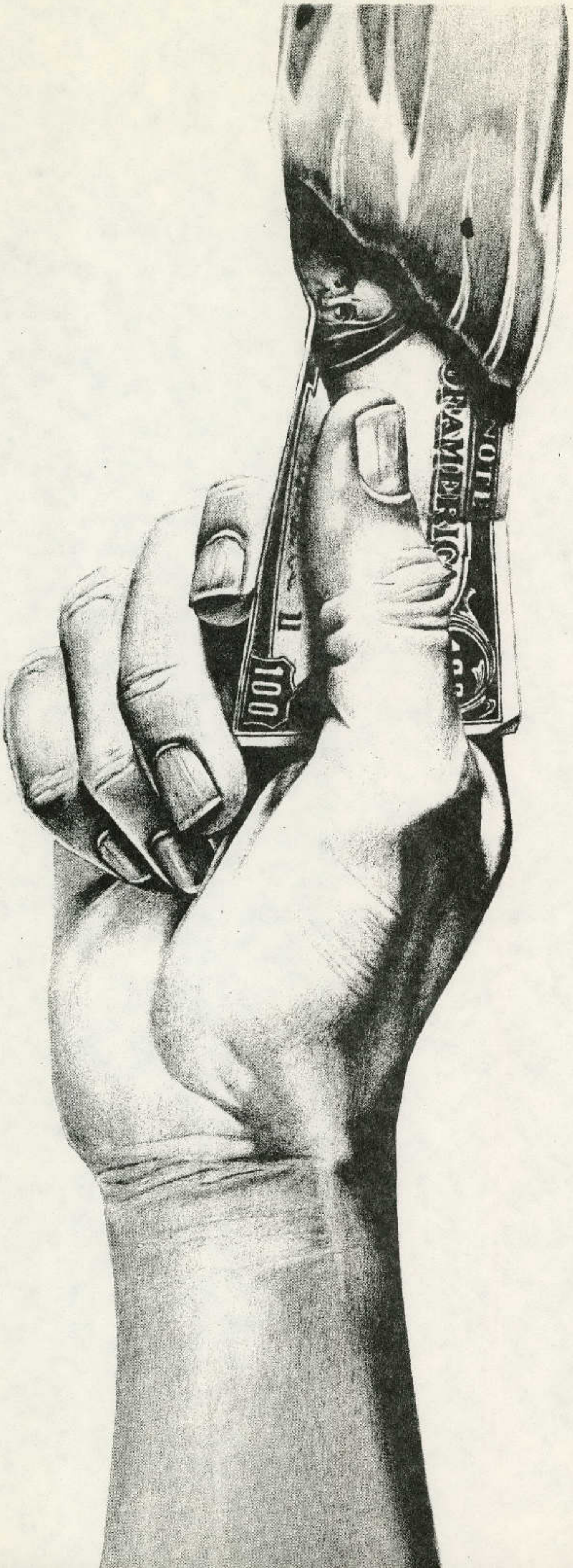


The Energy Story: The Danger.

Warning Signs.
Many San Antonians are already feeling the effects of the energy crisis. Their monthly utility bills are getting as high as their house payments, in some cases higher. I'm talking about people whose homes are less than five years old, some less than a year old. Homes either built before there was much concern for energy conservation, or homes with so-called "energy packages" that are hopelessly inadequate to effect energy efficiency.

Resale vs. No Sale.
It's true that a home is a wise investment, and that the *resale* value of homes in San Antonio has risen steadily with the rising cost of new housing. Regardless, nobody wants to buy a home that costs more to operate than to own.

So if your utility bills are approaching your monthly house payment, you may be faced with a rather unsettling reality—*your home may soon be obsolete*. There has never been a more urgent need to buy an energy efficient home.


NOTE
AMERICA
100

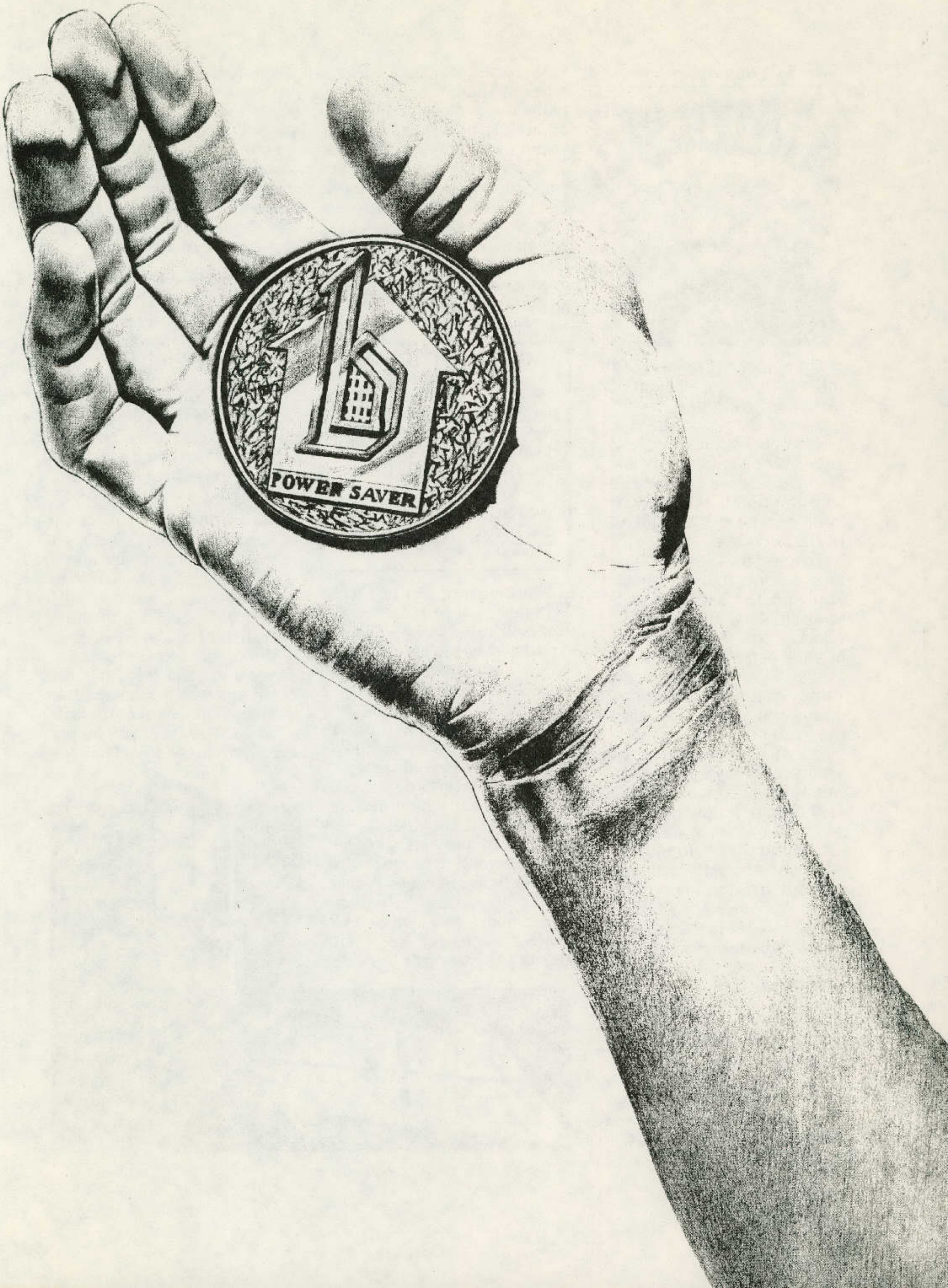
The Energy Story: The Solution.

Fifth Generation Power Saver Homes.

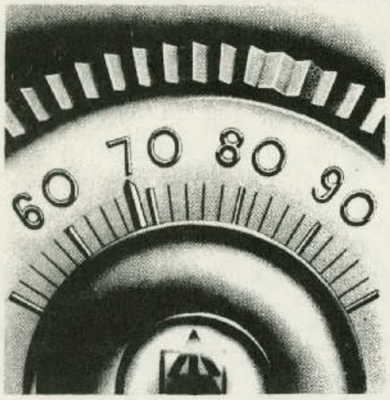
The Burns Co. has been designing, building and refining energy efficient Power Saver homes in San Antonio for over five years now. In our latest Power Saver V homes we offer for sale the most advanced *energy efficient construction* in the United States today.

Energy efficient construction (E.E.C.), simply put, means *controlling heat gain and loss*. Although energy efficient appliances and sensible use of lighting are important in conserving energy within your home, the major impact of reducing energy *waste* comes from E.E.C. For your home to achieve the maximum practical energy efficiency, it must be site-designed, constructed with proper materials and equipped with high energy efficient mechanical systems. And, of course, it must be operated properly.

Burns Co. Power Saver V homes incorporate a six-step approach to control heat gain and loss. The first step is actually up to *you*.


POWER SAVER

Step 1: Your Attitude.



No home, regardless of its inherent energy efficient construction, will effectively conserve energy without your cooperation. We have data which shows nearly a 200% difference in the utility consumption habits of two families who had occupied the same house!

Where you set your thermostat, how you use your appliances, what you teach your children and pets influences the energy efficiency of your home. With your Power Saver V home, we'll supply you with a compendium of tips for squeezing all the juice out of every kilowatt, without sacrificing your practical lifestyle. We encourage you to make an honest effort to follow certain recommendations; otherwise all the things we do may be quite useless. After all, we can only build so many Power Saver V homes each year, and we would prefer that people who are really serious about energy conservation own them.

Step 2: Design.

Most of our Power Saver V homes are *two-story* plans, as were our first Power Saver homes back in 1973. The reason is partially economics—two-stories are more cost-efficient than one. Two-story plans make more efficient use of land, they require far less roofing and foundation costs. But, a vital factor in energy construction is design, and here two-stories are sure and easy winners. Our most popular Power Saver V *one-story* plan requires a 32% greater air conditioning unit size than our typical two-story model.

AIR CONDITIONING REQUIREMENT: ONE VS. TWO-STORY POWER SAVER V HOME

1560 SQ. FT. ONE-STORY
2½ TON (30,000 BTU)
19.23 BTU/SQ. FT.

2061 SQ. FT. TWO-STORY
2½ TON (30,000 BTU)
14.55 BTU/SQ. FT.

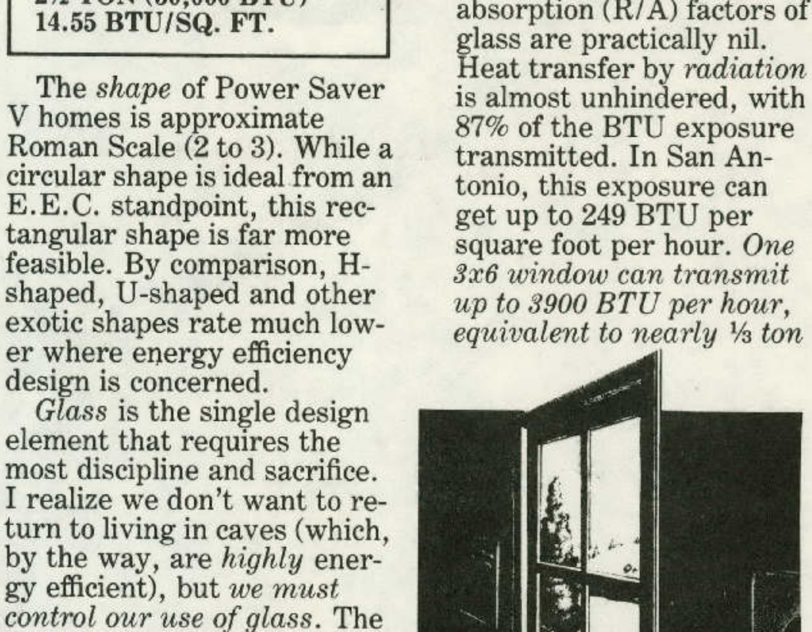
The *shape* of Power Saver V homes is approximate Roman Scale (2 to 3). While a circular shape is ideal from an E.E.C. standpoint, this rectangular shape is far more feasible. By comparison, H-shaped, U-shaped and other exotic shapes rate much lower where energy efficiency design is concerned.

Glass is the single design element that requires the most discipline and sacrifice. I realize we don't want to return to living in caves (which, by the way, are *highly* energy efficient), but *we must control our use of glass*. The Burns Co. attempts to design it completely out of walls that we know will have East or West exposure. Then we place 60% on our South, 40% on our North walls. We occasionally get less than 10% glass-to-floor-area (200 square feet of window on a 2000 square foot house), and rarely exceed 12%.

Three Modes Of Heat Transfer Through Glass:

Conduction. The R-Value of a standard glazed window (R-.94) is 26 times less than that for an opaque wall used in a Power Saver V home (R-24.6). This means the window transmits 26 times more heat by *conduction*, 24 hours a day.

Radiation. The reflection/absorption (R/A) factors of glass are practically nil. Heat transfer by *radiation* is almost unhindered, with 87% of the BTU exposure transmitted. In San Antonio, this exposure can get up to 249 BTU per square foot per hour. *One 3x6 window can transmit up to 3900 BTU per hour, equivalent to nearly ⅓ ton*

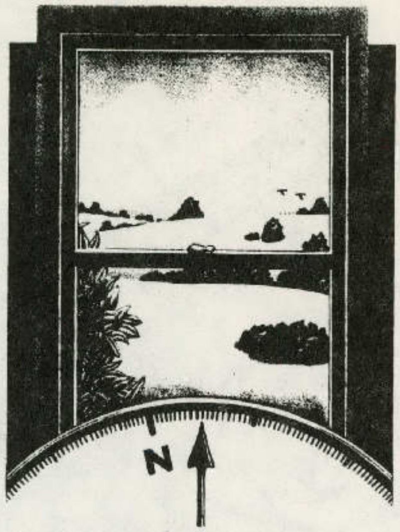


of air conditioning load. **Convection.** The average tolerance for air infiltration in a manufactured single-hung (only bottom sash movable) aluminum window, assuming 15 mph wind velocity, is .50 CFM/ lineal foot of "crackage." On a 3x6 window, "crackage" equals the perimeter dimensions of the movable sash, or 12 lineal feet. This means that 6 cubic feet per minute is the permissible infiltration tolerance. That's 360 cubic feet per hour, 8,640 cubic feet per day for *one* 18 square foot window! This heat gain or loss by *convection* is enormous, 24 hours a day, every day, and much greater when the wind blows stronger.

A home with over 30% glass ratio should unquestionably be outlawed . . . just think of the waste. One family uses what three could live with. Yet, look around and see how many of these wasteful structures are still being built.

Step 3: Orientation.

How your home is *oriented*, what direction it faces, has a lot to do with how much energy your home saves or wastes. We attempt to orient every Power Saver V home on its lot in a *North-South facing* (we think 10° East of North is optimum, 10° South of East disastrous), to aid cooling in summer and heating in winter by respectively reducing or intensifying the amount of sunlight which reaches the home during peak hours. This is one form of *passive solar energy system*—one which uses no mechanical devices to profit



from the natural warming properties of sunlight and cooling properties of shade.

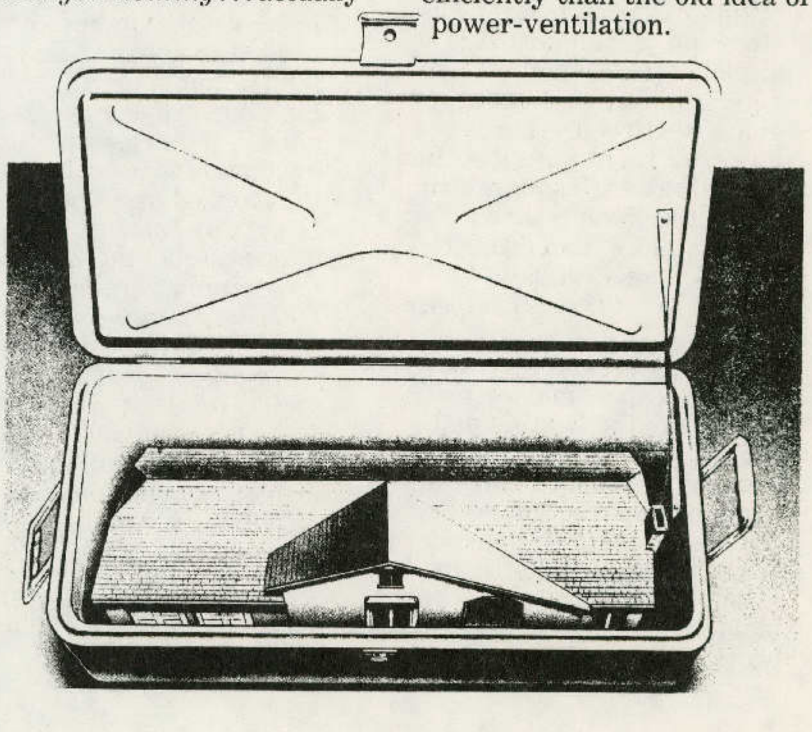
In addition, we have designed the roof pitch and lot placement of our Power Saver V homes to insure easy conversion to an *active* form of solar energy collection and storage in the future.

As a rule of thumb, good design and optimum orientation can account for a combined 38% of your potential E.E.C. savings. And, *they cost you nothing*... actually *save* you up-front costs in most cases.

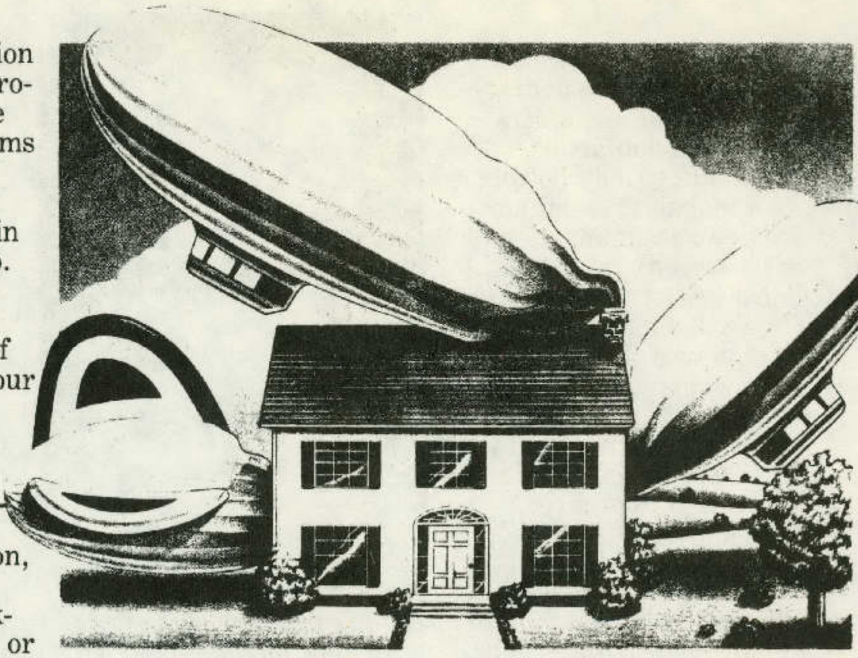
Step 4: Thermal Protection.

Many of us remember the old portable Coke ice chests. Metal, not much insulation, and they usually couldn't keep ice more than a few hours. Today's version of the portable ice chest, much improved, can resist the transfer of heat well enough to keep ice from melting for days.

Thermal protection simply means *keeping the heat from moving*. From moving *in* in the summer, *out* in the winter. Our Power Saver V homes have a sidewall R-Value of R-24.63. Our window configuration has a Value of R-1.85 (compared to the standard window mentioned with R-.94). Our exterior doors have a Value of R-14 compared to R-2.5 for standard wood doors. Our attic space is cooled by natural thermodynamics, much more efficiently than the old idea of power-ventilation.



Adding inches of insulation and R-Values of thermal protection above the levels we select (optimum levels) seems rather pointless, since the greatest achievement in thermal protection occurs in the first R-11 to R-15 or so. After that, the *practical* value nose-dives. And thermal protection by itself accounts for only 12% of your potential E.E.C. savings.



Step 5: Weatherization.

In their haste to jump on the insulation bandwagon, homebuilders who simply beef-up their "energy packages" with extra insulation or double-paned windows are overlooking the biggest energy-waster of all—*air infiltration*.

Air infiltration is the unnecessary movement of air into or out of your home. While some air movement occurs in daily activities, such as entering or leaving through a door, the overwhelming percentage escapes or enters through loose construction techniques. And although you cannot always detect this air movement, ongoing research by Texas Power & Light indicates that an average 1580 square foot home in a 15 mph wind "leaks" more than 600,000 cubic feet of air a day—*enough to fill three Goodyear blimps*!

This unnecessary air movement is responsible for the majority of the heating and cooling costs of your home, and can be reduced only through construction designed to *seal* your home. While the wall and attic insulation offered by most builders' energy packages protect a home from intense heat or cold, insulation does little to reduce air infiltration, as reported in recent industry journals:

> *Chemical Week*, February 8, 1978 Issue: "A new five-year study by the Department of Energy and the National Science Foundation may well deflate the booming home-insulation business. The study of air infiltration in urban buildings, says a DOE official, indicates that 'insulation is not what it's cracked up to be.' *Cracks or holes in walls and improper design, for example, are much more important factors in loss of heat and energy in buildings than lack of adequate insulation.* The study also indicates that adding insulation is not particularly effective in decreasing cold air flow."
>
> *Air Conditioning, Heating & Refrigeration News*, March 6, 1978 Issue: "Littleton, Colorado—'A recent study of home heating dynamics indicates the current faith in insulation may be based on erroneous assumptions, and that homeowners pouring money into the burgeoning insulation industry won't see the savings they have been promised,' according to Dr. Jay McGrew, president of Applied Science & Engineering here.
>
> '. . . The study found that in a house with three inches of attic insulation, about 66% of the heat is lost through infiltration, a process not affected by insulation.
>
> '. . . About 17% of the heat is lost through windows, about 11% through the ceiling, and about 6% through the walls.
>
> '. . . The breakdown of heat escape in an uninsulated house was found to be: 57% infiltration, 23% through the

ceiling, 15% through the windows, and 5% through the walls."

Hopefully, the "theory" of air infiltration will soon be defined and reduced to scientific formulas. Then we'll know precisely, confidently, just what we must do to stop or retard this flow. At the Burns Co., we believe that our weatherization techniques will prove to be very successful. And we will continue to place great emphasis on control of infiltration/exfiltration, because we know it accounts for *at least one-third of all heat gained or lost. Truly, perhaps as much as two-thirds!*

Step 6: Equipment.

Burns Co. Power Saver V homes are a likely forerunner of what will eventually become the Southwest's most efficient heating/cooling/water heating mechanical systems. Ours is one of the most advanced residential climate control concepts ever developed, yet we use existing technologies and proven systems, only in new combinations.

To EER Is Human. There's a lot of double-talk about EER these days. Simply put, EER means "Energy Efficiency Ratio." The more efficient an air conditioning system is, the higher its EER.

EER represents the amount of heat that one watt of electricity will remove from the air in one hour. It's figured by dividing the number of BTU's required for cooling purposes by the number of watts needed to produce it. Suppose, for instance, that a 36,000 BTU (three ton) air conditioning unit requires 6,000 watts per hour to operate. It would have an EER of

$$6.0 \left(\frac{36,000}{6,000} = 6.0\right).$$

Another three ton air conditioning unit might require only 4,300 watts to operate, and hence would have an EER of

$$8.4 \left(\frac{36,000}{4,300} = 8.4\right).$$

Incredibly enough, many builders show little concern for the efficiency of the air conditioning systems they install. Granted, it used to be cheaper to install a less efficient air conditioning system and use more energy than to install a more costly air conditioner and use less energy. But at a time when the cost of heating and cooling a home is fast approaching monthly house payments, a high EER air conditioning system should not only be a builder's concern, it's a builder's *responsibility*!

And while an EER of 7.0 is *acceptable* for air conditioning in Texas, the heat pump air conditioning systems in our Burns Co. Power Saver V homes have EER ratings between 8.0 and 9.0.

Sizing Up The Problem. The old rules of thumb for determining the proper size of air conditioning and heating units simply don't apply to our Power Saver V homes. Our homes can be heated and cooled using smaller equipment. And that's extremely important to homebuyers today.

Equipment that is too large for an energy efficient home will cycle on and off much more often than necessary, wasting energy. So if your equipment is oversized, you not only pay more for the unit and more for the installation, you pay more to *operate* it. Maintenance expenses will also be greater, yet you still won't be as comfortable in your new home as you would be with properly sized equipment.

With a Power Saver V home, the money you save on properly sized equipment can help cover the expense of such items as added insulation and storm windows. You recover part of your investment in energy efficiency *before you move in*!

Air Special Delivery. The air your central heating and cooling system produces is delivered through a system called "ductwork." Ductwork is usually located in your attic. The problem is, your attic is hot in the summer, when you're pumping cold air through the ductwork, and cold in the winter, when you're pumping warm air through the ductwork.

True, most ductwork is insulated these days. But in our Power Saver V homes, we go one *giant* step further: We build specially engineered floor trusses for our two-story homes which enable us to run all our ductwork in the cavity between floors, so *our ductwork is essentially air conditioned in summer and heated in winter*! This saves our homeowners an estimated 15% duct loss normal in most installations.

In our one-story homes, we build our ductwork into *fully-insulated* "furred down" ceiling cavities. Viewed from the attic, the entire attic floor is covered with insulation to prevent the heat gain or loss normally associated with furr downs.

The *length* of the ductwork is also an important consideration in designing an energy efficient heating and air conditioning system. Where two systems are of comparable quality, a design that cuts the length of a home's ductwork in half will also cut the duct system's energy losses in half! We run all our ductwork on *one level* in our Power Saver V homes, which eliminates duplicate horizontal and vertical runs, thereby eliminating up to 40% of the duct requirements. Plus, we join all ductwork tightly to the outlets in our ceilings and floors, and tape the joints between the ductwork and interior surfaces of our homes to further reduce air infiltration/exfiltration.

Texans In Hot Water. Next to heating and air conditioning, the biggest user of energy in Texas homes is the water heater. A water heater in a home built to today's typical construction standards accounts for roughly *17% of your total annual energy bill*! Impossible? Not when you consider that you use hot water for bathing, shaving, washing clothes, washing dishes, general cleaning, food preparation and on and on, every day of the year.

Burns Co. Power Saver V homes are heated and cooled by high-EER *heat pump* heating and air conditioning systems. Working with the systems engineers, we have developed a means of heating the majority of your home's water *as a by-product of this heat pump system*. Which means not only does *your water heating cost become insignificant*, your heating and cooling system runs at a greater efficiency, extending its life as well.

The *location* of your hot water heater, along with the location of other heat-producing equipment, also affects the energy efficiency of your home. Your hot water heater should be placed in relation to your bathroom and kitchen faucets so that the total length of the plumbing in your hot water system can be minimized. We have shortened the hot water plumbing system substantially in our Power Saver V homes.

Money To Burn? Last year a whopping 81% of the homebuyers interviewed in the U.S. said they wanted at least one fireplace in their next home. And most new homes in San Antonio have fireplaces. But would you still want one if you had to fuel it with dollar bills instead of firewood?

The *exfiltration rate*, the amount of expensively heated air that escapes through the chimney of a standard fireplace is devastating—as much as 200 cubic feet per minute. But Burns Co. Power Saver V homes incorporate a revolutionary new "zero-exfiltration" fireplace which uses fresh *outside* air for the fire's oxygen burning. When not burning, its special dampering system is far more efficient in reducing exfiltration than the standard dome dampers found in most builders' fireplaces.

Making A Long Story Short. In summary, there *is* a problem, there *is* a danger, but there *is* a solution. And as the old adage goes, if you're not part of the solution, you're part of the problem.

Step 1 of the solution, *your attitude*, makes the solution to energy efficient construction possible. The relative significance of the remaining 5 steps is summarized below:

Step2: Design	16.67%
Step3: Orientation ..	21.33%
Step4: Thermal Protection ...	12.00%
Step5: Weatherization	33.33%
Step6: Equipment ..	16.67%
	100.00%

The Next Step. The next step is up to you. If, after reading this brochure, you are seriously interested in buying an energy efficient home, we invite you to use the EER (Energy Efficiency Rating) checklist in the back of the brochure to investigate the efficiency of the homes you are thinking of buying. A Burns Co. representative can assist you in rating your choice of Burns Co. homes.

We applaud your interest in and concern for the energy crisis. We trust the information herein has helped you evaluate what we must *all* do to protect our future security.

Through energy conservation, *we* can do more to ease our country's problem now than all the researchers and politicians combined.

Life Cycle Costing

LIFE CYCLE COSTING.

How To Figure Your TOTAL Housing Costs.

I'm Buddy Burns.

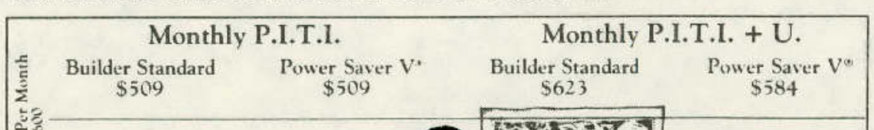
I'm a homebuilder. And I think it's time the housing industry told homebuyers what the *total* cost of a home will be over its average "ownership life cycle" of approximately seven years.* That's why I bought this ad, to tell you what the *total* cost of a Burns [illegible]ower Saver V® home

"Builder Standard" vs. Burns Co. Power Saver V.

Your monthly utility bill is a direct result of the energy efficiency of your home. The less energy efficient your home, the higher your utility bill. Most homes today are insulated in accordance with "Builder Standard," as defined by the current FHA Minimum Property Standards. Recently, this minimum requirement (R-19 for ceilings, R-11 for walls, and single glazed windows) was established by the homebuilding industry as the recommended new home insulation standard for San Antonio. The problem with "Builder Standard" is the logic behind it, in essence: "If the insulating technique used doesn't pay for itself over the first-ownership cycle of the home (7.2 years), don't use it."

I have a different philosophy. I don't build or insulate my homes to give their maximum service for only 7 years. To begin with, I build and insulate my homes to give maximum service for their minimum life expectance of 50 years. *But most important, I build and insulate my homes to protect the investment and equity of the families who I know buy my homes:* the young, growing older, and retiring. I'd hate to see any of our buyers lose their equities because of the forced obsolescence that is almost certain to occur on today's poorly constructed non-EEC home. After all, if "Builder Standard" energy packages are less than optimum today, who would want them in 7–10 years? They may have to be given away.

The chart below indicates the difference in *total* monthly housing costs, today and 10 years from today, between a $60,000 home built to "Builder Standard" and the same home built to Burns Co. Power Saver V.®



worth of home at today's prices, after a 20% down-payment.

Based on a 10-year Life Cycle Cost, the bottom line, then, is this: If you qualify for a non-EEC home with an average monthly housing cost (P+I+T+I+U) of $692, then you could qualify for a Burns Power Saver V® with an 80% loan amount of $54,528 the same as you could for a "Builder Standard" with an 80% loan amount of $48,000. The only question is, do your broker and lending institution agree? Let's find out.

***1987 prices of energy are based on the Innocept Report, "National Fuel Prices, 1975 to 2000." We used the $15 per barrel base.*

****$10.60 per month @ 9-1/2%–30 years, no city taxes. Figures are based on rates in effect as of April 1978 and are used as examples only. Rates will fluctuate in the market.*

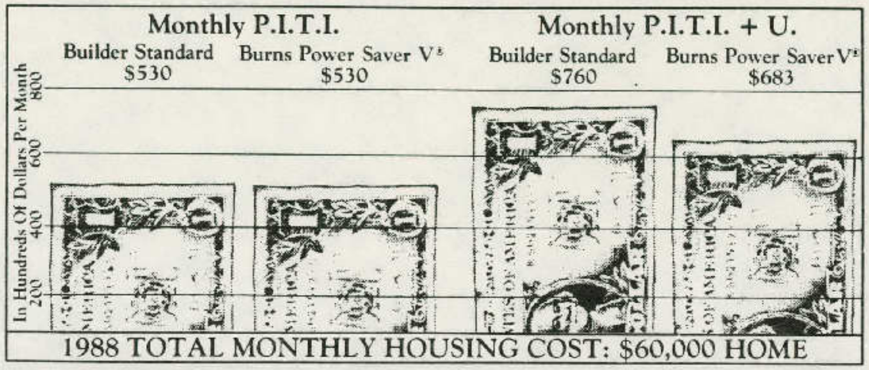
should between now and 1988. And to explain how my $68,150 home costs you the same as other $60,000 homes.

According to recent figures reported by the National Association of Home Builders Research Council, a family normally lives in a new home an average of 7.2 years.

P.I.T.I. vs. P.I.T.I.+U.

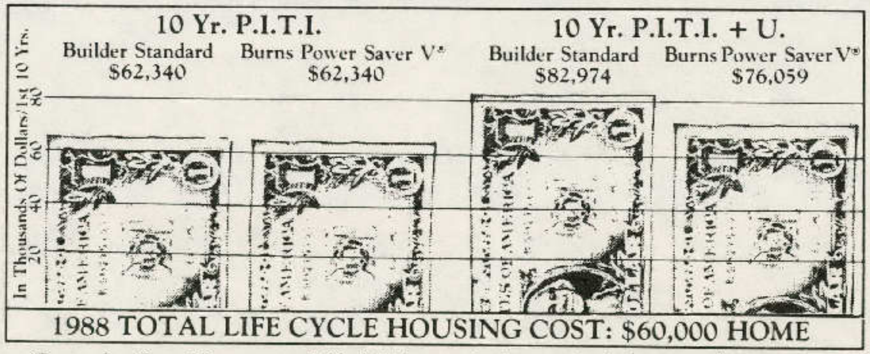
To begin with, most homebuilders figure the monthly housing cost of their homes by adding *Principal* (base monthly payment) and *Interest* (monthly interest charge), plus *Taxes* (monthly taxes), plus *Insurance* (monthly insurance charge). This all adds up to what is commonly called "P.I.T.I."

They ought to call it, "P.I.T.Y." Because if you think *their* total equals *your* monthly payment, you're pitifully mistaken. Your *total* monthly housing costs must include *Utilities* (monthly utility bills). *And the more you pay for utilities, the less you can afford to pay for a home.*



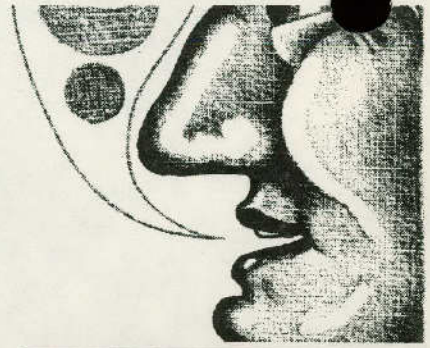
The Effects of Life Cycle Costing.

The typical Burns Co. Power Saver V® home saves you $39.00 *a month* today. And $77.00 a month in 1988. But the most important figure, and the figure the housing industry seems reluctant to talk about, is the *life cycle cost* of a home. In other words, what is the *total* housing cost of a $60,000 home built to "Builder Standard" vs. Power Saver V® Standards over the first 10 years?



Over the first 10 years, a $60,000 home built to "Builder Standard," including utility costs**, has a projected total cost for the homebuyer of $82,974. The same home built to Burns Co. Power Saver V® Standards, including 10-year *savings* on projected utility costs, should cost the homebuyer $76,059. *Clearly, the Burns Co. homebuyer saves $6,915 over 10 years.* Let's examine the significance of this as your housing dollars are concerned.

1) The $6,915 10-year savings means you save an average of $691.50 a year, or $58 a month.
2) That $58 monthly savings, based on today's P.I.T.I. factor rates ($10.60*** per month per $1,000 of loan amount), would buy an additional $5,471

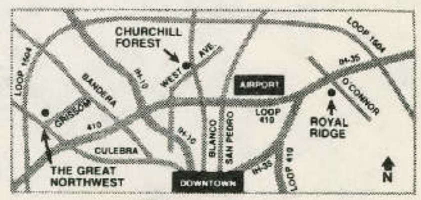


The $8,000 Question.

Show this ad to your bank or lending institution (chances are good they've already seen it). They'll ask you questions about your total family income, any outstanding indebtedness and your plans for the future. Make sure your answers are honest and accurate. Then ask *them* a question.

"If I qualify for an 80% loan on a $60,000 home built to 'Builder Standard,' shouldn't I *also* qualify for an 80% loan on a $68,150 Burns Co. Power Saver V® home, considering that the *total* housing cost over 10 years is actually the same?"

If their answer is anything but "yes," ask them to call me, Buddy Burns, 349-1471. I *know* my calculations are correct. And that the *total* life cycle cost of my Power Saver V® home is less. Today, and 10 years from today.



the Burns co

Protecting Your Investment.

the Burns-co
11831 Radium
San Antonio, Texas 78216
(512) 349-1471

Churchill Forest

CHURCHIL

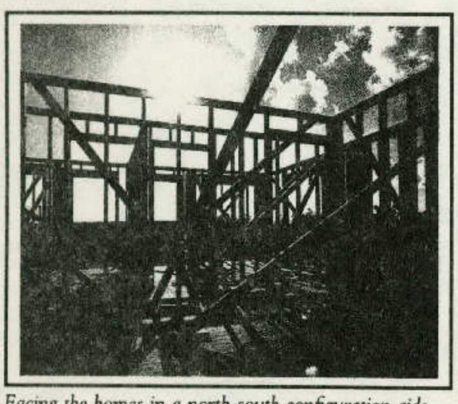
The Burns Co.'s Answer To

I'm Buddy Burns.

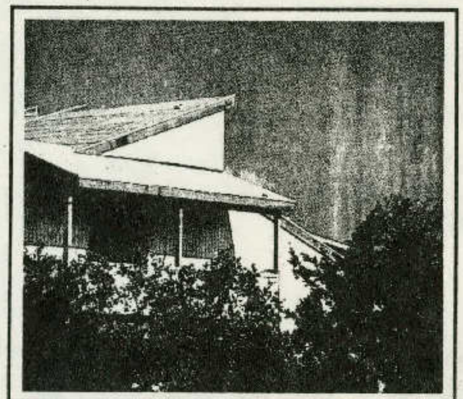
And since 1973, when I began building San Antonio's first energy efficient Power Saver® homes, there's been a lot of talk about the so-called "energy crisis". We've all noticed the steady rise in our utility bills, but all too often we blamed our natural gas supplier or common inflation for what we hoped was an overpublicized, temporary condition. Well, it's not. The energy crisis is real, and it's permanent. That's why I'm building all-electric homes in the first community in the Southwest designed to reduce energy *waste*.

Saving Face.

Believe it or not, how your home *faces* has a lot to do with



Facing the homes in a north-south configuration aids cooling in summer, heating in winter, and substantially lowers utility bills year-round.



A small amount of additional roof structure and a calculated roof pitch insure easy conversion to solar collectors in the future.

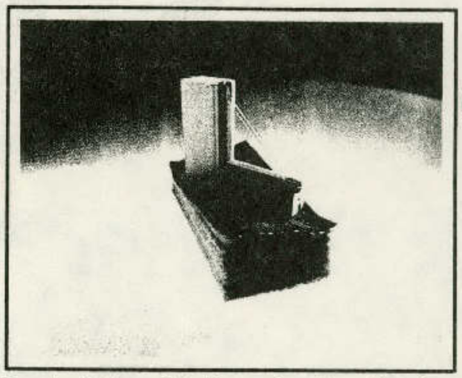
how much energy your home wastes. So when we began planning Churchill Forest, in prestigious north central San Antonio, we employed a simple yet effective energy-saving construction technique that will increase the energy-efficiency of our homes by 10 to 15%.

To begin with, we carefully designed the street patterns in Churchill Forest so we can have the majority of our lots with a *north-south facing* to aid cooling in summer and heating in winter by respectively reducing or intensifying the amount of sunlight which reaches the home during peak hours. This is one form of *passive* solar energy system—one which uses no mechanical devices to profit from the natural warming properties of sunlight and cooling properties of the shade.

In addition, we designed our roofs to coincide with the lot placement of the homes in Churchill Forest to insure easy conversion to an *active* form of solar energy collection and storage in the future.

Haste Makes Waste.

In their haste to jump on the insulation bandwagon, homebuilders who simply beef-up their "energy packages" with extra insulation or double-paned windows are overlooking the biggest energy-waster of all—*air infiltration*.



Extra insulation and double-paned windows alone do little to reduce the biggest energy-waster—air infiltration. Burns Co. Power Saver® V homes reduce air infiltration by as much as 50%.

Air infiltration is the unnecessary movement of air into or out of your home. While some air movement occurs in daily activities, such as entering or leaving through a door, the overwhelming percentage escapes or enters through leaks in the construction. And although you cannot always detect this air movement, ongoing research by Texas Power & Light indicates that the average 1580 square foot home in a 15 mph wind "leaks" more than 600,000 cubic feet of air a day—*enough to fill three Goodyear blimps!*

This unnecessary air movement is responsible for more than 40%

L FOREST

High Bills And Dull Homes.

of the heating and cooling costs of your home, and can be reduced only through construction designed to *seal* your home. While the wall and attic insulation offered by most builders' energy packages protect a home from intense heat or cold, insulation does little to reduce air infiltration. The Burns Co. Power Saver® V homes in Churchill Forest incorporate more than 25 construction techniques and equipment requirements designed specifically to *reduce air infiltration by as much as 50%.*

We Have Plans For You.

Does all this concern for conserving energy mean the homes in Churchill Forest have to be dull? Hardly! We have over 30 different floorplans for one-story, two-story and split-level semi-custom homes, ranging in size from 1550 to 2200 square feet, priced from $55,000. And each plan includes features normally reserved for the finest custom homes—indoor

There are more than 30 floorplans for one-story, two-story and split-level semi-custom homes in Churchill Forest.

planting areas, wet bars, second-story lofts, heat pump air conditioning systems, revolutionary recirculating fireplaces, marble vanities with custom framed mirrors, diagonal wood treatments inside and out, garden windows, and a variety of built-ins including breakfast nooks, bookshelves and entertainment centers.

Striking design and custom diagonal wood treatments add to the exciting individuality of the Burns Co. homes in Churchill Forest.

And we invite you, in fact *encourage* you, to select your own finish details—plush carpeting, designer wallcoverings, color-coordinated General Electric appliances, custom paneling and cabinetry finishes. Smoke alarms and maximum-security dead-bolt locks are standard safety equipment.

Grand Treeview.

Churchill Forest is just that, a *forest*. Every home shares the privacy of wooded homesites. Several cliffside homes will command a spectacular view of the

It's hard to see the homes for the trees in Churchill Forest, a very real forest in prestigious North Central San Antonio.

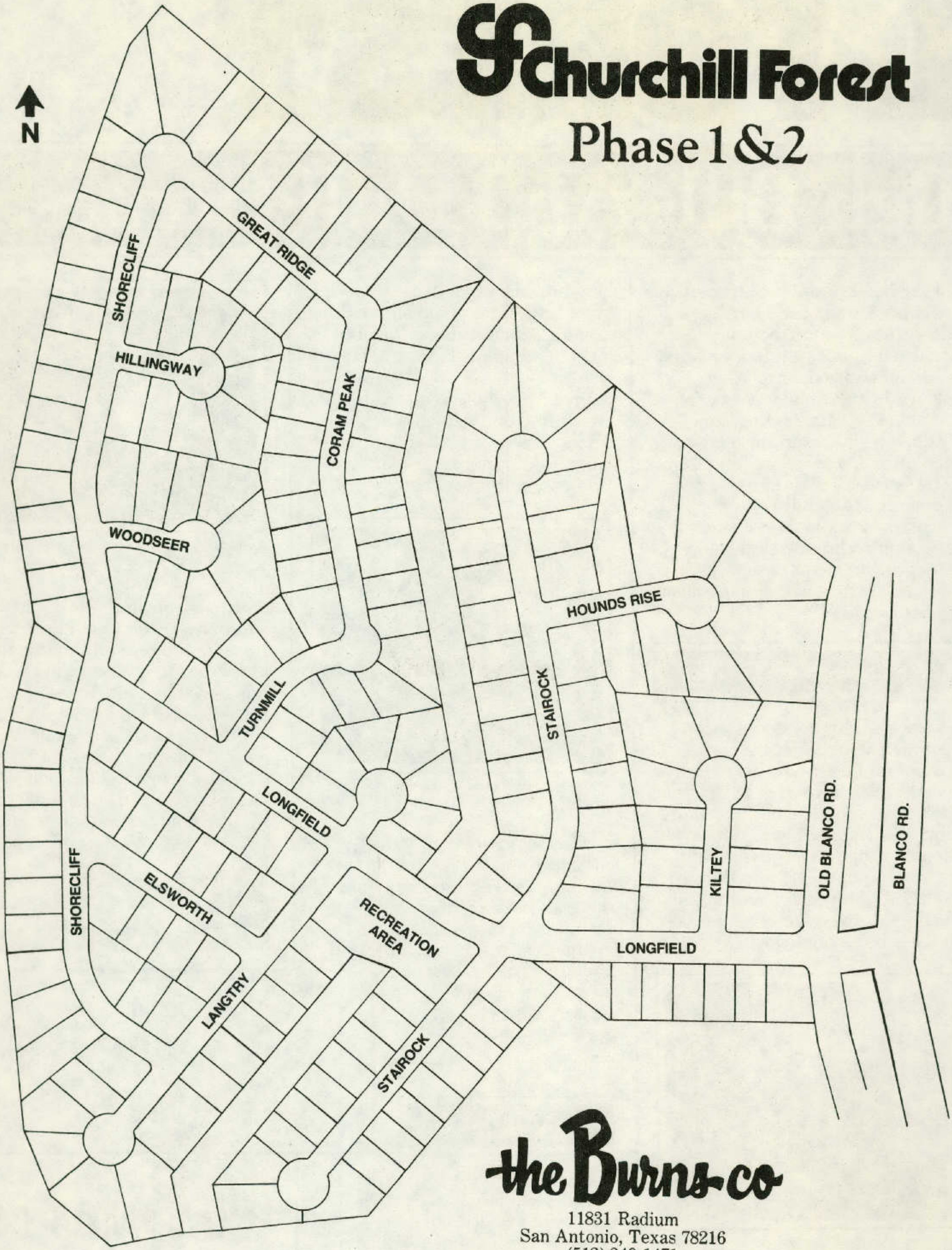
downtown skyline, several more will share a stunning hilltop view. If you're interested in moving up to a Burns Co. Power Saver® V home in Churchill Forest, in a highly-acclaimed school district with *no city taxes*, drive out Blanco Road north of Loop 410 past Churchill High School, left on Old Blanco Road and follow the signs. For additional information call 349-1471 Monday through Friday.

Churchill Forest

the Burns-co

Quality doesn't cost, it pays.

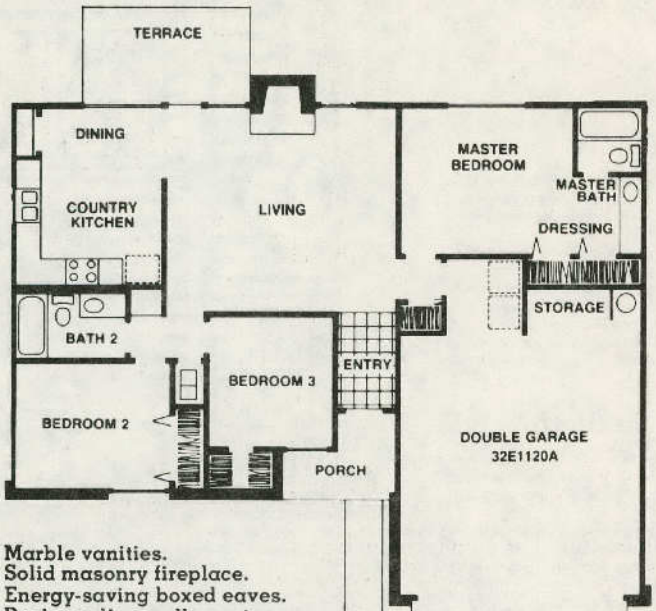
Churchill Forest
Phase 1&2



the Burns-co
11831 Radium
San Antonio, Texas 78216
(512) 349-1471

Grand Opening.

Austin's First Energy-Saver Model Home.



Marble vanities.
Solid masonry fireplace.
Energy-saving boxed eaves.
Designer line wallcoverings.
Hand-laid ceramic tile baths.
Energy-saving fiberglass ducts.
Master suite with dressing room.
Energy-saving Caloric appliances.
Energy-saving Solar Bronze windows.
Energy-saving Polycel One insulation.
Energy-saving 10-inch ceiling insulation.
Energy-saving thermal-seal insulated doors.

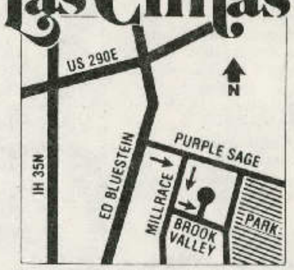
The Anaheim · 7001 Brook Valley Cr. · $32,200

You're invited to the Grand Opening today of the Bill Milburn Company's first Energy-Saver furnished model home. A home that's not only packed with luxury features and our old-fashioned quality, but that's designed to save you money where it counts. On your monthly utility bills.

An Energy-Saver home can save you up to 35% on your utility bills. And with our 8% VA financing, you can move in without paying a penny down. Or for non-veterans, we've got easy FHA and conventional financing.

Plus a good selection of one and two story homes with upstairs game rooms and hide-away master suites. A great location near Tracor, Bergstrom, UT, LBJ high school. And a new 80-acre city park across the street. Come see Las Cimas or call 258-6615 today.

Las Cimas



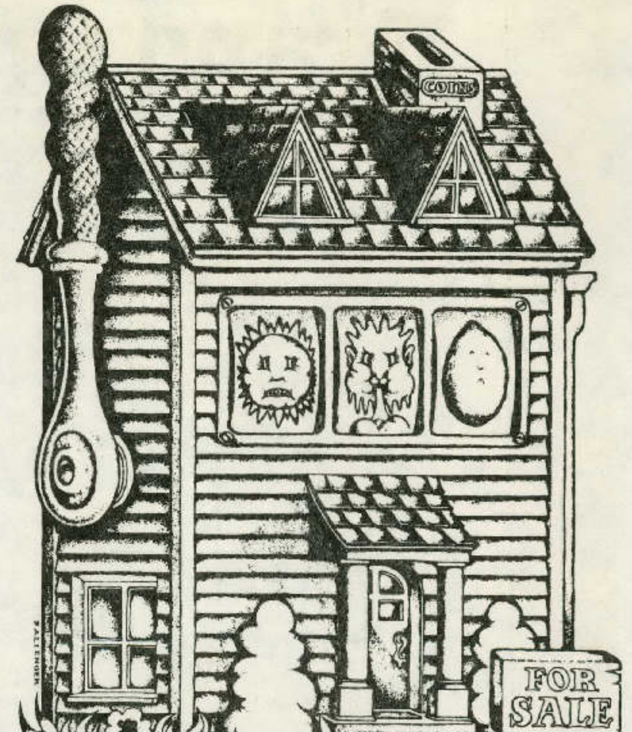
VA homes $28,900 to $38,000.

Cash Price $32,000 / piti $305 / 8-1/4% APR / 30 yrs.

The Bill Milburn Company

Building New Homes the Old Way

the
ENERGY GAME.



Choosing Sides.

There are many energy games on the market today. Some claim miraculous wins from expensive and essentially worthless energy packages. Others choose to ignore the energy issue altogether, and hope the problem will simply go away.

At the Milburn Company, we're dealing with the problem. And have spent a lot of time developing our Energy-Saver package, documenting its results with real facts and real people. We refuse to pad our homes with so-called "energy savers" that do nothing more than raise the price of the home.

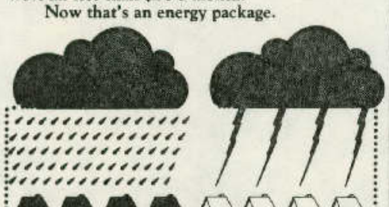
We make only one claim: Our Energy-Saver package pays for itself in 1.4 years. Any item that doesn't is replaced by one that does.

Testing Your Strength.

Last summer, we built eight identical homes. Four with our Energy-Saver package and four without. We asked the families who bought the homes to set their cooling at 78° and keep records.

Then we compared their utility bills over a three-month period (during the hottest summer in Texas history). Utilities for the homes without our Energy-Saver package averaged $110 a month. Utilities for the Energy-Saver homes were all less than $60 a month!

Now that's an energy package.



Making the Right Move.

We believe a home can be energy-efficient, and still win awards for design. So when you move into a Milburn home, you'll find soaring ceilings, overhanging balconies, window seats and skylights, gardens indoors and out.

We make sure our homes are air tight, well insulated, furnished with energy-saving equipment, and oriented on the site so glass areas aren't subjected to intense sun, without sacrificing design. Because a dull interior has nothing to do with energy savings. It's just a poor excuse for poor design.

Knowing Your Players.

We won't explain our entire Energy-Saver package in detail, but we'd like to mention the major features:

- **THERMAL INSULATED STEEL DOORS.** As air tight as your refrigerator, they'll preserve the interior climate of your home, no matter what the weather is outside.

- **UP TO 12 INCHES OF CEILING INSULATION.** All Energy-Saver homes contain from 8 to 12 inches of Rockwool insulation for an R-19 to R-26 rating. A major step toward insuring comfort year-round, as well as reducing the cost of the heating and cooling system for the home.

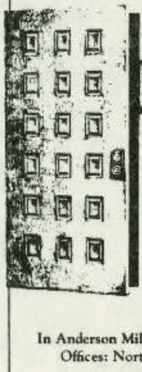
- **POLYCEL ONE. THE MOST EFFECTIVE WALL SEALANT ON THE MARKET.** Dispensed as a liquid much like shaving cream, it's hiding in the walls of every Energy-Saver home. Virtually guaranteed to stop air infiltration through gaps, cracks, joints and openings, it alone can save you 13% on monthly utilities.

- **HIGH 8.5 EER HEATING AND COOLING SYSTEMS.*** Energy Efficiency Ratio, not size, is the important consideration in assessing a heating and cooling system. And ours are far superior to the typical units with a 6 or lower EER rating. Ours work so efficiently they save you money going in, as well as month after month.

- **OWENS-CORNING HIGH-R EXTERIOR SHEATHING.*** Our isocyonarate sheathing does for our exterior walls what Polycel One does for the interiors. A foil-look board with an R-4 rating, compared to gyprock's .3, asphalt's 1.3, and Reflecto-foam's 3 ratings, it gives you anywhere from 33% to nearly 400% better insulation.

- **SOLAR BRONZE GLASS.*** It's like having a protective forest around your home, fighting blazing summer sun or winter's chilling winds.

- **ENERGY-SAVING CALORIC APPLIANCES.** Continuous cleaning gas ovens with silicone sealed doors and thick glass fiber insulation to keep the heat inside. Dishwashers with natural-dry cycles. Disposals with half horsepower motors for quick action. And gas ranges that maintain heat evenly and automatically.



- **FAST RECOVERY GAS HOT WATER HEATERS.** Our 40-gallon gas hot water heaters provide as much hot water as 60-gallon electric heaters at a faster rate and for less money.

**Due to design and other factors, high EER AC/H systems not available in Beacon Ridge. Owens-Corning sheathing and Solar Bronze glass not available in Southwest Oaks and Section V of Barrington Oaks.*

Playing to Win.

And now a final word about the energy problem. It's real. It's serious. And it affects us all. We're doing everything we can to build energy-efficient, cost-effective homes. But we need your help.

If you're looking for a new home, ask about the energy package. If you're in an older, existing home, think about retrofitting it with energy-saving items. Or consider buying a new home now.

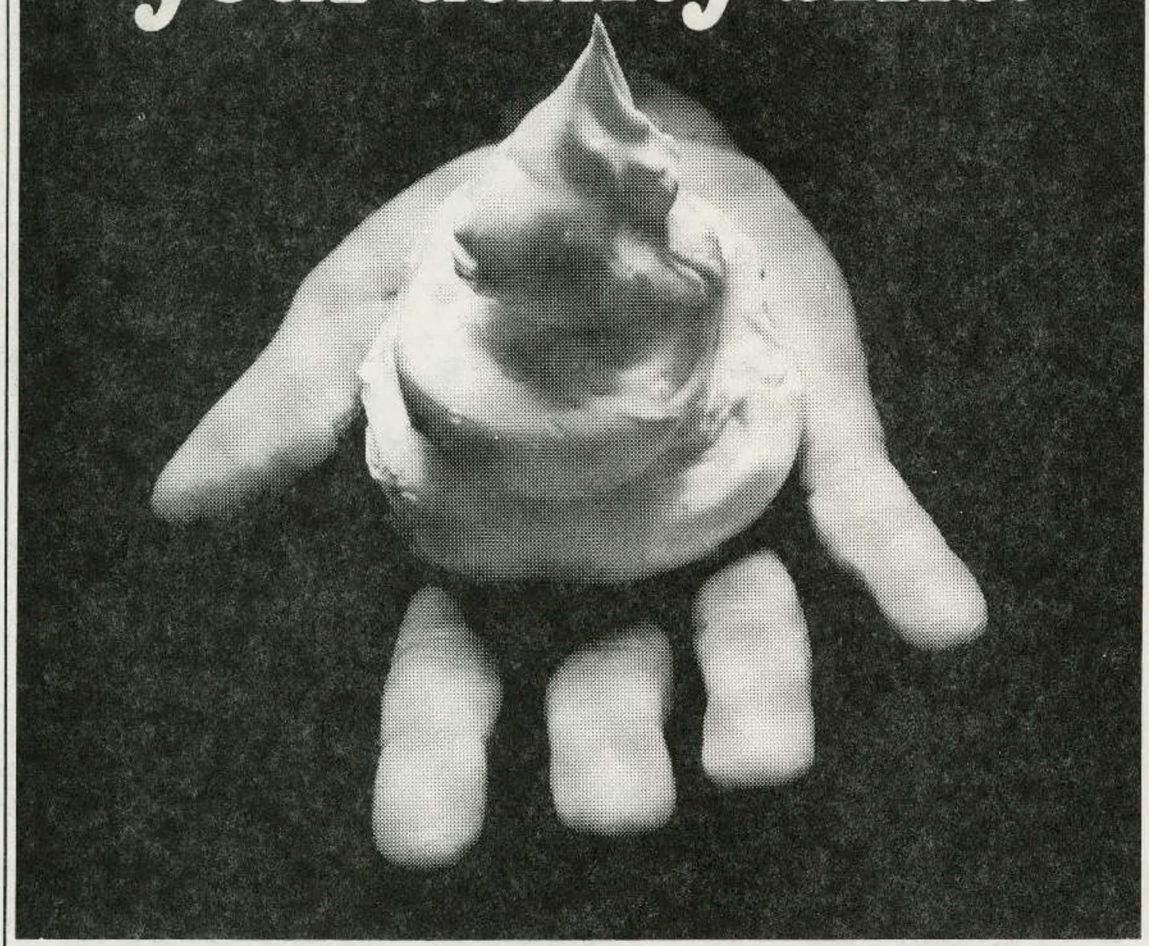
But whether you buy a home from us or from someone else, you should demand a home that's build to consume as little energy as possible. It's not only important to you, it's important to all of us. Everyone can be a winner.

The Bill Milburn Company

Selling New and Old Homes All Over Austin.

In Anderson Mill, Barrington Oaks, Woodbridge, Vista West, Horseshoe Bend, Beacon Ridge, and Southwest Oaks.
Offices: Northwest 258-6615/North 926-7620/South 892-1688/Southwest 441-6615/Millwood 345-8820.
For free brochures write to us, PO Box 14448, Austin 78761 or call collect.

This funny stuff can help you save 35% on your utility bills.

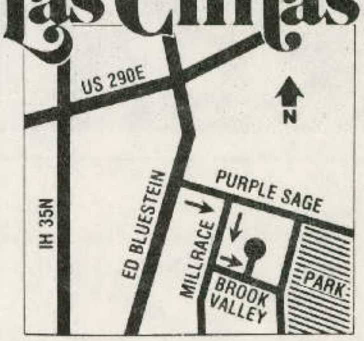


It's called Polycel One. A remarkable new insulation that's hiding in the walls of every new Energy-Saver home in Las Cimas. And there are other such items. Like bronze tinted glass, 10-inch ceiling insulation, fiberglass ducts, thermal-sealed insulated doors, and energy-saving Caloric appliances.

Plus luxuries like fireplaces, upstairs game rooms, garden kitchens, and designer wallcoverings. A great location near Tracor, Bergstrom, and UT, just a walk away from LBJ high school and a new city park. And easy no-money-down 8% VA financing.* Come see or call 258-6615 today. But hurry, the sold signs are already going up!

Cash price $31,100/piti $300/8-1/4% APR/30 yrs.

Las Cimas



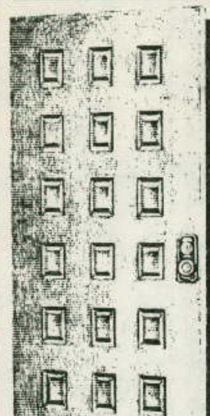
VA Homes $28,900 to $38,000

The Bill Milburn Company

Building New Homes the Old Way

Bill Milburn Introduces The Energy-Saver Home.

From $35,000 to $65,000 In 5 Choice Locations.



Welcome to the money-saving Energy-Saver.

We've designed an energy package that promises to reduce your utility bills, make living more comfortable year-round, give you good design and long-lasting beauty. And doesn't cost you a small fortune.

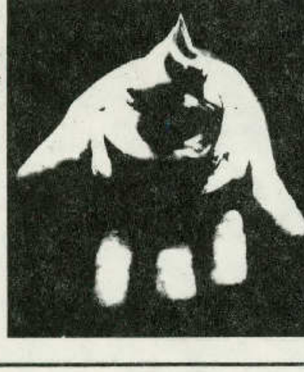
We call them Energy-Saver Homes. They're underway in five choice locations in a variety of price ranges, with easy VA, FHA or Conventional financing.

And they're not limited to any one architectural style or floor-plan. Right now, we have over 100 different Energy-Savers in various stages of construction.

Now, let's start with the door. It's top quality, rust-proof Benchmark, constructed of rust-proof steel that's insulated with polyurethane foam, completely weather-stripped, guaranteed not to shrink, warp, swell or twist. It has a frost-free adjustable threshold, and it preserves the interior climate of the home, no matter what the weather is outside. It's also so safe that it would take a couple of circus elephants to break it down.

Come on in. And let us show you what's inside.

This funny stuff can help you save 35% on your utility bills.



It's called Polycel One. A remarkable new polyurethane insulation that's hiding in the walls of every new Energy-Saver home.

Dispensed as a liquid, it's much like shaving cream, but acts as a sealant to stop air infiltration through gaps, cracks, joints and openings.

According to local studies, air infiltration accounts for 25% of all heating and cooling loss in the home. And Polycel's unique ability to expand and cure in place without exerting pressure makes it one of the most effective products on the market for reducing air infiltration and insulating walls.

It's non-solvent, so it never shrinks, dries, hardens, or pulls away. This one material alone can reduce your heating and cooling bills by 13%, paying for itself in two to three years.

But Polycel isn't the only thing that's hiding in the walls of every Energy-Saver home. Read on.

We dare a single drop of moisture to penetrate our isocyonarate insulation board.

Polycel One is guarding the interior walls, but there's something equally ferocious on the exterior walls of our Energy-Saver homes. It's Owens-Corning High-R isocyonarate sheathing that's impervious to moisture.

It works like this. To make your home more energy-conserving, you have to increase the resistance of the heat flow from warm air to cold air. The higher R-factor your home has, the greater its resistance to cold or warm air entering your home. And the greater that resistance, the lower your utility bills will be. (Not to mention the greater the comfort of your family!)

Every Energy-Saver home contains Polycel One, isocyonarate sheathing, foil, framing lumber, outside air film, inside air film, and sheet rock to give the walls a total R-19 value (several points higher than the City Code's minimum R-11 requirement).

But that probably doesn't mean a lot to you unless we show you a few comparisons. Isocyonarate board alone gets an R-4 rating. The most commonly used exterior insulating boards are gyp-rock (.3 rating), asphalt board (1.3 rating), and Reflecto-foam (3 rating). So, our new isocyonarate board gives you anywhere from 33% to nearly 400% better insulation than the others.

Every Energy-Saver home has 10 inches of ceiling insulation.

That's right, ten inches, for a total rating of R-26 in Barrington Oaks, Anderson Mill and Woodbridge, and R-22 in Beacon Ridge and Las Cimas. (And that's a whole lot better than the City's R-19 minimum.) It's a combination of batt and blown insulation, and it's one bundle that can save you a bundle. Won't it be nice to be warm this winter, or cool next summer, without worrying about higher utility bills?

And because of our high R-rating, our engineers were able to lower the requirements for heating and air conditioning, which reduced the cost of all heating and cooling systems for our Energy-Savers.

Which saves you money again.

Solar Bronze windows are like having a forest surrounding your home.

One thing that's different about our Energy-Savers is that we haven't sacrificed design and livability to bring you lower utility bills. We still offer dramatic clerestory windows, French doors, walls of glass and garden windows.

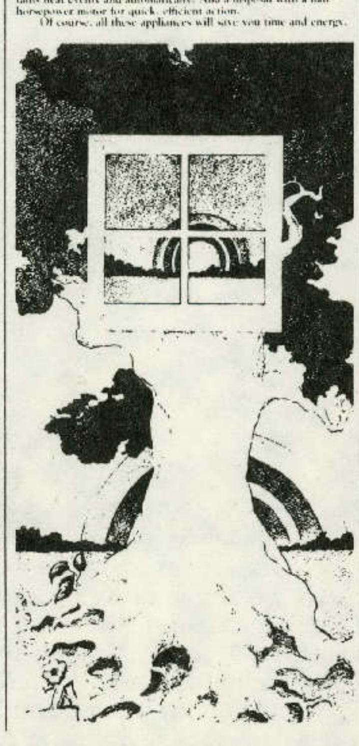
But they're constructed of energy-saving Solar Bronze glass. And that's just like having a forest around your home.

Solar Bronze windows insulate your home from that blazing summer sun or winter's chilling winds much the same way that a big shade tree outside every window would.

The right appliances can reduce your work. And your temperature.

In the kitchen of every Energy-Saver is a complete Caloric appliance package. A continuous cleaning oven that cleans while you bake, so there's no extra energy needed for cleaning. A dishwasher with immediate heating element, lower-cycle time. A range top that maintains heat evenly and automatically. And a disposal with a half-horsepower motor for quick, efficient action.

Of course, all these appliances will save you time and energy.



But how do they save you money? Easy. They're better insulated so that they reduce the heat gain in the kitchen.

Each oven door has a silicone wrap-around one-piece seal that keeps heat from escaping into the room. Thick, efficient glass fiber insulation lines the oven to keep the heat inside, reducing baking time and room temperature.

And in some models, there's an automatic pilotless ignition to assure quick action without energy-wasting pilots working when they aren't needed.

Ask us about our six-family survey.

Drive out today to the community nearest you and ask us about our Energy-Saver survey. We'll be glad to share with you our own survey of six families who spent the summer in air conditioned comfort testing our Energy-Saver homes. None spent more than $60 in August for total utilities!

If you're new in town, give us a call, and we'll take you on a tour of our Energy-Savers. But hurry. Your waiting costs us all.

But hurry. Until 7 p.m.

Anderson Mill
$46,000–$65,000
258-1696 or 258-6615

Barrington Oaks
$46,000–$65,000
926-7620 or 258-2255

Woodbridge
$48,000–$65,000
926-7620

Beacon Ridge
$35,000–$45,000
892-1688 or 327-3727

The Bill Milburn Company

Selling New and Old Homes All Over Austin

Make Conservation Attractive To The Under $40,000 Market

Most energy saving homes are built to be quality homes. And until recently, few builders thought that buyers of lower priced homes would be interested in paying more for energy saving extras. But the rising cost of energy and high utility bills have made those buyers more conscious of investing in homes that will save them money later.

Builder Bill Milburn of Austin noted this growing awareness. A few months ago, Milburn premiered his new energy saving homes ranging from $28,000 to $38,000 with no money down VA financing. Near the Bergstrom Air Force Base and the University of Texas, the homes have appealed particularly to young professionals and people who work nearby.

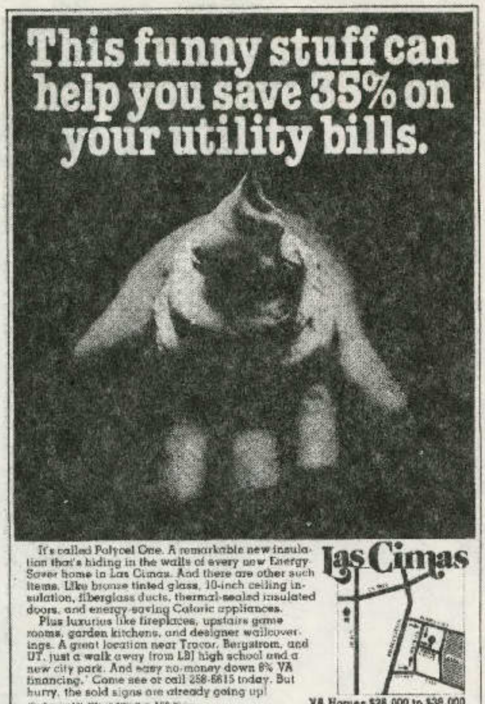
The one and two story designs include solid masonry fireplaces, upstairs game rooms, high ceilings, clerestory windows, overhanging balconies, and garden kitchens with indoor/outdoor patio bars.

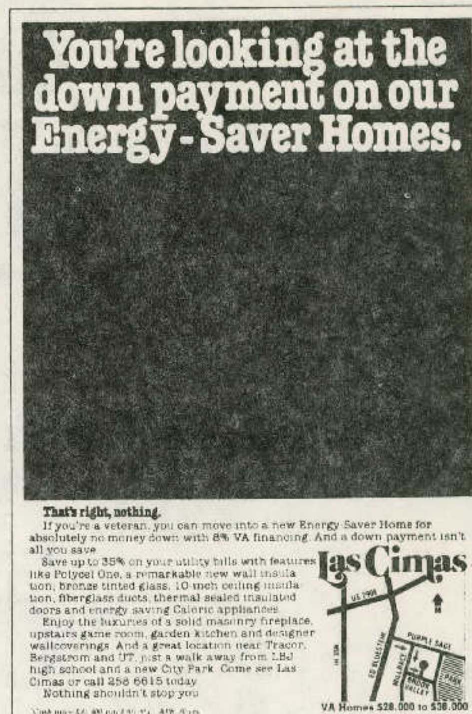
Milburn realizes that most buyers don't understand what comprises good energy saving construction. They are confused by terms and construction jargon. So Milburn's advertisements are designed to make things simple for the consumer.

ESP costs $800

Milburn's energy saving package adds about $800 to the price of each home, but energy savings make the added cost worthwhile to his buyers. His package includes polyurethane sealant to stop air infiltration through gaps, cracks, joints, and openings; R22 ceiling insulation and R13 wall insulation; bronze tinted glass windows to reduce heat gain; glass fiber ducts; exterior steel insulated doors with full weather stripping; energy saving appliances including dishwasher, disposal and continuous cleaning oven; and double-turbine roof vents. All of the homes are equipped with high efficiency central heating and air conditioning.

Designed to reduce utility bills up to 35 percent, the one and two story homes have made energy savings a real sales plus in the lower priced market. ■





"Look at energy savings the way the buyer will," Milburn's advertisement emphasizes (above left). His newspaper advertisement is supplemented with radio ads as well. Milburn realizes that buyers of lower priced homes are also interested in energy savings (ad above right). His homes are VA-financed with no money down.

"The Manchester", Milburn's highest priced home at $38,000, features energy savings in a three-bedroom two-story.

CHEAPER ISN'T BETTER

I'm J.W. Smith. And lately I've heard a lot of double-talk about how some builders build cheaper homes than I do. I agree! They *are* cheaper. Cheaper, but not *better*. If you'll take a few minutes to read this ad, you'll see why.

The Square Foot Myth.

I've had homebuyers tell me the cost per square foot of my homes was much higher than some other builder. At least that's what the other builder's *salesman* told them. The fact of the matter is (and I deal in *facts*, not salesmanship), if you check the latest copy of any accredited Realtor's Multiple Listing book (if you can't find one, I'll mail you a copy), you'll discover that my homes are rarely more than a dollar per square foot more expensive. In an average home of say, 1700 square feet, that's a difference of less than $2,000. The *big* difference isn't cost per square foot, it's *quality* per square foot.

The Shocking Truth.

Some builders will do anything to build a cheaper home. One way they save a few bucks is by installing aluminum wiring. And chances are you won't notice the difference when you buy your home. But aluminum wiring has a tendency to short circuit where it's connected at plugs and switches. So one day, when you flip on a light switch or plug in your electric razor . . . ZAP! That's why I use trouble-free, highly conductive *copper* wiring in all my homes. It costs a little more. But that shouldn't shock you.

Beware The Frame Game.

Another way some builders save money is by framing their houses on 24-inch centers, often using yellow pine. I guess they figure that what the homebuyer can't see, he won't miss. But believe me, you'll miss it. Because the wider the stud spacing, the greater the chance of crooked ("out of square") walls. That's why I frame all my homes on 16-inch centers, using No. 2 or Better *fir* lumber. My walls are stronger, truer. Just like my foundations.

Don't Take Your Foundation For Granite.

It's not. It's concrete. And unless it's sufficiently reinforced, it may not withstand the strain of shifting bedrock or eliminate seeping water after a Texas storm. That's why I use a 4½-bag concrete mix (most builders use 3½ or 4), poured on *steel bars*, not prestressed cable. Frankly, my foundations are probably better than they have to be. But so are my homes.

Double-Talk vs. Double Insulation.

If a builder tells you he uses "single glazed" (regular pane glass) windows because they're cheaper, he's telling you the truth. They *are* cheaper, for him. But what you save on the cost of windows when you buy, you stand to lose in a couple of months on utility bills. And unlike the builder, you keep on losing, year after year. That's why I install *double*-insulated windows in all my homes. No, they're not cheap. But neither are Austin's utility rates.

The Trim Trick.

The way most builders cut the cost of their homes is to cut the cost of the materials they use. The trick is to use cheap materials where most homebuyers won't notice them. Like the trim molding around doors and baseboards. Next time you look at a new home, look at the trim. Chances are you'll see cheap, "plain" grade molding. It's cheaper, and it looks it. That's why I use Grade A "fancy" solid ash and white pine trim. It takes stain or paint better, it won't split or warp like cheaper trim, it looks better and it *is* better.

See The Light.

Believe it or not, light fixtures are another one of the most commonly overlooked features in new homes. Apparently some builders know it, judging from the fixtures they install. And cheap light fixtures are not only an eyesore, they're apt to give you sore eyes! That's why I install top quality, decorator-selected light fixtures, carefully engineered for each room of your home.

The Extra Yard.

As far as I'm concerned, a home's not finished when there's dirt where the front yard should be. Some builders may tell you they're saving you money. But the truth is, the old fashioned "do-it-yourself" method can end up costing you *twice* as much, along with a few trips to a chiropractor. That's why every home I build gets a fully-sodded front yard. A thick, healthy carpet of St. Augustine grass, installed by landscape professionals. Plus a generous allotment of leafy shrubs. Some builders say they'll build you a home dirt cheap. And that's exactly what you'll get. Dirt. Cheap.

The True Test: Resale.

A new home is an investment. If your home is cheaply constructed, cheaply insulated and cheaply finished when *you* buy it, who's going to want it when you're ready to sell? Nobody. That's why I believe that *any home worth building is worth building right.* Just ask your banker, your realtor or any J.W. Smith homeowner. They'll tell you that my homes may cost a little more, but they traditionally *resale* for a lot more.

You Be The Judge.

Thank you for reading this ad. I hope you agree that cheaper *isn't* better. And I invite you to compare my homes with any other homes in Austin. For your convenience, I include a handy Homebuyer's Checklist. Come see my homes and see for yourself that what I say I'll do, I do. Then go see as many other homes as you like. If you can find a home anywhere in Austin that meets all my standards and still costs less, buy it.

Homebuyer's Checklist	J.W. Smith	Builder A	Builder B
Foundation			
Steel bars (not pre-stressed cable)	✓		
4½-bag concrete mix	✓		
Minimum slab elevation 1 ft. above grade	✓		
Framing			
No pre-fabricated framing	✓		
Fir lumber on 16 inch centers	✓		
2x6 or 2x8 ceiling joists, rafters	✓		
Finishing			
100% Masonry exterior	✓		
Solid wood exterior doors	✓		
Maximum security locks	✓		
Plush, deep pile carpeting	✓		
Custom ash paneling, cabinetry	✓		
Grade A "fancy" trim molding	✓		
100% Masonry fireplace	✓		
Built-in intercom system	✓		
Full backsplash on kitchen counters	✓		
Top quality appliances	✓		
Ample electrical outlets	✓		
Top quality light fixtures	✓		
Ample closet, storage space	✓		
Ceramic tile baths, marble vanities	✓		
Top quality plumbing fixtures	✓		
Extra capacity hot water heater	✓		
Fully-sodded front yard	✓		
Professional landscaping	✓		
Energy Efficiency			
Copper wiring	✓		
Double insulated windows, doors	✓		
3⅝ inch Fiberglas wall insulation (R-19)	✓		
8 inch Fiberglas batts ceiling insulation (R-26)	✓		
Proper ceiling ventilation	✓		
Caulking at all joints, seams, sills	✓		
High efficiency heating/cooling system	✓		

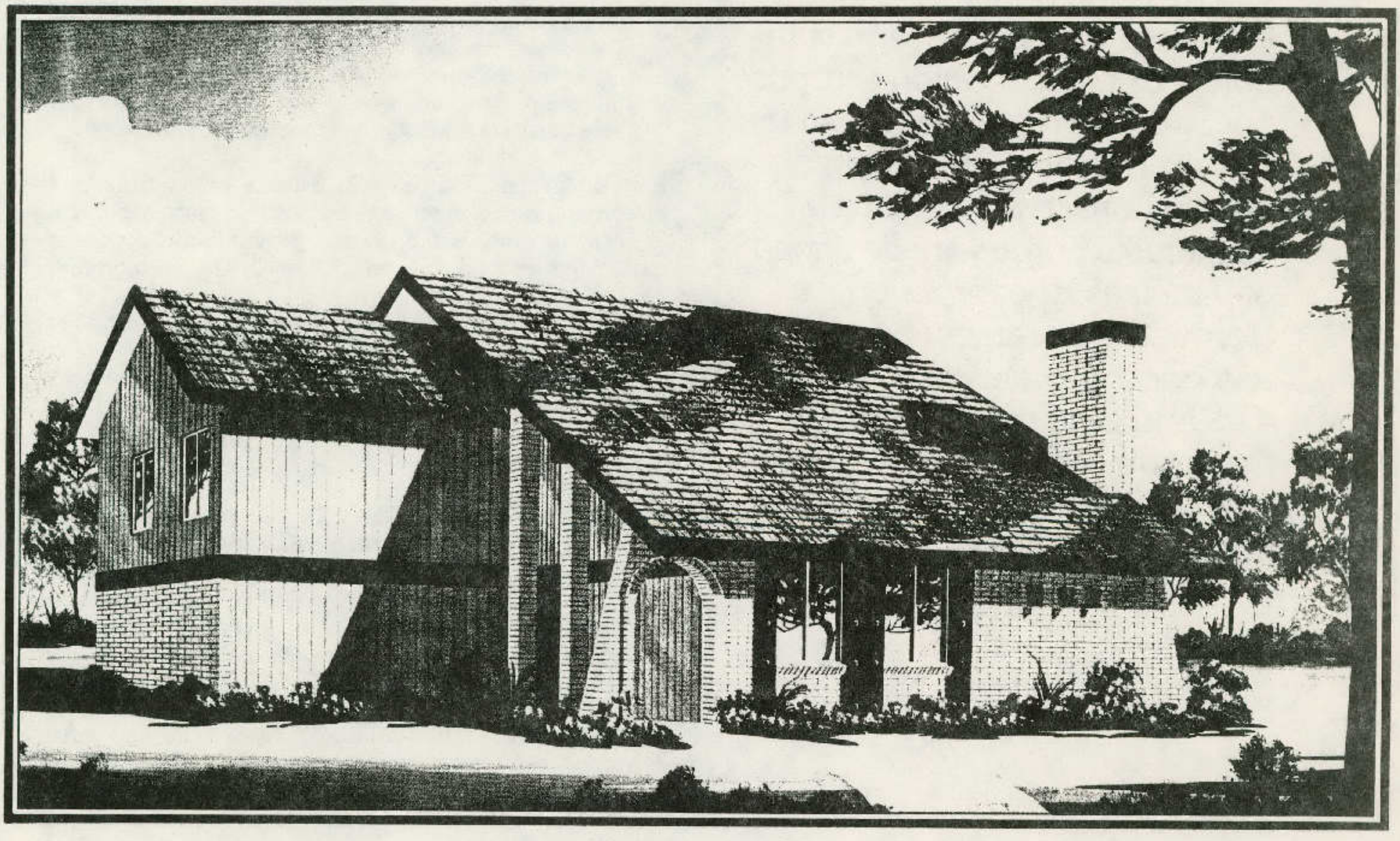
J. W. Smith builds outstanding family homes in Austin's finest communities—Anderson Mill in the Northwest, Onion Creek in the South, and Western Oaks (a J. W. Smith planned community) in the Southwest. Plus, J. W. will custom build you a home anywhere in Austin. And he'll personally arrange financing on any of his new homes at excellent rates. For more information, see the J. W. Smith representative in each community, your broker, or call J. W. at 892-1612 for a personal tour. For your free copy of J. W. Smith's Guide To Homebuilding, write J. W. Smith, 4638 South Lamar, Austin, Texas 78745.

J.W.SMITH

Any Home Worth Building Is Worth Building Right.

NO BETTER HOME FOR LOVE OR MONEY!

There's a magic moment that happens. It comes after you've looked at numerous possibilities and nothing has felt right. Suddenly you see it. The perfect home for you and your family! You love the way the home looks and feels. And you appreciate all the practical touches that mean living there will be fun, convenient and economical, too. That's the kind of home the Centennial Home Team has been building since 1957. Since then, we've seen a lot of magic moments.



Weyerhaeuser centennial homes

Supplement to Dallas Times Herald, Dallas Morning News & Fort Worth Star Telegram. 11/20/77 to 12/11/77

ONLY CENTENNIAL MEASURES UP TO THE TOUGHEST STANDARDS YET FOR ENERGY EFFICIENT HOMES.

Texas Power & Light has set tough energy standards for area homes. Centennial is the only volume home builder to meet these high standards. But that shouldn't surprise anyone. The Home Team led the way among area builders in energy conservation. All new Centennial homes are designed and built as Energy Saver Homes. They can cut heating and cooling costs an amazing 42% and even more! Compare that to the 10% savings some other builders actually brag about.

HERE'S HOW WE DO IT:

1. **ABOVE STANDARD ATTIC INSULATION:** Every Centennial attic is now getting a full 12" of insulation — a big R-26 rating! That's well over the minimum used by many other builders.

2. **SUPERIOR CAULKING:** After a Centennial caulking specialist finishes his work, it's almost impossible to find any gaps or air spaces around windows and doors. He caulks inside **and** out. And even **between** the sole plate and foundation!

3. **WEATHERSTRIPPING:** Look at your refrigerator door. That vinyl door seal is much the same as the weatherstripping we use around Centennial doors to stop air infiltration. And, because it's vinyl, you'll never have those noisy wind whistles you get with metal stripping.

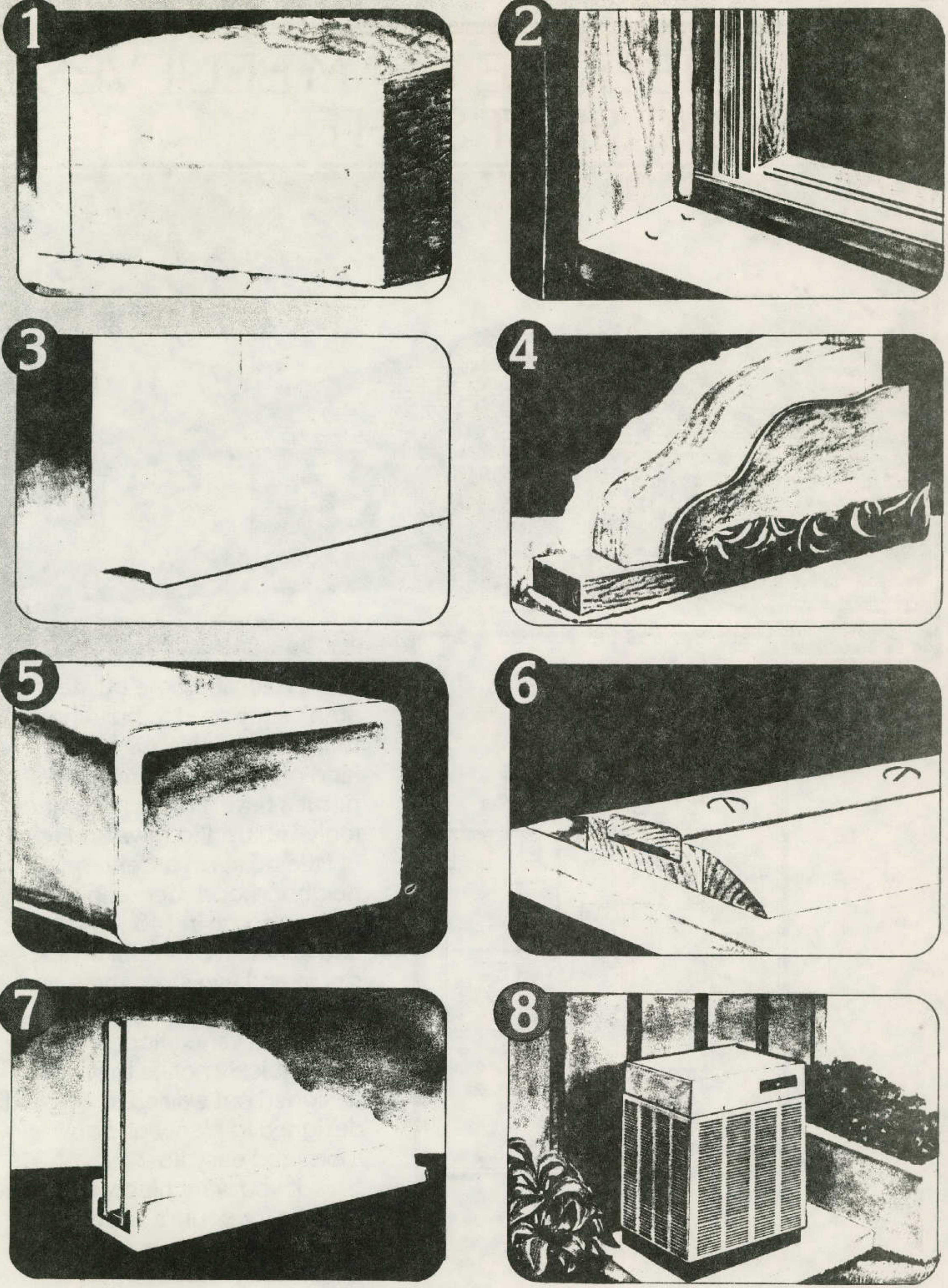
4. **POLYETHYLENE WRAP:** Sheets of air-tight polyethylene go on every wall and ceiling, further reducing air infiltration. Wintery winds stay outside. Indoor air stays inside. And you and your family stay comfortable.

5. **DROPPED DUCTS:** Attics have a way of getting very hot in summer and very cold in winter. So, we concealed our air ducts in the air conditioned spaces below. This allows your heating and cooling system to work more efficiently. This feature alone can save you 10% on heating and cooling.

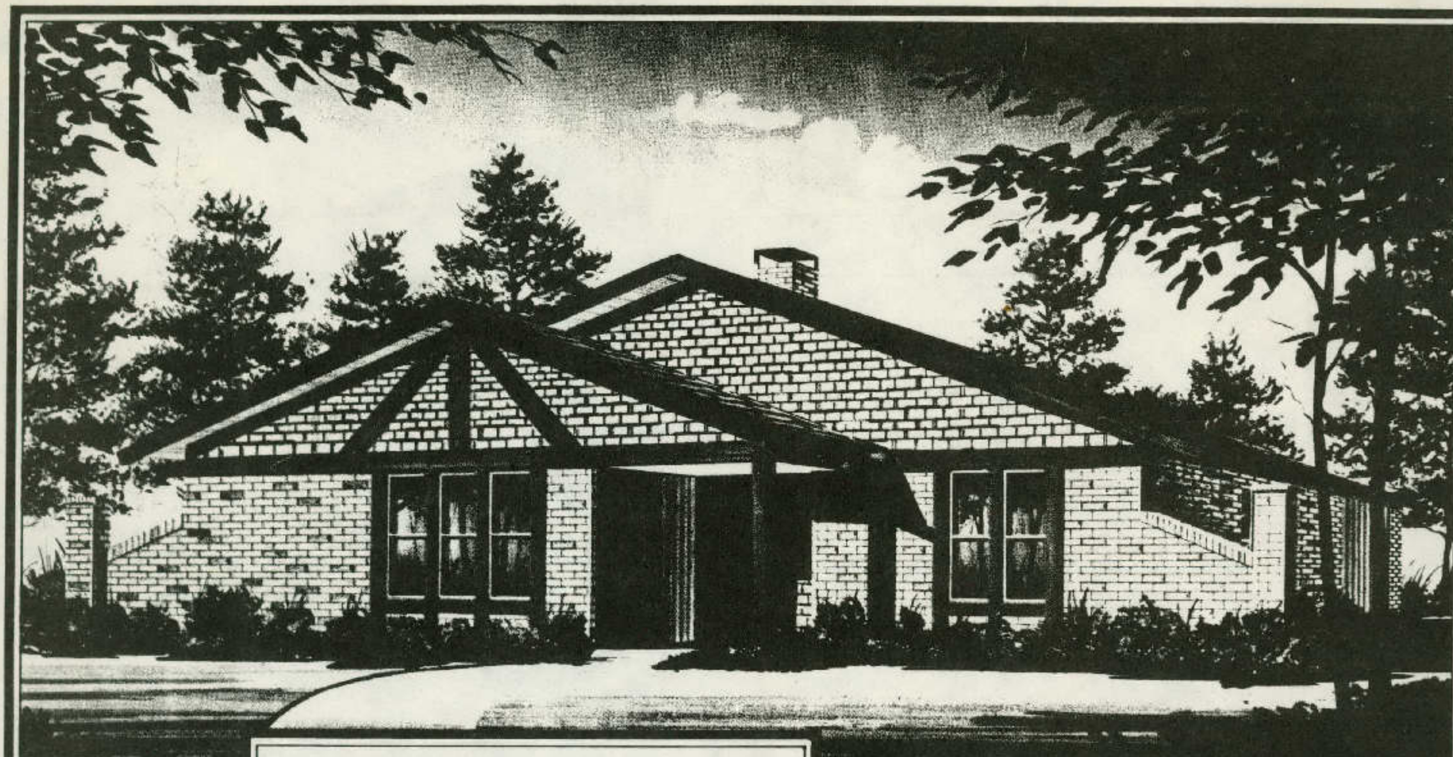
6. **ADJUSTABLE THRESHOLD:** This amazing feature is just one example of Centennial's ingenuity in engineering our energy efficient homes. You yourself can easily adjust this special oaken threshold so that it always fits snugly against the bottom of exterior doors. So snugly that drafts are eliminated, and so is a portion of your utility bill.

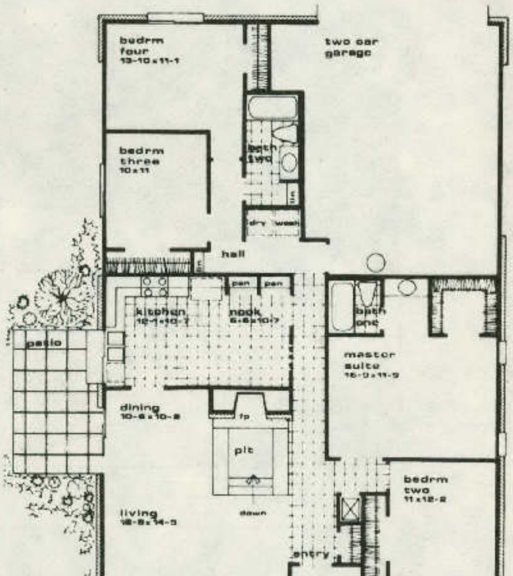
7. **TWIN-PANED INSULATED GLASS:** We use bronze-framed, twin-paned insulated windows and patio doors to protect against the hot rays of summer sun and bone-chilling winds of winter. 1/4 inch of insulating air nestles between the panes and prevents unwanted heat loss or gain.

8. **G.E. WEATHERTRON HEAT PUMP:** This remarkable feature is proven and recommended by the U.S. government as a more efficient way to heat and cool your home. It's more economical than conventional systems, delivering over two units of heat for every unit of electricity used. It's quieter, too.


1
2
3
4
5
6
7
8

THE HOME TEAM BELIEVES IN LOVE AT FIRST SIGHT.

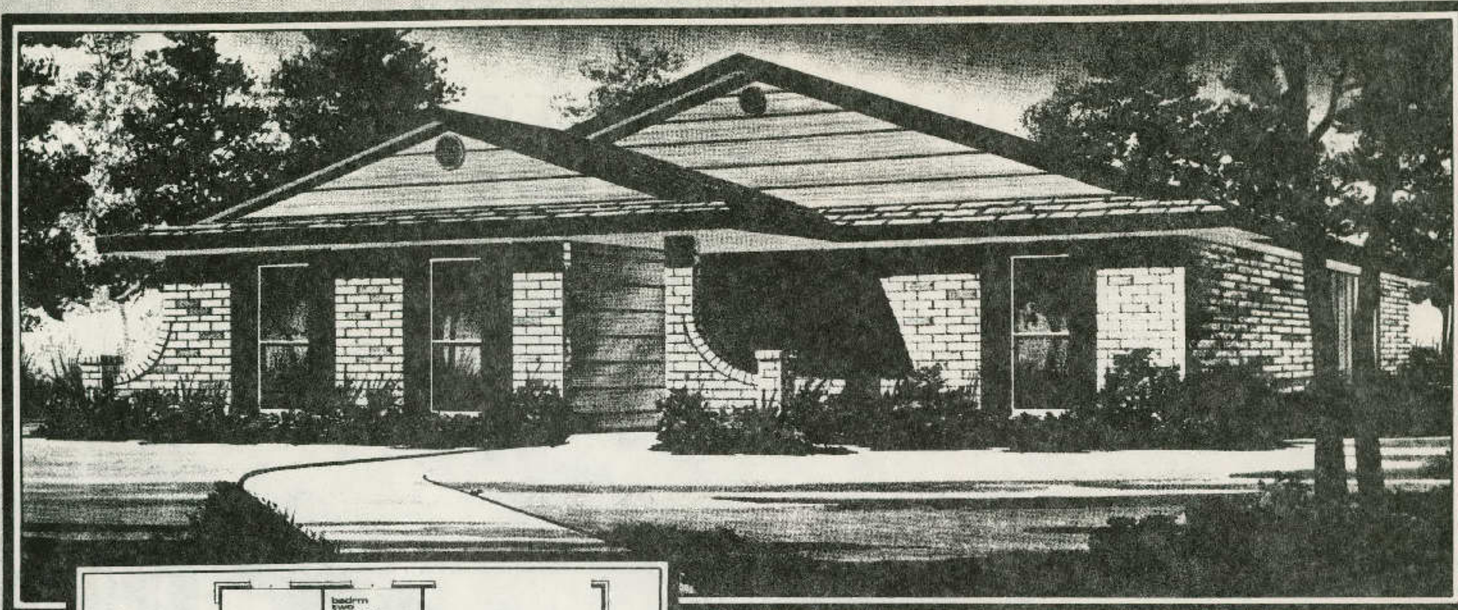


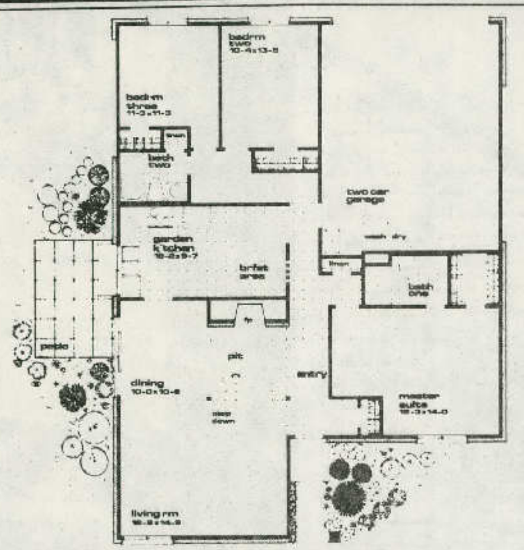


DALLASITES:
Mid $40's to upper $50's.

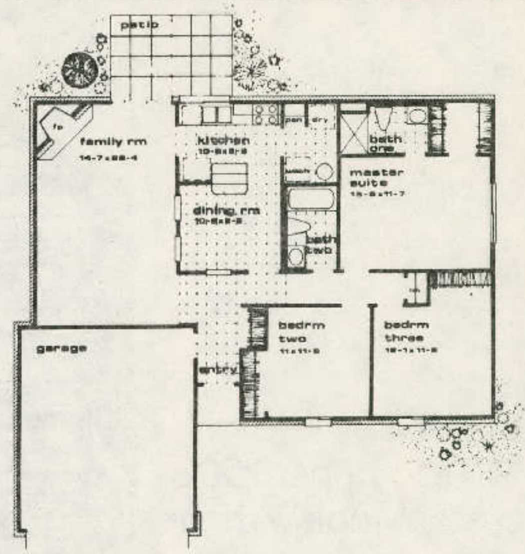
Volume home builders just aren't supposed to build homes that look like this. Or have the kind of quality features these homes have. No cookie-cutter look with us. No rows and rows of little boxes in a Centennial neighborhood. Centennial homes come in 148 handsome and distinctive exterior styles, single and two story, three and four bedroom models. As for our many and varied floor plans— you'll quickly notice that we've designed out wasted space and designed in plenty of elbow room and easy flow.

If you want plenty of square footage for your money, plus quality features, too…turn the page.



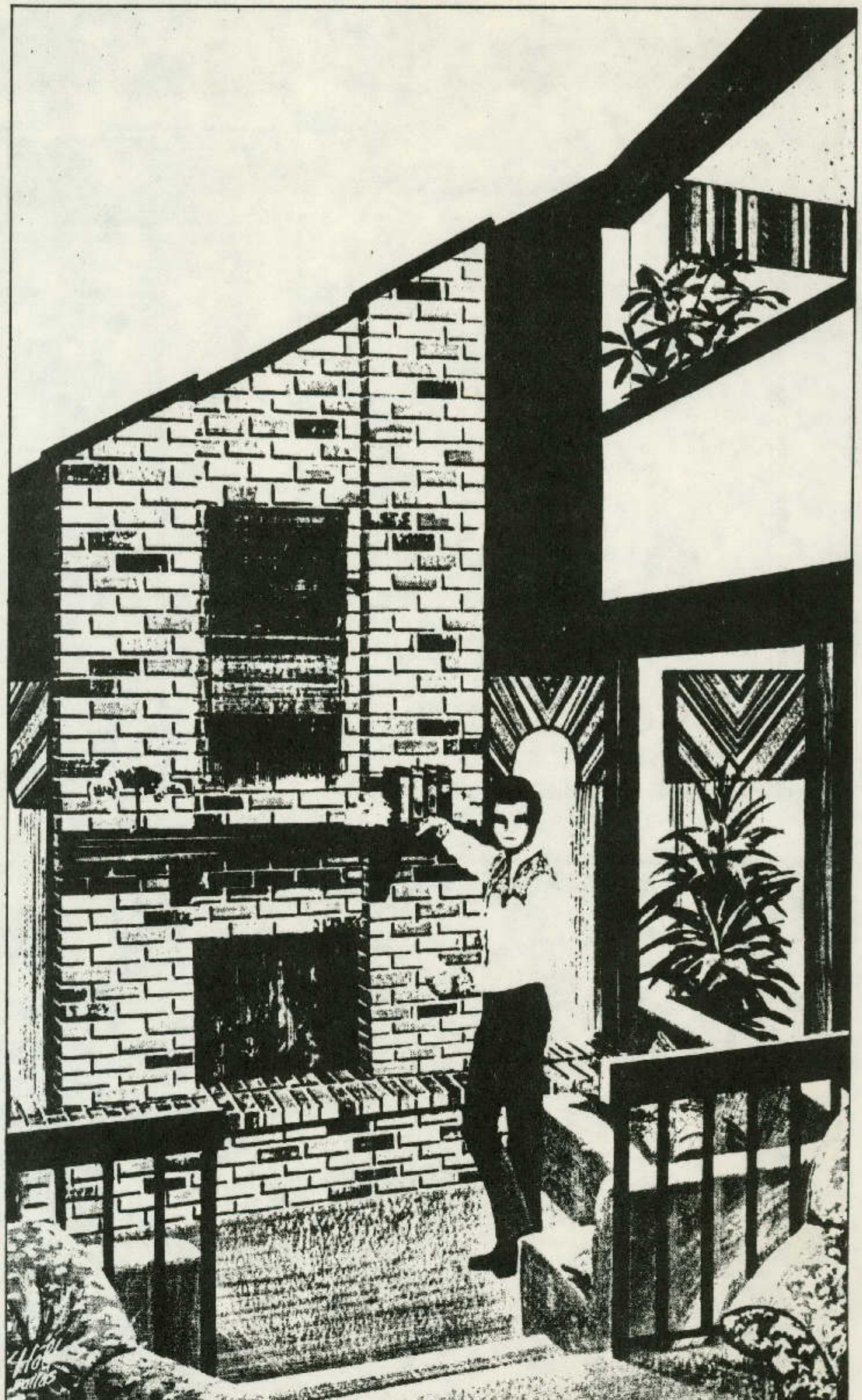


SOUTHWESTERNERS:
Low to upper $40's.



TEXANS:
Low to upper $30's.

THE HOME TEAM OFFERS FEATURES* YOU'D EXPECT IN MUCH HIGHER PRICED HOMES!

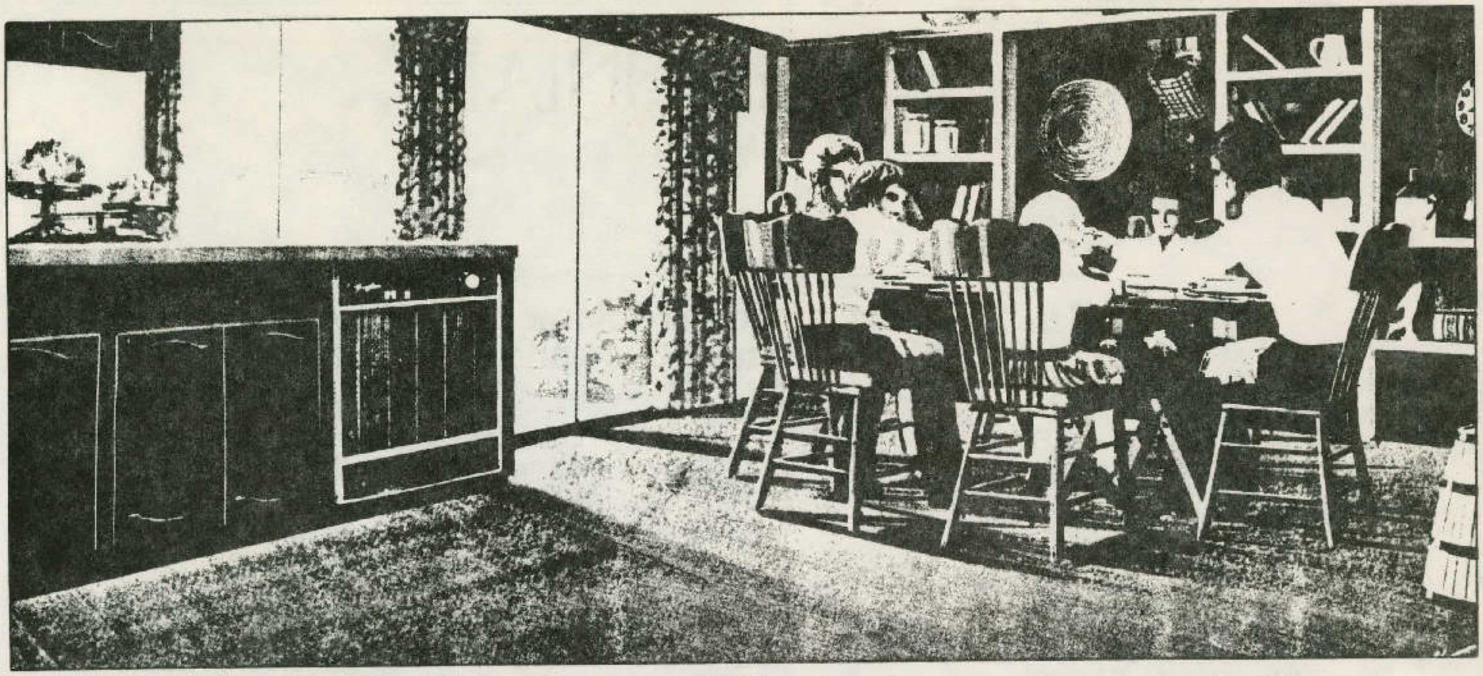


DALLASITES:

Mid $40's to upper $50's. The custom look without the custom price tag!

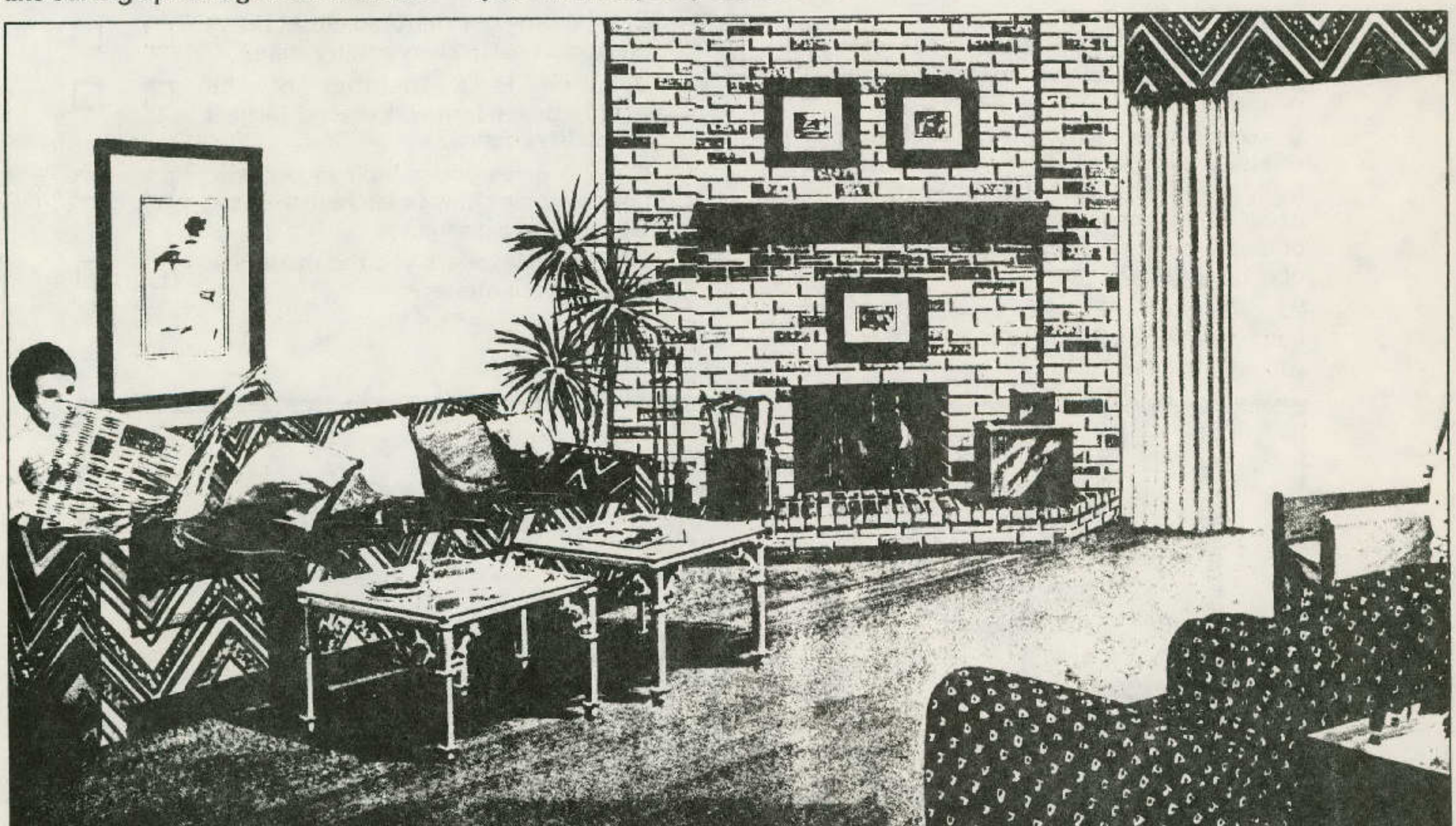
Relax in a sunken conversation pit with built-in sofas and wood-burning fireplace. It's an ideal spot for entertaining friends or just unwinding by yourself. Or enjoy a garden atmosphere with your own open air atrium. In the kitchen: GE appliances, rather than ordinary "builder" brands. The cabinetry is hand rubbed oak and very attractive. No plastic drawers here. We use real wood ceiling beams, too. And real wood paneling. And throughout the home, lots of beautiful imported wall coverings and decorator light fixtures. And that's just the top of the list!

*Many of the features mentioned can be found in Centennial models other than in the series in which they are listed.



SOUTHWESTERNERS: Low to upper $40's. Another way to say, "value"!

Like plush shag carpeting? There's lots of it in Centennial Southwesterners. Cabin-Craft by name, and it's in every single bedroom. You'll also like our big upstairs gamerooms and our spacious and airy country kitchens. GE appliances, naturally! That means, continuous cleaning oven, dishwasher with special pot scrubber cycle and heavy duty disposal. You'll also find mirrored closet doors and... well, come see for yourself. The list goes on and on...



TEXANS: Low to upper $30's. No one else can offer so much, for so little.

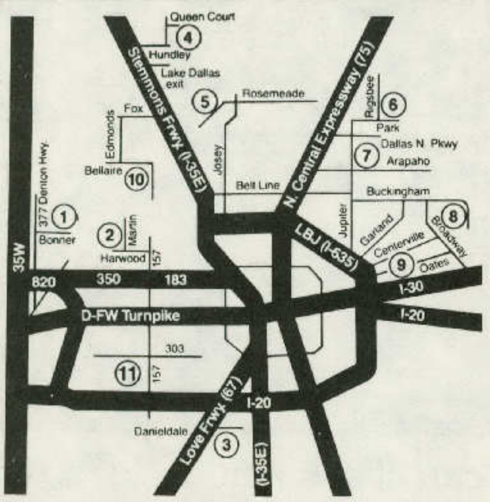
No wonder folks call these homes, "unbelievable"! Consider this line-up of features: big picture window, wood burning fireplace, separate dining room, oversized garage, automatic smoke detector, wall to wall shag carpeting, breakfast bar and even beautiful landscaping. Dollar for dollar, feature for feature, these Texans have to be the best home value you're going to find.

CENTENNIAL VS.

———————————————

Fill in the name of another volume home builder. Then go look at new homes. Ours and theirs. Compare.

	US	THEM
1. Who meets Texas Power & Light Company's tough standards for energy efficient homes—and actually cuts your heating and cooling costs 42% and even more?	☐	☐
2. Whose neighborhoods look like custom neighborhoods, with cul de sacs and gently curving streets, instead of regimented rows of boxes?	☐	☐
3. Who offers you GE kitchen appliances, including pot scrubber dishwasher and double-level ovens, instead of ordinary "builder" brands?	☐	☐
4. Who offers you the exciting sunken conversation area with built-in sofas and fireplace?	☐	☐
5. Who gives you — free — the services of a professional interior design consultant?	☐	☐
6. Who offers you more designer choices than any other local volume builder: 48 choices of wallpaper, 32 choices of carpeting, 14 choices of brick, 20 choices of flooring, 16 choices of counter tops?	☐	☐
7. Who offers you an upstairs gameroom? For that matter, who offers you an upstairs?	☐	☐
8. Who gives you real oak cabinetry, with solid wood drawers instead of plastic?	☐	☐
9. Who has quality oak paneling straight from the forests of Weyerhaeuser, instead of vinyl covered panels with printed wood grain?	☐	☐
10. Who offers you a selection of 59 floor plans—priced from the low 30's to upper 50's — each one designed to make the best use of each square foot of space?	☐	☐
11. Who starts out with the prime locations you want to live in; with good schools, easy commuting and convenient shopping and employment areas?	☐	☐
12. Who provides mirrored closet doors at no extra cost in every master suite?	☐	☐
13. Who is a member of the Weyerhaeuser family, the 2nd largest forester in America?	☐	☐
14. Who gives you a built-in ceramic chopping block in your kitchen, the kind that won't hold germs?	☐	☐
15. Who **really** offers you the most new home for your money?	☐	☐



The Ranch
mid $20's—
low $30's
498-3690

Canterbury
low $40's to
mid $50's
267-7622

Shenandoah Valley
upper $30's to
low $40's
298-3386

Lake Dallas
upper $20's to
upper $30's
241-7754

Rosemeade
mid $40's to
upper $50's
242-7402

Cimarron
upper $30's to
low $50's
423-4404

Camelot
low $40's to
upper $50's
495-2121/2157

North Lake
low $30's to
upper $30's
272-1743

Gatewood
mid $30's to
low $40's
271-6725

Timberbrook
low $40's to
mid $50's
436-1112/1322

Hillside
upper $30's to
mid $40's
opening Nov. 27, 1977

Weyerhaeuser **centennial homes**

EQUAL HOUSING OPPORTUNITIES

3

CODES

RESIDENTIAL BUILDING REGULATION

Building regulations comprise a body of laws and rules specifying how a specified type of building must be constructed, what materials may or may not be used and the zoning, either upon a parcel of land or within an area of a political subdivision. In Texas, depending on the political subdivision, all or none of these aspects of building regulation may be in force. Most cities in Texas require buildings to conform to a locally adopted building code. In many cities, zoning ordinances relegate various uses of buildings to specific areas of the city. Counties in Texas have no authority to enforce building codes or zoning ordinances but do enforce flood-plane requirements.

Building regulations have historically been instituted to protect the community from fire, safety, and health hazards, to promote the community's concept of orderly growth, and to protect the public welfare. Many building regulations were initially instituted as a result of fires which decimated portions of a city. As an aftermath of these fires, the insurance industry or city fathers required new construction to have noncombustible (e.g., masonry) exterior walls to prevent the spread of fire from building to adjoining building. Typically this type of construction would have interior walls, floors, and ceilings of combustible materials so that once a fire gained headway within a building the entire structure could be gutted. As buildings grew in height and area, fire and insurance officials recognized the need for additional regulations to protect building occupants as well as property. This was accomplished by requiring portions of the building interior to be flame resistant and by requiring fire exits. The first model building codes were issued by the insurance industry or by associations interested in fire protection. By the 1920's organizations were in existence which issued model codes containing requirements to protect the public from safety hazards as well as fire hazards.

Until the oil embargo in the early seventies, few if any building codes contained requirements to regulate a building's energy efficiency. The National Conference of States on Building Codes and Standards (NCSBCS), recognizing the need for such regulations, asked the American Society of Heating, Air Conditioning and Refrigerating Engineers (ASHRAE) to develop an energy conservation standard for new buildings. In 1975, ASHRAE published what is the most widely accepted energy conservation document, <u>ASHRAE Standard 90-75: Energy Conservation in New Building Design</u>. Two years later, in 1977, the <u>Model Code for Energy Conservation in New Building Construction</u>, was developed from the ASHRAE Standard by NCSBCS, under contract from DOE, using a committee comprised of the Building Officials and Code Administrators International, Inc. (BOCA), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International, Inc. (SBCC).

Although other organizations and states have published energy conservation codes or standards, the ASHRAE Standard 90-75 and the NCSBCS Model Code remain the most widely accepted documents relating to energy conservation in new buildings. Several states having statewide authority to regulate building construction have added either the ASHRAE Standard, the Model Code, or some other energy conservation standard to their building code requirements. New Mexico, for example has adopted the Uniform Building Codes version of the ASHRAE Standard 90-75.

Because of the many factors, such as resistance to change, interest groups, and complexity involved in reviewing and enacting energy conservation standards few cities in Texas have yet to adopt them. However, the Governor's Office of Energy Resources, as a part of the State

Energy Conservation Plan, has worked with thirteen cities to test the Model Code for Energy Conservation in New Building Construction during 1978. As a result the Model Code has already been adopted in El Paso, Garland, Sonora, and Alpine. It is being considered in Austin, Corpus Christi, Greenville, Sherman, LaGrange and Carrollton. Other cities are in the process of adopting the Model Code or similar standards provided by the model code organization with which they are affiliated.

As stated previously, just a few cities in Texas have yet enacted energy conservation legislation. However, this is not to say that many residential builders are not now building energy conserving homes. As early as the mid-50's the Federal Housing Administration recognized the desirability of protecting their loans and promulgated regulations as part of the Minimum Property Standards (MPS) which would help keep utility costs low. Requirements at first were minimal: insulation was required above the ceiling. In the mid-60's, insulation was required in walls. In 1974, and again in 1977 the MPS were revised and strengthened. Housing being built to current MPS has either to meet the specifications set out in the MPS or to meet the standard of ASHRAE 90-75.

A typical house, 1,575 sq. ft. (45 x 35), in a 2,600 degree day region of Texas, would be required to meet the following requirements under the MPS:

Component	Minimum Insulation
Roof Deck (Cathedral Ceiling) or Ceiling	R 12.5 (R-11 in cavities) R 20
Frame Windows	R 12.5
Windows	Single pane limited to 15% of exterior wall area
Slab Perimeter Insulation	R 2.5

To meet the Model Code requirements the following values would be required:

Roof Deck or Ceiling	R 12.5 R 20
Frame Walls	Varies: R 4.3 with 5% single glass R 9 with 15% single glass R 16.6 with 20% single glass R 4.3 with 10% double glass R 5.5 with 20% double glass R 9 with 30% double glass R 16.6 with 35% double glass
Window	Varies with walls
Slab Insulation	R 25

The ASHRAE/Model Code approach gives the builder greater freedom to meet the requirements of the MPS as the amount of wall insulation can be varied according to the type and area of windows used.

The Model Code also has three different methods of compliance, any one of which meet the intent of the Code. They are (and we quote):

> Path 1 -- (Section 4 of this Code) is the systems analysis design approach. This section includes non-depletable energy source utilization (Standard 90-75, Chapters 10 and 11).
>
> Path 2 -- (Section 5 of this Code) is the component performance design approach (Standard 90-75, Chapters 4 through 9).
>
> Path 3 -- (Section 6 of this Code) contains acceptable practice provisions for conventional residential buildings of three stories or less and small (heated only) commercial buildings of frame, concrete, or masonry-wall construction, all of less than 5,000 square feet in floor area. This section permits these structures to be constructed in accordance with designated provisions in lieu of performing a thermal analysis. Users of this section should be aware that it is generally more conservative and that greater initial construction economy may be obtained by utilizing Section 4 or 5.

Until March 15, 1978, the Farmers Home Administration used the MPS as their thermal insulation standard for loans they qualified. After March 15, the home described above would be required to meet the following standards, (Part III, A):

Component	Minimum Insulation
Roof Deck (Cathedral Ceilings) or Ceilings	R 30
Frame Walls	R 19
Windows	Double pane, storm doors if over 25% glass
Slab Perimeter Insulation	R 2.5

This is obviously a much stricter standard; however, there is an optional approach (Part III, C) which would require the following:

Roof Deck or Ceiling	R 22
Frame Walls	R 8.3 with 5% single glass R 19 with 12% single glass R 8 with 10% double glass R 11 with 16% double glass R 19 with 22% double glass

The FmHA is the most stringent standard being enforced; however the costs associated with meeting this standard should not be significantly greater than average, and the home would cost significantly less to operate.

The Federal government has already upgraded its energy requirements for Federally insured loans and is currently proposing energy performance standards for all new construction. In 1976 the Energy Conservation and Production Act (ECPA, PL 94-385) established a program to implement mandatory Building Energy Performance Standards for all new buildings by February 1981. Last year, at President Carter's request, the required implementation date was moved forward to February, 1980.

Failure to enforce these standards in all local political subdivisions by the specified date could result in the loss of federal financial assistance for construction of new residential, industrial or commercial buildings. The ECPA legislation requires Congress to approve the application of financial sanctions as the penalty for non-compliance. Federal financial assistance includes not only direct or indirect federal assistance, but also loans by banks and savings institutions regulated or insured by federal agencies.

HUD was given authority to develop the standards and recommend sanctions. This authority was transferred to the Department of Energy. HUD was responsible for developing the standards and plans to transfer all responsibility to DOE by interagency agreement during 1979. How strict these standards will be and what effect they will have on the residential builder remain to be determined. These standards are performance oriented and they give design requirements in terms of BTU/SQ.FT./YEAR.

The difference between the Model Code (based on ASHRAE 90-75) and the Federally required Building Energy Performance Standards to be introduced in the near future, is essentially their "prescriptive" and "performance" bases. The Model Code, like the ASHRAE 90-75 Standards, prescribes certain minimum requirements in building materials and construction techniques. By contrast the Performance Standards will allow the design to be built using the same materials and details as well as other techniques such as orientation, passive solar, and thermal inertia wall construction, so long as the designer can certify that the building will use no more than a basic budget of energy in one year in the particular climate zone of the building.

Since the prescriptive approach seems to limit the amount of glass and therefore the uses of passive solar design and similar concepts, it is hoped that adoption of the Model Code in Texas will include the adoption of the Building Energy Performance Standards in the same legislation, especially since the BEPS will be required by law in 1980 anyway.

At the time of this writing (March, 1979) the status of energy standards in building construction in Texas may be summarized as follows:

> Model Code -- Enabling legislation will be introduced in the 66th Texas Legislature adopting the NCSBCS code as the statewide standard with enforcement by the local authority. It is hoped that some accommodation for the Federally required (1980) Building Energy Performance Standards will be included.
>
> ASHRAE 90-75 -- The review process of the 90-75 standard is ongoing. Final form should be approved by 1980. That work will be divided in three parts: 90.1-75R (Sec. 1-9) by May 1-June 30, 90.2-75R (Sec. 10,11) out for review by June 30 ( ), and 90.3-75R (Sec. 12) date unknown.

In summary, though few building energy code standards are presently in effect, the residential builder can expect to see stricter standards for new homes being proposed in the near future. The economic impact of any new minimum standards appears minimal. A study of the ASHRAE 90-75 Standard by Texas A&M in January, 1979 indicates that that standard has little impact on the cost of a single family residence. Stricter standards in the coming years may increase construction costs, but they should also provide a more energy efficient home which can be marketed for a higher price by emphasizing the reduced operating costs of the home which will more than compensate for the increase in mortgage payment.

4

ORIENTATION & DESIGN

ORIENTATION AND DESIGN

In 1978 there were approximately 130,000 new home construction starts made in Texas. It is challenging to realize that about 512,200* barrels of oil per year for heating and cooling these homes could be saved before ground breaking if the proper decisions had been made for each of them regarding orientation and design.

Orientation, as it is used in this study, is the positioning of the house on its site in relation to the compass and thus to the movements of the sun through the seasons. Proper orientation to the sun's paths, assuming some basic design features, allows less heat gain in the summer and some free heating in the winter. This has the potential for saving about 17% of the energy that would be consumed in the standard home with improper orientation. Carrying the design considerations further we find that various shading devices, window exposures, and the positioning of rooms and other features, in relation to regional climatic factors, can account for about another 21% of the potential savings. It is hard to separate these two factors -- orientation and design, because they both relate so directly to the sun and its movement, so we must study them together.

---

*"512,200 barrels of oil per year savings" is based on the following:

1. 130,000 new home starts: from preliminary figures of the U.S. Census Bureau, February, 1979.

2. Calculations of heat gain and heat loss on a 1,370 Sq. Ft. home, using the N.A.H.B. method, and for Central Texas as being an "average" of Texas' climates, i.e.:

   Standard home:

Heating season	=	50,112,000 BTU
Cooling	=	70,083,000
Yearly need	=	120,195,000 BTU

3. Assume that 50% of this can be saved using a full range of energy saving measures. = 60,097,500 BTU

4. Assume that 38% of this is attributed to orientation and design = 22,837,050 BTU

5. $\frac{22,837,050 \text{ BTU}}{5,800,000 \text{ BTU per barrel oil}}$ = 3.94 barrels per house

6. 130,000 homes @ 3.94 = 512,200 barrels

Although planning lot layouts and making decisions on floor plans, roof lines and window details is an expense for a developer, it does occur before ground breaking and usually it is spread over many homes' costs. It is not part of the materials and labor to build the home, but it accounts for about 38% of the possible utility bill savings (the 17% + 21% indicated above). If this is not persuasive enough, consider the importance of orienting and sloping the new house roof so that future solar collector panels can be attached. They must face south, and be angled about equal to the degrees of latitude of the site.

The sun in summer rises north of east and sets north of west, and at noon it is very high in the sky. By contrast, in winter the sun rises south of east, it sets south of west, and at noon it is relatively low in the sky. In Texas, with its hot summer sun and with possible passive solar heating in winter, it is very important to respond to the angles of the sun in building design and orientation. The actual sun angles vary somewhat with latitude so solar charts should be used for design purposes. Table #1 shows the approximate latitude for several of Texas' cities. Table #2 shows the important sun angles for those latitudes, and Figure #1 shows diagrams depicting the movement of the sun in summer and winter.

TABLE #1

City	Latitude
Abilene	32.26
Amarillo	35.13
Austin	30.16
Beaumont	30.5
Brownsville	25.55
Corpus Christi	27.48
Dalhart	36.4
Dallas	32.47
El Paso	31.46
Fort Worth	32.45
Galveston	29.19
Houston	29.45
Laredo	27.30
Lubbock	33.35
Midland	32.0
Orange	30.6
San Angelo	31.27
San Antonio	28.20
Texarkana	33.25
Waco	31.35
Wichita falls	33.54

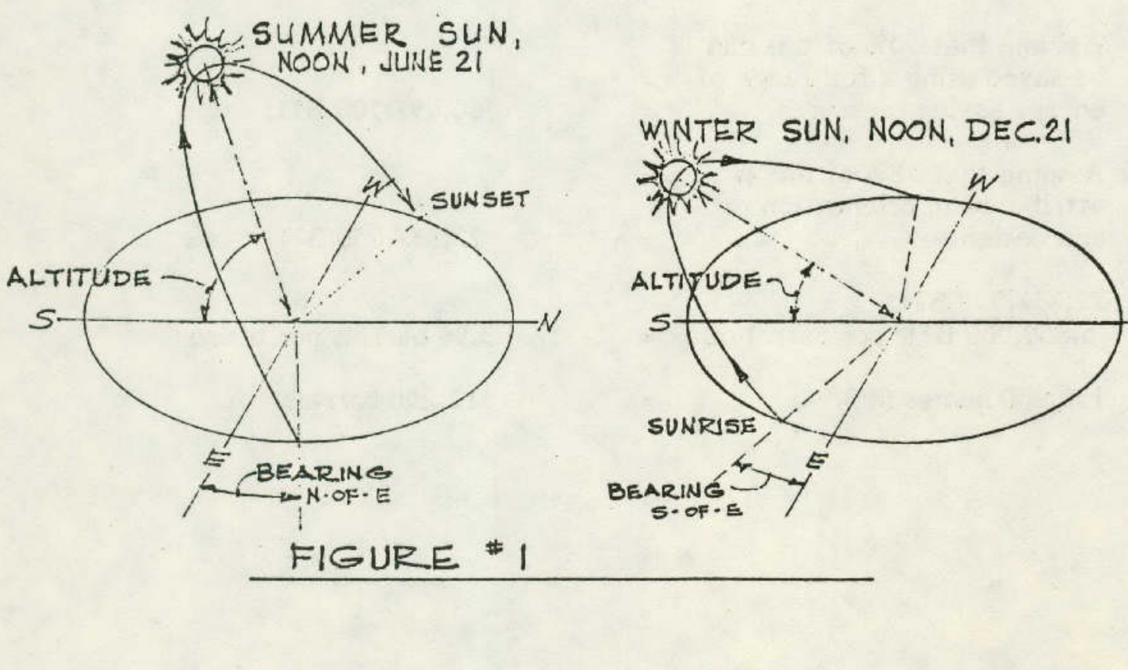


FIGURE #1

TABLE #2

Latitude	Summer June 21 Altitude @ Noon	AM/PM Bearing from East or West	Winter December 21 Altitude @ Noon	AM/PM Bearing from East or West
26°	88°	25°N	41°	26°S
28°	86°	26°N	39°	27°S
30°	84°	26°N	37°	27°S
32°	82°	27°N	35°	28°S
34°	80°	27°N	33°	29°S
36°	78°	28°N	31°	30°S
38°	76°	28°N	30°	31°S

NOTE: Altitude values are rounded off to even degrees, and Bearings are approximate. Bearings will vary for all sites because of hills, trees and other "horizon barriers".

Since the sun is so high in the sky in the summer at noon time, a reasonable roof overhang of about two and a half feet will shade all the south wall for a single story house, properly oriented. This is shown in Figure #2. For the same house the winter sun can shine under that roof overhang at noon and come in south windows to provide free heat. As shown in Figure #2, if there is a patio door on that south side, about fifteen feet of floor area is heated. If that floor has some mass, such as a concrete slab floor with a dark color it will act as a "heat sink" absorbing that solar heat and re-radiating it to the room after the sun has moved on to the west. Using this "passive heat" in the winter, lined drapes should be drawn across the glass at night to reduce thermal flow out through the glass to the cold outdoors.

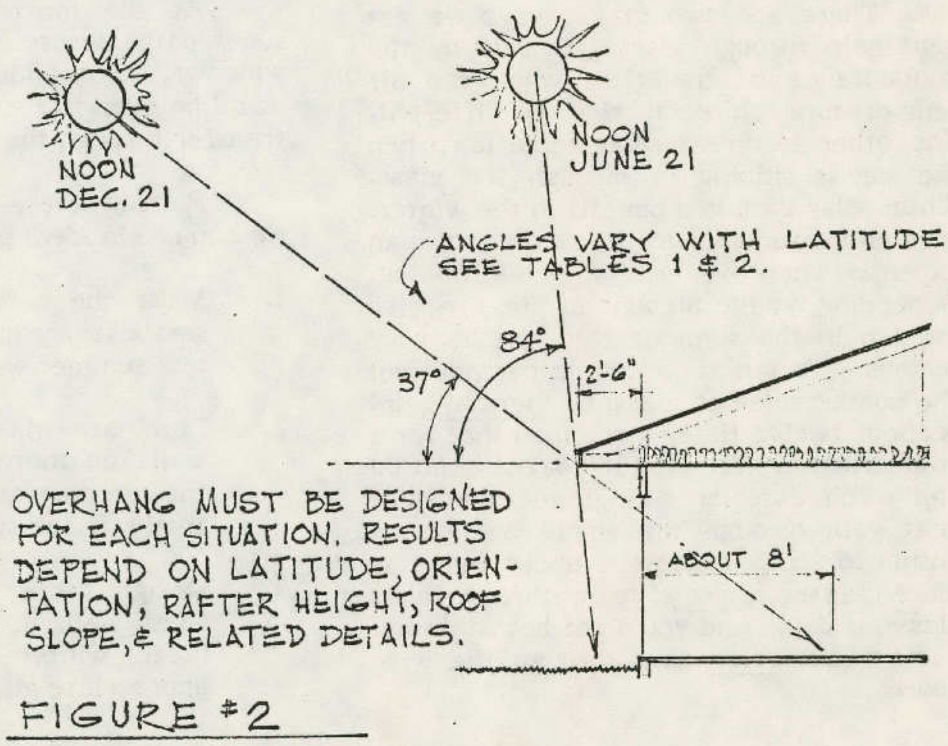
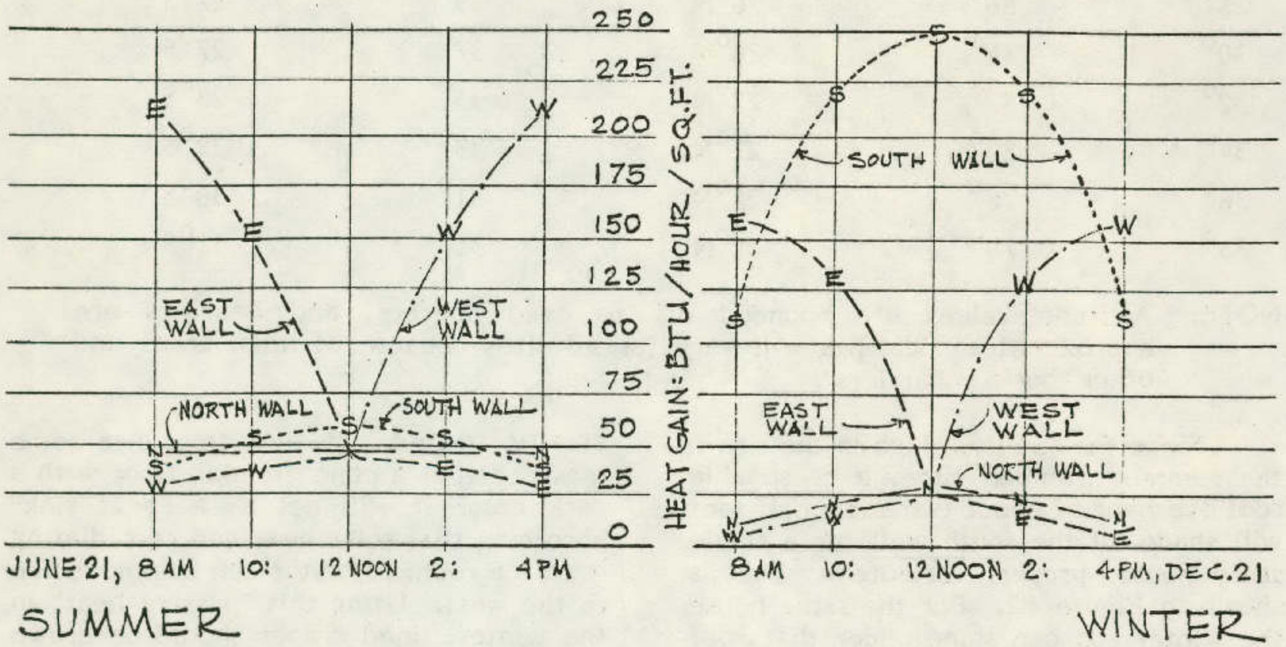


FIGURE #2

The solar heat gain on the walls of a house will vary with summer and winter sun movement and with the wall exposure according to orientation and the time of day. The charts in Figure #3 show this solar heat gain in BTU per square foot of wall surface per hour, for eight hours per day, for the four compass exposures, and for the summer and winter conditions. These charts are revealing...consider especially the solar heat gain if the wall is glass!



SOLAR HEAT GAIN ON EXTERIOR WALLS

FIGURE #3

There are two major ways we get heat gain through glass. One is by the conductance of the glass when the air temperature on each side is different. The other is direct solar radiation when the sun is shining in through the glass. While solar gain is a benefit in the winter, it is uncomfortable in the summer and an expense when we use air conditioning. Depending on the amount of glass receiving sun in the summer this can be very serious. To put it in simple perspective; the conductance of glass, or thermal gain, is about twelve times more than that for a standard stud wall with 3½" batt insulation and wood exterior siding; and the solar heat gain through the whole day on an unshaded south window is about twice as much as the thermal gain through that glass all day. And you'd get both thermal and radiant solar gain through the windows.

At the most critical time in the sun's path across east or west facing windows, in one hour the solar heat gain could be over four times the thermal heat transfer through the glass.

Putting these solar facts together we can see in ideal pattern developing.

1. Make the east and west walls the smallest areas of exterior wall for less summer wall exposure.

2. Eliminate glass on east and west walls or thoroughly shade them in the morning and afternoons, respectively, in the summer.

3. Design proper overhangs to shade south walls in summer, and to allow useful winter sun to enter through appropriate glass areas.

4. Use windows on the north for light and cross ventilation.

5. Slope the roof to the south at an angle about equal to the degrees of latitude for proper placement of possible solar collector panels in the future.

These few guidelines indicate that this house will have to face north or south with its roof ridge running east and west. And it would be helpful if the garage were located on the west end as an additional shade to the west wall of the house itself. The house orientation might look something like one of these plans, Figure 4.

You will note in Figure 4 that the streets run east and west to make this ideal scheme possible. There are other designs that can be developed when the streets run other directions. One of these is shown in Figure 5. Note the use of the prevailing breeze as well as the control of solar exposure.

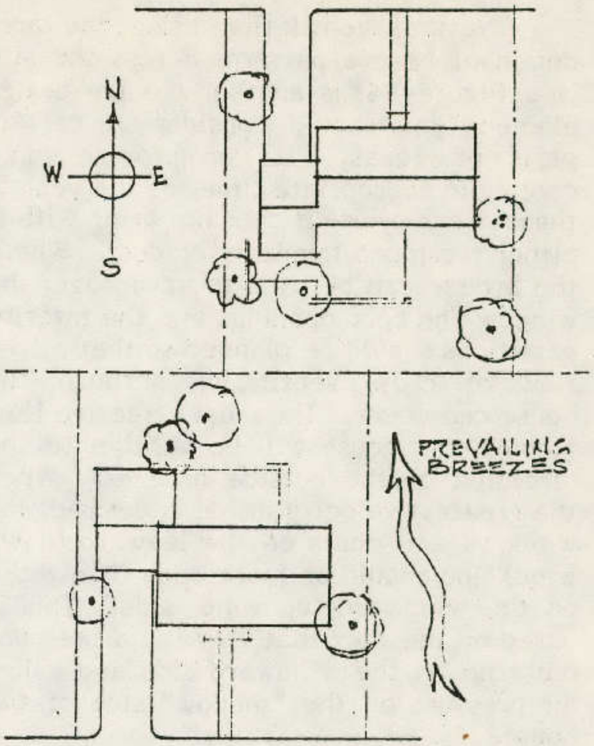


FIGURE #4

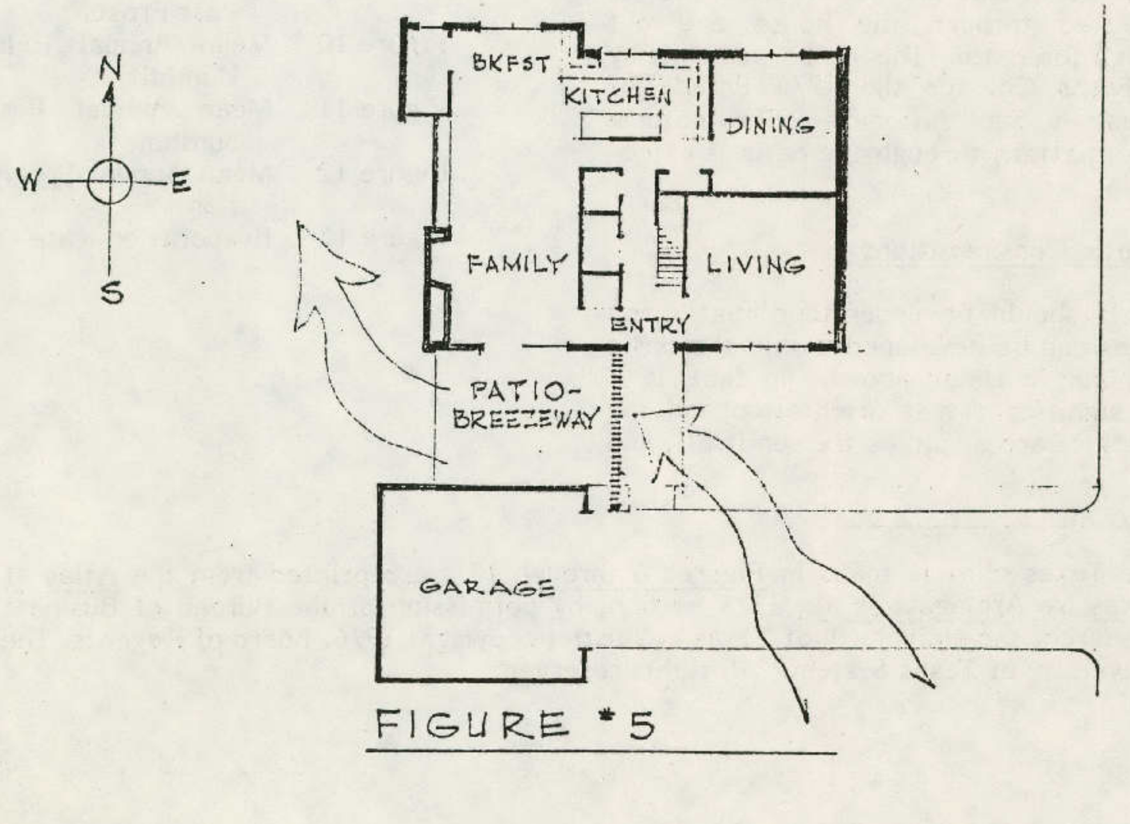


FIGURE #5

Natural ventilation using the predominant breeze patterns across the site (see Figure #6) is another passive design element you should consider in certain parts of Texas. It can provide some cooling in appropriate times of the year in those areas where it does not bring with it either too much humidity or dust. Where the breeze can be used to advantage, the window and door openings and the interior partitions should be planned so that a free flow of cross ventilation through the house can occur. The most effective flow through the house will be parallel to the direction of the outside breezes. When the greatest velocity inside is desired, the windows and doors on the leeward (down wind) side should be more open than those on the windward (up wind) side. This is based on the fact that there is a pressure build up on the windward side and a low air pressure on the "shadow" side of the house.

Since the breeze shown in Figrue 5 must "converge" to go through the screened patio, between the house and the garage the air velocity is increased. It acts like a venturi, so that if the patio doors are opened a little and the windows on the north side are also opened, the air is sucked through the house and out through the patio. This house was built by the Burns Co. for the 1975 Parade of Homes in San Antonio. The natural breeze pattern through the patio is effective.

Climatic Considerations

It should be understood that many designs can be developed within the basic disciplines outlined above. In fact, it is very significant that orientation and the sun angles are as old as the sun itself; and these design considerations have been used since man began to improve his dwelling structures in all past cultures. Of course, wind patterns, temperature, humidity, rain and snow also had their influences on man's homes. The only time they were not of much concern was during the era of "free energy" with our development of total heating and air conditioning systems. Now we must turn again to those basic design disciplines of sun angles and breeze, and we should consider them, accordingly, in relation to the other climatic conditions in the various regions of Texas.

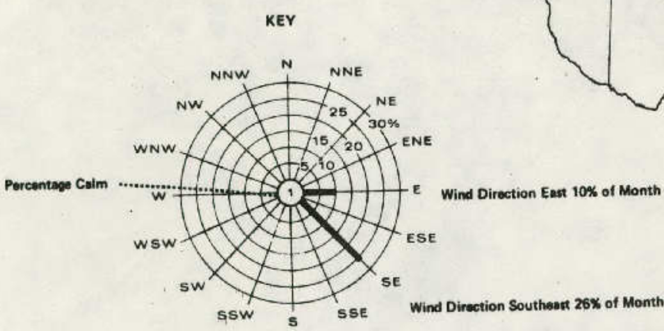
Besides sun angles and breezes we should consider the amount of the sunshine we can expect, the annual temperature patterns and the relative humidity where we build. Most of these factors are shown on the maps of Texas in Figures #6 through #13*, providing data, as follows:

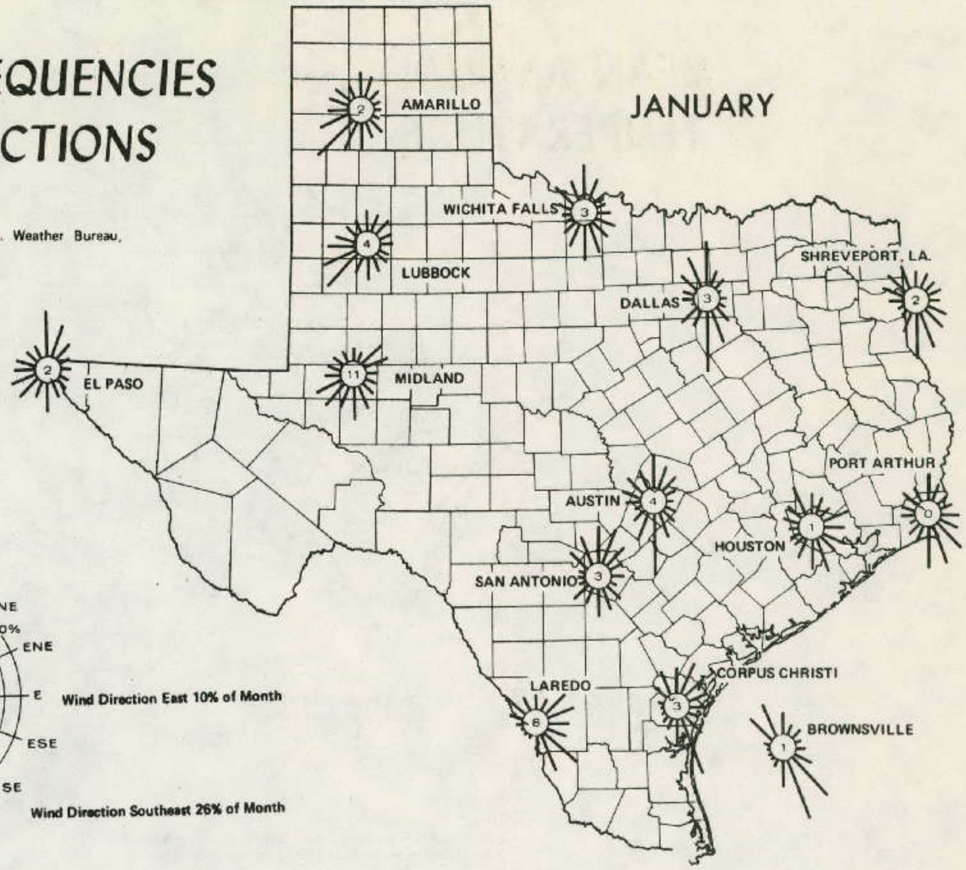
Figure 6	Wind Directions
Figure 7	Mean Annual Temperature
Figure 8	Mean Length of Warm Season
Figure 9	Mean Dates of First & Last Frosts
Figure 10	Mean Annual Relative Humidity
Figure 11	Mean Annual Possible Sunshine
Figure 12	Mean Annual Precipitation
Figure 13	Evaporation Rate

* The Texas climate maps in Figures 6 through 13 are reprinted from the Atlas of Texas by Arbingast et al., 1976 edition, by permission of the Bureau of Business Research, the University of Texas at Austin; copyright 1976, Board of Regents, The University of Texas System. All rights reserved.

PERCENTAGE FREQUENCIES OF WIND DIRECTIONS

Source: Texas State Climatologist, U.S. Weather Bureau, Austin, Texas, 1966.





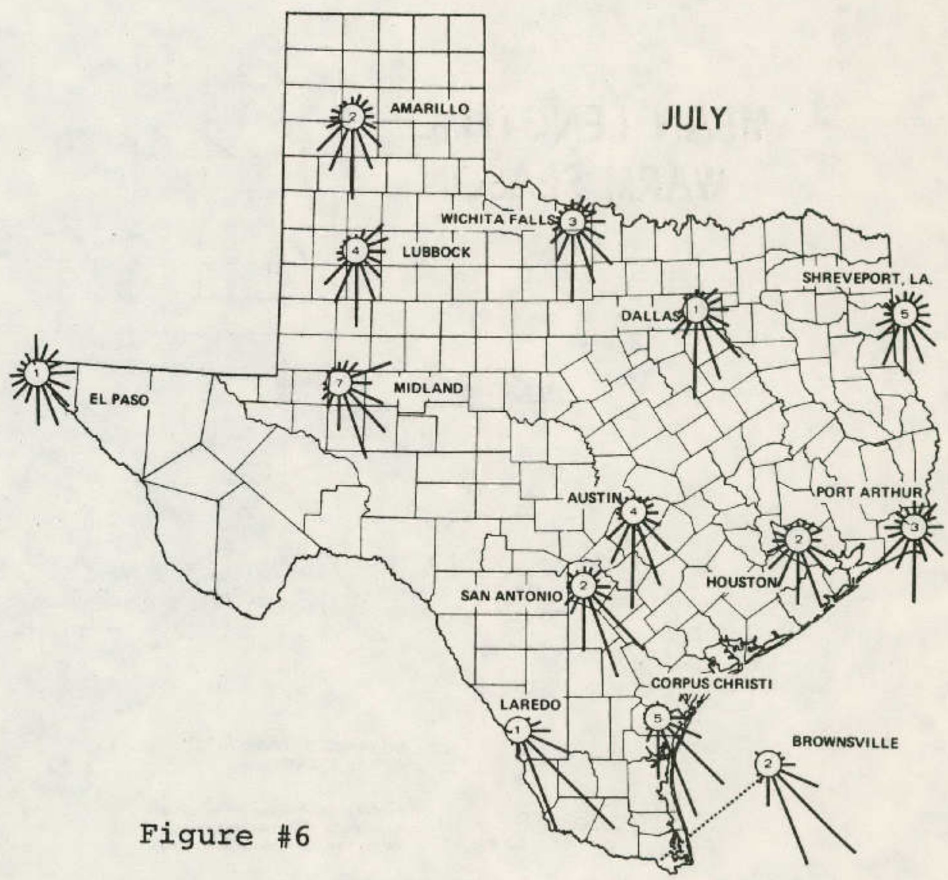


Figure #6

MEAN ANNUAL TEMPERATURE*

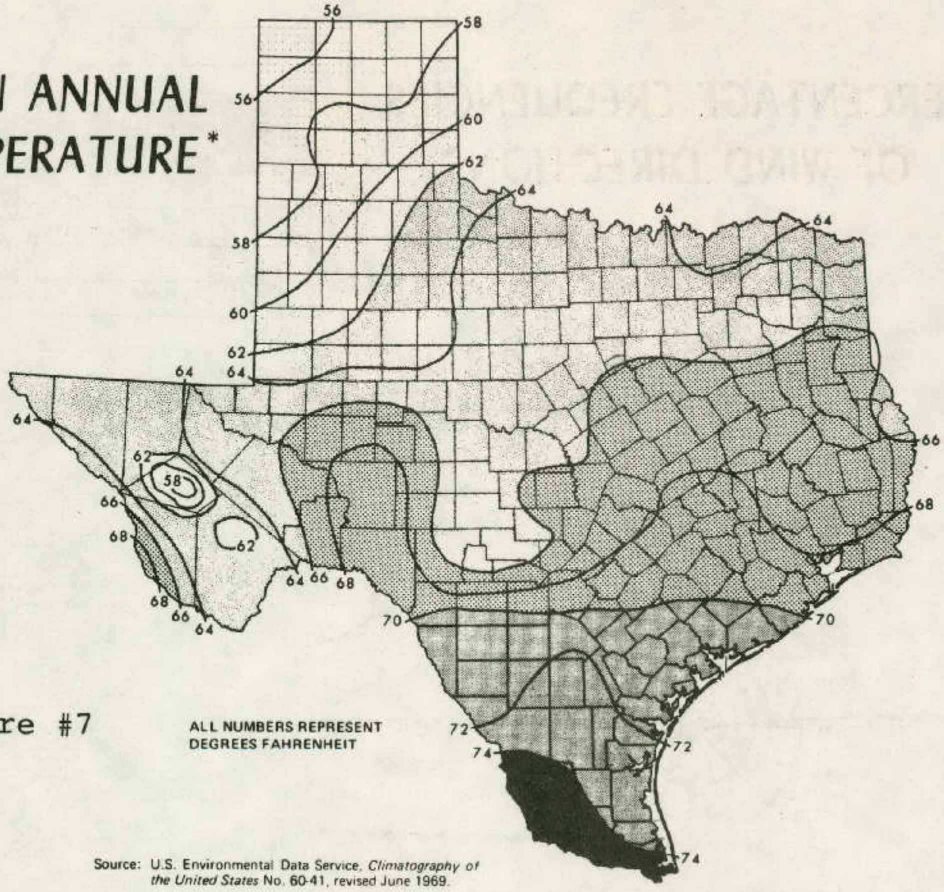
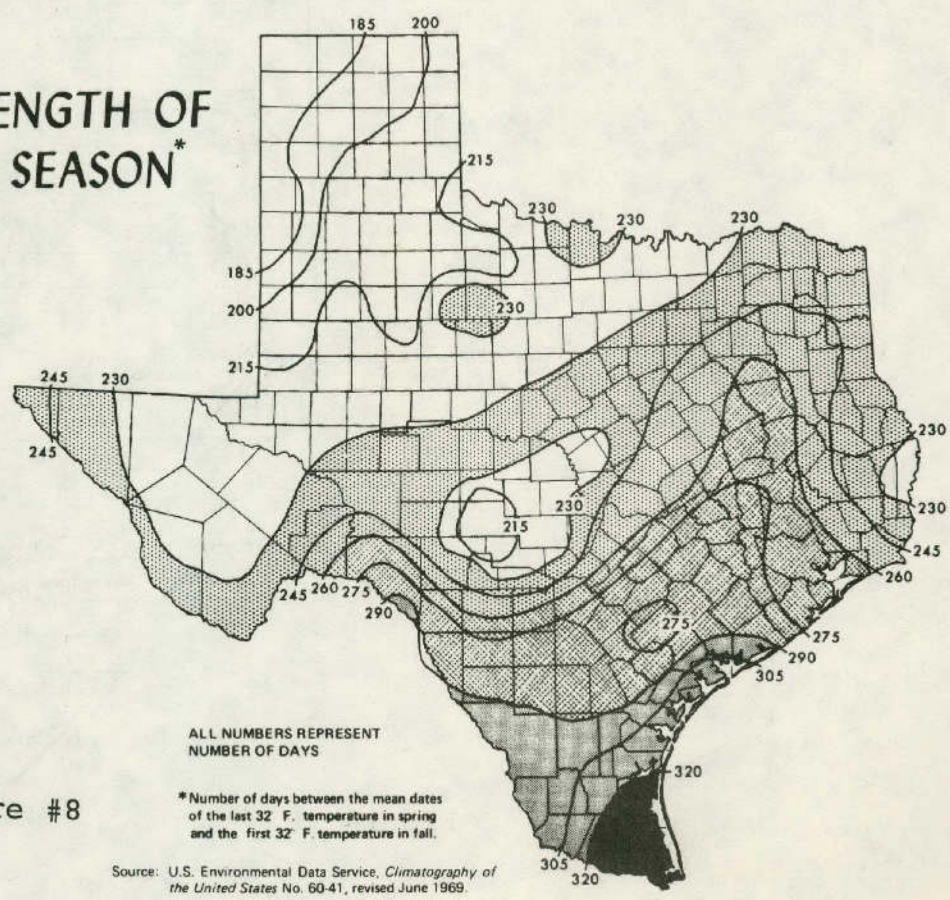


Figure #7

ALL NUMBERS REPRESENT
DEGREES FAHRENHEIT

Source: U.S. Environmental Data Service, *Climatography of the United States* No. 60-41, revised June 1969.

MEAN LENGTH OF WARM SEASON*



ALL NUMBERS REPRESENT
NUMBER OF DAYS

Figure #8

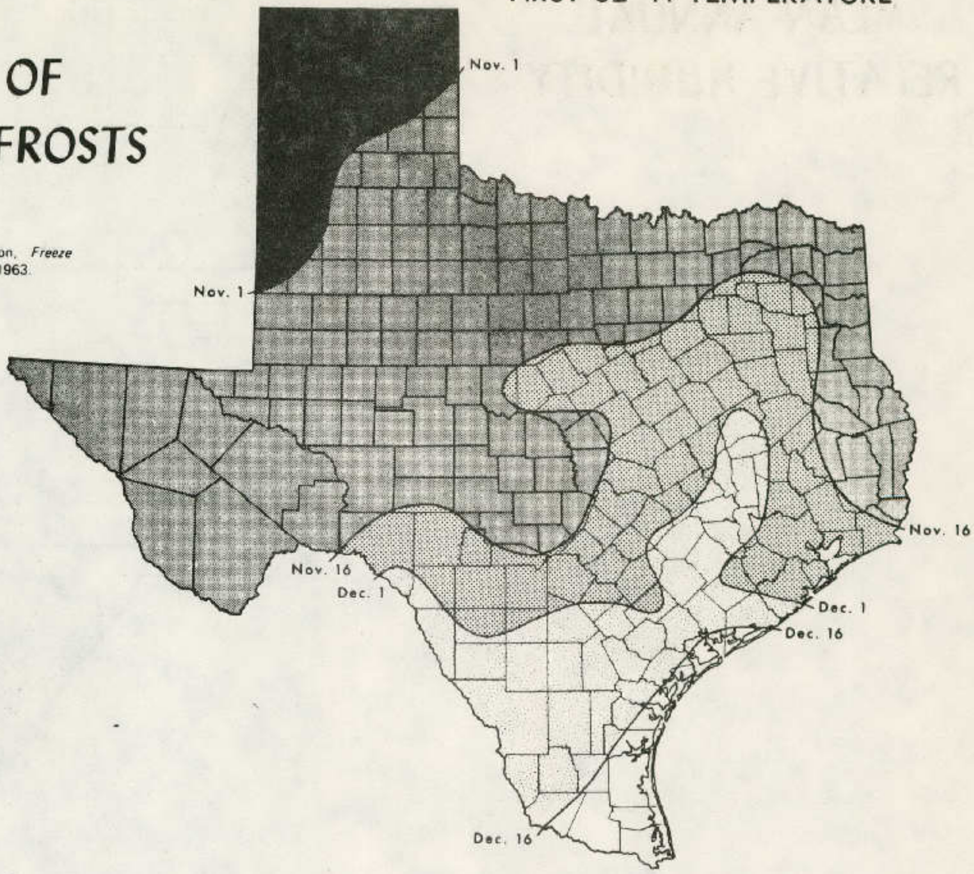
*Number of days between the mean dates of the last 32° F. temperature in spring and the first 32° F. temperature in fall.

Source: U.S. Environmental Data Service, *Climatography of the United States* No. 60-41, revised June 1969.

MEAN DATES OF FIRST AND LAST FROSTS

Source: Texas Agricultural Experiment Station, *Freeze Probabilities in Texas*, Bulletin MP-657, 1963.

FIRST 32° F. TEMPERATURE



LAST 32° F. TEMPERATURE

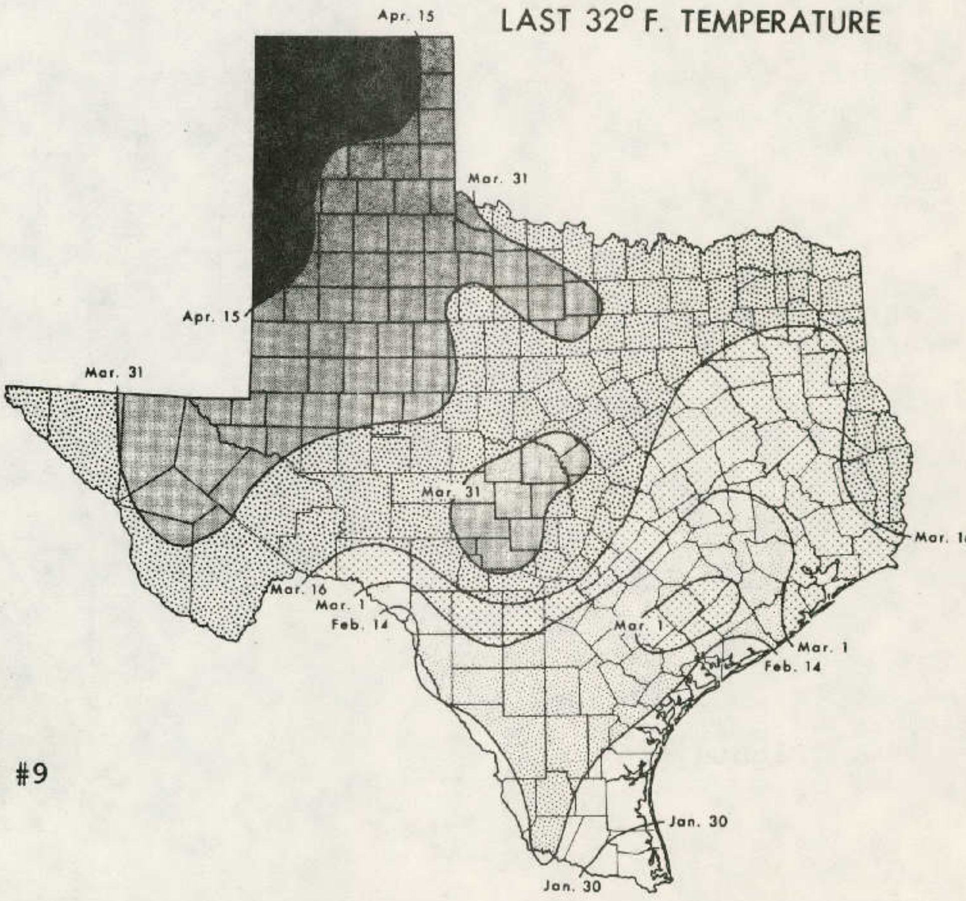


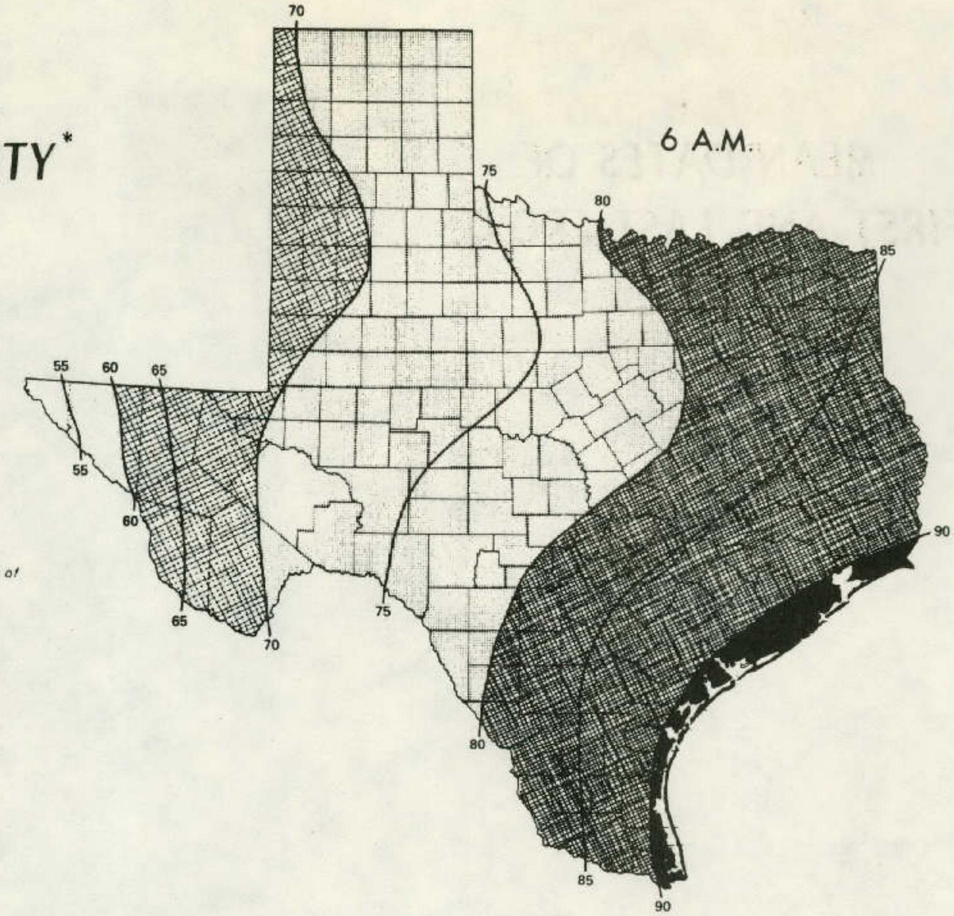
Figure #9

MEAN ANNUAL RELATIVE HUMIDITY*

ALL NUMBERS REPRESENT PERCENTAGES

* Data based on records through 1967

Source: U.S. Environmental Data Service, *Climatography of the United States* No. 60-41, revised June 1969.



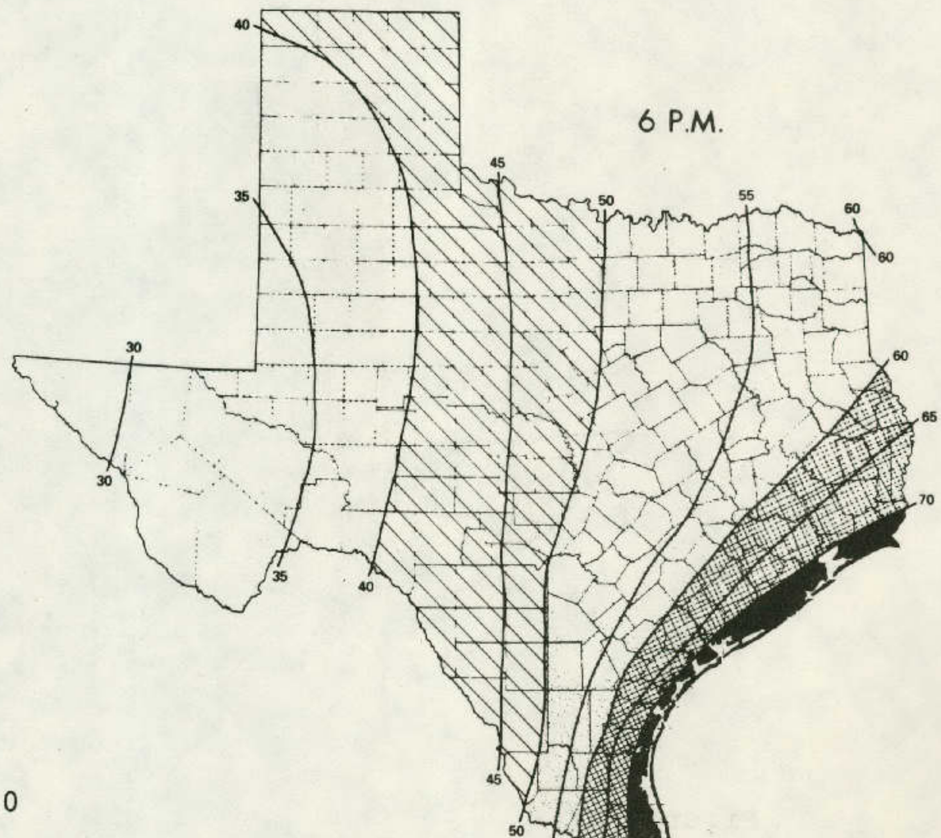


Figure #10

MEAN ANNUAL POSSIBLE SUNSHINE

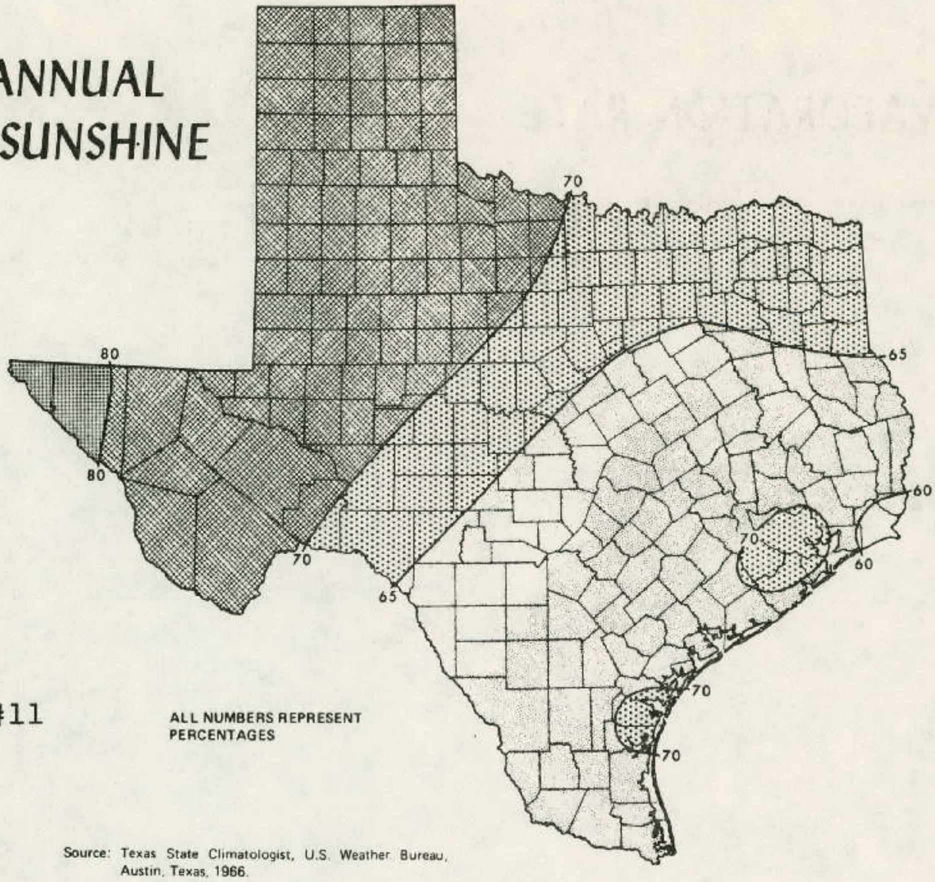


Figure #11

ALL NUMBERS REPRESENT PERCENTAGES

Source: Texas State Climatologist, U.S. Weather Bureau, Austin, Texas, 1966.

MEAN ANNUAL PRECIPITATION *

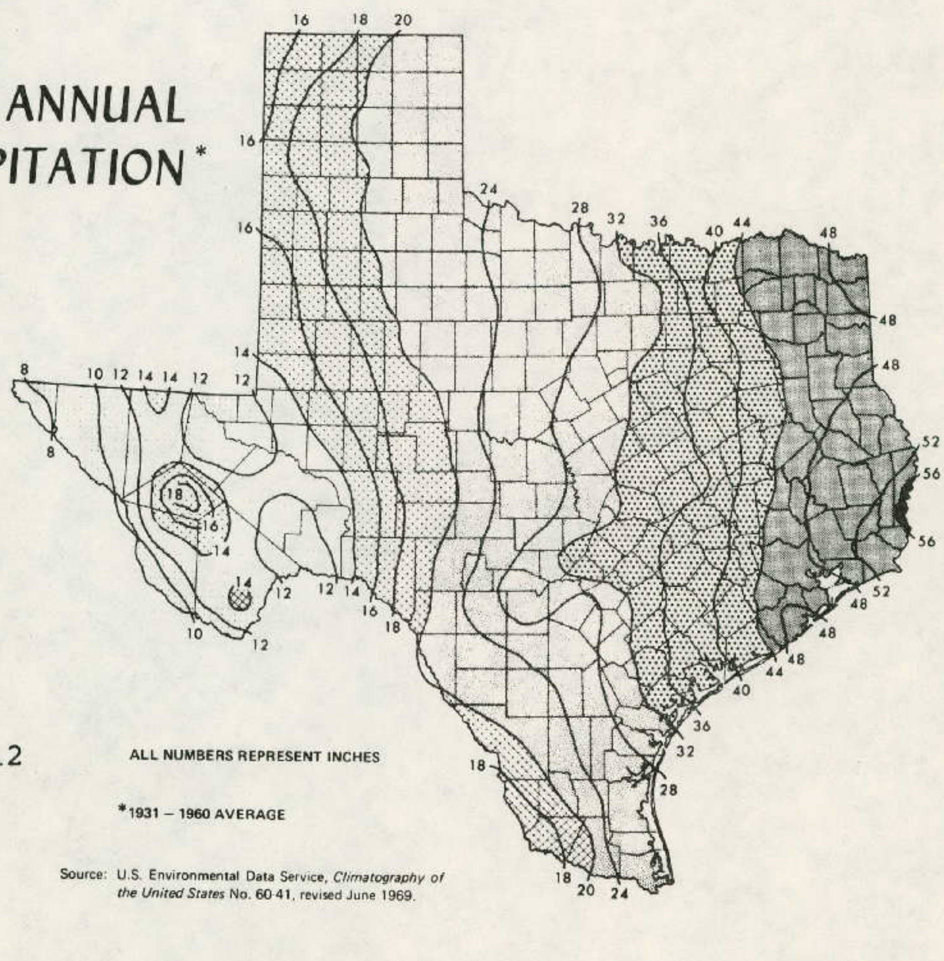


Figure #12

ALL NUMBERS REPRESENT INCHES

*1931 – 1960 AVERAGE

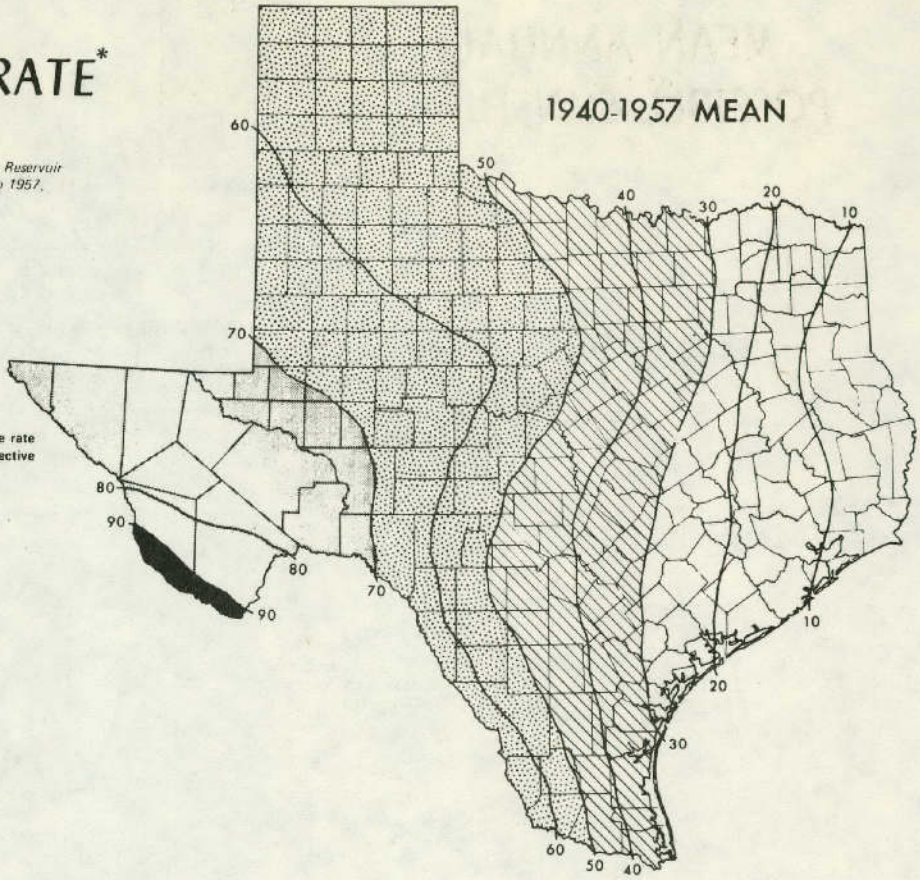
Source: U.S. Environmental Data Service, *Climatography of the United States* No. 60-41, revised June 1969.

EVAPORATION RATE*

Source: Texas Water Development Board, *Monthly Reservoir Evaporation Rates for Texas, 1940 through 1957*, 1960.

ALL NUMBERS REPRESENT INCHES

*Mean Annual Net Lake Surface Evaporation Rate—the rate of evaporation from lake surfaces after the effective rainfall has been subtracted.



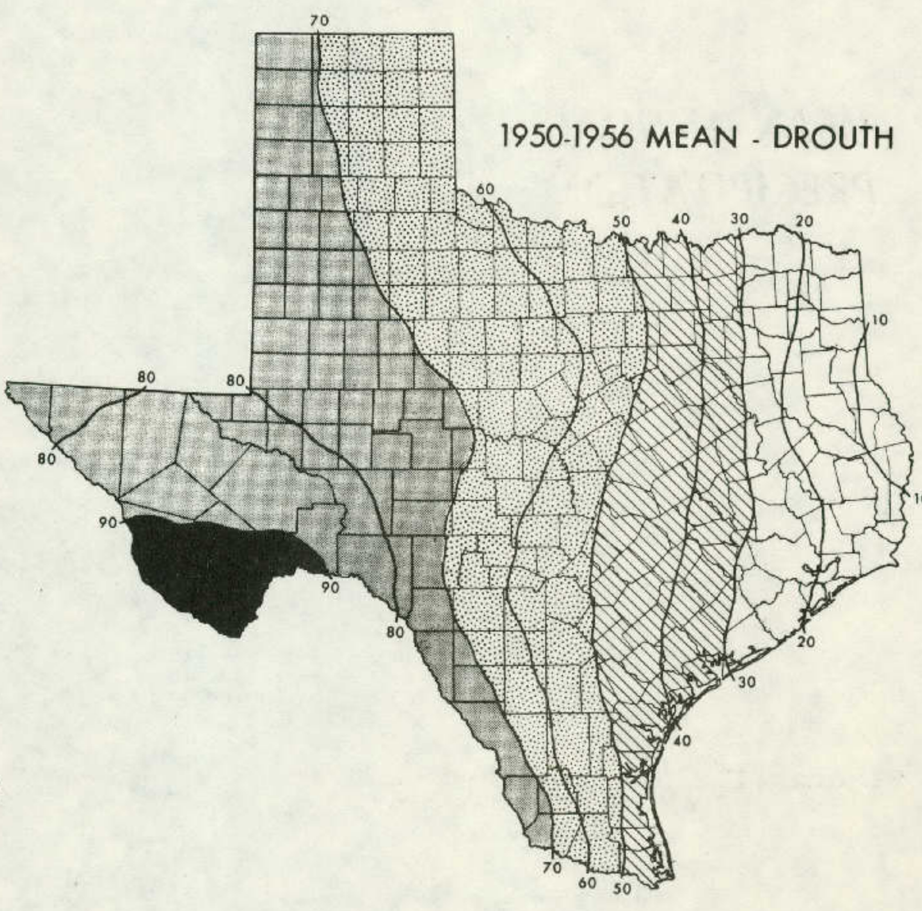


Figure #13

Climatic regions cannot be easily defined on a map. There are too many variables. The patterns vary, often from year to year. Also, as they say in Texas, "If you don't like it, wait a minute"! It is more important for the designer and builder to know their own region for its possibilities and limitations, as well as those passive design techniques which were used successfully by the early Texans in that region. Keeping those factors in mind, certain general guidelines can be discussed for designing. These climatic considerations are so basic that they should apply to all houses, and , whether the house is "energy conscious" or not, they will be meaningful.

We have found it appropriate for this text, to establish ten[1] general regions in Texas for which some design guidelines, or design considerations, can be written. In terms of climatic factors the adjacent regions often overlap and are usually distinct because only one factor changes. Across the state, however, there are dramatic differences, as all Texans know. We have designated these regions only by using typical regional titles and by indicating only the major cities in each. These regional design guidelines, which here follow, are presented: (1) as reminders, (2) to emphasize the difference in climatic design parameters across the state, and (3) to provide, possibly, a "jumping off point" for the builder and developer who has not given enough consideration previously to orientation and climate in his design concepts. While studying these considerations remember that "there is nothing new under the sun."

Regional Design Considerations

1. GULF COAST -- Beaumont, Galveston, Houston, Corpus Christi, Brownsville

   * Hot, humid summers.
   * Mild winters, also humid.
   * Breezes vary with openess or tall trees.
   * Southerly winds dominate upper half and southeasterly winds dominate lower half of this region.
   * Note that temperature extremes vary along this coastal strip...as a region it is defined more by its humidity than by temperature patterns.
   * Put vapor barrier on outside of studs...that's the warm, humid side; the inside is usually dryer and cooler with air conditioning. Stop the humidity on the outside. Keep house closed.
   * Must rely on air conditioning; and since winters are mild, the heat pump works well for all year, including the water heat exchanger (see Mechanical chapter) for "free" hot water.

2. EAST TEXAS -- Lufkin, Longview, Marshall, Tyler, Texarkana

   * Somewhat humid.
   * Hot summers.
   * Cold winters in northern counties, milder in southern counties of East Texas.
   * Breezes generally from south, varies with openness, tall pine forests, etc.

---

[1] In slight contrast to this text, the Federally proposed Building Energy Performance Standards are being developed with the whole country divided into seven Climate Regions. Of these seven regions, four cross Texas' land. Humidity and breeze are probably not given as much consideration in the BEPS climate factors as we do in this text.

* Air conditioning, with gas heat; or all electric with heat-pump and water-heat-exchanger as a consideration.
* Opening house to the breezes is not so much an advantage due to the humidity.

3. NORTH TEXAS -- Dallas, Fort Worth, Dennison, Wichita Falls

    * Hot summers, average humidity.
    * Cold winters, temperature and snow variable.
    * Passive solar heating can be useful.
    * Breeze in winter both north and south.
    * Breeze in summer south and south-east.
    * Most people could live in a "convertable" house: passive solar in winter, open it up in spring and fall, and air condition in summer (consider heat pump: for winter back-up also).
    * Air conditioning might be dispensed with for some individuals, using good passive design and air movement relying on some tolerance to heat as did the old time Texans.
    * Induced natural ventilation would work if house properly designed -- except when humidity occurs.
    * Heat pumps are good in this region.
    * Consider active solar, or prepare structure for it in future...proper orientation, etc.

4. CENTRAL TEXAS -- Waco, Temple, Austin, San Antonio

    * Hot summers, average humidity.
    * Winters (January and February): sometimes cold with occasional ice or snow, sometimes mild.
    * Breezes southerly in summer, and both north and south in winter.
    * Passive solar heating can be good, but a little less sunshine than north Texas.
    * "Convertable" house feasible: passive solar in winter, open it up in spring and fall, air conditioning in summer; consider heat-pump for summer cooling and winter back-up. Consider induced natural ventilation.
    * Just a few people in ideal breeze conditions might dispense with air conditioning, but breeze and low humidity can't be relied upon.
    * Consider active solar, or prepare structure for future application...use proper orientation, etc.

5. SOUTH TEXAS (Not Gulf Region) -- McAllen, Edinburg, Mission

    * Hot summers, average humidity.
    * Mild winters, somewhat humid, occasional freeze.
    * Breezes generally southeast, stronger in summer.
    * Region noted for winter growing season but also noted for occasional freezes.
    * Air conditioning assumed, some heating necessary in winter...good climate for heat pump and solar considerations.
    * Consider "convertible" house concept also, when climate allows house to be opened up.

6. SOUTHWEST-CENTRAL TEXAS -- Del Rio, Uvalde, Eagle Pass, Laredo

    * Hot summers.
    * Mild winters generally, but snow and freezing occur.
    * Average humidity.

* Breezes generally southwesterly, strongest in summer, direction more variable in winter.
* Air conditioning in summer and heating in winter assumed. Consider heat pump and passive solar possibilities.
* Consider active solar systems, or preparation for same in future.

7. WEST CENTRAL TEXAS -- Junction, San Angelo, Abilene

   * Hot summers, cold winters.
   * Average humidity.
   * Breezes mostly southeasterly in summer, some south, and more variations in winter.
   * Air conditioning and heating assumed. Heat pump may be considered.
   * Some use of evaporative coolers, but not quite as efficient as in dryer regions to west and northwest.
   * Consider both passive and active solar concepts.
   * Opening house to breeze restricted by dust conditions.

8. WEST TEXAS -- Midland, Odessa, Lubbock

   * Hot summers, low humidity.
   * Cool summer nights.
   * Breezes southerly and southeasterly in summer; variable, including southwesterly in winter.
   * Cold winters.
   * Air conditioning and heating assumed. Consider the heat pump also.
   * Low humidity makes evaporative cooler system effective and economic.
   * Low humidity also makes pools and fountains effective when house can be opened up in warm weather because evaporation cools the air.
   * Homes may occasionally be opened, but winds are often very dusty.
   * Cool nights, in summer indicate use of mass walls, as with adobe...thermal inertia process is effective in dry climate.

9. PAN HANDLE -- Amarillo

   * Hot summers with cool nights.
   * Cold winters.
   * Low humidity.
   * Breezes southerly and southwesterly, more variable in winter with some northerly.
   * Air conditioning and heating assumed, consider the heat pump also.
   * Low humidity makes evaporative cooler systems effective and very economic.
   * Homes may be opened occasionally, but winds are often dusty. Courtyard pools and fountains are effective in warm weather when house can be opened up because evaporation cools the air.
   * Cool nights in summer indicate use of mass walls, as with adobe . . . thermal inertia process is effective in this dry climate.

10. TRANS-PECOS -- El Paso

    * Hot summers with cool nights.
    * Winters: mild to cold in spells with some freezing.

* Lowest humidity in Texas is in El Paso.

* Least rain and most sunshine in Texas is in El Paso.

* Mountain areas of this region are more like West Texas and Pan Handle.

* Breezes: South-southwesterly in summer, and variable in winter with some strong northwind.

* Spring and fall months: air temperature is good for through ventilation (except for some dust in spring and some inversions in fall).

* Low humidity makes evaporative cooler systems effective and economic; therefore air conditioning is neither common or economic.

* Pools and fountains will cool the air by evaporation in this low humidity and this can be an asset when house can be opened up.

Passive Solar and Energy Conscious Design

The term "passive solar" has been used in many ways. Probably its most accepted definition and application relates to using the sun as an energy (heat) source without solar collector panels and related "active" mechanical systems. That is the intended definition of the term "passive solar" in this text. It should be noted however that passive solar concepts lead one into design concepts affecting other aspects of the human comfort environment, especially those which are similarly passive. Such features as natural ventilation, thermal convection air movement and the thermal inertia of mass-type walls, are examples of other "passive" systems.

When a designer searches beyond the standard home-planning approach for unusual energy saving design concepts, he must accept first the basic requirements of house orientation to the sun and related design influences. He will then find, if he looks, a whole new world of ideas in the ever increasing literature on "passive solar" design. These ideas can go way beyond just solar design features, and they might better be called, "passive solar and energy conscious design" concepts. Possibly a simpler but encompassing term will come into genreal use as this approach to design becomes more common.

In the ever increasing literature on passive solar design one book stands out as an ideal beginning text because it will challenge the reader to come up with new architectural forms rather than prescribe those forms. It is "Natural Solar Architecture, a Passive Primer" by David Wright, AIA., published by Van Nostrand Reinhold Company, New York, in 1978.

A second book worth studying is Regional Guidelines for Building Passive Energy Conserving Homes, by the AIA Research Corporation, Washington, D.C. written for U.S. HUD/DOE, November, 1978, available through the U.S. Government Printing Office. This book parallels our regional guidelines but depicts only five regions overlying Texas. We particularly recommend Part II of this text, for techniques in heating and cooling without mechanical processes.

Occasionally there are good articles on imaginative, energy conscious design in the architectural and builder magazines. Some of those articles are very good for both concepts and related details, but their main value is in getting one out of regular patterns of thinking by arousing the readers imagination.

Subdivisions and Solar Rights

As we move inexorably into the solar age the need for orientation of the house to the sun's movement becomes a greater and greater concern. The developer who comes to grips with the ramifications of solar considerations will be a jump ahead of the other builders in just a few years. Those others will be wondering why they "hadn't thought about it before."

We have discussed the passive solar requirement of proper orientation, and we have indicated that for future active solar applications on present buildings, the roofs must be properly angled as well as oriented to the sun's movement. And there are more solar problems which we must consider.

Once you have accepted the old, old concepts or orientation, plus preparing for future technology, you must find building sites which have streets running east and west. There are alternatives through planning and landscaping, but many builders are finding it more effective to influence the subdivision street patterns before they are "set in concrete." They may even get involved with their city planning commission as Buddy Burns has done successfully in San Antonio. He has used solar orientation as a basis for getting approval of certain street layouts in his subdivision planning.

It is not hard to imagine a whole community in the future with all the roofs facing the sun to gather solar energy in their solar collectors. It is also not hard to imagine the consternation and the law suits that may occur when someone builds a tall building in front of a few of these collectors and shades them from the winter sun. This could happen also with a high, two story residence, and even with trees, close to the southside of a low roofed residence. The consideration of "solar rights" of individual property owners will become a major issue. It would be far better for our communities, our zoning commissions, and our state government to face this issue soon, and work out both the guidance and the legal protection language that is inevitable. Such efforts are occurring in California and elsewhere; and we, in Texas, should be looking hard over their shoulders to see how "solar rights" are being developed and used.

With a little planning that could pay back through marketing techniques, a developer could layout a whole subdivision where each house is not directly south of another house, and where all houses are properly oriented with properly angled roofs. He could become famous for "getting ready for solar while using it now."

5

HEAT FLOW

HEAT FLOW

Orientation and design of residential structures is the essential preliminary step toward the energy efficient dwelling. After the structure has been designed with energy efficiency in mind, and after proper orientation on the lot to take advantage of solar radiation and prevailing wind patterns, the builder must now construct the building envelope to reduce the flow of heat into and out of the envelope. Human thermal comfort is determined essentially by the proper control of heat. Too much heat or too little heat, and we suffer discomfort.

Heat flows by conduction, by radiation, or by convection, and it always flows from areas of higher temperature to areas of lower temperature.

Thermal conduction occurs as heat is transferred from molecule to molecule in solid materials. The handle of a cast iron skillet gets hot because heat is conducted from the cooking surface up the sides of the skillet and along the handle. Metal windows with no thermal break conduct heat from the hotter side of the window to the colder side and they sometimes become so cold on the warm side (inside) that condensation occurs. Well insulated walls, ceilings, and floors effectively control the rate of thermal heat flow.

Thermal convection occurs as heat is transferred through the medium of air by the flow of the air itself. For a radiator system, the heated air around the radiator rises and starts a natural convection current that distributes the heated air throughout the room. A central residential heating system forces air through the supply system and registers into the space to be conditioned, creating forced convection currents. Warm air escapes from the dwelling by thermal convection through building openings and the loss of warm air in winter through exfiltration should be carefully controlled by the techniques discussed in the chapter on Infiltration. Useful natural convection can be created by design, as with a stair well which becomes the highest space in the house, and natural cooling with breezes can be used if the hot upper air is allowed to escape out of the top of the high stair well in the summertime.

Thermal radiation is the transfer of heat energy by electromagnetic waves. The sun's heat to the earth is transferred by radiation. Radiant heat streams through windows directly, and by reflection off other surfaces. A radiator radiates heat as well as transferring heat through convection and conduction. Heat always radiates from warmer to colder surfaces. The body gains heat while standing next to a fire, and loses heat while standing by a cold window in winter.

These three heat transfer methods -- collectively called heat transmission -- constitute a significant part of the builder's problem of providing thermal comfort to homeowners. The other part of the problem, infiltration and exfiltration, will be discussed in that chapter.

Heat transmission must be quantified in order to determine the heat gain or heat loss of a dwelling. The amount of heat gain or loss is determined by the thermal characteristics of building materials. The terms used in evaluating and quantifying heat transmission should be defined.

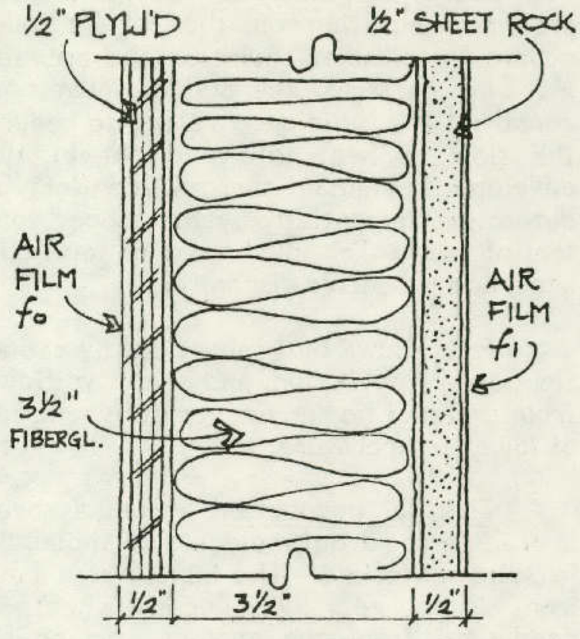
BTU (British Thermal Unit) -- a unit of heat measurement defined as the amount of energy requiried to raise the temperature of one pound of water one degree farenheit, from 59^{o} to 60^{o}F. A wooden kitchen match burned end to end provides about 1 BTU of energy. To heat enough water (from 60^{o} to 120^{o}F) for one shower (10 gallons; 8.33 lbs. per/gallon) would take almost 5,000 BTUs. (60^{o}F rise x 8.33 lbs/gal. x 10 gal. = 4,998 BTUs.) A KWH of electricity has 3,413 BTUs. At a cost of 5¢/KWH, cost of electricity per BTU = .001465¢. Cost per BTU (.001465¢) x 4,998 BTU = 7.32¢, the cost of an average shower, using an electirc water heater.

Two additional terms, K-Value (thermal conductivity) and C-Value (thermal conductance) will be found in the ASHRAE tables at the end of the chapter on Insulation, but these terms have little practical usefulness for builders and will not be defined here. The most useful measures of thermal characteristics for residential construction are R-values and U-values. They are also found in the same ASHRAE tables listing these values for most building materials.

R-Value (thermal resistance) -- the ability of a building material to retard heat flow. R-Values have been measured for all homogeneous and non-homogeneous building materials, and for air spaces and air films. The building envelope is usually composed of several materials, such as rock, sheathing, insulation, vapor barrier, sheetrock, etc. The total R-value (R_T) of the wall is simply the sum of the R-values for each building component, plus the R-values of inside and outside air films (Fi and Fo). An example of the total R-value of a construction, and its U-value are shown in Figure #1 from p. 3.4 of A&M pub. Energy Conservation New Building Construction - Series 100).

U-Value (overall coefficient of heat transmission) -- is defined as the number of BTU's passing through one square foot of the building section in one hour per degree farenheit of temperature difference. U is the reciprocal of R, (U = 1/R), R is the reciprocal of U, (R = 1/U). The lower the U-value, the higher the insulating capability.

EXAMPLE:
CALCULATE U-VALUE FOR WALL SHOWN BELOW.



R-VALUES

R fo	.2
R ½" PLYW'D	.625
R 3½" FIBERGL.	11.0
R ½" SHEETROCK	.4
R fi	.6
R_{TOTAL} =	12.82

$U = 1/R_{TOTAL} = 1/12.82 = .078$

fi : INSIDE AIR FILM
fo : OUTSIDE AIR FILM

Figure 1

In order to determine the total heat transmission of a building section, the equation used is:

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

Q = total amount of heat transmitted through a wall, ceiling, or other building construction in one hour = BTUH

U = coefficeint of heat transmission

A = total area of building element being considered

ΔT = "Delta T" = the temperature differential between outside and inside design temperatures

Most Texas builders can rely on their mechanical system supplier to calculate the heat gain and loss for a dwelling. Many HVAC contractors make use of computer programs to calcualte a dwelling's thermal characteristics in order to determine the size of heating and cooling equipment required. These, of course, may be limited to standard design and construction approaches . . . passive solar and natural ventilation would probably not be included. A builder interested in making his own calculations can use one of several load calculation methods available. Builders who are members of the National Association of Home Builders (NAHB) are probably familiar with the load calculation procedure outlines in NAHB's (1) Designing, Building, and Selling Energy Conserving Homes, (2) Insulation Manual: Homes and Apartments, or (3) Thermal Performance Guidelines for One and Two Family Dwellings. Other widely used methods are (4) Load Calculation: Manual J, published by the National Environmental Systems Contractors Association, (5) the method described in Chapter IV of the ASHRAE Handbook of Fundamentals, 1977, and (6) the one adapted specifically for the Texas climate in the Texas State Building Commission's Energy Conservation Manual: Part I Residential Buildings. All of these procedures are reliable indicators of a dwelling's thermal characteristics, and the builder is encouraged to use any of them with which he is familiar.

While it is not the intent of this text or the related workshops to teach the methods of calculating heat gain and/or heat loss, it is entirely appropriate to (1) discuss the basic concepts of the calculation and (2) see what can be learned about a house design from the results. The equation described above:

$Q = U \times A \times \Delta T = BTUH$

can be calculated for each component of the house "building envelope". What you are calculating is how much heat is lost in winter in one hour, or gained in one hour in the summer, as BTUs are transmitted through all possible paths of transmission. Then all these "Q's" are added up to provide the total BTU per hour (BTUH) for each season. To get the total BTUs gained in the summer multiply the summer BTUH by the "Summer Cooling Hours Over 80°F" for that house's location. For the total BTUs lost in the winter divide the BTUH by the ΔT and multiply by 24 (hours per day) and by the number Degree Days listed for that location in the ASHRAE, NAHB, etc. tables.

Some of the components which are typically included in the BTUH calculation, with their special considerations, are as follows:

(1) Walls: each wall type, varying with thickness, construction, interior and exterior finishes and types of insulation used, will have to be tabulated separately. Each has a different U-value and a different A (square feet). Note that the insulation types and thicknesses are the major contributors to the different wall U-values.

(2) Ceilings: When there is an attic space properly ventilated above the ceiling and its insulation, only the ceiling material and its

insulation are used. That is typical. Occasionally the ceiling surface is the lower face of the roof construction, and in such cases the U-value of the whole construction is used.

(3) Floors: The floor construction type is taken into consideration, i.e., whether it is a slab on grade, a pier and beam construction and, if so, whether the crawl space is ventilated or not, or over an open space, and according to insulation type. Perimeter slab insulation is a concern in the winter especially in regions with more than 2,600 Degree Days. There is little concern with heat gain through crawl spaces and slab edges in the summer.

(4) Windows & Sliding Glass Doors -- all glass areas must be considered carefully in the BTUH calculation because they contribute so much more heat flow than usual wall constructions. Also the frames and moving sash can allow air infiltration and exfiltration through cracks. Different thicknesses of glass, combinations of double glazing or storm windows, and insulating films would have different U-values. In summer, when solar heat gain is of great concern the orientation of the windows to the sun, and the shading of the glass makes a significant impact on the total BTUH calculation. Since there are so many factors to consider the simplified calculation systems (such as NAHB's) usually present tables based on the various factors of glass type, orientation, leakage and area, to give a value similar to the U-value for each glass condition in the house plans.

(5) Doors -- Doors vary with types of materials (wood, metal, insulated) thickness and infiltration rates. Doors are usually handled similarly to windows (4 above).

(6) Ducts -- The ducts used for distributing the warmed or cooled air can lose or gain heat up to 10 or 15 percent of the total BTUH according to where they are located and how well insulated. The worst condition is to locate the ducts above the ceiling insulation (outside the "insulation envelope") and with a minimum of insulation (typically 1", flexible insulation). The best location for the ducts is inside the conditioned space, as below the ceiling in a hallway in a furred-down construction.

(7) Occupants -- In summer the heat contributed by the occupants is part of the total heat gain. In the calculation the number of occupants is multiplied by an average BTUH value such as 400 BTUH if they are usually sedentary, or more if they are constantly active (the human being generates over 4,000 BTUH expending energy climbing stairs).

(8) Appliances -- The number and type of appliances must also be considered in the summer heat gain calculation. The average value which is used in the NAHB tabulation method is 1,600 BTUH for the average builder house.

The total BTUH for winter (heat loss) and for summer (heat gain) are values which can have significance in design considerations. Not only is the mechanical equipment size based on these values, but the designer can consider the overall impact of such things as the types of windows used and their orientation.

Examples of these calculations, made for ten cities in Texas, are presented at the end of this chapter. The reader is urged to examine these forms to compare the results for the "standard" house and the "energy improved" house, looking for the changes that were made (window types and glazing; door and window leakage, insulation in walls, ceiling and floor slab, and duct location) for the same house plan. Note also for the Austin example that the summer calculation was repeated with the house rotated 90° clockwise to see the effect of having the major glass areas exposed to the sun.

COOLING WORKSHEET

FROM HEAT GAIN TABLE No 5 → STANDARD / ENERGY IMPROVED

COMPONENT OF LOAD		AREA	HEAT GAIN
Windows ☑Single ☑Double	N	86	3530 / 2550
Exposure	E	35	3070 / 2520
	S	85	4440 / 3485
	W	0	—
Doors ☑Single ☐Storm		54	1180
Number of Occupants 4 x 400			1600
Appliances			1600
Heat Gain Excluding Building Sections			15420 / 12935

BUILDING SECTION		INSUL-ATION R-VALUE	HEAT GAIN	TRIAL NO. 1 (STANDARD)	TRIAL NO. 2 (ENERGY IMPROVED)	TRIAL NO. 3
Ceilings 1370 sq. ft.		R-30	2845		2845	
		R-26				
		R-19	4395	4395		
Walls	Frame 1220 sq. ft.	R-19+5	5720		5720	
		R-11+5				
		R-11+1	7270	7270		
	Masonry ___ sq. ft.	R-11				
		R-3				
Floors Over Open Spaces[a] ___ sq. ft.		R-19				
		R-11				
		R-7				
		R-0				
Heat Gain Through Building Sections				11665		8565
Transfer heat gain excluding building sections to these three boxes				15420		12935
Subtotal Excluding Ducts				27085		21500
Duct Multiplier[b]				1.15		1.0
TOTAL HEAT GAIN[c]				31148		21500
EQUIPMENT SIZE				EER 6.5 30000		EER 8.5 20000

ESTIMATED ANNUAL COOLING COST

1) 31148 / 2) 21500	X	2250	=	70,083,000 / 48,375,000
Heat Gain/Hour		Hours/yr		Btu/yr
___	÷	6500 / 8500	=	10,782 / 5,691
Btu/yr		EER X 1000		Kwh/yr
___	X	.067	=	$722.40 / 381.31
Kwh/yr		$/Kwh		$ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	(1) 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	(2) 1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 8° F. interior design temperature swing.

70° THERMOSTAT
−25° ASHRAE WINTER DESIGN
45 = ΔT

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

HEATING WORKSHEET

BUILDING SECTION (A)		WINDOW,[a] DOOR TYPE / INSUL. R	HEAT LOSS MULTIPLIER "U"	TEMP. DIFF. ΔT	HEAT LOSS Q BTUH	TRIAL NO. 1 (STANDARD) BTUH	TRIAL NO. 2 (ENERGY) BTUH	TRIAL NO. 3 (HEAT LOSS MULTIPLIER)
Windows 38 / 128 sq. ft.		FIXED / SLIDING	.734 / 1.421	45°	1255 / 8133	1255 / 8133	1086 / 4038	0.635 / .701
Doors 40 / 54 sq. ft.		SLIDER / STORM	1.028 / .863	45	1850 / 2097	1850 / 2097	1202 / 955	.668 / .393
Ceilings 1370 sq. ft.		(2) R-30	0.03	45	1850		1850	
		R-26	0.04					
		(1) R-19	0.05	45	3083	3083		
Walls	Frame 1220 sq. ft.	(2) R-19+5	0.04	45	2196		2196	
		R-11+5	0.055					
		(1) R-11+1	0.07	45	3843	3843		
	Masonry ___ sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces ___ sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	45	1737		1737	
		1" x 12" insulation	0.46					
		No insulation	0.81	45	6707	6707		
Duct Heat Loss (if applicable)[b]		1370 x .07 x 45 = 4316				4316	-0-	
TOTAL CALCULATED HEAT LOSS		Q	(BTUH)			31,284	13066	
					EQUIPMENT SIZE			

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. (2) Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 (1)

c. A thermostat setting of 70° F. is assumed.

ESTIMATED ANNUAL HEATING COST[c]

1) 33125 / 2) 13179	÷	45°	=	696 / 290
heat loss/hour		temp diff		heat loss/° F.
___ X 24 X 1800	÷	.6	=	50,112000 (1) / 20,850000 (2)
heat loss/°F. hours/day degree days		seasonal efficiency		Btu/yr.
___ X 3.5 MCF	÷	1000000	=	$175.37 (1) / $73.08/yr. (2)
Btu/yr. $/heat unit		Btu/heat unit		

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

AUSTIN

ROTATE 90°

COOLING WORKSHEET

COMPONENT OF LOAD		AREA	HEAT GAIN	BUILDING SECTION		INSULATION R-VALUE	HEAT GAIN	TRIAL NO. 1 (STANDARD)	TRIAL NO. 2 (ENERGY IMPROVED)	TRIAL NO. 3
Windows ☐ Single ☐ Double				Ceilings .... sq. ft.		R-30				
Exposure	N	—				R-26				
	E	86	7536 / 6202			R-19				
				Walls	Frame .... sq. ft.	R-19+5				
	S	35	1705 / 1435			R-11+5				
						R-11+1				
	W	85	7450 / 6130		Masonry	R-11				
Doors ☐ Single ☐ Storm			1180		.... sq. ft.	R-3				
Number of Occupants				Floors Over Open Spaces[a]		R-19				
.... x 400			1600	.... sq. ft.		R-11				
						R-7				
Appliances			1600			R-0				
Heat Gain Excluding Building Sections			21071 / 18147	Heat Gain Through Building Sections				11665	8565	
Transfer heat gain excluding building sections to these three boxes →								21071	18147	
Subtotal Excluding Ducts								32736	26712	
Duct Multiplier[b]								1.15	1.0	
TOTAL HEAT GAIN[c]								37646	26712	
EQUIPMENT SIZE										

ESTIMATED ANNUAL COOLING COST

37646 / 26712 (Heat Gain/Hour) X 2250 (Hours/yr) = 84703500 / 60,102,000 (Btu /yr)

(Btu /yr) ÷ 6500 / 8500 (EER X 1000) = 13031 / 7071 (Kwh /yr)

(Kwh /yr) X ,067 ($/Kwhr) = 873.88 / 473.76 ($ .... /yr)

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

AUSTIN (HOUSE TURNED 90° RE SUN)

COOLING WORKSHEET

FROM HEAT GAIN TABLE Nº 5

COMPONENT OF LOAD		AREA	HEAT GAIN	BUILDING SECTION	INSULATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Windows ① ☒ Single ② ☒ Double — Exposure	N	86	3530 / 2550	Ceilings 1370 sq. ft.	② R-30	2845		2845	
					R-26				
	E	35	3070 / 2520		① R-19	4395	4395		
				Walls — Frame 1220 sq. ft.	② R-19+5	5720		5720	
	S	85	4440 / 3485		R-11+5				
					① R-11+1	7270	7270		
	W	0	—	Walls — Masonry — sq. ft.	R-11				
Doors ☒ Single ☐ Storm		54	1180		R-3				
Number of Occupants 4 x 400			1600	Floors Over Open Spaces[a] — sq. ft.	R-19				
					R-11				
					R-7				
Appliances			1600		R-0				
Heat Gain Excluding Building Sections			15420 / 12935	Heat Gain Through Building Sections			11665	8565	
				Transfer heat gain excluding building sections to these three boxes →			15,420	12,935	
				Subtotal Excluding Ducts			27,085	21,500	
				Duct Multiplier[b]			1.15	1.0	
				TOTAL HEAT GAIN[c]			3114-8	21500	
				EQUIPMENT SIZE			EER=6.5 30000	EER=8.5 20000	

ESTIMATED ANNUAL COOLING COST

① 31148 37,377,600
② 21500 X 1200 = 25,800,000

Heat Gain/Hour — Hours/yr — Btu/yr

÷ 6500 / 8500 = 5750 ① / 3035 ②

Btu/yr — EER X 1000 — Kwh/yr

______ X ______ = $ .... /yr

Kwh/yr — $/Kwh

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
8° = ASHRAE DESIGN TEMP.
62° = ΔT

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

HEATING WORKSHEET

A BUILDING SECTION SQ. FT.		WINDOW,* DOOR TYPE INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	HEAT LOSS MULTIPL'R ~~TRIAL NO. 3~~
Windows 38/128 sq. ft.		FIXED / DBL. HG	.734 / 1.421	62°	1729 / 11277	1729 / 11277	1476 / 5563	.685 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.026 / .863	62	2544 / 2889	2544 / 2889	1657 / 1316	.668 / .393
Ceilings 1370 sq. ft.		② R-30	0.03	62	2548		2548	
		R-26	0.04					
		① R-19	0.05	62	4247	4247		
Walls	Frame 1220 sq. ft.	② R-19+5	0.04	62	3026		3026	
		R-11+5	0.055					
		① R-11+1	0.07	62	5295	5295		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over vented crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and unvented crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" (2) insulation	0.21	62	2376		2376	
		1" x 12" insulation	0.46					
		No (1) insulation	0.81	62	9240	9240		
Duct Heat Loss (if applicable,[b] 1370 ⁽ᵗ⁾ x .07 x 62 = 5946						5946	-0-	
TOTAL CALCULATED HEAT LOSS						43167	18002	
					EQUIPMENT SIZE			

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. (2) Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 (1)

c. A thermostat setting of 70° F. is assumed.

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

ESTIMATED ANNUAL HEATING COST[c]

① 43167 696
② 18002 ÷ 62 = 290

heat loss/hour — temp diff — heat loss/° F.

______ X 24 X 4000 ÷ .6 = 111,360,000 ① / 46,400,000 ②

heat loss/° F. — hours/day — degree days — seasonal efficiency — Btu/yr.

______ X ______ ÷ ______ = $ ______ /yr.

Btu/yr. — $/heat unit — Btu/heat unit

AMARILLO

COOLING WORKSHEET

FROM HEAT GAIN TABLE № 3 — STANDARD — ENERGY

COMPONENT OF LOAD		AREA	HEAT GAIN	BUILDING SECTION		INSUL-ATION R-VALUE	HEAT GAIN BTUH	TRIAL NO. 1 BTUH	TRIAL NO. 2 BTUH	TRIAL NO. 3
Windows ① ☐ Single ② ☐ Double	N	86	2818 / 2130	Ceilings 1370 sq. ft.		② R-30	2408		2408	
						R-26				
Exposure	E	35	2695 / 2275			① R-19	3713	3713		
				Walls	Frame	② R-19+5	4346		4346	
	S	85	3700 / 3015		1220 sq. ft.	R-11+5				
						① R-11+1	5553	5553		
	W	0	—		Masonry	R-11				
Doors ☒ Single ☐ Storm		54	908		— sq. ft.	R-3				
Number of Occupants 4 x 400			1600	Floors Over Open Spaces[a]		R-19				
				— sq. ft.		R-11				
						R-7				
Appliances			1600			R-0				
Heat Gain Excluding Building Sections			13321 / 11528	Heat Gain Through Building Sections				9266	6754	
Transfer heat gain excluding building sections to these three boxes								13321	11528	
				Subtotal Excluding Ducts				22587	18282	
				Duct Multiplier[b]				1.15	1.0	
				TOTAL HEAT GAIN[c]				25975	18282	
				EQUIPMENT SIZE				EER:6.5	EER:8.5	

ESTIMATED ANNUAL COOLING COST

① 25975

② 18,282 X 1800 = 46,755,000 / 32,907,600

Heat Gain/Hour — Hours/yr — Btu /yr

____ ÷ 6500 / 8500 = 7193 ① / 3871 ②

Btu /yr — EER X 1000 — Kwh /yr

____ X ____ = ____

Kwh /yr — $/Kwh — $ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	① 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	② 1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
29° = ASHRAE DESIGN TEMP.
41° = ΔT

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

HEATING WORKSHEET

STANDARD — ENERGY — HEAT LOSS MULTIPL'R

BUILDING SECTION (A) SQ. FT.		WINDOW,[a] DOOR TYPE INSUL. R	HEAT LOSS MULTIPLIER	TEMP. DIFF. (ΔT)	HEAT LOSS (Q) BTUH	TRIAL NO. 1 BTUH	TRIAL NO. 2 BTUH	~~TRIAL NO. 3~~
Windows 38/128 sq. ft.		FIXED / DBL.HG	.734 / 1.421	41°	1144 / 7457	1144 / 7457	989 / 3679	.635 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.028 / .863	41	1686 / 1911	1686 / 1911	1096 / 870	.668 / .393
Ceilings 1370 sq. ft.		② R-30	0.03	41	1685		1685	
		R-26	0.04					
		① R-19	0.05	41	2809	2809		
Walls	Frame 1220 sq. ft.	② R-19+5	0.04	41	2001		2001	
		R-11+5	0.055					
		① R-11+1	0.07	41	3501	3501		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces	R-19	0.05					
		R-11	0.08					
	— sq. ft.	R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21 ②	41	1584		1584	
		1" x 12" insulation	0.46					
		No insulation	0.81 ①	41	6111	6111		
Duct Heat Loss (if applicable,[b] 1370 ☐ x .07 ① x 41 = 3932)						3932		
TOTAL CALCULATED HEAT LOSS						28,551	11904	
					EQUIPMENT SIZE			

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. ② Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed.

ESTIMATED ANNUAL HEATING COST[c]

① 28551 / ② 11904 ÷ 41 = 696 / 290

heat loss/hour — temp diff — heat loss/° F.

____ X 24 X 1000 ÷ .6 = 27,840,000 ① / 11,600,000 ②

heat loss/°F. — hours/day — degree days — seasonal efficiency — Btu /yr.

____ X ____ ÷ ____ = $ ____ /yr.

Btu /yr. — $/heat unit — Btu/heat unit

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

BEAUMONT

COOLING WORKSHEET

FROM HEAT GAIN TABLE № 3

COMPONENT OF LOAD		AREA	HEAT GAIN
Windows ① ☑ Single ② ☑ Double (Exposure)	N	86	2818 / 2130
	E	35	2695 / 2275
	S	85	3700 / 3015
	W	0	—
Doors ☑ Single ☐ Storm		54	908
Number of Occupants 4 x 400			1600
Appliances			1600
Heat Gain Excluding Building Sections			13321 / 11528

BUILDING SECTION		INSULATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Ceilings 1370 sq. ft.		② R-30	2408		2408	
		R-26				
		① R-19	3713	3713		
Walls	Frame 1220 sq. ft.	② R-19+5	4346		4346	
		R-11+5				
		① R-11+1	5553	5553		
	Masonry — sq. ft.	R-11				
		R-3				
Floors Over Open Spaces[a] — sq. ft.		R-19				
		R-11				
		R-7				
		R-0				
Heat Gain Through Building Sections				9266	6754	
Transfer heat gain excluding building sections to these three boxes →				13321	11528	
Subtotal Excluding Ducts				22587	18282	
Duct Multiplier[b]				1.15	1.0	
TOTAL HEAT GAIN[c]				25,975	18282	
EQUIPMENT SIZE				EER 6.5	EER 8.5	

ESTIMATED ANNUAL COOLING COST

① 25,975 59,472,500
② 18,282 X 2300 = 42,048,600

Heat Gain/Hour | Hours/yr | Btu /yr

6500 9191 ①
÷ 8500 = 4947 ②

Btu /yr | EER X 1000 | Kwh /yr

_____ X _____ = $ _____ /yr

Kwh /yr | $/Kwhr | $ /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
36° = ASHRAE DESIGN TEMP.
34° = ΔT

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

HEATING WORKSHEET

A BUILDING SECTION		WINDOW,[a] DOOR TYPE / INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	HEAT LOSS MULTIPL'R (~~TRIAL NO. 3~~)
Windows 38/128 sq. ft.		FIXED / DBL.HG	.734 / 1.421	34°	948 / 6184	948 / 6184	820 / 3051	.635 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.028 / .863	34	1378 / 1584	1378 / 1584	908 / 722	.668 / .393
Ceilings 1370 sq. ft.		② R-30	0.03	34	1397		1397	
		R-26	0.04					
		① R-19	0.05	34	2329	2329		
Walls	Frame 1220 sq. ft.	② R-19+5	0.04	34	1659		1659	
		R-11+5	0.055					
		① R-11+1	0.07	34	2904	2904		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	34	1314		1314	
		1" x 12" insulation	0.46					
		No insulation	0.81	34	5067	5067		
Duct Heat Loss (If applicable,[b] 1370# x .07① x 34 = 3261						3261	-0-	
TOTAL CALCULATED HEAT LOSS						23675	9871	
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. ② Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation–
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation–
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed.

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

ESTIMATED ANNUAL HEATING COST[c]

① 23,675 696
② 9,871 ÷ 34 = 290

heat loss/hour | temp diff | heat loss/° F.

_____ X 24 X 600 ÷ .6 = 16,704,000 ① 6,960,000 ②

heat loss/°F. | hours/day | degree days | seasonal efficiency | Btu /yr.

_____ X _____ ÷ _____ = $ _____ /yr.

Btu /yr. | $/heat unit | Btu/heat unit

BROWNSVILLE

COOLING WORKSHEET

FROM HEAT GAIN TABLE № 3

COMPONENT OF LOAD	AREA	HEAT GAIN	BUILDING SECTION	INSULATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Windows (1) ☑ Single (2) ☐ Double — Exposure N	86	2818 / 2130	Ceilings 1370 sq. ft.	(2) R-30	2408		2408	
				R-26				
E	35	2695 / 2275		(1) R-19	3713	3713		
S	85	3700 / 3015	Walls — Frame 1220 sq. ft.	(2) R-19+5	4346		4346	
				R-11+5				
W	0	—		(1) R-11+1	5553	5553		
Doors ☑ Single ☐ Storm	54	908	Walls — Masonry — sq. ft.	R-11				
				R-3				
Number of Occupants 4 x 400		1600	Floors Over Open Spaces[a] — sq. ft.	R-19				
				R-11				
				R-7				
Appliances		1600		R-0				
Heat Gain Excluding Building Sections		13321 / 11528	Heat Gain Through Building Sections			9266	6754	

	STANDARD TRIAL NO. 1	ENERGY TRIAL NO. 2	TRIAL NO. 3
Transfer heat gain excluding building sections to these three boxes	13321	11528	
Subtotal Excluding Ducts	22587	18282	
Duct Multiplier[b]	1.15	1.0	
TOTAL HEAT GAIN[c]	25975	18282	
EQUIPMENT SIZE	EER: 6.5	EER: 8.5	

ESTIMATED ANNUAL COOLING COST

(1) 25975   66,236,250
(2) 18282 X 2550 = 46,619,100
Heat Gain/Hour   Hours/yr   Btu /yr

______ ÷ 6500 / 8500 = 10190 (1) / 5485 (2)
Btu /yr   EER X 1000   Kwh /yr

______ X ______ = ______
Kwh /yr $/Kwh $ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation (1)	1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces (2)	1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
32° = ASHRAE DESIGN TEMP
38° = ΔT

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

HEATING WORKSHEET

BUILDING SECTION (A) SQ. FT.		WINDOW,[a] DOOR TYPE INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	~~TRIAL NO. 3~~ HEAT LOSS MULTIPL'R
Windows 38 / 128 sq. ft.		FIXED / DBL. HG.	.734 / 1.421	38°	1062 / 6912	1062 / 6912	917 / 3410	.635 / .701
Doors 40 / 54 sq. ft.		SLIDER / STORM	1.028 / .863	38	1563 / 1771	1563 / 1771	1015 / 806	.668 / .393
Ceilings 1370 sq. ft.		(2) R-30	0.03	38	1562		1562	
		R-26	0.04					
		(1) R-19	0.05	38	2603	2603		
Walls	Frame 1220 sq. ft.	(2) R-19+5	0.04	38	1854		1854	
		R-11+5	0.055					
		(1) R-11+1	0.07	38	3245	3245		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	38	1468		1468	
		1" x 12" insulation	0.46					
		No insulation	0.81	38	5664	5664		
Duct Heat Loss (if applicable,[b] 1370# x .07 (1) x 38					3644	3644	- 0 -	
TOTAL CALCULATED HEAT LOSS						26,462	11032	
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. (2) Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 (1)

c. A thermostat setting of 70° F. is assumed

ESTIMATED ANNUAL HEATING COST[c]

(1) 26,462   696
(2) 11,032 ÷ 38 = 290
heat loss/hour   temp diff   heat loss/° F.

______ X 24 X 1000 ÷ .6 = 27,840,000 (1) / 11,600,000 (2)
heat loss/°F.   hours/day   degree days   seasonal efficiency   Btu /yr.

______ X ______ ÷ ______ = $ ______ /yr.
Btu /yr. $/heat unit   Btu/heat unit

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

CORPUS CHRISTI

COOLING WORKSHEET

(FROM HEAT GAIN TABLE Nº5)

STANDARD — ENERGY

COMPONENT OF LOAD	Exposure	AREA	HEAT GAIN
Windows ☑ Single ☑ Double	N	86	3530 / 2550
	E	35	3070 / 2520
	S	85	4440 / 3485
	W		
Doors ☑ Single ☐ Storm		54	1180
Number of Occupants 4 x 400			1600
Appliances			1800
Heat Gain Excluding Building Sections			15420 / 12935

BUILDING SECTION		INSULATION R-VALUE	HEAT GAIN	TRIAL NO. 1 (STANDARD)	TRIAL NO. 2	TRIAL NO. 3 (ENERGY)
Ceilings 1370 sq. ft.		R-30	2845			2845
		R-26				
		R-19	4395	4375		
Walls	Frame 1220 sq. ft.	R-19+5	5720			5720
		R-11+5				
		R-11+1	7270	7270		
	Masonry — sq. ft.	R-11				
		R-3				
Floors Over Open Spaces[a] — sq. ft.		R-19				
		R-11				
		R-7				
		R-0				
Heat Gain Through Building Sections				11,665		8565
Transfer heat gain excluding building sections to these three boxes				15420		12935
Subtotal Excluding Ducts				27085		21500
Duct Multiplier[b]				1.15		1.0
TOTAL HEAT GAIN[c]				31148		21500
EQUIPMENT SIZE				EER: 6.5 20000		EER: 8.5 20000

ESTIMATED ANNUAL COOLING COST

(1) 31148 X 2300 = 7,164,100
(3) 21500 X 2300 = 4,945,000

Heat Gain/Hour — Hours/yr — Btu/yr

Btu/yr ÷ 6500 / 8500 (EER X 1000) = 11022 / 5815 Kwh/yr

Kwh/yr X $/Kwh = $ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	(1) 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	(3) 1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° THERMOSTAT
19° ASHRAE WINTER DESIGN
51° = ΔT
Q = U·A·ΔT

HEATING WORKSHEET

STANDARD — HEAT LOSS MULTIPLIER — ENERGY

BUILDING SECTION (A)		WINDOW,[a] DOOR TYPE / INSUL. R	HEAT LOSS MULTIPLIER "U"	TEMP. DIFF. ΔT	HEAT LOSS (Q) BTUH	TRIAL NO. 1 BTUH (STANDARD)	TRIAL NO. 2 (HEAT LOSS MULTIPLIER)	TRIAL NO. 3 BTUH (ENERGY)
Windows 2 TYPES 35 / 128 sq. ft.		FIXED / DBL. H.G.	.734 / 1.421	51		1922 / 9276	.635 / .701	1230 / 4514
Doors 2 TYPES 40 / 54 sq. ft.		SLIDER / STORM	1.026 / .821	51		2077 / 2377	.660 / .393	1347 / 1082
Ceilings 1370 sq. ft.		R-30	0.03	51	2096			2096
		R-26	0.04					
		R-19	0.05	51	3494	3494		
Walls	Frame 1220 sq. ft.	R-19+5	0.04	51	2489			2489
		R-11+5	0.055					
		R-11+1	0.07	51	4355	4355		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over vented crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and unvented crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	51	1971			1971
		1" x 12" insulation	0.46					
		No insulation	0.81	51	7601	7601		
Duct Heat Loss (if applicable,[b] 1370 x .07 x 51						(1) 4891		(3) 0
TOTAL CALCULATED HEAT LOSS						35513		14807
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, (3) assume no heat loss. Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation–
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation –
Duct heat loss = Floor area x Temperature difference x 0.07 (1)

c. A thermostat setting of 70° F. is assumed

ESTIMATED ANNUAL HEATING COST[c]

35513 / 14807 (heat loss/hour) ÷ 51° (temp diff) = 696 (1) / 290 (3) (heat loss/° F.)

heat loss/°F. X 24 (hours/day) X 2100 (degree days) ÷ .6 (seasonal efficiency) = 66816000 / 27840000 Btu/yr.

Btu/yr. X $/heat unit ÷ Btu/heat unit = $ /yr.

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

DALLAS

COOLING WORKSHEET

FROM HEAT GAIN TABLE № 4 — STANDARD — ENERGY

COMPONENT OF LOAD		AREA	HEAT GAIN
Windows ① Single ② Double (Exposure)	N	86	① 3490 ② 2430
	E	35	2995 / 2500
	S	85	4400 / 3550
	W	—	—
Doors ☑ Single ☐ Storm		54	980
Number of Occupants 4 x 400			1600
Appliances			1600
Heat Gain Excluding Building Sections			15065 / 12660

BUILDING SECTION	INSULATION R-VALUE	HEAT GAIN BTUH	TRIAL NO. 1 BTUH (STANDARD)	TRIAL NO. 2 BTUH (ENERGY)	TRIAL NO. 3
Ceilings 1370 sq. ft.	② R-30	2520		2520	
	R-26				
	① R-19	3890	3890		
Walls — Frame 1220 sq. ft.	② R-19+5	5250		5250	
	R-11+5				
	① R-11+1	6520	6520		
Walls — Masonry — sq. ft.	R-11				
	R-3				
Floors Over Open Spaces[a] — sq. ft.	R-19				
	R-11				
	R-7				
	R-0				
Heat Gain Through Building Sections			10410	7770	
Transfer heat gain excluding building sections to these three boxes			15,065	12660	
Subtotal Excluding Ducts			25475	20,430	
Duct Multiplier[b]			1.15	1.	
TOTAL HEAT GAIN[c]			29,296	20,430	
EQUIPMENT SIZE			EER 6.5 30000	EER 8 20 000	

ESTIMATED ANNUAL COOLING COST

① 29296 ② 20430 x 1850 = 37,795,500 / 54,197,600

Heat Gain/Hour × Hours/yr = Btu/yr

Btu/yr ÷ 6500 / 8000 EER X 1000 = 8338 / 4724 Kwh/yr

Kwh/yr X $/Kwh = $ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	① 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	② 1.00

c. Total Heat Gain in Step 10 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
21° = ASHRAE DESIGN TEMP.
49° = ΔT

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

HEATING WORKSHEET

BUILDING SECTION (A) SQ. FT.		WINDOW,[a] DOOR TYPE / INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	TRIAL NO. 1 BTUH (STANDARD)	TRIAL NO. 2 BTUH (ENERGY)	~~TRIAL NO. 3~~ HEAT LOSS MULTIPL'R
Windows 38/12.8 sq. ft.		FIXED / DBL. HG	0.734 / 1.421	49°	1367 / 8913	1367 / 8913	1182 / 4397	.635 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.028 / .863	49°	2015 / 2283	2015 / 2283	1309 / 1040	.665 / .393
Ceilings 1370 sq. ft.		R-30 ②	0.03	49	2014		2014	
		R-26	0.04					
		R-19 ①	0.05	49	3357	3357		
Walls	Frame 1220 sq. ft.	② R-19+5	0.04	49	2391		2391	
		R-11+5	0.055					
		① R-11+1	0.07	49	4185	4185		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs — Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	49	1893		1893	
		1" x 12" insulation	0.46					
		No insulation	0.81	49°	7303	7303		
Duct Heat Loss (if applicable,[b] 1370 ♯ x .07 ① x 49° = 4699						4699	-0-	
TOTAL CALCULATED HEAT LOSS						34122	14226	
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. ② Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

ESTIMATED ANNUAL HEATING COST[c]

34122 / 14226 ÷ 49 = 696 ① / 290 ②

heat loss/hour ÷ temp diff = heat loss/° F.

heat loss/°F. X 24 hours/day X 2800 degree days ÷ .6 seasonal efficiency = 77,952,000 / 32,480,000 Btu/yr.

Btu/yr. X $/heat unit ÷ Btu/heat unit = $ /yr.

EL PASO

COOLING WORKSHEET

(FROM HEAT GAIN TABLE № 3) — STANDARD — ENERGY

COMPONENT OF LOAD	AREA	HEAT GAIN	BUILDING SECTION	INSULATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Windows ① ☑ Single ② ☑ Double — Exposure N	86	2818 / 2130	Ceilings 1370 sq. ft.	R-30	2408		2408	
				R-26				
E	35	2695 / 2275		R-19	3713	3713		
			Walls — Frame 1220 sq. ft.	R-19+5	4346		4346	
S	85	3700 / 3015		R-11+5				
				R-11+1	5553	5553		
W			Walls — Masonry — sq. ft.	R-11				
Doors ☑ Single ☐ Storm	54	908		R-3				
Number of Occupants 4 x 400		1600	Floors Over Open Spaces[a] — sq. ft.	R-19				
				R-11				
				R-7				
Appliances		1600		R-0				
Heat Gain Excluding Building Sections		13321 / 11528	Heat Gain Through Building Sections			9266	6754	
			Transfer heat gain excluding building sections to these three boxes →			13321	11528	
			Subtotal Excluding Ducts			22587	18282	
			Duct Multiplier[b]			1.15	1.0	
			TOTAL HEAT GAIN[c]			25,915	18,282	
			EQUIPMENT SIZE			EER 6.5	EER 8.5	

ESTIMATED ANNUAL COOLING COST

① 25975 / ② 18282 (Heat Gain/Hour) X 1900 (Hours/yr) = 49,352,000 / 34,735,800 (Btu/yr)

(Btu/yr) ÷ 6500 / 8500 (EER X 1000) = 7593 / 4087 (Kwh/yr)

______ (Kwh/yr) X ______ ($/Kwh) = $ ______ /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation ①	1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces ②	1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
28° = ASHRAE OUTSIDE DESIGN
42° = ΔT = TEMP. DIFF.
$Q = U \times A \times \Delta T$

HEATING WORKSHEET

STANDARD — ENERGY — HEAT LOSS MULTIPL'R

BUILDING SECTION (A) SQ.FT.		WINDOW,[a] DOOR TYPE / INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	~~TRIAL NO. 3~~ (HEAT LOSS MULTIPL'R)
Windows	38/128 sq. ft.	FIXED / DBL. HG	.734 / 1.421	42°	1171 / 7639	1171 / 7639	1013 / 3769	.635 / .701
Doors	40/54 sq. ft.	SLIDER / STORM	1.028 / .863	42°	1727 / 1957	1727 / 1957	1122 / 891	.668 / .393
Ceilings 1370 sq. ft.		R-30	0.03	42	1726		1726	
		R-26	0.04					
		R-19	0.05	42	2877	2877		
Walls	Frame 1220 sq. ft.	R-19+5	0.04	42	2050		2050	
		R-11+5	0.055					
		R-11+1	0.07	42	3587	3587		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	42°	1623		1623	
		1" x 12" insulation	0.46					
		No insulation	0.81	42	6260	6260		
Duct Heat Loss (if applicable,[b] 1370 × .07 ① × 42° = 4028						4028	-0- ②	
TOTAL CALCULATED HEAT LOSS						29246	12174	
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no ② heat loss. Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed.

ESTIMATED ANNUAL HEATING COST[c]

29246 / 12174 (heat loss/hour) ÷ 42 (temp diff) = 696 ① / 290 ② (heat loss/° F.)

______ (heat loss/°F.) X 24 (hours/day) X 1400 (degree days) ÷ GAS .6 (seasonal efficiency) = 38,976,000 ① / 16,240,000 ② (Btu/yr.)

______ (Btu/yr.) X ______ ($/heat unit) ÷ ______ (Btu/heat unit) = $ ______ /yr.

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

HOUSTON

COOLING WORKSHEET

(FROM HEAT GAIN TABLE 4)

COMPONENT OF LOAD	AREA	HEAT GAIN	BUILDING SECTION	INSULATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Windows ① ☑ Single ② ☑ Double — Exposure N	86	3490 / 2430	Ceilings 1370 sq. ft.	② R-30	2520		2520	
				R-26				
Exposure E	35	2995 / 2500		① R-19	3890	3890		
			Walls — Frame 1220 sq. ft.	② R-19+5	5250		5250	
Exposure S	85	4400 / 3550		R-11+5				
				① R-11+1	6520	6520		
Exposure W	0	—	Walls — Masonry — sq. ft.	R-11				
Doors ☑ Single ☐ Storm	54	980		R-3				
Number of Occupants 4 x 400		1600	Floors Over Open Spaces[a] — sq. ft.	R-19				
				R-11				
				R-7				
Appliances		1800		R-0				
Heat Gain Excluding Building Sections		15065 / 12660	Heat Gain Through Building Sections			10410	7770	
Transfer heat gain excluding building sections to these three boxes →						15065	12660	
			Subtotal Excluding Ducts			25475	20430	
			Duct Multiplier[b]			1.15	1.0	
			TOTAL HEAT GAIN[c]			29296	20430	
			EQUIPMENT SIZE			EER: 6.5 30000	EER: 8.5 20000	

ESTIMATED ANNUAL COOLING COST

① 29296 / ② 20430 (Heat Gain/Hour) X 1900 (Hours/yr) = 55,662,400 / 38,817,000 (Btu /yr)

_____ (Btu /yr) ÷ 6500 / 8500 (EER X 1000) = 8563 ① / 4567 ② (Kwh /yr)

_____ (Kwh /yr) X _____ ($/Kwh) = $ .... /yr

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	① 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	(2) 1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT
19° = ASHRAE DESIGN TEMP.
51° = ΔT

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

HEATING WORKSHEET

BUILDING SECTION (A) SQ. FT.		WINDOW,[a] DOOR TYPE / INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	~~TRIAL NO. 3~~ HEAT LOSS MULTIPLIER
Windows 38/128 sq. ft.		FIXED / DBL. HG.	.734 / 1.421	51°	1422 / 9276	1422 / 9276	1231 / 4576	.635 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.028 / .863	51	2097 / 2377	2097 / 2377	1363 / 1082	.668 / .393
Ceilings 1370 sq. ft.		② R-30	0.03	51	2096		2096	
		R-26	0.04					
		① R-19	0.05	51	3494	3494		
Walls	Frame 1220 sq. ft.	② R-19+5	0.04	51	2489		2489	
		R-11+5	0.055					
		① R-11+1	0.07	51	4356	4356		
	Masonry — sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over *vented* crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and *unvented* crawl — See basement worksheet							
	Concrete Slabs — Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	51	1971		1971	
		1" x 12" insulation	0.46					
		No insulation	0.81	51	7601	7601		
Duct Heat Loss (if applicable,[b] 1370 x .07 x 51 = 4891						4891	-0-	
TOTAL CALCULATED HEAT LOSS						35514	14808	
					EQUIPMENT SIZE			

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. (2) Use the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces:
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed.

ESTIMATED ANNUAL HEATING COST[c]

① 35514 / ② 14808 (heat loss/hour) ÷ 51 (temp diff) = 696 / 290 (heat loss/° F.)

_____ (heat loss/°F.) X 24 (hours/day) X 2600 (degree days) ÷ .6 (seasonal efficiency) = 72,384,000 ① / 30,160,000 ② (Btu /yr.)

_____ (Btu /yr.) X _____ ($/heat unit) ÷ _____ (Btu/heat unit) = $ _____ /yr.

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

MIDLAND

COOLING WORKSHEET

(FROM HEAT GAIN TABLE No 5)

COMPONENT OF LOAD		AREA	HEAT GAIN
Windows ① ☒ Single ② ☒ Double	N	86	3530 / 2550
	E	35	3070 / 2520
Exposure	S	85	4440 / 3485
	W	0	—
Doors ☒ Single ☐ Storm		54	1180
Number of Occupants 4 x 400			1600
Appliances			1800
Heat Gain Excluding Building Sections			15420 / 12935

BUILDING SECTION		INSUL-ATION R-VALUE	HEAT GAIN BTUH	STANDARD TRIAL NO. 1 BTUH	ENERGY TRIAL NO. 2 BTUH	TRIAL NO. 3
Ceilings 1370 sq. ft.		② R-30	2845		2845	
		R-26				
		① R-19	4395	4395		
Walls	Frame 1220 sq. ft.	② R-19+5	5720		5720	
		R-11+5				
		① R-11+1	7270	7270		
	Masonry ___ sq. ft.	R-11				
		R-3				
Floors Over Open Spaces[a] ___ sq. ft.		R-19				
		R-11				
		R-7				
		R-0				
Heat Gain Through Building Sections				11,665	8565	
Transfer heat gain excluding building sections to these three boxes				15,420	12935	
Subtotal Excluding Ducts				27085	21500	
Duct Multiplier[b]				1.15	1.0	
TOTAL HEAT GAIN[c]				31148	21500	
EQUIPMENT SIZE				EER 6.5 30000	EER 8.5 20000	

ESTIMATED ANNUAL COOLING COST

① 31148 62,296,000

② 21500 X 2000 = 43,000,000

Heat Gain/Hour Hours/yr Btu/yr

÷ 6500 / 8500 = 9584 ① / 5059 ②

Btu/yr EER X 1000 Kwh/yr

___ X ___ = $ ___ /yr

Kwh/yr $/Kwh

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of cooling operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

NOTES

a. Floor heat gain to be calculated only for floors over open spaces, such as bedrooms over garages. Slab-on-grade floors, floors over basements, and floors over vented and unvented crawl spaces may be considered to have no heat gain. In most cases, worksheet entries for floors should be omitted.

b. Multipliers for heat gain to ducts:

Ducts in attic, 1" flexible insulation	① 1.15
Ducts in attic, 2" flexible insulation, 1" rigid insulation, or 1" fiber glass duct	1.10
Ducts in other unconditioned spaces above grade, 1" flexible insulation	1.05
Ducts in unconditioned spaces below grade, including unconditioned basements, no duct insulation	1.05
Ducts in conditioned spaces	② 1.00

c. Total Heat Gain in Step 18 may be reduced 15 per cent if a 4½° F. interior design temperature swing is used or may be reduced 30 per cent for a 6° F. interior design temperature swing.

70° = THERMOSTAT

25° = ASHRAE DESIGN TEMP

45° = ΔT

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

HEATING WORKSHEET

BUILDING SECTION		WINDOW,[a] DOOR TYPE / INSUL. R	"U" HEAT LOSS MULTIPLIER	ΔT TEMP. DIFF.	Q HEAT LOSS	STANDARD TRIAL NO. 1	ENERGY TRIAL NO. 2	HEAT LOSS MULTIPL'R ~~TRIAL NO. 3~~
Windows 38/128 sq. ft.		FIXED / DBL. HG	.734 / 1.421	45°	1255 / 8185	1255 / 8185	1086 / 4038	.635 / .701
Doors 40/54 sq. ft.		SLIDER / STORM	1.026 / .863	45	1850 / 2097	1850 / 2097	1202 / 955	.668 / .393
Ceilings 1370 sq. ft.		R-30	② 0.03	45	1850		1850	
		R-26	0.04					
		R-19	① 0.05	45	3082	3082		
Walls	Frame 1220 sq. ft.	R-19+5	② 0.04	45	2196		2196	
		R-11+5	0.055					
		R-11+1	① 0.07		3843	3843		
	Masonry —, sq. ft.	R-11	0.07					
		R-3	0.17					
Floors	Floors over vented crawl spaces — sq. ft.	R-19	0.05					
		R-11	0.08					
		R-7	0.11					
	Floors over basement and unvented crawl — See basement worksheet							
	Concrete Slabs —Exposed Length Of Slab Edge 184 Lin. ft.	2" x 24" insulation	0.21	45	1739		1739	
		1" x 12" insulation	0.46					
		No insulation	0.81	45	6707	6707		
Duct Heat Loss (If applicable,[b] 1370 # x .07 ① x 45 = 4316						4316	- 0 -	
TOTAL CALCULATED HEAT LOSS						31335	13066	
EQUIPMENT SIZE								

NOTES:

a. Heat loss multipliers for windows and doors include infiltration losses.

b. If ducts run through conditioned spaces, assume no heat loss. Use ② the equations below if ducts run through attics, crawl spaces, or other non-conditioned spaces.
With 1" flexible insulation—
Duct heat loss = Floor area x Temperature difference x 0.10
With 2" flexible or 1" rigid insulation—
Duct heat loss = Floor area x Temperature difference x 0.07 ①

c. A thermostat setting of 70° F. is assumed

ESTIMATED ANNUAL HEATING COST[c]

① 31335 / ② 13066 ÷ 45° = 696 / 290

heat loss/hour temp diff heat loss/° F.

___ X 24 X 1600 ÷ .6 = 44,544,000 ① / 18,560,000 ②

heat loss/°F. hours/day degree days seasonal efficiency Btu/yr.

___ X ___ ÷ ___ = $ ___ /yr.

Btu/yr. $/heat unit Btu/heat unit

The NAHB Research Foundation, Inc., assumes no responsibility for the validity of heating operating cost estimates in relation to actual costs in specific instances because of the many possible variations in occupancy, equipment efficiency, living habits, and other factors.

SAN ANTONIO

6

INSULATION

INSULATION

The importance of anticipating and controlling "thermal performance" was discussed in the preceding chapter. While design concepts (passive solar, etc.) and infiltration controls are major contributors to overall thermal performance, the amounts and types of insulation used in the building components are a basic ingredient affecting thermal performance of the basic building envelope.

Insulation keeps a residence cooler in summer and warmer in winter by helping to keep heat where it is wanted -- out in the summer and in in the winter. The ability of insulation to do its work is dependent on two things: (1) it's R-value, or resistance to heat flow, and (2) the quality of workmanship used in its installation. Different materials have different R-values; therefore different thicknesses are required to do the same job. R-values for various building materials are listed in the ASHRAE tables at the end of this chapter.

Knowing which R-values are required by a building design concept for good control of heat flow, as well as for meeting code requirements, should come ahead of decisions on which type of insulation material to use. For most builders and designers, however, the two decisions occur at the same time, along with considerations of thickness.

The Model Code, when applied to most cities in Texas, from Amarillo to Brownsville and El Paso to Lufkin, indicates minimum R-values of R-11 in walls and R-19 in ceilings with proportional limitations on glass areas for both single and double panel. It should be understood however that code requirements are only minimum standards...good practice and effective energy conservation point to higher R-values. A maximum for Texas climates, guided by the "law of diminishing returns", should be R-19 in the walls and R-30 in ceilings.

It is not practical to develop a chart of R-values for each city according to the Model Code because so much of the requirement is based on building design variables such as materials, glass types, wall and window areas, Degree Days, etc. But again, reflecting on codes as "minimums", we wish to recommend the R-values shown in the following map of Texas, Figure 1. It should be noted that these R-values correspond approximately to current recommendations of the National Bureau of Standards, but that they are a broad generalization of insulation practices, and individual cases should be based on specific building conditions and utility costs.

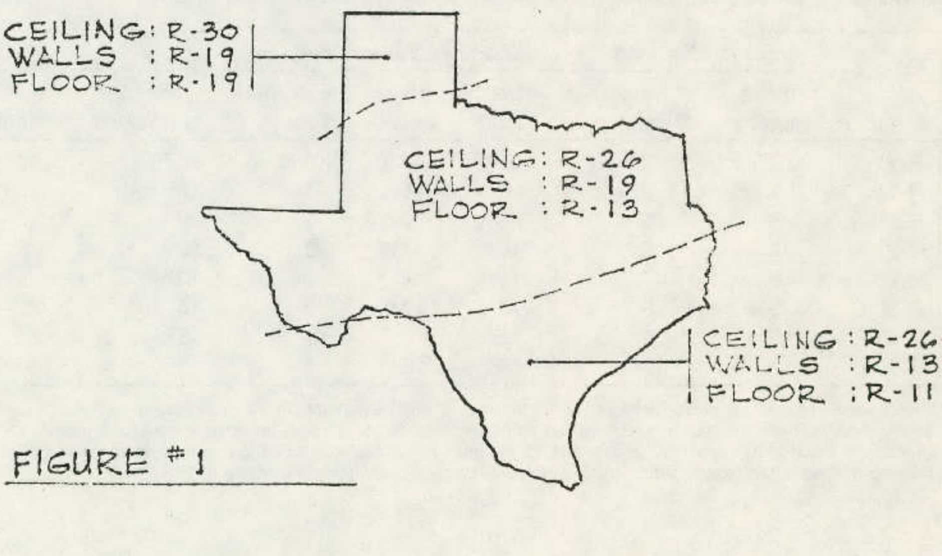


FIGURE #1

One thing to consider in choosing R-values, insulation types and thicknesses -- when you are already paying for the labor to put the material in place, increasing the thickness, and thus the R-values, should cost very little more than the cost of the added material alone (the laborer is already there).

There are several types of insulation materials which may be used. Glass fiber and mineral wool, probably the most widely used, are available in the form of batts and blankets, and loose and blown fill. Vermiculite and perlite are also loose and blown materials. These products have been with us a long time and their use and handling has developed into accepted practice.

Cellulose fiber insulation is newer and it has had its share of problems associated mainly with manufacturing processes. It is generally made of reprocessed paper, and when not properly treated it can be a fire hazard. Some fires have been blamed on the material and its processing. The cellulose must be treated with fire retardant chemicals. Boric acid is generally used, but it must be processed properly. Sulfates are also used but these can cause corrosion problems. The Consumer Product Safety Commission tackled this problem a year ago, and Congress passed the Emergency Interim Consumer Product Safety Standard Act of 1978. Now all cellulose insulation manufactured after September 8, 1978, must pass tests for flame resistance and corrosiveness, and the bags it is shipped in must be labled: "ATTENTION: this material meets the applicable minimum Federal flammability standard. This standard is based on laboratory tests only, which do not represent actual conditions which may occur in the home."

Urea-formaldehyde is a foam-in-place type insulation and also has attendant problems. Humidity and high temperatures may cause deterioration and a formaldehyde odor which lingers after installation. Exposure to light and open air can also cause deterioration. Studies have shown also that the material may shrink for several months after installation. Proper mixing of components and special care in installation are required, and subcontractors for this service should be picked with great care.

Rigid plastic foam boards such as beadboard, urethane and polystyrene are used for exterior sheathing; and the sturdiest material, such as Dow's Styrofoam, are used in foundation insulation applications. These materials are combustible and they should be covered with fire retardant materials.

Several types of wall and ceiling insulation with differnet R-values for the different materials and the standard thicknesses used are shown in Table 1.

Nominal R-Values for Various Thicknesses of Insulation (in inches)

	Batts or Blankets		Loose and Blown Fill*				
R-Value	glass fiber	rock wool	glass fiber	rock wool	cellulose fiber	vermiculite	perlite
R-11	3½ in.	3 in.	5 in.	4 in.	3 in.	5 in.	4 in.
R-13	4	3½	6	4½	3½	6	5
R-19	6	5	8½	6½	5	9	7
R-22	7	6	10	7½	6	10½	8
R-26	8	7	12	9	7	12½	9½
R-30	9½	8	13½	10	8	14	11
R-33	10½	9	15	11	9	15½	12
R-38	12	10½	17	13	10	18	14

*The R-Value for urea-formaldehyde foam is 4.2 per inch of thickness. However, a recent bulletin (Use of Materials Bulletin No. 74, Sept. 15, 1977) from the Department of Housing and Urban Development (HUD) indicates that the effective R-Value of this type of fill is only 3.3 per inch when installed, due to a 6 percent average linear shrinkage. Therefore, urea-formaldehyde foam in a 3½ inch wall cavity would have an R-Value of 10.5.

Table #1

There are many locations where insulation should be used besides in the basic exterior walls, ceiling-attic, and in floors over vented crawl spaces. Such locations may be overlooked but they always occur in construction between conditioned (heated or cooled) and non-conditioned spaces. A case in point would be knee walls...the wall areas between a high room and the attic space over an adjacent, normal height room. Another would be in the floor of a cantilevered or overhanging room. To be sure that all proper spaces are treated one must simply think of all building parts that make up the entire "building envelope" which contains the space to be heated or cooled.

The insulation of a cathedral ceiling deserves special consideration because it is also possible to achieve "attic" ventilation between the roof rafters. When the roofing sheathing is on top of the rafter and the ceiling material (gypsum board) is on the underside of the same rafter, if that rafter is a 2 x 10 (9½"), the insulation could be 5" or 6" batts with a foil or paper face upwards...with the insulation held against the ceiling board there will be a 3" or 4" air space over the insulation. Then, if there are screened vents at the wall line (roof overhang, or soffit), and a continuous ridge vent, there will be natural convection current created within each rafter space, allowing coller air to enter at the bottom and exit, warmer, at the ridge vent. Such a system provides a surprising release from summer sun heat built up in the roof itself.

The R-value of insulation is only as effective as the quality of the installation. Poorly installed R-30 attic insulation may be no better than properly installed R-19. The workshop presentation of "Wrap it up Right", the narrated slide presentation developed by NAHB, explains the proper installation techniques for insulation. Some of the points to consider are:

(1) The material must <u>fill</u> the stud space completely <u>without being compressed</u> at top or bottom or at the sides.

(2) The material must <u>fit</u> snuggly around and behind electrical boxes.

(3) Electrical wire-runs should be located so that it does not force the insulation to be jammed and squeezed behind it.

(4) There should be <u>no gaps</u> between adjacent runs of insulation batts, or between batts and framing pieces.

(5) Do not block the flow of desirable attic ventilation air from the soffit vents over the top plates and into the attic space.

(6) Do not cover recessed light fixtures...keep the material at least three inches away from the fixture box. Better still -- do not use recessed lighting fixtures at all because they vent away from the rooms below air which has been heated or cooled.

(7) With blown insulation in attics, cover just the area indicated on the bag label for the R-value desired. If the insulation is deeper than expected, remember that it may settle and compact a little. Be sure the right number of bags are used for the R-value desired and the area covered.

There have been many claims about the importance of insulation in saving energy. It would seem that its importance is mainly in that it has been the first thing people think of...the "first line of resistance" to heat flow. Seeing all possibilities for saving energy -- orientation, design, thermal, infiltration and mechanical systems, as discussed in the Overview in this text; the thermal barriers in which insulation is used provide only about 12% of the potential for saving energy and dollars.

Remember that no matter how good a wall may be as a thermal barrier heat can flow around it through cracks and through weaker barriers like windows. While insulation is important, it alone cannot do the proper job.

Table 3A

Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a]

(For Industrial Insulation Design Values, see Table 3B)

These constants are expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference). Conductivities (k) are per inch thickness, and conductances (C) are for thickness or construction stated, not per inch thickness

Material	Description	Density (Lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat, Btu per (lb) (F deg)
BUILDING BOARD[c] BOARDS, PANELS, SUBFLOORING, SHEATHING, WOODBASED PANEL PRODUCTS[17]	Asbestos-cement board	120	75	4.0	—	0.25	—	
	Asbestos-cement board ... 1/8 in.	120	75	—	33.00	—	0.03	
	Asbestos-cement board ... 1/4 in.	120	75	—	16.50	—	0.06	
	Gypsum or plaster board ... 3/8 in.	50	75	—	3.10	—	0.32	
	Gypsum or plaster board ... 1/2 in.	50	75	—	2.25	—	0.45	
	Plywood	34	75	0.80	—	1.25	—	0.29
	Plywood ... 1/4 in.	34	75	—	3.20	—	0.31	0.29
	Plywood ... 3/8 in.	34	75	—	2.13	—	0.47	0.29
	Plywood ... 1/2 in.	34	75	—	1.60	—	0.62	0.29
	Plywood or wood panels ... 3/4 in.	34	75	—	1.07	—	0.93	0.29
	Insulating board							
	Sheathing, regular density ... 1/2 in.	18	75	—	0.76	—	1.32	0.31
	... 25/32 in.	18	75	—	0.49	—	2.06	0.31
	Sheathing intermediate density ... 1/2 in.	22	75	—	0.82	—	1.22	0.31
	Nail-base sheathing ... 1/2 in.	25	75	—	0.88	—	1.14	0.31
	Shingle backer ... 3/8 in.	18	75	—	1.06	—	0.94	0.31
	Shingle backer ... 5/16 in.	18	75	—	1.28	—	0.78	0.31
	Sound deadening board ... 1/2 in.	15		—	0.74	—	1.35	0.30
	Tile and lay-in panels, plain or acoustic	18	75	0.40	—	2.50	—	0.32
	... 1/2 in.	18	75	—	0.80	—	1.25	0.32
	... 3/4 in.	18	75	—	0.53	—	1.89	0.32
	Laminated paperboard	30	75	0.50	—	2.00	—	
	Homogeneous board from repulped paper	30	75	0.50	—	2.00	—	0.28
	Hardboard							
	Medium density siding ... 7/16 in.	40	75	—	1.49	—	0.67	0.28
	Other medium density	50	75	0.73	—	1.37	—	0.31
	High density, service temp. service, underlay	55	75	0.82	—	1.22	—	0.33
	High density, std. tempered	63	75	1.00	—	1.00	—	0.33
	Particleboard							
	Low density	37	75	0.54	—	1.85	—	0.31
	Medium density	50	75	0.94	—	1.06	—	0.31
	High density	62.5	75	1.18	—	0.85	—	0.31
	Underlayment ... 5/8 in.	40	75	—	1.22	—	0.82	0.29
	Wood subfloor ... 3/4 in.		75	—	1.06	—	0.94	0.34
BUILDING PAPER	Vapor—permeable felt	—	75	—	16.70	—	0.06	
	Vapor—seal, 2 layers of mopped 15 lb felt	—	75	—	8.35	—	0.12	
	Vapor—seal, plastic film	—	75	—	—	—	Negl.	
FINISH FLOORING MATERIALS	Carpet and fibrous pad	—	75	—	0.48	—	2.08	
	Carpet and rubber pad	—	75	—	0.81	—	1.23	0.34

Table 3A .... Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a] (Continued)

Material	Description	Density (Lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat, Btu per (lb) (F deg)
FINISH FLOORING MATERIALS (*Continued*)	Cork tile.......................⅛ in.	—	75	—	3.60	—	*0.28*	
	Terrazzo.......................1 in.	—	75	—	12.50	—	*0.08*	
	Tile—asphalt, linoleum, vinyl, rubber.	—	75	—	20.00	—	*0.05*	0.30
	Wood, hardwood finish..........¾ in.	—	75	—	1.47	—	*0.08*	
INSULATING MATERIALS	Mineral Fiber, fibrous form processed from rock, slag, or glass							
BLANKET AND BATT	approx.[e] 2–2¾ in................	—	75	—	—	—	*7*[d]	0.18
	approx.[e] 3–3½ in................	—	75	—	—	—	*11*[d]	0.18
	approx.[e] 5½–6½ in...............	—	75	—	—	—	*19*[d]	0.18
BOARD AND SLABS	Cellular glass.........................	9	75	0.40	—	*2.50*	—	0.24
	Glass fiber, organic bonded..........	4–9	75	0.25	—	*4.00*	—	0.19
	Expanded rubber (rigid).............	4.5	75	0.22	—	*4.55*	—	
	Expanded polystyrene extruded, plain............................	1.8	75	0.25	—	*4.00*	—	0.29
	Expanded polystyrene extruded, (R-12 exp.)......................	2.2	75	0.20	—	*5.00*	—	0.29
	Expanded polystyrene extruded, (R-12 exp.) (Thickness 1 in. and greater)..	3.5	75	0.19	—	*5.26*	—	0.29
	Expanded polystyrene, molded beads.	1.0	75	0.28	—	*3.57*	—	0.29
	Expanded polyurethane[f] (R-11 exp.)	1.5	75	0.16	—	*6.25*	—	0.38
	(Thickness 1 in. or greater)........	2.5						0.38
	Mineral fiber with resin binder.......	15	75	0.29	—	*3.45*	—	0.17
	Mineral fiberboard, wet felted							
	Core or roof insulation............	16–17	75	0.34	—	*2.94*	—	
	Acoustical tile....................	18	75	0.35	—	*2.86*	—	
	Acoustical tile....................	21	75	0.37	—	*2.70*	—	
	Mineral fiberboard, wet molded							
	Acoustical tile[g]....................	23	75	0.42	—	*2.38*	—	
	Wood or cane fiberboard							
	Acoustical tile[g]..............½ in.	—	75	—	0.80	—	*1.25*	0.30
	Acoustical tile[g]..............¾ in.	—	75	—	0.53	—	*1.89*	0.30
	Interior finish (plank, tile)	15	75	0.35	—	*2.86*	—	0.32
	Insulating roof deck							
	Approximately.............1½ in.	—	75	—	0.24	—	*4.17*	
	Approximately...............2 in.	—	75	—	0.18	—	*5.56*	
	Approximately...............3 in.	—	75	—	0.12	—	*8.33*	
	Wood shredded (cemented in preformed slabs)..................	22	75	0.60	—	*1.67*	—	0.38
LOOSE FILL	Cellulose insulation (milled paper or wood pulp).......................	2.5–3	75	0.27	—	*3.70*	—	0.33
	Sawdust or shavings................	0.8–1.5	75	0.45	—	*2.22*	—	0.33
	Wood fiber, softwoods...............	2.0–3.5	75	0.30	—	*3.33*	—	0.33
	Perlite, expanded....................	5.0–8.0	75	0.37	—	*2.70*	—	
	Mineral fiber (rock, slag or glass)							
	approx.[e] 3 in......................	8–15	75	—	—	—	*9*[d]	0.18
	approx.[e] 4½ in.....................	8–15	75	—	—	—	*13*[d]	0.18
	approx.[e] 6¼ in.....................	8–15	75	—	—	—	*19*[d]	0.18
	approx.[e] 7¼ in.....................	8–15	75	—	—	—	*24*[d]	0.18
	Silica aerogel.........................	7.6	75	0.17	—	*5.88*	—	
	Vermiculite (expanded).............	7.0–8.2	75	0.47	—	*2.13*	—	
		4.0–6.0	75	0.44	—	*2.27*	—	
ROOF INSULATION[h]	Preformed, for use above deck							
	Approximately...............½ in.	—	75	—	0.72	—	*1.39*	
	Approximately...............1 in.	—	75	—	0.36	—	*2.78*	
	Approximately.............1½ in.	—	75	—	0.24	—	*4.17*	
	Approximately...............2 in.	—	75	—	0.18	—	*5.56*	
	Aopproximately.............2½ in.	—	75	—	0.15	—	*6.67*	
	Approximately...............3 in.	—	75	—	0.12	—	*8.33*	
	Cellular glass......................	9	75	0.40	—	*2.50*	—	0.24
MASONRY MATERIALS CONCRETES	Cement mortar......................	116		5.0	—	*0.20*	—	
	Gypsum-fiber concrete 87½% gypsum, 12½% wood chips................	51		1.66	—	*0.60*	—	
	Lightweight aggregates including expanded shale, clay or slate; expanded slags; cinders; pumice; vermiculite; also cellular concretes	120		5.2	—	*0.19*	—	
		100		3.6	—	*0.28*	—	
		80		2.5	—	*0.40*	—	
		60		1.7	—	*0.59*	—	
		40		1.15	—	*0.86*	—	
		30		0.90	—	*1.11*	—	
		20		0.70		*1.43*		

Table 3A . . . . Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a] (Continued)

Material	Description	Density (lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat, Btu per (lb)(F deg)
MASONRY MATERIALS CONCRETES (*Continued*)	Perlite	40	75	0.93	—	*1.08*	—	
		30		0.71	—	*1.41*	—	
		20		0.50	—	*2.00*	—	
	Sand and gravel or stone aggregate (oven dried)	140		9.0	—	*0.11*	—	
	Sand and gravel or stone aggregate (not dried)	140		12.0	—	*0.08*	—	
	Stucco	116		5.0	—	*0.20*	—	
MASONRY UNITS	Brick, common[i]	120	75	5.0	—	*0.20*	—	
	Brick, face[i]	130	75	9.0	—	*0.11*	—	
	Clay tile, hollow:							
	1 cell deep, 3 in.	—	75	—	1.25	—	*0.80*	
	1 cell deep, 4 in.	—	75	—	0.90	—	*1.11*	
	2 cells deep, 6 in.	—	75	—	0.66	—	*1.52*	
	2 cells deep, 8 in.	—	75	—	0.54	—	*1.85*	
	2 cells deep, 10 in.	—	75	—	0.45	—	*2.22*	
	3 cells deep, 12 in.	—	75	—	0.40	—	*2.50*	
	Concrete blocks, three oval core:							
	Sand and gravel aggregate, 4 in.	—	75	—	1.40	—	*0.71*	
	8 in.	—	75	—	0.90	—	*1.11*	
	12 in.	—	75	—	0.78	—	*1.28*	
	Cinder aggregate, 3 in.	—	75	—	1.16	—	*0.86*	
	4 in.	—	75	—	0.90	—	*1.11*	
	8 in.	—	75	—	0.58	—	*1.72*	
	12 in.	—	75	—	0.53	—	*1.89*	
	Lightweight aggregate (expanded shale, clay, slate or slag; pumice), 3 in.	—	75	—	0.79	—	*1.27*	
	4 in.	—	75	—	0.67	—	*1.50*	
	8 in.	—	75	—	0.50	—	*2.00*	
	12 in.	—	75	—	0.44	—	*2.27*	
	Concrete blocks, rectangular core.[j]							
	Sand and gravel aggregate							
	2 core, 8 in. 36 lb.[k]	—	45	—	0.96	—	*1.04*	
	Same with filled cores[l]	—	45	—	0.52	—	*1.93*	
	Lightweight aggregate (expanded shale, clay, slate or slag, pumice):							
	3 core, 6 in. 19 lb.[k]	—	45	—	0.61	—	*1.65*	
	Same with filled cores[l]	—	45	—	0.33	—	*2.99*	
	2 core, 8 in. 24 lb.[k]	—	45	—	0.46	—	*2.18*	
	Same with filled cores[l]	—	45	—	0.20	—	*5.03*	
	3 core, 12 in. 38 lb.[k]	—	45	—	0.40	—	*2.48*	
	Same with filled cores[l]	—	45	—	0.17	—	*5.82*	
	Stone, lime or sand	—	75	12.50	—	*0.08*	—	
	Gypsum partition tile:							
	3 × 12 × 30 in. solid	—	75	—	0.79	—	*1.26*	
	3 × 12 × 30 in. 4-cell	—	75	—	0.74	—	*1.35*	
	4 × 12 × 30 in. 3-cell	—	75	—	0.60	—	*1.67*	
METALS	(See Chapter 30, Table 3)							
PLASTERING MATERIALS	Cement plaster, sand aggregate	116	75	5.0	—	*0.20*	—	
	Sand aggregate, 3/8 in.	—	75	—	13.3	—	*0.08*	
	Sand aggregate, 3/4 in.	—	75	—	6.66	—	*0.15*	
	Gypsum plaster:							
	Lightweight aggregate, 1/2 in.	45	75	—	3.12	—	*0.32*	
	Lightweight aggregate, 5/8 in.	45	75	—	2.67	—	*0.39*	
	Lightweight agg. on metal lath, 3/4 in.	—	75	—	2.13	—	*0.47*	
	Perlite aggregate	45	75	1.5	—	*0.67*	—	
	Sand aggregate	105	75	5.6	—	*0.18*	—	
	Sand aggregate, 1/2 in.	105	75	—	11.10	—	*0.09*	
	Sand aggregate, 5/8 in.	105	75	—	9.10	—	*0.11*	
	Sand aggregate on metal lath, 3/4 in.	—	75	—	7.70	—	*0.1*	
	Vermiculite aggregate	45	75	1.7	—	*0.59*	—	
ROOFING	Asbestos-cement shingles	120	75	—	4.76	—	*0.21*	
	Asphalt roll roofing	70	75	—	6.50	—	*0.15*	
	Asphalt shingles	70	75	—	2.27	—	*0.44*	
	Built-up roofing, 3/8 in.	70	75	—	3.00	—	*0.33*	0.35
	Slate, 1/2 in.	—	75	—	20.00	—	*0.05*	
	Wood shingles, plain a plastic film faced	—	75	—	1.06	—	*0.94*	0.31

Table 3A .... Conductivities, Conductances, and Resistances of Building and Insulating Materials—(Design Values)[a] (*Concluded*)

Material	Description	Density (lb per Cu Ft)	Mean Temp F	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness (1/k)	Resistance[b] (R) For thickness listed (1/C)	Specific Heat Btu per (lb) (F deg)
SIDING MATERIALS (ON FLAT SURFACE)	Shingles							
	Asbestos-cement	120	75	—	4.76	—	*0.21*	
	Wood, 16 in., 7½ exposure	—	75	—	1.15	—	*0.87*	0.31
	Wood, double, 16-in., 12-in. exposure	—	75	—	0.84	—	*1.19*	0.31
	Wood, plus insul. backer board, 5/16 in.	—	75	—	0.71	—	*1.40*	0.31
	Siding							
	Asbestos-cement, ¼ in., lapped	—	75	—	4.76	—	*0.21*	
	Asphalt roll siding	—	75	—	6.50	—	*0.15*	
	Asphalt insulating siding (½ in. bd.)	—	75	—	0.69	—	*1.46*	
	Wood, drop, 1 × 8 in.	—	75	—	1.27	—	*0.79*	0.31
	Wood, bevel, ½ × 8 in., lapped	—	75	—	1.23	—	*0.81*	0.31
	Wood, bevel, ¾ × 10 in., lapped	—	75	—	0.95	—	*1.05*	0.31
	Wood, plywood, ⅜ in., lapped	—	75	—	1.59	—	*0.59*	0.29
	Aluminum or Steel[m], over sheathing							
	Hollow-backed	—	—	—	1.61	—	*0.61*	
	Insulating-board backed nominal ⅜ in.	—	—	—	0.55	—	*1.82*	
	Insulating-board backed nominal ⅜ in. foil backed	—	—	—	0.34	—	*2.96*	
	Architectural glass	—	75	—	10.00	—	*0.10*	
WOODS	Maple, oak, and similar hardwoods	45	75	1.10	—	*0.91*	—	0.30
	Fir, pine, and similar softwoods	32	75	0.80	—	*1.25*	—	0.33
	Fir, pine, and similar softwoods ... ¾ in.	32	75	—	1.06	—	*0.94*	0.33
	... 1½ in.	32	75	—	0.53	—	*1.89*	0.33
	... 2½ in.	32	75	—	0.32	—	*3.12*	0.33
	... 3½ in.	32	75	—	0.23	—	*4.55*	0.33

Notes for Table 3A

[a] Representative values for dry materials is selected by the ASHRAE Committee 2.4 on Insulation. They are intended as design (not specification) values for materials of building construction in normal use. For conductivity of a particular product, the user may obtain the value supplied by the manufacturer or secure the results of unbiased tests.

[b] Resistance values are the reciprocals of C before rounding off C to two decimal places.

[c] See also Insulating Materials, Board.

[d] Includes paper backing and facing if any. In cases where the insulation forms a boundary (highly reflective or otherwise) of an air space, refer to Tables 1 and 2, to obtain the insulating value of air space for the appropriate effective emissivity and temperature conditions of the space.

[e] Conductivity varies also with fiber diameter. See also Factors Affecting Thermal Conductivity and Fig. 1, Chapter 17. Insulation is produced by different densities, therefore, there is a wide variation in thickness for the same R-value between various manufacturers. No effort should be made to relate any specific R-value to any specific thickness. The commercial thicknesses generally available range from 2 to 7 in.

[f] These are values for aged board stock. For discussion on the change in conductivity with age of Refrigerant 11 expanded urethane see Chapter 17, Factors Affecting Thermal Conductivity.

[g] Insulating values of acoustical tile vary depending on density of the board and on the type, size, and depth of the perforations. An average conductivity k value is 0.40.

[h] The U. S. Department of Commerce, *Simplified Practice Recommendation for Thermal Conductances Factors for Performed Above-Deck Roof Insulation*, No. R 257-55, recognizes the specification of roof insulation on the basis of the C values shown. Roof insulation is made in thicknesses to meet these values. Therefore, thickness supplied by different manufacturers may vary depending on the conductivity k value of the particular material.

[i] Face brick and common brick do not always have these specific densities. When the density is different from that shown, there will be a change in the thermal conductivity.

[j] Data on rectangular core concrete blocks differs from the above data on oval core blocks due to core configuration, different mean temperatures and possibly differences in unit weights. Weight data on the oval core blocks tested is not available.

[k] Weights of units approximately 7⅝ in. high and 15⅝ in. long. These weights are given as a means of describing the blocks tested, but conductance values are all for one square foot of area.

[l] Vermiculite, perlite or mineral wool insulation. Where insulation is used vapor barriers or other precautions must be considered to keep insulation dry.

[m] Values for metal siding applied over flat surfaces vary widely depending upon the amount of ventilation of air space beneath the siding, whether the air space is reflective or nonreflective, and on the thickness, type, and application of insulating backing-board used. Values given are averages intended for use as design guide values and were obtained from several guarded hot-box tests (ASTM C236) on hollow-backed types and on types made using backer-board of wood-fiber, foamed plastic, and glass fiber. Departures of ±50 percent, or more, from the values given may occur.

INFILTRATION

INFILTRATION

"Infiltration" is the uncontrolled movement of air into a dwelling. It must be accompanied by an equal "exfiltration" of air flowing out of that dwelling if air pressures are to balance inside and out. Sometimes this air movement through a house is caused by external conditions such as the wind, or by internal pressures such as thermal convection air currents. Occasionally this air movement is useful...when one wants through ventilation; but usually it represents a waste of conditioned air which the home owner has already heated or cooled.

For convenience and brevity, the term "infiltration" will be used to indicate air movement both into and out of the dwelling.

Of all things the planner and builder can do to make an energy efficient home out of an "average" house plan, the control of infiltration is the most important. As discussed in the Overview, infiltration control has the possibility of saving one-third of all the energy we know how to save in the typical builder home. It also has two and a half times more potential to save energy than increasing the insulation from what was used ten years ago.

When the wind blows around a "leaky" house the infiltration problem is very serious indeed. This can be quantified in terms of the volume of air that moves through the house. It is referred to in terms of "air changes per hour"...one air change per hour indicating that all the air in the house is replaced by outside air in one hours time. Research that has been done by a number of agencies in this country indicates the following rates of air change according to the looseness or tightness of construction:

Air Changes per Hour
(assuming 15 mph wind)

Very loose construction =
4 changes

Loose Construction =
3 changes

Average Dwellings =
2 changes

Tight Construction =
1 changes

A 1600 square foot home with an 8 foot ceiling height has a volume of 12,800 cubic feet of air. If it is an average home with the average infiltration rate of 2 air changes per hour, in a 15 mph wind blowing for one day there will be

12,800 cubic feet x 2 x 24 = 614,400 cu. ft.

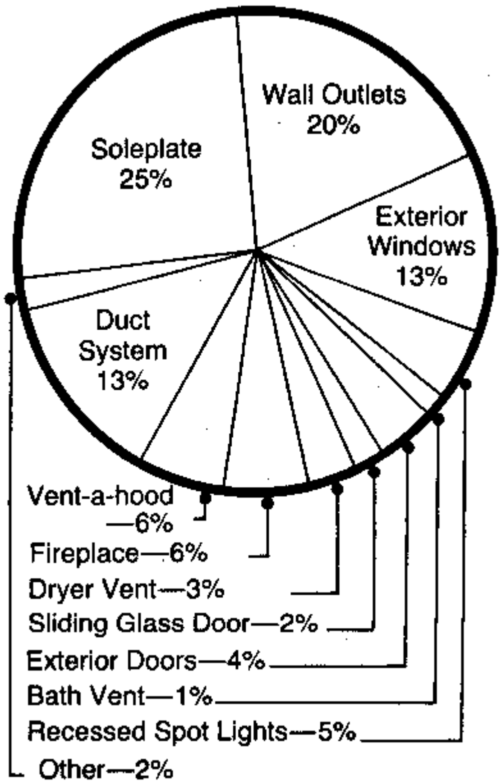
of air passing through that structure. To put this in perspective, imagine three Goodyear blimps at 202,000 cu. ft. each...the air going through that house in one day would fill three Goodyear blimps.

Now lets consider where all this leakage is occuring. There has been some very valuable testing on leakage done here in Texas by the Texas Power and Light Co. From a series of air infiltration tests conducted by TP&L on 50 houses in the Dallas-Ft. Worth area the results shown in Figure #1 were documented.

It appears that in the average home, the worst leakage, at 25%, occurs under the sole plate. (For those unfamiliar with construction terms: the sole plate is the first piece of framing lumber (a 2 x 4 or 2 x 6) put down on the concrete floor slab as a base for the wall studs.) So, no matter how good the wall is, the wind can leak in under, and out under, that wall unless it is properly caulked.

The next worst leakage, at 20%, occurs through the electrical boxes, i.e., the wall outlets. This occurs in the average home on the inside walls just as easily as on the outside walls. The air path is down through the stud space via

Air Leakage Test Results
for Average Home of 1,728 Sq. Ft.



Source: Texas Power and Light Co.

Figure #1

the large holes in the top plate drilled for the electrical wiring. These holes, and the leakage through the electric outlets, directly connect the attic space to the rooms below. These holes must also be thoroughly caulked during construction.

It is hard to believe, until you witness the testing, that the leakage through the electrical outlets can be more than that of all the doors and windows combined!

The importance of weatherstripping and gasketing exterior doors is made very clear when one estimates the crack area around a typical door. Assume a front door which, for convenience is three feet wide and seven feet high. The crack around all four edges of the door is twenty feet long. If that crack is one-twelfth of an inch wide...that's not much, its between a sixteenth and an eighth of an inch...then in twelve inches there will be a crack area of one square inch. In the twenty feet around the door, therefore, there is a total crack area of twenty square inches. That's the same as a four inch by five inch hole in the middle of the door!

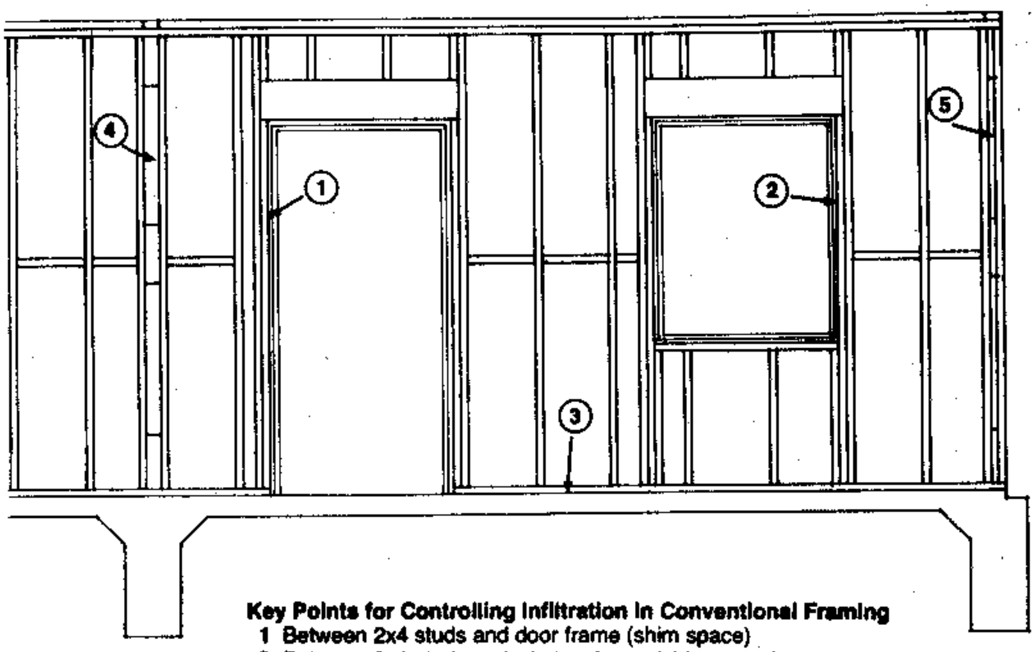
Imagine the equivalent area for an average one-sixteenth inch crack all the way around a house under the sole plate. For each four feet there will be three square inches of space. If a house is 30 feet by 50 feet (1,500 sq. ft.) that average crack could add up to 120 square inches or a 10 inch by 12 inch hole in the wall on the windy side!

There are other places, too, where infiltration must be controlled, and understanding the techniques and materials which can be used for controls is most important. A variety of foam products, caulks, pads, gaskets, sealants, weatherstripping and vapor barriers are available for such purposes.

Probably the most effective new product available today for caulking all sorts of cracks is a single component urethane foam material which expands as it sets so that it fills up all voids in cracks and penetrations, and it conforms to the materials to which it is applied. Two popular brands of this material are "Polycel One", Coplanar Corp., Oakland, CA, and "Insta-Foam", Insta-Foam Products, Inc., Joliet, Illinois. It is very effectively used under sole plates and as a caulking medium for all those wiring and plumbing penetrations in the framing, and in all the sheathing cracks which one can see before the interior gypsum wall board is installed. It should also be used between framing studs and finished door frames and window frames to control leaking which often occurs behind the trim. This foam caulking comes in small throw-away canisters, and it can also be handled with a portable tank, hose and nozzle for large project applications. It is tricky to install well, it is easy to waste, and it is wise to hire an experienced applicator.

Another method of sealing the inevitable cracks under the sole plate is using a 4" or 6" wide, 1" pad of continuous fiberglass material which compresses to fill the crack shapes.

Figure 2 shows five typical places in the basic wall framing where infiltration controls are required.



Key Points for Controlling Infiltration in Conventional Framing
1 Between 2x4 studs and door frame (shim space)
2 Between 2x4 studs and window frame (shim space)
3 Between 2x4 baseplate and concrete slab
4 In framing "T" where interior partition joins exterior wall
5 In corner where exterior walls join

Figure #2

For controlling air leakage around doors one could use the old fashioned metal weatherstripping but it is not usually as tight as a compressable neoprene gasket properly adjusted. Those can be used on both jambs and at the head. There are other forms of gaskets, interlocking thresholds and drop-seals for the bottom of the door. One of the best door seals is a magnetic type similar to refrigerator seals . . . it can be used effectively on metal doors. Note also that some of the steel panel doors with the insulating foam-in-place core have high R-values compared to wood doors.

Sliding glass doors and windows have special leakage problems which are solved variously by their manufacturers, with vinyl "wipes", felt and pile gasketing, and by the tightness of the design. Manufacturers of some of these units are now showing their infiltration ratings, and it is hoped that this information will soon be available for all makes and models.

Two other aspects of sliding doors and windows should be mentioned in this context. Many units are now available with double, insulating glass in the frame. Some are also available with storm sash for additional thermal barrier. It should be noted that, generally, storm sash also provide a second barrier against infiltration as those sash must be set in the basic frame as well as the regular sash.

The second point is that many of these units with their own storm sash have a "thermal break"...a plastic separator...between the inside and outside portions of the basic aluminum frame. This thermal break prevents the inside aluminum from becoming very cold in winter and thus preventing moisture condensation on the inside. It's major function is to keep heat from escaping outside so fast in the winter or coming in so fast in the summer.

The interior walls of our homes are punctured in many places besides for the electrical outlet boxes. There are the electrical switch boxes, and especially the recessed electrical boxes on which light fixtures are mounted. These are particularly subject to leakage and air transfer when they are cut into the ceiling. Probably the worst offender is the wholly recessed light fixture because all fixtures must be vented on the top sides to cool the fixture by natural convection currents created by the bulbs heat. Recessed fixtures cannot be sealed off in the attic and the attic insulation must clear them by three inches.

The solution to recessed lights is usually to eliminate them...to replace them with ceiling mounted fixtures for which the ceiling penetration can be sealed with urethane foam or other sealant technique.

Little rectangular, cellular gaskets are now availabel to mount behind the electrical box cover plates for outlets and switches. Along with two-prong plastic plugs, they seal up rather well. However, they should not replace the use of sealants in the holes in the top plate, etc. discussed earlier in this chapter.

Another type of penetration of our gypsum board walls and ceilings is that for our air supply and return ducts for heating and cooling systems. It is not a loss down the duct which concerns us...the duct must be air-tight also...it is the crack around the outside of the duct, between the duct and the cut edges of the gypsum board, which must be sealed. That crack allows a lot of air to move between the rooms and the attic or the stud-spaces. We have seen this crack sealed with duct tape behind the grille covers, but we are concerned about the duct tape staying in place. That crack could be sealed with urethane foam also. Another technique being used is to apply a self-sticking sponge neoprene gasket strip around the four edges and compress it when the grille cover is screwed to the duct.

To understand infiltration problems clearly one must be able to visualize what is happening in structural elements behind the walls' interior finish. Imagine a furred-down sheetrock facing above kitchen wall cabinets. The basic wall material, such as gypsum wall board should go up behind the cabinets <u>and the fur-down</u> to meet the ceiling <u>gypsum board</u> above the <u>fur-down</u>; otherwise the attic air can come down into the fur-down and then into the stud space behind the cabinets, and eventually through all the electrical and plumbing penetrations in the wall and cabinets below.

Look around. . .you will find more ideas. . .the dryer uses house air which has been heated or cooled. It keeps sucking in conditioned air and blowing it out of the house. One builder we know uses two dryer exhaust ports back-to-back at the air intake to the dryer so it uses the outside air rather than the air the owner is paying to heat or cool.

Another major problem of infiltration identified as 6% in Figure #1, is the <u>exfiltration</u> that can occur with fireplaces. As attractive a sales feature as fireplaces are, they are a potential liability for energy conservation. If a fireplace is to be installed in a new home, it should have the following features:

(1) tight fitting, positive closure damper;

(2) outside combustion air intake; and

(3) glass firescreen.

Without the damper, conditioned air escapes up the flue as easily as through an opened window. Without an outside combustion air intake, conditioned air is sucked into the fireplace for combusion and exhausted through the flue. That air must be replaced and reconditioned, causing an additional load on the heating system. The glass firescreen insures that conditioned room air is not drawn into the fireplace, even though the fireplace may have outside air intakes. The glass firescreen also allows the homeowner to effectively smother the fire when desired and prevent complete combustion of the logs if he can also close the outside air intakes. The glass firescreen inhibits some fireplace heat radiation to the room, but it stops much more heat convection out of the room and up the chimney, and when the glass firescreen gets warm it also radiates some of the fires' heat into the room.

There are several manufacturers of prefabricated fireplaces (Heatilator, Martin "Octa-Therm", etc.) which provide recirculating air systems. In these, the room's air enters the steel box behind the firewall from low grilles, is warmed, and then it flows by natural convection currents out of higher grilles to circulate across the room, or by short ducting to an adjacent room. By using this warmed, recirculated house air, and by using outside air for the burning process the fireplace becomes far more energy efficient than in times past.

The chapter on Orientation and Design discusses the advantages of situating a house to make fullest use of prevailing breezes. These same breezes that are used to ventilate the living area of a house can be used as well to help ventilate the attic space.

Of the two major options available to builders for attic ventilation -- natural and mechanical -- most studies in Texas climates suggest that powered attic ventilators are generally not cost effective nor are they necessary. The Commerce Department's National Bureau of Standards conducted tests on Houston houses installed with several different kinds of attic ventilation equipment. Based on these tests, NBS engineers found that adding attic ventilation "was not an effective energy conservation procedure for those houses which had moderately insulated attics." "Moderately" is defined as 4" or more. The extra ventilation was found to produce less than a three percent reduction in the daily cooling loads for the test houses. Power attic fans consumed more energy than they saved by lowering the air-conditioning energy requirements.

The NBS tests were conducted in only one Texas area, but some generalizations can be cautiously drawn. In a well insulated house, the primary function of attic ventilation is moisture removal -- not energy conservation. Attics must be ventilated to code standards, but only in rare circumstances where a home may be situated in an area with virtually no natural air movement is power attic ventilation indicated. In fact, a properly designed attic ventilation system using a combination of soffit vents and continuous ridge venting will create its own forced venting by internal thermal convection currents in the attic. This is as important in the winter for eliminating excess humidity as it is for cooling the attic in the summer.

Related to the studies on attic ventilation is the factor of roof color. It is generally held that the lighter the roof, the less heat gain in the attic, subsequently the less heat penetrating the ceiling. The NBS tests cited earlier would suggest that roof color has only a minimal effect on heat gain through ceilings, assuming adequate insulation.

A final technique of infiltration control deserves special attention. It is a somewhat controversial problem because it involves moisture movement and condensation. Many people in different parts of the country say different things according to research and experience in their climates, apparently. This is the problem of the vapor barrier and where to put it.

It is not the charge of this text-writing to settle the problem of vapor barriers and condensation, but it should be helpful to the reader to discuss some observations, while pointing out the infiltration control provided by complete vapor barriers.

Since insulation was used more in the northern states, in the early years, for the purpose of reducing heat loss, the need for a vapor barrier became apparent there earlier than in the southern states. For the cold climates the vapor barrier, placed on the inside of the insulation material, prevented the moisture in the warm inside air from traveling to the "dew point," near the outerside of the insulation, and condensing there.

Such condensation is like that on the outside of an ice tea glass on a warm Texas summer day. The surface of the glass is colder than the "dew point" of the humid air around it so condensation occurs.

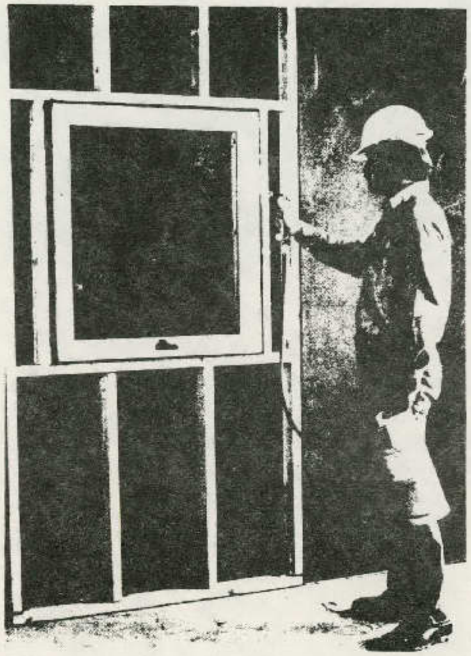
Along the Texas coastline where it is generally warm and humid, and where air conditioning is used inside the home, an opposite condition occurs. The humidity in the warm outside air seeks to penetrate the walls, to reach the dryer, cooler air on the inside. When those conditions prevail the location of the vapor barrier should be on the outside of the insulation materials so it cannot penetrate and condense in the walls.

Where the break line occurs between these two conditions involving humidity, temperature, and yearly seasons has not been defined clearly. It is a problem that should be studied thoroughly by an unbiased agency not just for Texas, though that is our immediate concern, but for all the United States. Builders in central Texas have been using the vapor barrier on the inside of the insulation. We assume that the line of change occurs somewhere between central Texas and inland from the Gulf Coast, but this has not been defined. Experience may be the best indicator.

In any case a thorough vapor barrier of polyethelene film in the walls of a home is an effective addition to the several infiltration controls already discussed. The use of a vapor barrier above the ceiling is questionable. The vapor is going to move somewhere when it is more humid inside than out, as it is in most of Texas in the winter (the Gulf Coast may be an exception). As stated above it appears that the major need for attic ventilation is for the discharge of humidity that goes through the ceiling board and the insulation to the attic space above. In fact recent research states that turban vents should not be covered in the winter for this very reason.

In summary, this chapter on infiltration has discussed several new ideas, some new products, and some building techniques which we should be instituting whether we are interested in saving energy or not. If we could say "I'm going to do 'this' because I build quality homes and I'm also going to do 'that' to save energy" we'd find that we would not be increasing the cost for energy by a whole lot, and we must remember that infiltration control is probably the most important energy item to concern us in the actual construction process.

The amazing
new polymeric foam
sealant
that stops air infiltration through
gaps, cracks,
joints and
openings...



Polycel One

POLYCEL ONE is the remarkable new polyurethane product which is packaged as a single component liquid system in aerosol cylinders. When it is dispensed into the atmosphere it partially expands, much like shaving cream, and reacts with moisture in the air or on surfaces it contacts. Within a few hours it fully expands and cures to a closed cell semirigid foam. It is this unique ability of POLYCEL ONE to expand and cure in place without exerting pressure that makes it so effective in stopping air infiltration. Unlike caulks and sealants it is a non solvent system—so it never shrinks, dries or hardens—never pulls away. It is the best protection available against air and moisture infiltration.

AVAILABLE FROM

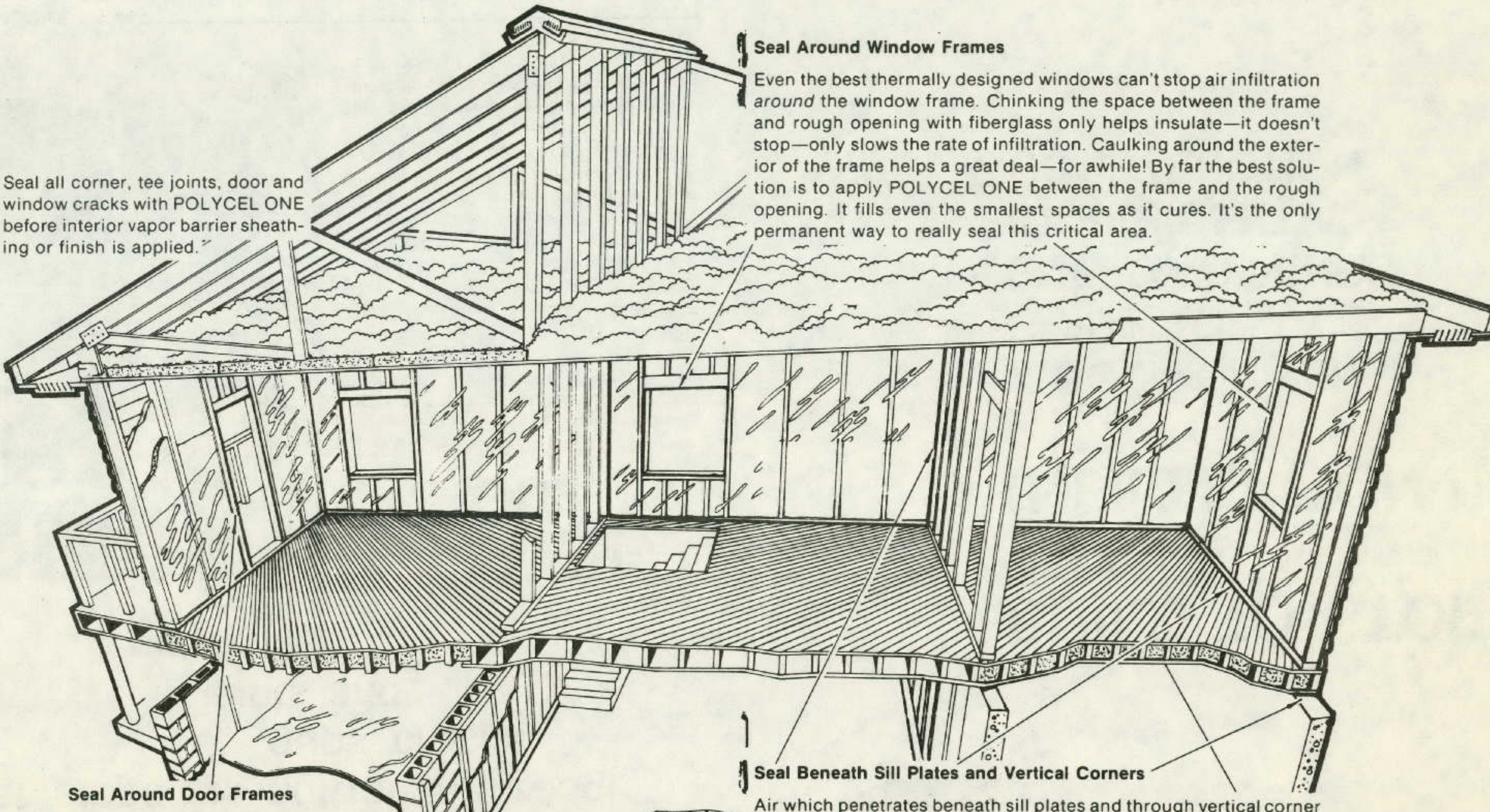
This pamphlet is published by Coplanar Corporation manufacturer of POLYCEL ONE foam sealant products for builders. The information obtained herein is thought to be correct and reliable. However, no warranty, express or implied, is made as to the accuracy of the information or the performance of any product.

COPLANAR CORPORATION/1631 San Pablo/Oakland/Ca 94612

BUILD TO STOP AIR INFILTRATION !!

A COMMON SENSE GUIDE TO ENERGY SAVINGS IN RESIDENTIAL CONSTRUCTION

To build an energy sealed house, stop air infiltration by applying POLYCEL ONE in the places shown on these pages...



Seal all corner, tee joints, door and window cracks with POLYCEL ONE before interior vapor barrier sheathing or finish is applied.

Seal Around Window Frames

Even the best thermally designed windows can't stop air infiltration *around* the window frame. Chinking the space between the frame and rough opening with fiberglass only helps insulate—it doesn't stop—only slows the rate of infiltration. Caulking around the exterior of the frame helps a great deal—for awhile! By far the best solution is to apply POLYCEL ONE between the frame and the rough opening. It fills even the smallest spaces as it cures. It's the only permanent way to really seal this critical area.

Seal Around Door Frames

Heat loss through exterior doors is reduced by using doors with insulated cores and weatherstripping. The space *around* the door frame still remains a primary source of air infiltration. You can permanently seal it by using POLYCEL ONE. As an added bonus sound transmission is also reduced and the rigidity of the frame, because it's bonded to the structural framing, in substantially increased.

Seal Beneath Sill Plates and Vertical Corners

Air which penetrates beneath sill plates and through vertical corner cracks is the biggest single cause of heat loss due to air infiltration in most residential construction. Caulking compounds simply aren't meant to fill the kind of gaps which can occur here—and fiberglass only does part of the job. POLYCEL ONE expands into *all* the spaces as it cures, bonds the plates to the slab or block and provides a permanent closed cell foam barrier to stop infiltration.

There really is an energy crisis-

AND IT'S GOING TO GET WORSE!

"Unfortunately, even if completely satisfactory agreements were to assure the free flow of oil around the world tomorrow, the world energy situation would change very little because the world is simply running out of oil and gas."

This statement from Fortune Magazine in January 1975 sums up the problem. For home builder and buyer alike, it simply means that CONTROLLING HEAT LOSS IN RESIDENTIAL CONSTRUCTION IS VITAL because energy is going to cost more and more money!

Electric and gas rates have already doubled in less than two years in many places. Natural gas is going to be a premium fuel everywhere.

Sure, there are some answers. New heating and cooling equipment that offers more efficient fuel expenditure—designing homes to take advantage of location—tighter windows—solar power—more insulation.

All of these are partial answers to the problem, but—

OF ALL THE THINGS IT'S POSSIBLE TO DO, REDUCING AIR INFILTRATION IS THE MOST EFFECTIVE—AND IT COSTS LESS THAN MOST!

Unfortunately, too little has been said about this critical area of heat loss. Here are some answers that show where *real* energy savings can be achieved.

Air infiltration-

WHAT IS IT?

It is the actual movement of air into or out of enclosed space. This movement occurs for lots of reasons such as wind action, the operation of household equipment (such as gas furnaces), or from pressure differences caused by changes in inside-outside temperatures.

If it's cold air penetrating warm space, then it must be heated to maintain a constant inside temperature. If it's warm air penetrating cold space then heat must be removed to keep the same temperature.

WHERE DOES IT OCCUR?

Through any opening that isn't sealed! Some areas that are especially vulnerable are these:

—under sill plates

—around window and door frames

—through cracks in corner framing

—around electrical boxes

—around hose bibs

HOW IMPORTANT IS IT?

"The heat loss associated with air leakage through the enclosure of a typical detached house may be as much as 40% of the total heat loss," according to work published by the National Research Council of Canada.*

This same study showed that an average of 47.6% of air infiltration occured in the walls, 20.5% through windows and 31.9% through ceilings. In the walls alone the infiltration was equivalent to leaving a 137 square inch opening in the wall of an 1800 square foot house!

*"Measurement of Air Leakage Characteristics of House Enclosures"
G.T. Tamura, Building Services Section, NRC, Ottowa, Canada.


Finally. A Better Way To insulate And seal At Your Fingertips
The portable insulating sealer systems that save!
The use of urethane foam as an insulating sealer isn't new to the building industry. We have developed two portable systems, Insta-Seal® Kits and Froth-Pak® Kits. They take the place of material you now use to insulate and seal door and window stud-to-jam air spaces, pipe and conduit holes, roof flashing and joint gaps... anywhere there's a void.
Insta-Seal® Kits and Froth-Pak® Kits fill, insulate and seal quickly and easily. You save on insulating costs. And, your customer benefits in reduced energy costs.
So, grab an Insta-Seal® Kit or Froth-Pak® Kit today and discover the better way to insulate and seal. They're the all-around, portable insulating sealer systems that can point the way to big savings for everyone.
For the dealer nearest you, write or phone the toll free number listed below.
insta seal kit
I-S 550
The Insulation Innovators
2050 N. Broadway
Joliet, Illinois 60435
815/726-6241 – Telex: 72-3415
Nationwide Toll Free Information:
(800) 435-9359 or in
Illinois (800) 892-0117
Now Energy Conservation
insta-foam PRODUCTS INC.
☐ Gentlemen! Tell me more about the better way to insulate and seal. Rush me your ______ Instal-Seal® Kit and/or ______ Froth-Pak® Kit Brochure today!
INSTA-FOAM PRODUCTS, INC.
2050 N. Broadway
Joliet, Illinois 60435
NAME ______ TITLE ______
FIRM ______
ADDRESS ______
CITY ______ STATE ____ ZIP ____
PHONE ______

Single Component Urethane Fills the Gap In Energy Crisis

BY
Martin R. Kovarik
Insta-Foam Products Inc.
Joliet, IL 60435

Discussions on the subject of ENERGY CONSERVATION increase in frequency as the weather gets worse. But -- unlike the weather, which no one seems to find time to do anything about -- ENERGY CONSERVATION is getting action...

-- action from Federal, Military, State and municipal agencies in publicly-owned buildings by upgrading existing facilities to meet new standards.

-- action of building code officials by adaptation of energy conservation "model codes" and acceptance of new products.

-- action by the conscientious building owner in performing specific retrofit procedures to save on fuel consumption.

All this, and more, are made possible by an industry which has been advocating energy conservation for the last twenty years -- the urethane foam industry.

The Problem

In some parts of our country today we are faced with increasing fuel costs in excess of 50 per cent over the last five years. If an owner were to have performed enough energy conservation retrofit procedures to reduce fuel consumption by 50 per cent, the cost of heating and cooling would have remained the same -- and that's great. But -- what we are being faced with is even more dramatic than maintaining "costs"... that is availability of that energy which allows us to maintain the comfort level we all enjoy.

In order to conserve energy, maintain our acceptable comfort level and maintain costs, we must understand where heat losses occur in conventional construction.

Studies are being conducted in every sector of industry and government. One conclusion seems to be evident, although the percentages vary from report to report, and that is THE MAJOR CAUSE OF HEAT LOSS (or gain) IN TODAY'S CONSTRUCTION IS DUE TO AIR INFILTRATION.

Air infiltration or exfiltration is best defined as that air movement which occurs through the normal cracks in construction systems -- IN or OUT. Winter or summer -- north or south -- the direction of effort is the same -- keep the conditioned air 'in' and the ambient air 'out'.

"Energy Conservation with Windows" the title of a recent release prepared and published by the Federal Energy Administration with assistance by the National Bureau of Standards, outlines more effective methods of energy conservation and protection against heat loss of windows.

It is emphasized -- "cold air leaking through cracks in a well insulated house can account for 30% of the load on the heating system. This figure can be reduced by as much as 50% by making windows and doors tighter.

In a U.S. Department of Housing & Urban Development-authored paper titled "Studies of Residential Energy Consumption in a single family home based on characteristic housing in the Washington D.C. metropolitan area" analysis showed that the greatest energy savings could be attained through the reduction of air infiltration.

Infiltrated air was the greatest load component with respect to both heating and cooling as indicated by the following breakdown of heating and cooling loads for the characteristic house:

	% of Heating Load	% of Cooling Load
Ceiling	3.7	2.3
Floor	2.2	2.4
Total window	13.6	4.1
Total door	1.4	0.4
Total wall	23.9	14.2
Infiltration load	55.2	41.5
Internal load	--	35.1
Total:	100.0	100.0

Whichever of the above-mentioned reports you choose to believe, you must agree with the premise "Infiltrated air was the greatest (single) load component" to heat loss or gain.

Putting it all together, the accumulation of cracks in a typical single family dwelling built today will be equal to an approximately 2½ square foot hole in the house (3 feet diameter). It's difficult -- to say the least, to heat or cool under these conditions.

The Law

August 14, 1976, the Congress passed PL94-385; "Amendment to Federal Energy Administration Act of 1974; Titled "The Energy Conservation and Production Act." Title III, "Energy Conservation Standards for new Buildings" mandates certain procedures to be performed in New Buildings to effect energy conservation -- a section of that Law is as follows:

502.5 Air Leakage for all Buildings:

(a) the requirements of this section shall apply to all buildings and structures and apply to those locations separating outdoor ambient conditions from the interior spaces that are heated or mechanically cooled and are not applicable to the separation of interior conditions spaces from each other.

(b) Exterior joints around windows and door frames: openings between walls and foundations, between walls and roof, 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 sealed in an approved manner.

Under "The Law", all provisions must be enforced as soon as practical -- but no later than three years after issuance -- enforcement is to be handled by the Department of Housing and Urban Development. The LAW has teeth -- since non-conformity will result in withdrawal of Federal participation i.e. Banks, Savings and Loan Associations, Housing and Urban Development or Veterans Administration - insured loans would be affected.

Model Codes

The three major Model Code Authorities, ICBO, BOCA & SBCC have adopted the PL94-385 guidelines relating to air-infiltration heat losses in 1977 energy conservation amendments to their codes. In at least one case (Garland Texas) the amendment has already been included into the City Code and conformity **is** requiring the "sealing of openings around doors, windows and other exterior openings, shall be done with polyurethane foam. Sole plates shall be set in a polyurethane foam."

Problem Solution

The problem of sealing the cracks and crevices responsible for air infiltration heat losses can be handled in many ways -- traditional caulks and sealants are thought of first because they've been around and the developed expertise of use is known. These products do, however, present drawbacks -- they are slow, expensive (cost/unit volume) and in many cases, eventually shrink resulting in the original problem, a crack.

A relatively new product, INSTA-SEAL® KIT manufactured by Insta-Foam Products Inc., of Joliet, Illinois, introduced at the ASHRAE Show at Chicago's McCormick Place in February 1977, has found acceptance in solving the problem.

INSTA-SEAL® KIT, a single component urethane foam is, prior to infield use, maintained in a single pre-pressurized container as a liquid until use. At the time of use, the liquid is forced into the cavity to be filled and expands immediately to "fill the gap."

Unlike traditional urethane foam systems, the INSTA-SEAL® KIT expansion is immediate and complete at the instant of installation allowing the applicator to continue filling with confidence that no further growth will occur which might require trimming after cure.

All necessary raw materials for INSTA-SEAL® KIT are in a single pressurized container - no mixing or blending is necessary. Container sizes range from 14 ozs. to 40 lbs. capacity and all containers are disposable.

Attached to the larger containers for industrial use, is a hose with a valve and nozzle. When the valve is opened, the contents of the cylinder come out of the nozzle fully expanded and are easily directed into the gap.

The foam adheres firmly to most surfaces without any pre-treatment. Adhesion to wet surfaces is excellent, an important requirement on a building site.

Since its introduction, INSTA-SEAL® KIT has been accepted for application in Canada as well as in the U.S. -- several million lineal feet have been applied and more applications are being found daily. The average 1600 sq. ft. house will require approximately three pounds of INSTA-SEAL® KIT and no more than one-half hour in labor.

Why Its Different

Urethane foam is normally formed by the reaction of a minimum of two compounded components fed through a metering and mixing device. The curing of the foam is usually achieved by use of a cross-linking agent and a catalyst.

On one-component urethane foam, all the ingredients are premixed in a single container as a semi-polymerized material. The foam is fully cured after dispensing as it is exposed to moisture from the air. The one component system requires no external power source, is highly portable and requires no special skills to use.

The main difference between the new product and conventional gap and joint fillers is its density. Urethane foam has a density of two to four pounds per cubic foot, whereas latexes and silicones have a density of 68-80 pounds per cubic foot. Another unique advantage of urethane foam is its ability to adhere to wet surfaces.

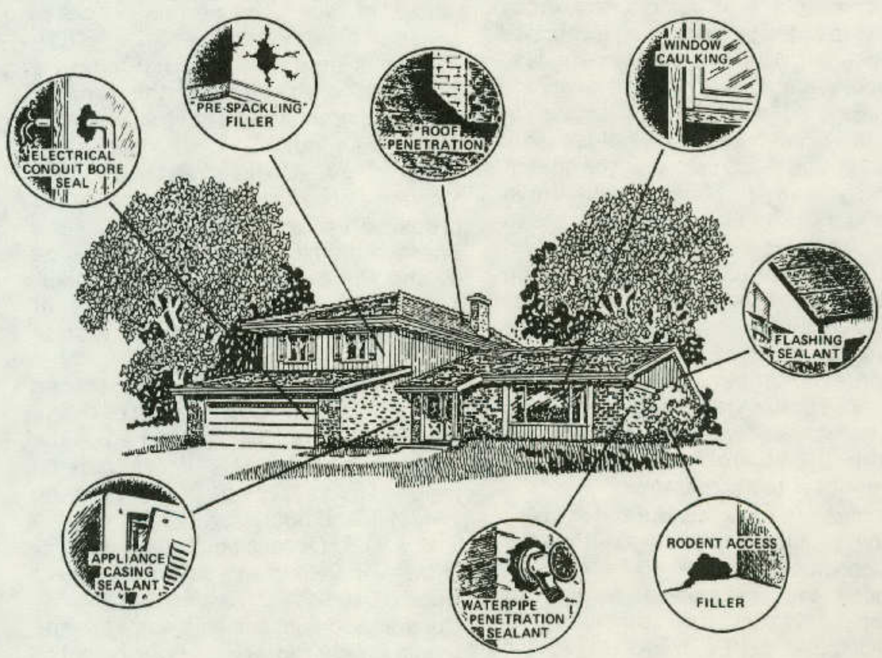
Where It Will Be Used

One component foam is expected to find ready acceptance because of its convenience in industrial, commercial, automotive as well as home applications.

The uncured foam is tacky when it leaves the container, so it sticks readily to wood, metal, concrete, brick, glass and most plastics (except polyethylene) and other materials. It gains adhesive power as it cures. It hardens fully in 24 hours, and can be cut or trimmed and otherwise finished in two to three hours.

The 1978 National Association of Home Builders' Show will allow Home Builders to examine this product for the first time. Booth 1181.

THE KEYS TO SOLVING ENERGY CONSERVATION PROBLEMS... RESIDENTIAL COMMERCIAL INDUSTRIAL



8

MECHANICAL

BASIC CONSIDERATIONS FOR MECHANICAL SYSTEMS

As energy prices increase, more and more homebuyers are going to make their decision about which home to purchase based on its energy efficiency. As a homebuilder, one of the most visible and beneficial energy conserving measures you can feature is high efficiency air conditioning and heating equipment.

In the past, the selection of heating, ventilating and air conditioning systems was generally made on the basis of first cost. But energy economics and the realization of the need for energy conservation have produced another method of selection, that being an analysis of the "life cycle" costs. Life cycle costing takes into account such factors as level of efficiency, maintenance rate and life expectancy, first costs and the price of fuel. All of these factors have a bearing on how much it will cost the homeowner to maintain satisfactory levels of comfort in his new home.

Thus, the purpose of this section will be to present the energy conserving equipment available today and how to incorporate this equipment into an energy efficient design.

Energy conservation in residential mechanical systems has been symbolized in the past few years by one term, that being Energy Efficiency Ratio or EER.

Definition: Energy Efficiency Ratio (EER) -- The ratio of net cooling capacity of the mechanical equipment (BTU per hour) to the total rate of electric input (watts) under prescribed operating conditions.

$$EER = \frac{\text{Cooling Output}}{\text{Electrical Input}} = \frac{\text{BTU/HR}}{\text{Watt}}$$

The minimum EER levels prescribed for specific systems can be found in the Model Code for Energy Conservation in New Building Construction, pages 40 and 41.

There has been some discussion that a new version of the EER, to be called the SEER, for Seasonal Energy Efficiency Ratio, would be put into use in early 1979. At this writing nothing definitive on the SEER has appeared. We understand that it would involve more specialized rating systems than are now used for the EER.

Design

The two basic steps in the design of heating, ventilating and air conditioning (HVAC) systems are: equipment/auxiliary sizing and duct design.

A. EQUIPMENT/AUXILIARY SIZING

The first step in the design process must be a load determination; the procedure for this was discussed in the "Heat Flow" section of this workbook. Auxiliary equipment such as fan motors, gas lines and refrigerant tubing will generally be determined by the equipment manufacturer for proper operation of the system.

This step within the design phase is of extreme importance and should be given a great deal of attention. Since it is usually done for the builder by his mechanical engineer or system supplier, the builder must choose this service with great care.

B. DUCT DESIGN

There are three methods available for use in the design of a duct or air distribution system:

1. Equal Friction Method -- The principle of this method is to make the pressure loss per foot of length the same for the entire system.

   By converting the turns, baffles and diffusers into equivalent lengths of duct runs, and knowing the velocity and quantity of air delivered by the fan, one may determine the friction loss rate and maintain that loss rate while sizing the ductwork throughout the system, (see Chart 2).

2. Static Regain Method -- Using this method, the duct velocities are systematically reduced so that the change in velocity pressure equals the pressure loss, i.e., the decrease in total pressure.

3. Total Pressure Method -- This method involves the determination of actual friction and momentum losses throughout the system, and allows control over the internal pressures and velocities.

   In essence, it differs from methods 1 and 2 in that the system design does not have to be dependent upon assumed fan discharge velocities.

Although methods 2 and 3 allow for better control of the system, method 1 is the procedure normally followed in residential construction. The primary qualities of this method lie in its relative ease in the design stage plus its "forgiving" nature when unforeseen changes must be made on the job site.

The specific step-by-step calculation procedure for the Equal Friction Method can be found in numerous publications and, thus, will not be covered here. We will however, discuss certain applications which may be encountered which will decrease the systems heat loss/gain or pressure drops and therefore decrease energy consumption and operating expense.

Duct Location

As noted on the heating and cooling worksheets, ducts which are located within the conditioned space require no adjustment for heat loss or heat gain, respectively. This means, simply, that the load and thus the equipment size, may be smaller than in applications in which the ductwork is placed in non-conditioned spaces. This technique may be employed in conjunction with drop ceilings or via furred-in areas within the conditioned space.

In order to determine the amount of heat lost from a duct located in non-conditioned spaces, (and also from extremely long duct runs in conditioned spaces), so that the proper insulation may be chosen, the following equation should be applied:

$$Q = UPL\left(\left(\frac{t_1 + t_2}{2}\right) - t_3\right)$$

Where,

Q = heat loss, (BTU per hour)

U = coeffient of heat transfer through duct wall, (BTU/hour, square foot, ^oF)

P = duct perimeter, (feet)

L = length of duct, (feet)

t_1 = temperature of air entering duct, (^oF)

t_2 = temperature of air leaving duct, (^oF)

t_3 = temperature of air surrounding duct, (^oF)

The U-value of this equation will be the primary unknown and can be found by obtaining the conductivity, k, from Table 3A, at end of Insulation chapter, and using this value with Figure 20. Thus, we now have means of determining the amount of heat lost from the duct with differing thicknesses and with various types of insulation.

It is important to discuss one particular side-effect which results from the development of a more efficient home and its HVAC system. Through the achievement of energy savings in the design of the energy conserving home, it has become apparent that in many cases the size of the air-conditioning equipment will be reduced. The many positive factors associated with this result are evident, but there stems from this design another element which must be considered: air movement. Although the house doesn't need as large a system as would previously have been used it still has about the same air movement needs.

Regardless of the refrigeration tonnage calculated, there remains the requirement of a minimum air movement to obtain comfort within the space. Thus, the advent of smaller systems with inherently lower air moving capabilities produces the new design consideration.

One method for overcoming this problem could be the establishment of a minimum CFM per square foot of floor area, e.g., with an 8 ft. ceiling, minimum quantities in the range of 1/2 to 3/4 CFM/sq. ft. would allow a "safe" range of design. If the equipment chosen through load calculations yields lower CFM quantities than the minimum, use the next larger size fan unit but do not increase the size of the evaporator coil. Simply install a bypass with a damper to divert a certain portion of the air, (based upon the calculated pressure drop across a wet coil), around the coil. This procedure will negate a small portion of the conserved energy calculated earlier, but it will enhance the system by allowing only the minimum airflow necessary to achieve comfort. It will also improve the humidity control.

In any case, the system should not be oversized. It is better for a system to run longer than to have an oversized unit run for a shorter time and stop and then start again, cycling more often with less even temperatures.

The question is often asked about whether the fan should be left on to circulate air after the thermostat has turned off the air conditioning cooling cycle. Since the cooling coils have a great deal of moisture from the house condensed on them and about to drip into the condensate drain, the fan should not be left on. If the fan were left on this moisture would be blown back into the house.

A great many builders in Texas and elsewhere are using heat pumps for both cooling and heating, especially where they want to go "all electric". A heat pump operates much like an air conditioner for "pumping" heat out of the house in the summer, and then, with a reversing system, it also "pumps" heat out of the winter air (leaving that air colder) and puts that heat into the house. At the end of this chapter the reader will find literature on the heat pump and some related systems, published by the Department of Energy, which explains the system in more detail.

One of the advantages of using a heat pump is that you can use with it on a year round basis a water "heat exchanger" to get "free" domestic hot water most of the year. The heat exchanger, located next to the compressor, transfers system heat to the hot water lines and thus into the hot water tank for storage and use. The tank should be a large, standard electric hot water tank. When the heat pump is off a few days in the fall and spring, and when there are some very cold days in winter, the system will rely on the electric hot water system...otherwise the water heating is free. Additionally, in the summer cooling sequence, the water heat exchanger, by taking heat out of the superheated refrigerant, allows the heat pump to operate much more efficiently (raising its EER). Note also, the water heat exchanger can also be used on air conditioners, but that limits the use to the cooling season.

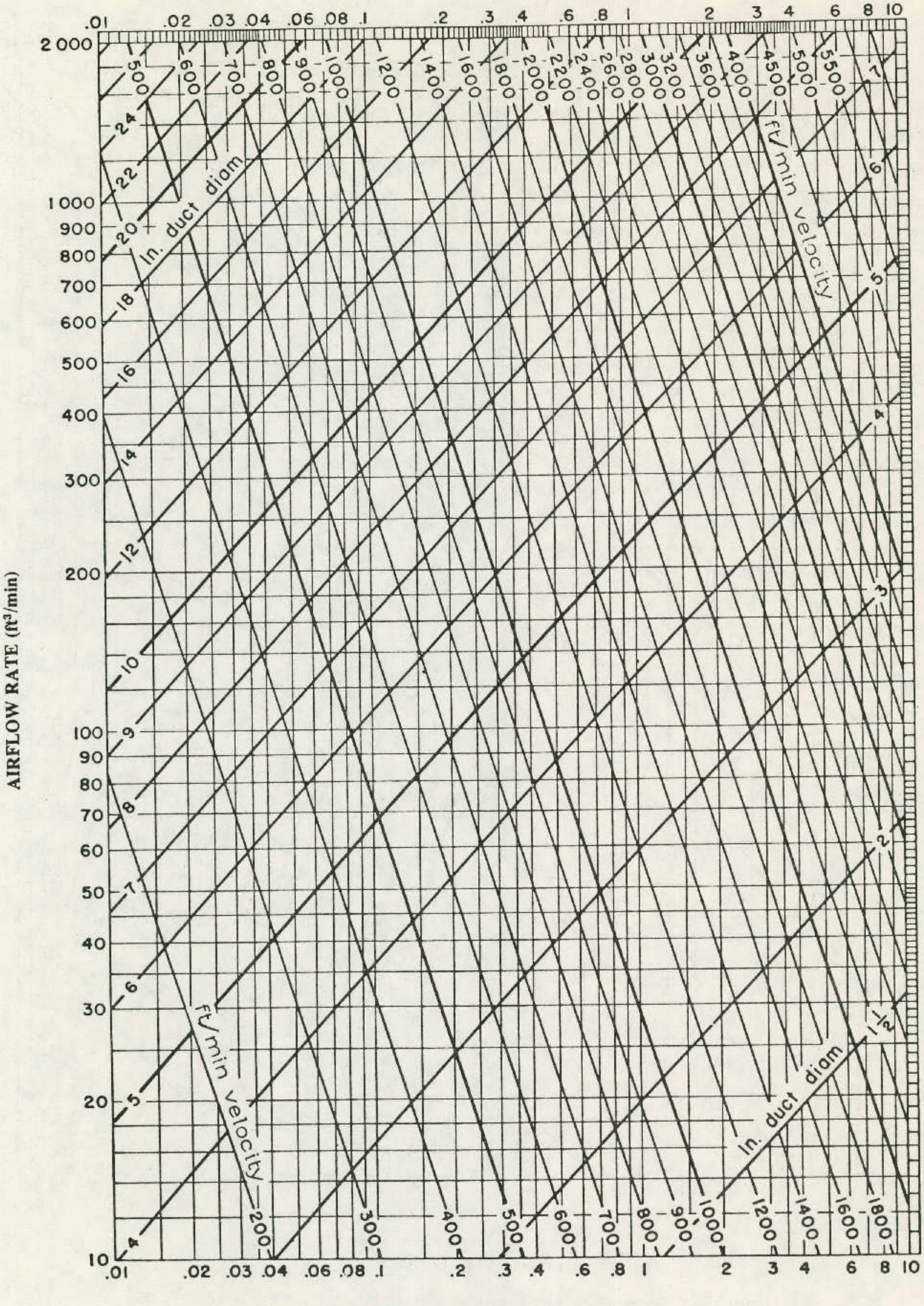
As noted in the chapter on Orientation and Design there are a few climate regions of Texas in which the humidity is low enough in the summer that evaporative coolers are quite efficient for cooling homes. These regions inlcude El Paso, Midland, Odessa, Lubbock, Amarillo and as far east as Abilene.

In evaporative cooling the actual process of cooling occurs as air is pulled through the pads which are kept wet by the water pumped through a distribution system from the unit's reservoir. As the water evaporates in the dry air coming through the pads the air is cooled by the evaporation process. Such systems cost less to install then regular air conditioning and much less to operate in such dry areas as El Paso. They are therefore energy conserving and dollar saving. They are used in reasonably expensive new homes in west Texas and they are achieving a renewed popularity due to the oil crisis and the increasing costs of energy.

BIBLIOGRAPHY

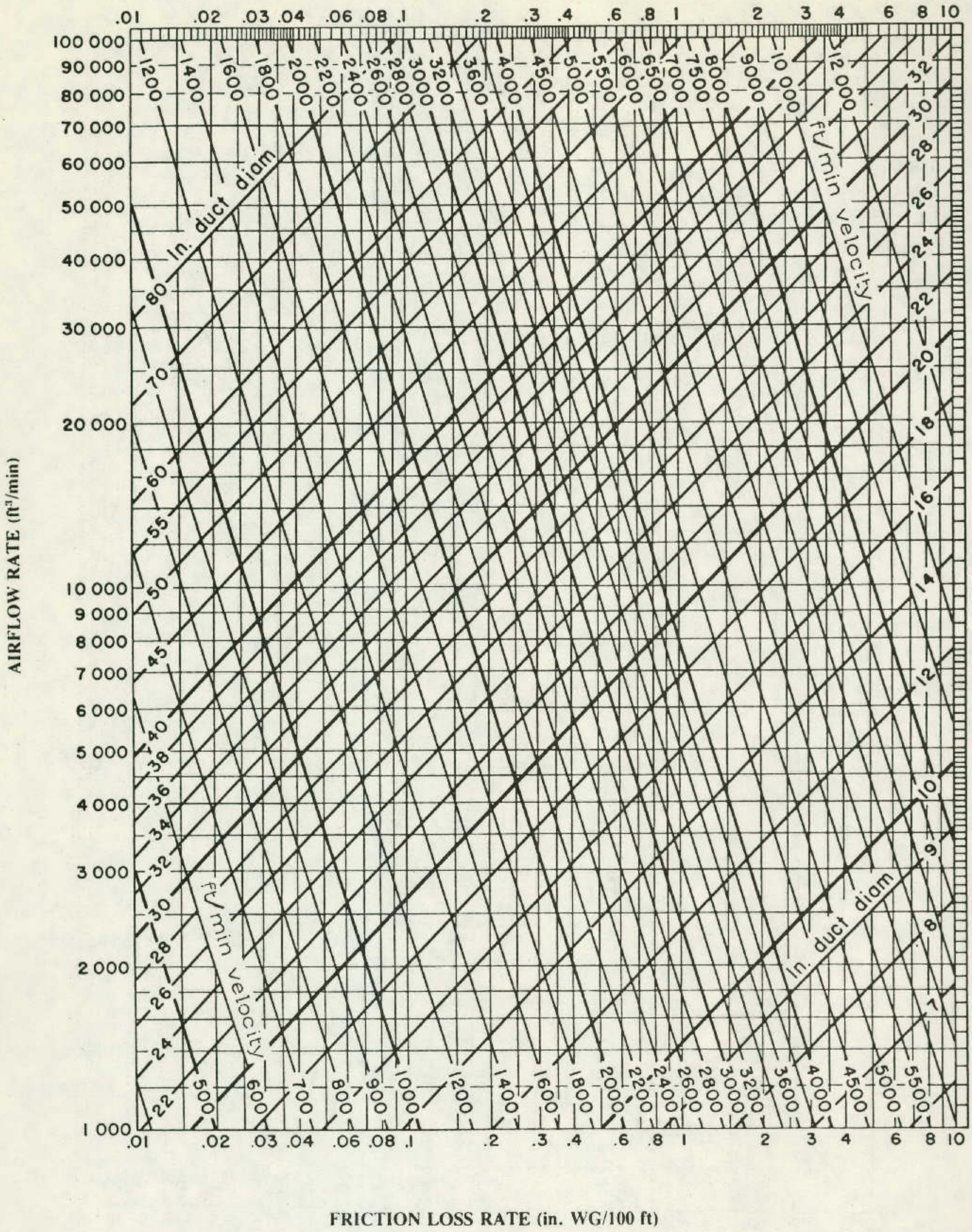
1. "Evaluation of the Air-to-Air Heat Pump for Residential Space Conditioning", Gordian Associates, Inc., 1976, Prepared for: Federal Energy Administration.

2. ASHRAE Transaction, 1977, Part One, pp. 865-878, "Heat Balance and Efficiency Measurements of Central, Fuel-Air, Residential Gas Furnaces", by Eugene C. Hise, P.E., and Allen S. Holman.



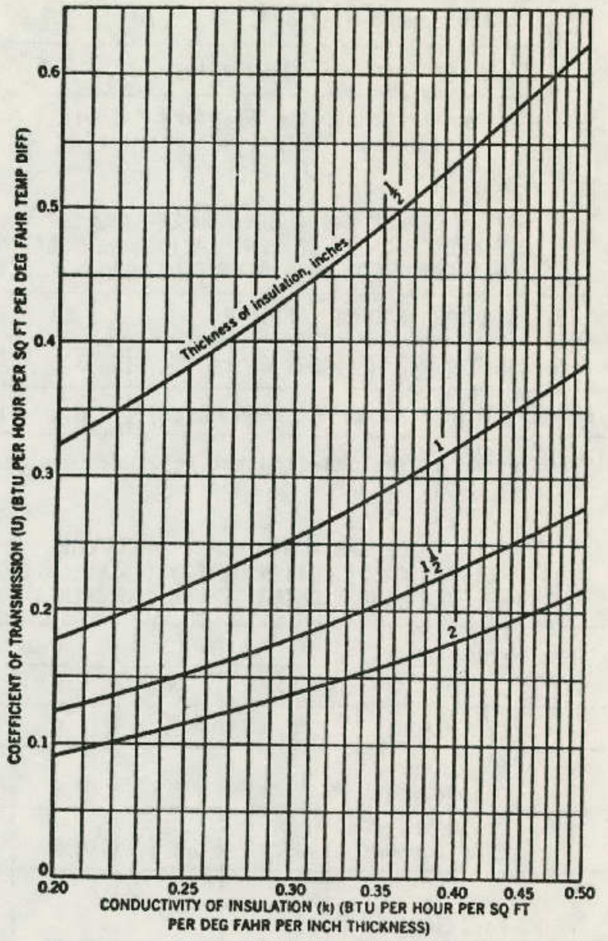
FRICTION LOSS RATE (in. WG/100 ft)

CHART 2 - Air Friction in Straight Ducts



(Based on Standard Air of .075 lb/ft³ density flowing through average, clean, round galvanized metal ducts having approximately 40 joints per 100 ft.)
Reprinted by permission from ASHRAE Guide and Data Book, 1967.

CHART 2 (con't) - Air Friction in Straight Ducts



[a] For round ducts less than 30 in. diameter, increase heat transmission values by the percentages shown below.

Thickness of Insulation (Inches)	½	1	1½	2
12- to 21-in. Duct Diameter..........	3%	5%	7%	9%
21- to 30-in. Duct Diameter..........	1%	2%	3%	4%

Fig. 20 .... Heat Loss Coefficients for Insulated Ducts[a]

TABLE 5-4
MINIMUM COP FOR HEAT PUMPS, HEATING MODE[1]

SOURCE AND OUTDOOR TEMPERATURE (F)	MINIMUM COP
Air Source - 47 dB/43WB	2.2
Air Source - 17 dB/15WB	1.2
Water Source - 60 Entering	2.2

[1]When tested at the Standard Rating specified in Table 5-9A.

TABLE 5-5 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM EQUIPMENT - COOLING[1]

STANDARD RATING CAPACITY	EER	COP
Under 65,000 Btu/h (19,050 watts)	6.1	1.8
65,000 Btu/h (19,050 watts and over)	6.8	2.0

[1]When tested at the Standard Rating Conditions specified in Table 5-9B.

TABLE 5-6 - MINIMUM EER AND COP
FOR ELECTRICALLY DRIVEN HEATING, VENTILATING AND
AIR CONDITIONING SYSTEM COMPONENTS[1]

COMPONENT	CONDENSING MEANS	AIR		WATER		EVAPORATOR	
		EER	COP	EER	COP	EER	COP
	Centrifugal	7.5	2.2	12.9	3.8		
Self-contained Water Chillers	Positive Displacement	7.2	2.1	10.9	3.2		
Condenserless Water Chillers	Positive Displacement	8.9	2.6	10.9	3.2		
Compressor and Condenser Units 65,000 Btu/h (19,050 watts and over)[2]	Positive Displacement	7.8	2.3	11.3	3.3	11.3	11.3

[1]When tested at the Standard Rating Conditions specified in Table 5-9C.

[2]Ratings in accordance with Std RS-14 as applicable. COP based on condensing unit Standard Rating Capacity and energy input to the unit, all at sea level.

TABLE 5-7 - MINIMUM COP
FOR HEATING, VENTILATING AND AIR CONDITIONING SYSTEM HEAT OPERATED COOLING EQUIPMENT

HEAT SOURCE	MINIMUM COP
Direct fired (gas, oil)	0.40
Indirect fired (steam, hot water)	0.65

TABLE 5-8
MINIMUM PIPE INSULATION

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, F	INSULATION THICKNESS IN INCHES FOR PIPE SIZES					
		RUN-OUTS UP TO 2"[1]	1" AND LESS	1½ to 2"	2½ to 4"	5" to 6"	8" AND LARGER
HEATING SYSTEMS							
Steam and Hot Water							
High Pressure/Temp	306-450	1½	1½	2	2½	3½	3½
Med. Pressure/Temp	251-305	1½	1½	2	2½	3	3
Low Pressure/Temp	201-250	1	1	1½	1½	2	2
Low Temperature	120-200	½	3/4	1	1	1	1½
Steam Condensate (for Feed Water)	Any	1	1	1	1½	1½	2
COOLING SYSTEMS							
Chilled Water	40-55	½	½	3/4	1	1	1
Refrigerant, or Brine	Below 40	1	1	1½	1½	1½	1½

[1] Runouts not exceeding 12' in length to Individual Terminal Units.

Heat Pumps

In the face of rising energy costs and diminishing energy supplies, consumers have been attempting to stretch their energy dollars by taking such actions as turning down their thermostats and adding insulation to their homes. To help consumers achieve energy savings, architects, builders, and manufacturers have been working to develop energy-efficient heating and cooling equipment that offers long-term energy savings. One device that has recently been attracting attention as an efficient, economical alternative to conventional heating and cooling systems is the heat pump.

Heat pumps are not new; electric heat pumps were originally developed and marketed in the 1930s. The heat pumps being marketed today are reliable, and many applications offer substantial energy and dollar savings as well.

When heat pumps first became available, however, they had a reputation for poor reliability. Compressors failed, valves leaked, and wires frayed. Today, most of these technical problems have been solved, and installation and maintenance techniques have improved.

What Is a Heat Pump?

Basically, a heat pump is a device that pumps heat from a relatively cool area to another, warmer area. In its cooling mode, an air-to-air heat pump works like an ordinary air conditioner, by extracting heat from inside a building and pumping it outdoors. But unlike an air conditioner, the heat pump can reverse itself. During cold weather, a heat pump absorbs heat from the air outdoors and transfers it inside to heat the air indoors.

Even very cold air contains heat—"cold" simply means that some, but not all, of the heat has been removed. For example, at 0°F, air contains 89 percent of the heat available at 100°F. Heat is totally absent from the air only at a temperature of absolute zero, or 460° below 0°F. Thus, even on a cold day, a heat pump can extract some heat from the outdoor air and pump it into a building to maintain a comfortable temperature.

How Does a Heat Pump Work?

Heat energy will flow naturally from a warmer area to a cooler one, as from a warm house to the cooler outdoors. A heat pump works against this natural flow by using a refrigerant to move heat from a cooler area to a warmer one. To do

Department of Energy

Copies of these Fact Sheets may be obtained from:
DOE Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

this, the heat pump uses an outdoor coil containing a low-pressure liquid refrigerant that is even cooler than the air. When a fan blows outdoor air across this coil, the cooler refrigerant absorbs the heat from the air, "boils," and turns to a vapor. The refrigerant vapor is then pumped through a compressor, where it becomes "superheated."

Once superheated, the refrigerant vapor is pumped through an indoor coil. Because the vapor is now hotter than room temperature, it condenses—that is, turns to a liquid. The change from vapor to liquid releases the heat, which is then blown through the duct system to heat the house.

The cycle begins again as the liquid refrigerant, cooled by releasing its heat to the house, is pumped back outside. On the way, it passes through an expansion valve, which lowers the refrigerant's pressure again so that it can boil more easily in the outdoor coil.

Heat pumps can cool as well as heat simply by reversing the heating operation. When cooling, they absorb heat from the indoor air, pumping it outside, just as air conditioners do.

How Efficient Is a Heat Pump?

The efficiency of a home heating system is measured by the number of units of heat energy output obtained for each unit of energy input. **Of all the conventional heating systems available today, heat pumps alone can return more heat than they consume.**

How can heat pumps multiply their energy input? In simplest terms, while conventional systems use energy to ***create*** heat, heat pumps use energy to ***transfer*** and ***intensify*** heat that is already available in the surrounding environment. A heat pump uses energy only to run the fan and the compressor.

Using available heat gives the heat pump a head start compared to conventional electric resistance heaters and oil or gas furnaces, enabling it to deliver as much as three times the heat energy it consumes.

A simple analogy will make this clearer. Suppose you need the force of water dropping 200 feet to power a paddlewheel, and the present source of water drops only 100 feet before reaching the paddlewheel. By investing only enough energy to pump that available water up an additional ***100 feet,*** you can capture the force of water dropping ***200 feet.*** You've multiplied your energy input, producing more energy than you consumed. Similarly, a heat pump produces more energy than it consumes, making it much more effective than conventional heating systems.

Is A Heat Pump Right For Your Home?

The increased efficiency offered by heat pumps translates readily into savings on utility costs. While actual savings depend upon such factors as climate and the price and availability of natural gas, oil, and electricity, heat pumps offer an average of 20 percent savings over conventional cooling systems and central electric resistance heating. In some regions of the country, installing a heat pump can reduce electricity bills by 35-45 percent. Of course, as with any heating system, proper installation and adequate insulation in the house are essential to ensure satisfactory results at minimal operating costs.

In determining whether a heat pump represents an economical alternative to another type of heating and cooling system for your home, a number of factors should be assessed.

First, heat pumps are most economical when used year-round for both winter heating and summer cooling. If a heat pump is needed for heating only, the system will lie unused for part of the year. Similarly, if a heat pump is needed for cooling only, it will not offer energy or dollar savings over a conventional air conditioner; for, in their cooling mode, heat pumps are no more efficient than most air conditioners. But if used for both heating and cooling, long-term fuel savings justify the higher initial cost of a heat pump.

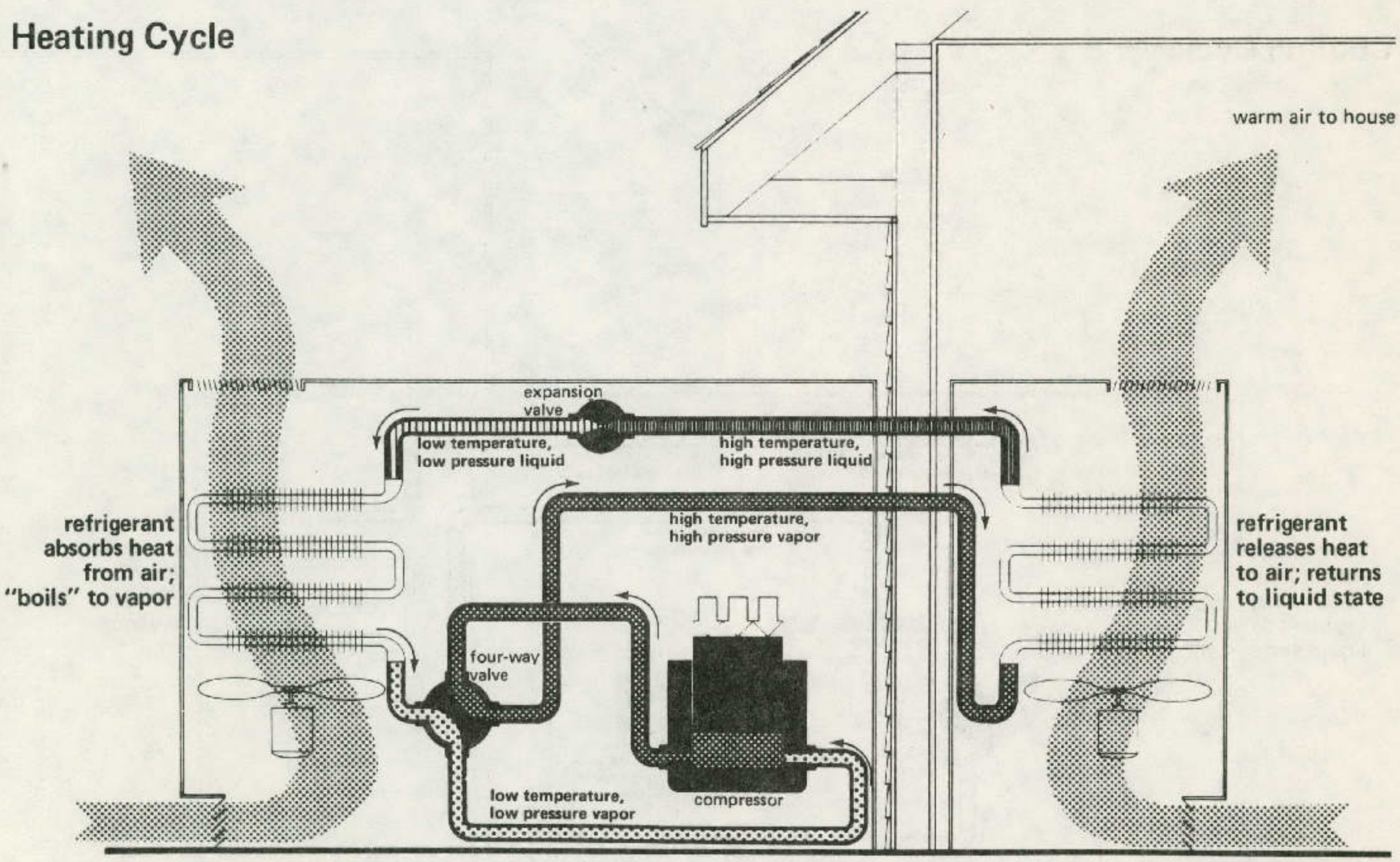
Second, the efficiency of a heat pump varies significantly with the outdoor temperature. While a heat pump may be twice as efficient as a conventional heating system at 50°F, it may be only slightly more efficient at 35°F. Typically, when the outdoor temperature drops below 35° F, the heat pump must be supplemented by another heating system, such as electric resistance heating; or in the case of a "hybrid" system, the heat pump is supplemented by an oil or gas furnace.

Therefore, a heat pump will prove to be the most economical alternative where winters are relatively mild and the temperature typically is above 25°F to 30°F, because the heat pump alone will provide sufficient heat the majority of the time.

In areas of the country where the temperature in winter frequently drops below 25°F, requiring frequent use of the backup heating system, the installation of a heat pump may not be economically justifiable.

Finally, the initial cost of installing a heat pump is 10 to 25 percent higher than the cost of installing a conventional system. A gas furnace

Heating Cycle



and central air conditioning system costs approximately $2,500, versus $2,700-3,300 for a heat pump system. The cost of converting a standard home heating and cooling system, if ductwork and additional wiring are needed, could run as high as $3,500. Consequently, if a heat pump will not substantially increase energy efficiency, the long-term savings may not justify the initial expense.

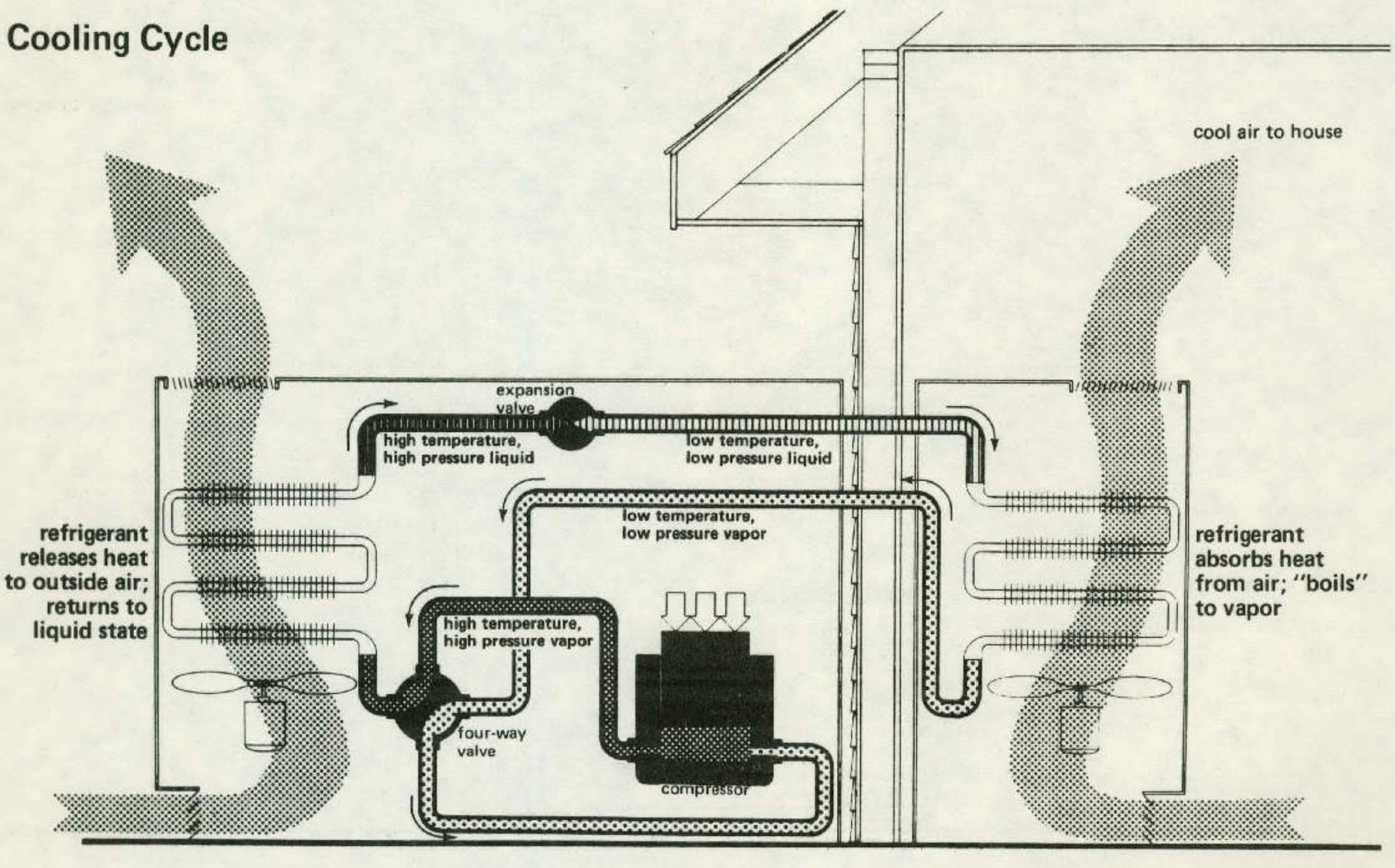
What Types of Electric Heat Pumps Are Available?

Three types of electric heat pumps are presently on the market. The most commonly used are *air-to-air* heat pumps, which transfer heat from the air.

Water-to-air heat pumps exchange heat with either groundwater, surface water, or water passed through cooling towers (for industrial or commercial use). Systems that use groundwater appear to have the greatest potential for efficient and economical operation, as the temperature of most groundwater stays at around 50°F for most of the year; however, some environmental problems must be resolved before these systems are generally available.

Ground-to-air heat pumps have also been tried, but with uneven results. Although ground temperature also remains relatively constant throughout the year, the earth does not conduct heat as readily as does water or air. Furthermore, if frost develops around the underground coils, the efficiency of the system will plummet. Therefore, these types of heat pumps are generally not recommended.

Cooling Cycle



How Should a Heat Pump Be Selected?

Heat pumps come in different types and sizes, ranging from window units to large commercial and industrial units. Climate, and the building size and design are the most important factors to be considered in determining the type and size heat pump that will operate most efficiently and economically to meet particular heating and cooling needs.

A local power distributor can help determine the type and size of heat pump needed to heat and cool a house or building efficiently, and can estimate its operating cost. A dependable contractor can then help select and install the most efficient, reliable heat pump for that home or building.

Contractors need not be relied upon completely, however; the efficiency of different brands of heat pumps can be compared. The manufacturer's label should list the efficiency rating of a heat pump in terms of a ***coefficient of performance*** (COP) or its cooling efficiency rating in terms of an energy efficiency ratio (EER). In simplest terms, these are the ratios of energy produced by the system to the energy it requires to operate. Regardless of the standard used, however, the higher the rating, the more efficient the heat pump. Other features that distinguish the most reliable heat pumps include:

Filter drier, which keeps the system clean and moisture-free.

Accumulator, which improves reliability by taking the strain off the compressor.

Crankcase heater, which boils off liquid refrigerant in the compressor, thus providing better lubrication and faster compressor starts.

Positive defrost system, which prevents excessive frost buildup on the outdoor coil, thereby maintaining maximum heating efficiency.

Outdoor thermostat, which insures that the backup heating system, whether a gas or oil furnace or an electric resistance heater, is not used unless the temperature outdoors drops below a certain point.

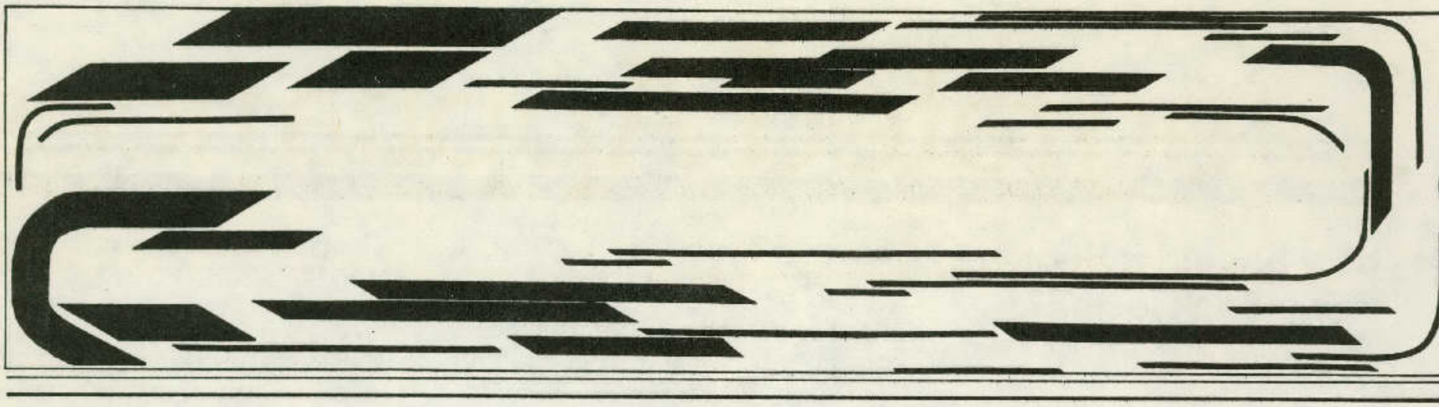
Is the Federal Government Working to Develop Heat Pumps For Residential Space Heating?

The Department of Energy (DOE) is presently conducting several projects to improve the efficiency and reliability of the residential and commercial heat pumps generally available today. Work is under way to improve existing air-to-air heat pump systems and to develop more reliable installation and maintenance practices.

DOE's Oak Ridge National Laboratory has just completed a study assessing the potential for energy savings from existing air-to-air residential heat pumps used in conjunction with reduced indoor temperatures and nighttime setbacks.* The study found that temperature setbacks of residential heat pumps effect substantial energy savings where winter climates are mild. Where winters are severe, as in Minnesota, heat pumps alone are insufficient for space heating and must be accompanied by auxiliary heaters. As nighttime temperature setbacks reduce the need for an auxiliary heater, setbacks have been found to affect energy savings positively, even in severe climates.

DOE is also working on several advanced heat-pump systems, some of which should be available commercially by the 1980s. One program, an Annual Cycle Energy System (ACES) is being prepared for the market. The principal components of the ACES are a heat pump and an insulated tank of water that serves as an energy storage bin. During the winter, the heat pump draws heat from the water in the tank (which can be located in the basement or under a driveway or patio) for use in heating a house and providing domestic hot water. This removal of heat from the water gradually turns the water into ice over a period of months. In the summer months, the ice water from the bin is used to provide air conditioning for the building. This action causes the ice to melt gradually, and thus stores heat for use in the winter.

The initial costs of this system are high; current costs are about $1,700 more than conventional systems for a new average-size house, and about $3,000 to retrofit an existing house. However, the long-term savings are also high—as much as a 50-percent energy savings every year. Further refinements and volume production can be expected to lower costs and increase savings as well.



Experimental work is being conducted jointly by DOE and several utility and manufacturing companies to develop ***thermally activated*** heat pumps, which would be powered by gas burned on-site rather than electricity generated off-site. As the on-site use of gas is more cost-effective than the off-site generation of electricity, these new pumps should earn an even greater return on energy invested than electric heat pumps. Furthermore, while these heat pumps will initially be designed to burn natural gas, future models could use other heat energy sources, such as oil, coal, synthetic fuels, and solar energy.

A gas heat pump could heat and cool a house for 75 percent of the present cost of air conditioning **and** electric-resistance heating that house. On a national scale, thermally activated heat pumps could be incorporated into the heating and cooling systems of many new or existing residential or commercial buildings.

The technical barrier to developing the new thermally activated heat pump has been the lack of an inexpensive, efficient, and sufficiently small engine to convert heat to mechanical energy. To overcome this barrier, DOE is co-sponsoring two demonstration projects with private industry. With DOE's assistance in developing new equipment, the gas heat pump could be on the market by the early 1980s. Replacing worn-out gas furnaces with these new heat pumps as they become commercially available could save more than 792 million cubic feet of natural gas a day by the year 2000.

Information Services

Information on the topics introduced in this fact sheet is available from a variety of sources. For a more comprehensive understanding of heat pumps, how they work and how they are used, consult a reliable manufacturer or dealer. The *Directory of Certified Unitary Air Conditioners and Heat Pumps* provides COP ratings for certified units, and is available for a $2.00 charge. To obtain this publication, write:

Directory of Certified Unitary Air Conditioners and Heat Pumps
Air Conditioning and Refrigeration Institute
1815 N. Fort Myer Drive
Arlington, VA 22209
202/524-8800

In addition, the following agencies can answer questions on heat pumps and other conservation methods:

Energy Advisory Service for Texas
Center for Energy and Mineral Resources
Texas A&M University
College Station, Texas 77843
713/845-8025

Center for Energy Policy and Research
New York Institute of Technology
Old Westbury, New York 11568
Energy Hotline 516/686-7744

American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
Technical Division
345 East 47th Street
New York, New York 10017
212/644-7852

Integrated Appliances

In the United States, single family homes and commercial buildings account for 24 percent of all primary energy consumed. Most of this energy is used to operate large appliances, such as refrigerators, water heaters, air conditioners, and space heating equipment.

Rising utility costs and the national emphasis on energy conservation have led researchers to explore ways to reduce the amount of energy consumed by appliances. One approach being examined involves combining, or integrating, the energy systems of two or more appliances. These ***integrated appliances*** offer users the opportunity to save substantial amounts of energy.

What Are Integrated Appliances?

Integrated appliances are two or more appliances whose energy systems are combined into a single system, which consumes less fuel than do separate energy systems. Researchers are investigating two promising ways to integrate the energy systems of major residential and commercial appliances.

The first approach capitalizes on the fact that the energy requirements of some appliances are similar, even though the functions each performs are different. For example, both water and space heaters use energy to create heat. The energy systems in these appliances can be integrated to create a single energy source, more efficient than individual sources, to provide energy to perform both functions.

The second approach takes advantage of the fact that some appliances use energy in a complementary manner. For example, refrigerators reject heat as a by-product of the cooling process, and water heaters require heat to function. Through "heat reclamation," some of the 55 percent of the energy wasted by home appliances as hot air exhausted through vents and flues or hot water released down the drain can be recaptured and used by other appliances. For every unit of energy in the form of heat that is captured and used, that much less primary energy is needed, and fuel and fuel dollars are saved.

Research has been conducted to evaluate the many alternatives for combining or integrating two or more appliances into energy-conserving systems. Criteria used to determine those alternatives having the greatest potential for further development were potential energy savings, projected consumer acceptance, ease of installation, and projected return on investment. Among the most promising integrated appliance systems identified are the three discussed below: a combined space and water heater for residential use, a range/oven heat-recovery system for commercial use, and an air conditioner heat-recovery system.

Combined Space and Water Heater for Residential Use

A combination space and water heater is being developed for residential use which conserves energy by using a single heat source—an oil or gas burner—for space and water heating (see Figure 1).

Hot "boiler" water is the medium used to transfer the heat generated by the burner to air for space heating and to water for the domestic hot water supply. This boiler water (as differentiated from the domestic hot water supply) is heated when it passes over the burner as it circulates in a closed network of pipes and heat exchanger coils. One heat exchanger coil is located in a small water storage tank; the other is located in an air handler.

Copies of this Fact Sheet may be obtained from:
U.S. Department of Energy
Distribution
Washington, D.C. 20585

March 1978

U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Conservation and Solar Applications
Division of Buildings and Community Systems

In supplying domestic hot water, the system works in the following way: cold water from the building's water supply enters the bottom of the water storage tank and absorbs heat as it passes over the heat exchanger coil in the tank. Hot water is then drawn from the top of the tank as needed to supply sinks, taps, and dishwashers.

The hot water in a tank of this size (2 to 10 gallons), in combination with the rapid heating capability of this system, is sufficient to meet average hot water demands. If the demand for hot water at a given time exceeds the capacity of the tank, boiler water is diverted to the heat exchanger coils in the water storage tank. This is accomplished by means of a temperature gauge, which ensures that the hot water in the storage tank is maintained at the required temperature. If the temperature of the water drops below a certain level, a three-way valve operates to channel the boiler water through the coils in the water storage tank, rather than through the coils in the air handler. This redirection of boiler water will not significantly affect the space heating function, however, because periods of heavy hot water demand are usually of short duration.

Space heating is performed in a similar manner. A fan in the air handler draws air over the heat exchanger coils; the air absorbs heat from the hot boiler water circulating in the coils, and is then blown through the ductwork to heat the house.

Energy savings result from the use of a single, advanced combustion system to provide both space and water heating, rather than the two combustion systems required by a separate water heater and furnace. Although the combined system requires a slightly greater initial investment than two separate units, the homeowner can expect a return on his investment in less than two years from savings on reduced utility bills.

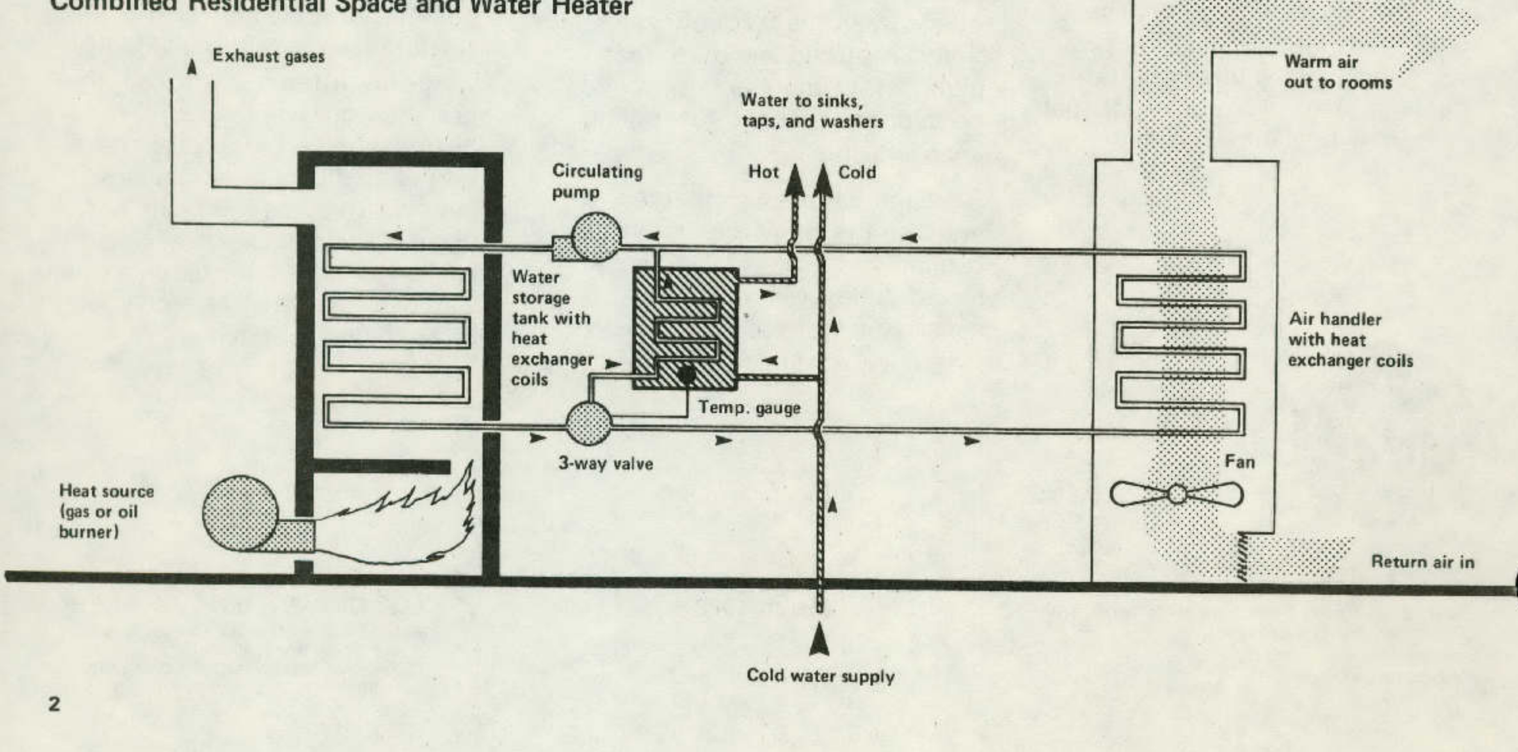
Commercial Range/ Oven Heat-Recovery System

Cooking appliances operated by restaurants and large institutions such as hospitals and schools generate a substantial amount of waste heat, which normally is expelled outdoors through vents. Researchers are developing heat-recovery systems for ranges and ovens to capture this waste heat and use it to heat the domestic hot water supply (see Figure 2).

One such "heat reclamation" system works in the following way. As cold water enters the building,

Figure 1

Combined Residential Space and Water Heater



it either flows directly to sinks and taps, or to a preheat tank. When ovens and ranges in the building are generating heat, a water-circulating pump switches on in conjunction with the kitchen exhaust fan. This pump draws cold water from the bottom of the preheat tank through a heat-recovery coil located in the kitchen exhaust duct over the range. The fan draws the hot exhaust into the duct and the cold water in the coil absorbs heat from the hot exhaust. This preheated water flows back to the preheat tank and is either stored for later use or drawn through the existing water heater, where it is heated to the required temperature before going to sinks and dishwashers. As long as the cooking appliances are generating heat, the circulating pump draws the stored water through the heat-recovery coil, so that the water continues to absorb more heat as it circulates.

This heat-recovery system saves fuel by reducing the need for the standard water heater to operate; the preheated water is generally hot enough for sinks, and needs only a boost to raise it to the temperature required by dishwashers. When ovens and ranges are not in use, incoming cold water enters the bottom of the preheat tank and displaces the previously heated water. The displaced water flows to the existing water heater, where it is heated to the required temperature.

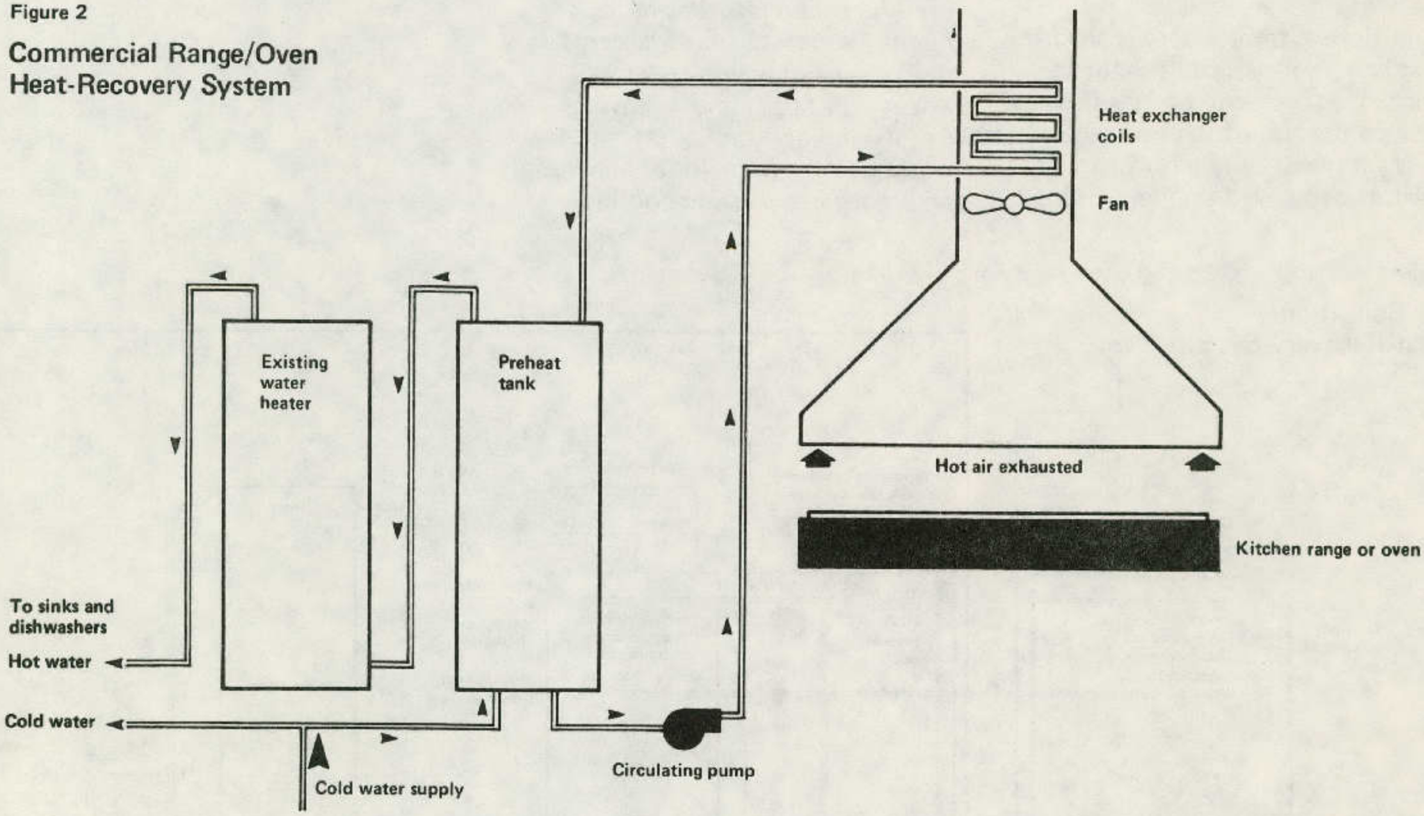
Air Conditioner Heat-Recovery System

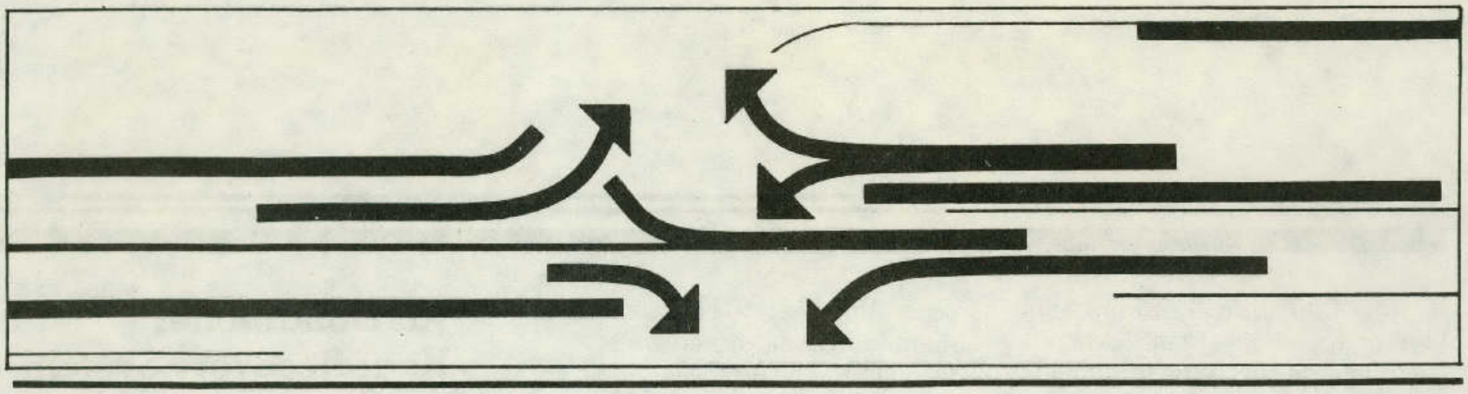
A third type of integrated appliance is a combination central air conditioner and heat-recovery system (see Figure 3). In this system, the waste heat generated as a by-product of the air conditioning process can be partially recovered and used to heat the domestic water supply.

A conventional air conditioning process utilizes a refrigerant circulating in a coil to absorb heat from inside a building and carry it outdoors, where it is released to the outside air. An integrated air conditioner heat-recovery system, however, recovers this heat by

Figure 2

Commercial Range/Oven Heat-Recovery System





means of a heat-recovery coil located in the air conditioning unit. The heat-recovery coil is entwined with the coil that circulates the refrigerant. The heat that would be released by the refrigerant to the outside air in a standard air conditioner is partially absorbed by the water circulating in the heat-recovery coil.

The system works in the following way: cold water entering the building flows either directly to sinks or taps or to the bottom of the existing water heater. A circulating pump, which switches on in conjunction with the air conditioning unit, pumps cold water from the bottom of the water heater through the heat-recovery coil in the air conditioning unit, where it absorbs heat being released by the refrigerant. This preheated water flows back to the top of the water heater, where it needs only a boost to reach the required temperature before being drawn as needed by sinks, tubs, and washers.

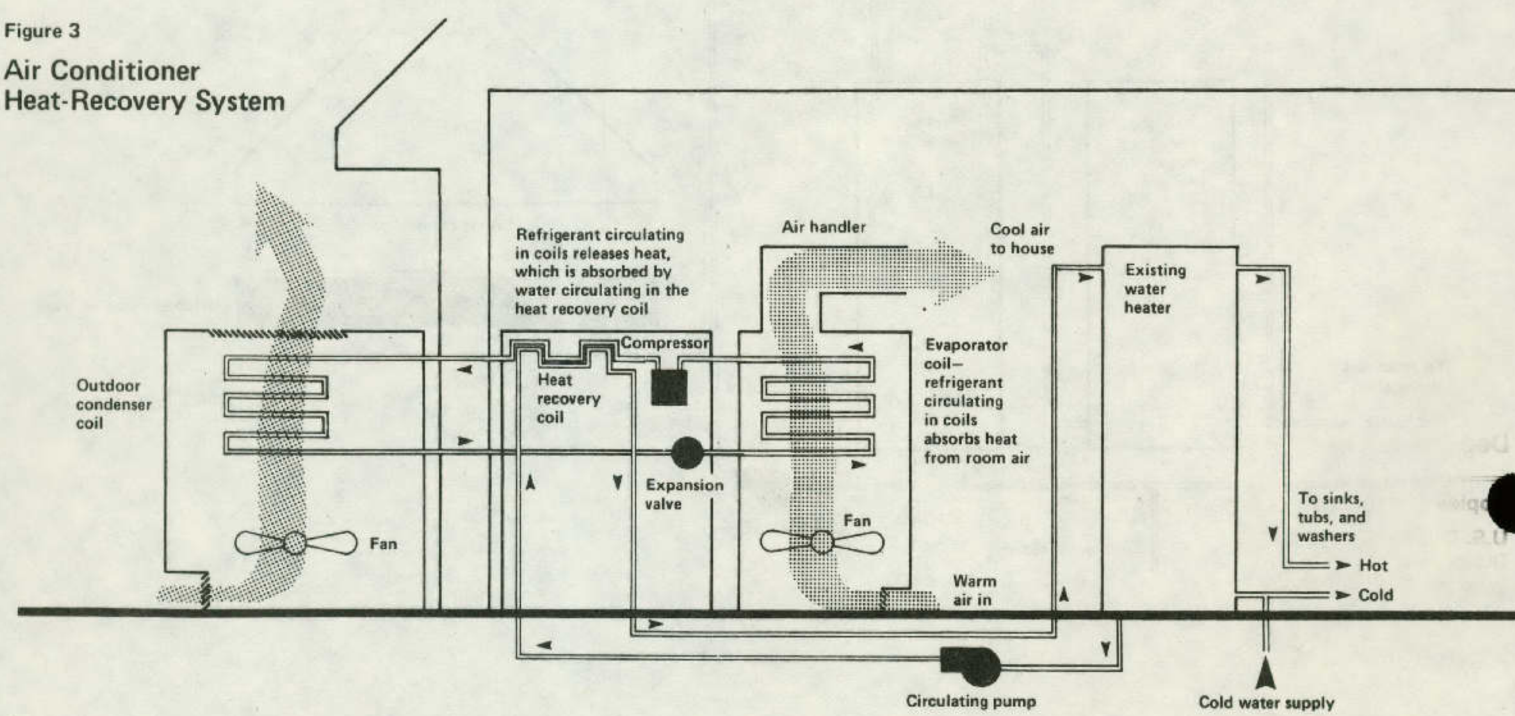
As long as the air conditioner is operating, the circulating pump pumps water through the heat-recovery coil, maintaining or even increasing the temperature of the water in the tank. Like the commercial range/oven heat-recovery system, this system reduces the operating time of a standard water heater, conserving some of the fuel it would ordinarily consume.

Savings Potential

Practical, cost effective, and energy-saving integrated appliances should be on the market within five years. By installing integrated appliances in new buildings and as replacements for conventional systems as they wear out, a consumer can effect significant energy savings. For example, if one-quarter of the waste heat from major appliances and space heating and cooling equipment in an average seven-room house were to be recovered through the use of integrated appliances, utility bills could be reduced by 14 percent. Nationwide, this amounts to potential energy savings of 2.1 percent of the total U.S. energy consumption, or 250 million barrels of oil per year for an annual savings of $3.6 billion.

Figure 3

Air Conditioner Heat-Recovery System



ACES

Energy used for heating and cooling residential buildings accounts for more than one-fourth of the total energy used in the United States today. Much of the existing housing was built when energy was readily available and inexpensive; therefore, little concern was directed to developing efficient heating and cooling systems. The nation's energy situation has changed, however, and it is now imperative that alternative home heating and cooling systems that minimize energy consumption be developed.

One alternative under development by the Department of Energy (DOE) is the Annual Cycle Energy System (ACES), an energy-efficient system designed not only to heat and cool living space, but to provide domestic hot water as well. ACES takes advantage of the yearly weather cycle in much of the United States, in which the heating required to warm residences in the winter (and provide hot water year-round) and the cooling required to air-condition them in summer are fairly well-balanced.

What is ACES?

The principal components of ACES are an insulated tank of water, which serves as an energy-storage bin, and an electrically driven unidirectional (heating only) heat pump. In the winter months, the heat pump draws heat from the water in the tank in much the same manner that a conventional home heat pump draws heat from the air. The heat drawn from the water is used to warm the building and provide domestic hot water. Over a period of months, this withdrawal of heat gradually turns the water into ice. In the summer months, the chilled water from the bin is used to provide air-conditioning to the home. The removal of the chilled water from the bin causes gradual melting of the ice over several months, thereby storing heat for use in the winter.

How Does ACES Work?

When home heating or hot water is needed (see Figure 1), a compressor pumps a hot, high-pressure refrigerant (a heat-transfer agent that boils at a low temperature) through the hot-water heat exchanger. In the exchanger, some of the vapor's heat is extracted to heat water for domestic use. The hot refrigerant is then

Department of Energy

Copies of these Fact Sheets may be obtained from:
U.S. Department of Energy
Distribution
Washington, D.C. 20585

directed through an indoor heating coil, where it releases its heat, which is blown through the ducts to the house, and condenses. The warm, liquid refrigerant then flows through an expansion valve, where its pressure is lowered, causing it to boil in the evaporator.

The outside surface of the evaporator is an ice-maker plate. When the compressor is in operation, water from the bottom of the ice bin is continuously sprayed across this plate. As the refrigerant boils and evaporates, a thin layer of ice forms on the surface of the plate. After it leaves the ice-maker plate, the cold, low-pressure refrigerant returns to the compressor, where it is "superheated"—that is, its temperature and pressure are greatly elevated.

When a thin layer of ice (1/4 inch or so) has formed on the ice-maker plate, the warm refrigerant vapor is released to the evaporator. Heat from the vapor loosens the ice adhering to the plate, and the water spray from the distributor carries that ice away from the plate into the storage bin. When all the ice has been cleared from the freezing plate, the condensed refrigerant is again allowed through the expansion valve and the cycle is repeated.

During the cooling cycle (see Figure 2), the compressor operates only when needed to provide hot water, and ice water is circulated through the chilled-water coil. Air blowing over this coil provides air-conditioning.

An alternative to using the ice-maker plate is to immerse brine-carrying coils directly into the water in the storage bin. The coils freeze the water during the heating season and melt the ice during the cooling season.

Where Can ACES Be Used?

The overall purpose of ACES is to conserve a maximum amount of energy by balancing the heating and cooling requirements of a home

Figure 1.

ACES Heating Cycle

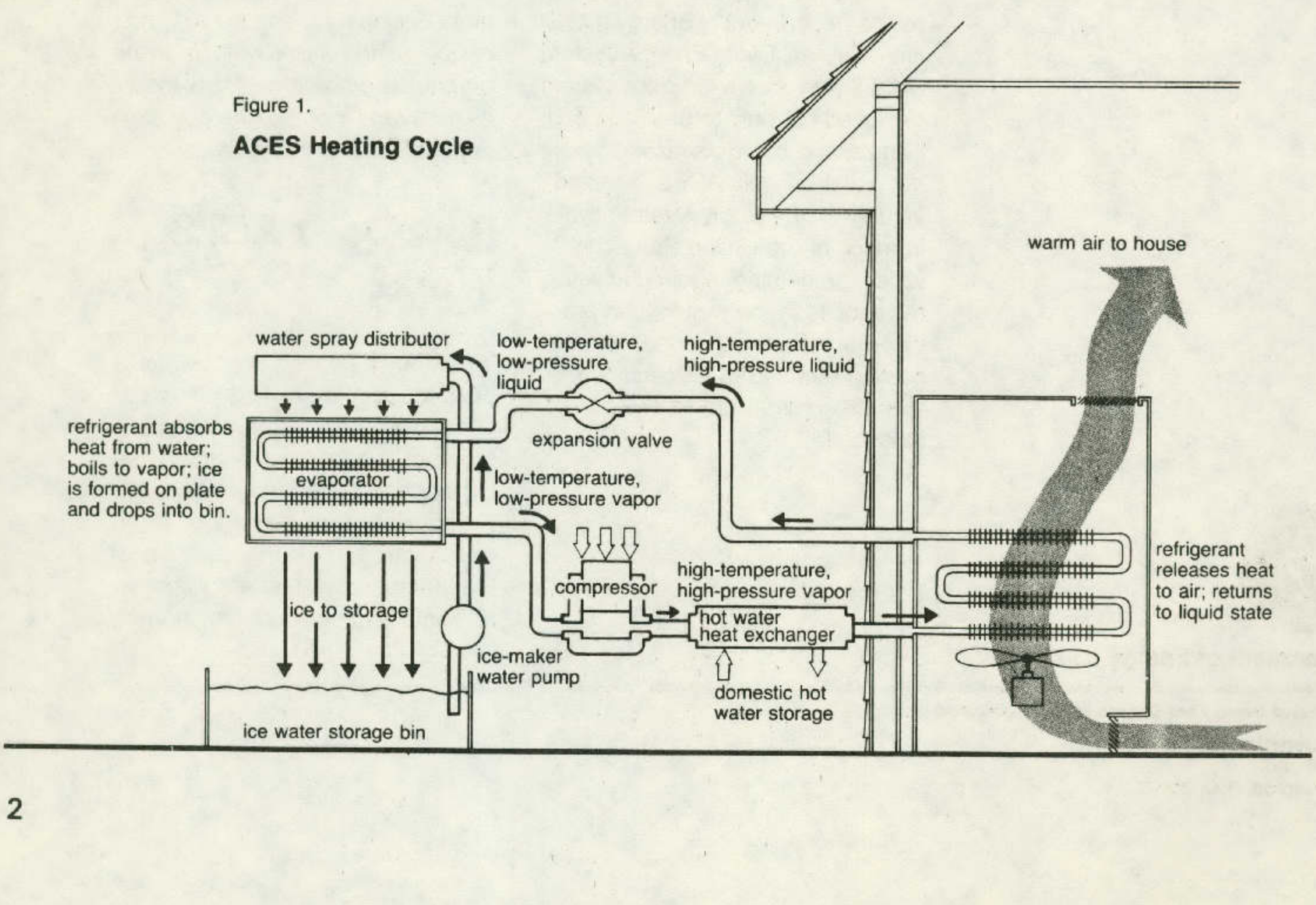
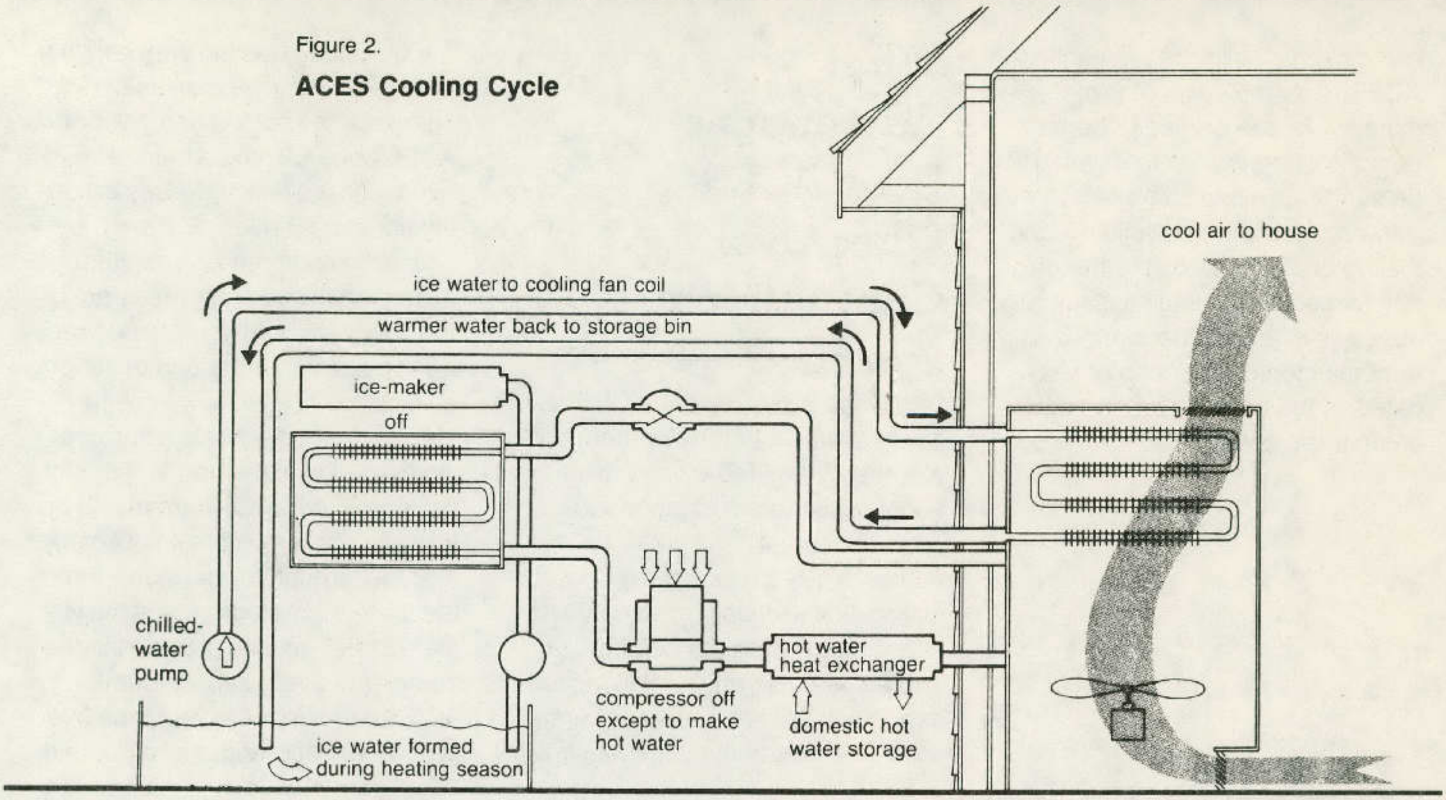


Figure 2.

ACES Cooling Cycle



over a complete annual cycle. Variations in climatic conditions, house usage, and lifestyle, however, all work against an exact balance. The ACES design compensates for any imbalance in annual heating and cooling requirements through the use of auxiliary solar/convector panels and/or external fan coils.

In northern areas of the United States, where the greatest proportion of energy is required for heating, storage of all the ice produced during the heating season would result in an accumulation of excess ice by the end of the winter. To prevent freezing-over of the ice bin, a solar/convector panel can be used to supply solar and convective energy as needed—and as available—to melt the ice. The panel would either be located in a south-facing part of the roof, or designed in the form of a solar fence with vertical panels. Because these panels operate at a low internal temperature (32°F), they are efficient on sunny days even at relatively low ambient temperatures.

In southern climates, where the greatest proportion of energy is required during the cooling season, ACES uses a bin sized to store all the ice generated during the heating season. If the amount of ice stored is not sufficient to meet total summer cooling needs, the compressor operates during the night to generate the additional ice needed. The heat extracted from the water through operation of the compressor is rejected to the environment by means of an air-cooled fan coil. Nighttime operation of the compressor has several advantages: (1) dissipation of the waste heat is more efficient at lower nighttime temperatures, and (2) off-peak electric power rates are available at night in many areas. An artist's conception of a typical application of an ACES with an ice-maker attached to a single-family home in a southern location is shown in Figure 3.

Heating and cooling balances over annual cycles are more difficult to achieve in commercial buildings, which have internal heat sources (e.g., lights, machines, people) and therefore tend to be self-heating. Cooling and load management (e.g., storing the excess heat removed during the day for heating at nights and on weekends) present the greatest difficulties in conventional buildings. A modified ACES that employs a smaller ice storage bin can be used: the heat pump is operated at night, when demand is low and "off-peak" rates may apply, to heat the building, and the ice stored is available the next day for cooling. If heating is not required at night, the heat removed from the stored water can be dissipated to the atmosphere through outdoor fan coils.

What Advantages Does ACES Offer Over Conventional Systems?

Initial results indicate that ACES can save as much as 50-70 percent of the energy needed by a conventional system to heat, cool and provide domestic hot water for a home. ACES saves energy over a conventional system in three basic ways. ***First***, both the heating and cooling outputs of the heat pump are used, with the compressor operating in the wintertime only. Most of the electricity used in conventional air-conditioning systems is consumed by the compressor. ***Second***, ACES does not have a defrost cycle, which causes energy losses in conventional heat pumps. ***Third***, because the compressor operates between input and output temperatures that are both known and fixed, it can be designed to operate at high efficiency.

The efficiency of a heating and cooling system is measured in terms of its "coefficient of performance," or the ratio of energy coming out of the system (as heat) to energy input into the system (as electricity). If the virtually "free" cooling provided in the summer is taken into account, ACES can supply as much as five units of heating and cooling output

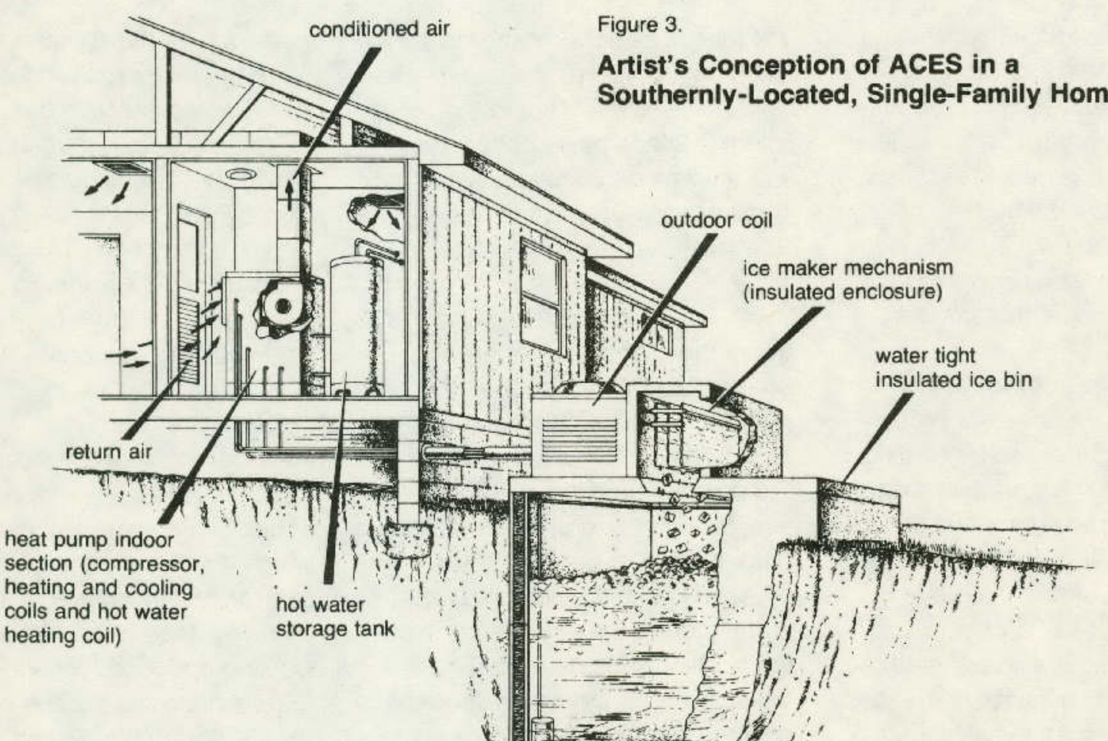


Figure 3.
Artist's Conception of ACES in a Southernly-Located, Single-Family Home

for each unit of electricity input; in comparison, a conventional heat pump provides about two units of output for each unit of electrical input. Like a conventional heat pump, ACES uses energy to transfer and intensify heat that is already available in the surrounding environment. However, unlike a conventional heat pump, ACES' efficiency is independent of outside weather conditions. As a result, even under very cold conditions, the electrical load imposed by ACES is markedly lower than that imposed by a conventional system.

How Does the Cost of ACES Compare with the Cost of a Conventional System?

The initial cost of ACES will be higher than that of a conventional heating and cooling system, primarily because of the cost of the energy-storage bin. Each ACES will be built to suit the specific location, size, and load requirements of an individual home; therefore, the cost of ACES will vary from house to house. Nevertheless, current estimates are that the reduction in utility bills resulting from the energy savings associated with ACES will more than offset the initial cost in most areas of the country.

Storage bin size can be minimized by reducing the heating and cooling load through the installation of optimum insulation and energy-conservation techniques throughout the home. A smaller bin can be used if solar assistance is relied upon for heating in the winter and nighttime compressor operation for cooling in the summer.

The estimated cost of constructing a standard home heating and cooling system with ACES ranges from $3,500-5,000. Though these figures are high, the long-term savings are high. For instance, in a well-insulated 2,000-square-foot home in Knoxville, Tennessee, an ACES application would have a cost payback of 5.3 to 7.6 years.

ACES is made up principally of standard hardware components and must presently be assembled piece-by-piece. As the technology matures and field demonstrations prove the ACES can save significant amounts of energy, complete, prefabricated systems will become available and both equipment and installation costs will decrease.

What is the Federal Government's Role in ACES?

DOE is currently engaged in an extensive program of ACES research, development, and demonstration. Experimental research on ice-maker heat pumps, heat-exchanger coils, and solar/convector panels is being conducted at DOE's Oak Ridge National Laboratory (ORNL). DOE had also awarded contracts to private firms to: study innovative ice-storage bin designs; develop reliable, inexpensive system controls; study the impact of widespread use of ACES and similar advanced heat pump technologies on utility system loads; and investigate the barriers that might impede public acceptance of ACES as an efficient energy-saving device. Two ACES design handbooks, one for residential and one for large commercial installations, are being developed,* and an economic analysis is being performed to determine the potential competitiveness of ACES with conventional systems.

Several full-scale field demonstrations of the ACES concept are also under way. On the campus of the University of Tennessee near Knoxville, an ACES house, a solar house, and a control house have been built as a cooperative venture by DOE, the University of Tennessee, and the Tennessee Valley Authority. Data from all three houses (which are otherwise identical) are being collected and compared. Operational data from an ACES house built in Richmond, Virginia by a private consortium are also being collected and evaluated under a DOE contract, and the demonstration of a load-management ACES installation will soon be under way in

*The commercial design handbook will not be completed before 1980; a preliminary draft of the residential design handbook will be completed in September 1978. Both publications, however, will be highly technical. For more information about these publications, contact the ACES program manager whose address is given under Information Services.

Philadelphia, Pennsylvania. Several privately financed ACES installations, both in residential and commercial buildings, exist throughout the United States.

Large commercial demonstrations of ACES are being presented by the Veterans Administration in their Wilmington, Delaware nursing home, and jointly by DOE and the State of Maryland in a general service and office building to be constructed in Elkton, Maryland.

Information Services

For more information on the ACES concept, contact:

ACES Program Manager
Building 3603
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830

Publications available on ACES include:

Summary of Annual Cycle Energy System (Workshop I)
Date: July 1976
Document Number: ORNL/TM-5243
Cost: $5.00

The Annual Cycle Energy System: Initial Investigation
Date: October 1976
Document Number: ORNL/TM-5525
Cost: $4.50

Design Report for the ACES Demonstration House
Date: October 1976
Document Number: ORNL/CON-1
Cost: $4.50

Copies of the above publications may be obtained from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

EVAPORATIVE AIR COOLING

System Design; Applications for Residential, Commercial, Industrial, Equipment, and Process Cooling; Farm Building, Produce, and Greenhouse Cooling

EVAPORATIVE cooling, properly applied, is the most practical means available today to improve the environment of the worker in hot operations such as mills, factories, foundries, canneries, power plants, etc., in humid and dry climates. Various devices have been developed and manufactured to utilize evaporation directly in the air stream or indirectly to cool the air in a heat exchange process. Today, direct evaporative cooling represents the vast majority of installations, as indirect systems are usually too costly to justify their use.

Evaporative cooling units are being used successfully to reduce the dry bulb temperature and to provide a better environment not only for humans, both at rest and at work, but also for domesticated animals and fowl. In addition, they are often used to improve products grown or manufactured by controlling either/or dry-bulb temperatures and relative humidities. It is the oldest method used in man's attempt to produce comfort. In biblical times,[1,2,3] wetted grass mats and porous jars utilized the evaporative process to cool air or water. Since then, evaporative cooling has been mechanized.

In cases where temperature or humidity must be controlled within very narrow limits, mechanical refrigeration may supplement the evaporative coolers during certain hours when unusual weather conditions occur.

Evaporative cooling equipment, including unitary equipment and air washers, is discussed in Chapter 4 of the 1975 ASHRAE HANDBOOK & Product Directory.

SYSTEM DESIGN

The design of evaporative cooling systems can be broken down into two main categories: (1) to improve environment for people, animals, or process with no attempt to control ambient temperature and humidity (spot cooling); and (2) to improve ambient conditions in a building (area cooling).

The performance of evaporative air cooling for a particular application is determined by the climatic conditions. It is true that the outdoor, wet-bulb temperature governs the ultimate dry-bulb temperature of the air discharged from an evaporative cooler. However, the maximum wet-bulb temperature during warm weather throughout the United States and most of the world has a narrow range of not more than 5 F deg.[11] Therefore, the true capability of the cooler is determined by the elevation of the temperature of the dry bulb above the wet bulb.

Man is always concerned with the removal of heat from his body. In hot areas where ambient heat control is difficult or impractical, man will be cooled when air below skin temperature is passed over him. Evaporative coolers can provide air below skin temperature for this purpose.

The evaporative cooling process involves what is known as an adiabatic exchange of heat. The sensible heat of the air is reduced proportionately to the amount of evaporation that takes place. The water in the cooler, if recirculation is used, assumes the wet-bulb temperature of the air and cooling proceeds with the enthalpy or total heat content of the air remaining essentially constant. The maximum possible dry-bulb temperature reduction is the difference between the entering air dry-bulb and wet-bulb temperatures, which is usually referred to as the wet-bulb depression. If it were possible to cool the air to the wet-bulb temperature, the air would be completely saturated. Since this is not the case in actual practice, evaporative cooling systems operate at less than 100% effectiveness. The efficiency of the system depends upon the depression of the dry-bulb temperature of the air leaving the unit, and may vary from 70 to 90%, depending upon the type of equipment. For personnel cooling in humid climates, maximum saturation efficiency should be 20 to 80%.

When the unit can not provide the conditions desired, the water in the unit is chilled by mechanical refrigeration to provide lower wet- and dry-bulb temperatures and lower humidity. Such an arrangement will reduce the total cost of operation, often by 25 to 40% of the cost of using mechanical refrigeration 100% of the time.

What happens when air is passed through an evaporative cooler is illustrated on a psychrometric chart in Fig. 1.

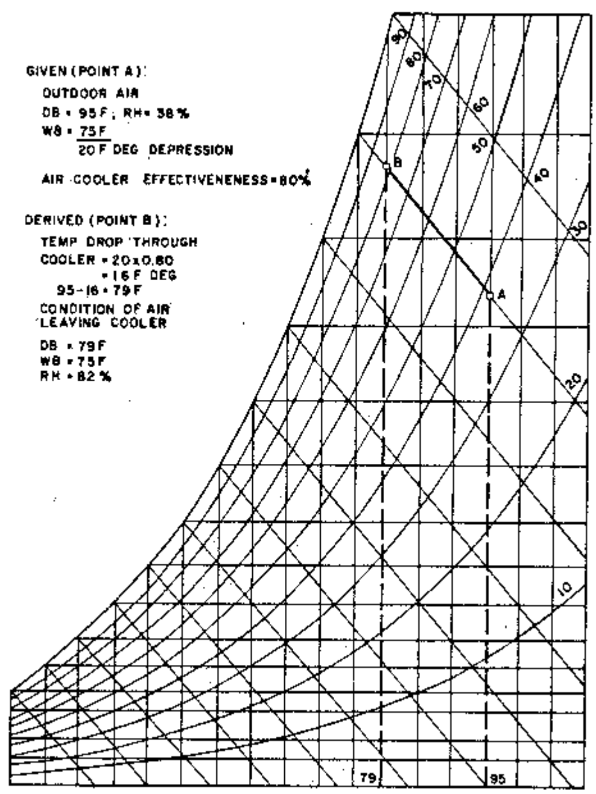


Fig. 1. . . . Example of Evaporative Cooler Effectiveness

The preparation of this chapter is assigned to TC 5.7, Evaporative Cooling.

RESIDENCE OR COMMERCIAL COOLING[4,5,6]

In dry climates evaporative cooling is effective, with lower air velocities than those required in humid climates. This makes it suitable for use in applications where low air velocity is desirable. For residential and commercial application, packaged evaporative coolers are commonly used. Cooler capacity requirements may be determined from standard heat gain calculation (see Chapter 22, 1972 HANDBOOK OF FUNDAMENTALS).

Detailed calculation of heat load, however, is usually not economically justified. It is customary to use one of several rules-of-thumb which, with proper consideration, will give satisfactory results.

One method is to divide the difference between dry-bulb design temperature and coincident wet-bulb temperature (from Table 1) by 10, and consider this to be the number of minutes needed for each air change.

The preceding or any other arbitrary rules for equating cooling capacity with cfm depends on cooler evaporative effectiveness of 70 to 80%. Obviously, it must be modified if unusual conditions exist. Large unshaded glass areas, uninsulated roof exposure, or high internal heat gain are some reasons for modifying the design.

Such empirical methods make no attempt to predict air temperature at specific points in the system. They only establish an air quantity for use in sizing equipment.

Example 1: An evaporative cooling system is to be installed in the one-story office building shown in Fig. 2. Outdoor design conditions are assumed to be 95 F dry-bulb and 65 F wet-bulb. The heat gains which are to be used in the design of the cooling system are:

All walls, roof and doors	78,500 Btuh
Glass area	5,960
Occupants (sensible load)	17,000
Lighting	62,700
Total sensible heat load	164,160 Btuh
Total latent load (occupants)	21,250
Total heat load	185,410 Btuh

Find the required air quantity, the temperature and humidity ratio of the air leaving the cooler (entering the office) and the temperature and humidity ratio of the air leaving the office.

Solution: A temperature rise of 10 F deg in the cooling air is assumed. The air volume required to be supplied by the evaporative cooler may be found from Equation 1.

$$Q_{ra} = q_s/1.08\ (t_i - t_s) \qquad (1)$$

$$164{,}160/(1.08)(10) = 15{,}200 \text{ cfm}$$

where

Q_{ra} = required air quantity through equipment, cubic feet per minute.
q_s = instantaneous sensible heat load, Btu per hour.
t_i = indoor air dry-bulb temperature, Fahrenheit.
t_s = room supply air dry-bulb temperature, Fahrenheit.

This air volume represents a 2.6 min air change for a building of this size. The evaporative air cooler is assumed to have a saturation effectiveness of 80%. This is the ratio of the reduction of the dry-bulb temperature to the wet-bulb depression of the entering air. The dry-bulb temperature of the air leaving the evaporative cooler is found from Equation 2.

$$t_2 = t_1 - e_h(t_1 - t') \qquad (2)$$

$$= 95 - 0.8\ (95 - 65)$$
$$= 71 \text{ F}$$

where

t_2 = dry-bulb temperature of the leaving air, Fahrenheit.
t_1 = dry-bulb temperature of the entering air, Fahrenheit.
e_h = humidifying or saturating effectiveness, percent.
t' = thermodynamic wet-bulb temperature of the entering air, Fahrenheit.

The humidity ratio of the cooler discharge air, W_2, is found from the

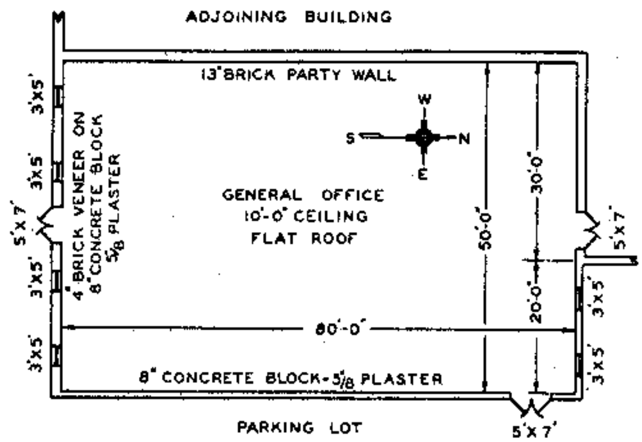


Fig. 2. . . . Plan of One-Story Office Building

psychrometric chart to be 0.01185 lb per pound dry air. The humidity ratio of the air leaving the space being cooled, W_3 is found from Eq 3.

$$W_3 = (q_e/4840\ Q_{ra}) + W_2 \qquad (3)$$

$$= (21{,}250/4840 \times 15{,}200) + 0.01185$$
$$\doteq 0.01214 \text{ lb/lb dry air}$$

where

q_e = latent heat load, Btu per hour.

The remaining values of wet-bulb temperature and relative humidity for the problem may be found from the psychrometric chart (see Fig. 3 for the values in this example). Fig. 4 illustrates the various relationships of the outdoor air, supply air to the space and the discharge air.

In the skeleton psychrometric chart of Fig. 4, the problem is solved graphically.

Using the wet-bulb depression method:

$$\text{minutes per air change} = \text{WBD}/10 = (95 - 65)/10$$
$$= 3.0 \text{ min/air change}$$

$$Q_{ra} = \frac{\text{volume}}{\text{air change rate}} = \frac{80 \times 50 \times 10}{3.0} = 13{,}300 \text{ cfm}$$

While not exactly alike, these two air volume calculations are close enough to result in the selection of cooler equipment of the same size.

Exhaust Required

A consideration of great importance in the design of systems is the need for adequate exhaust from the cooled space. If air is not discharged freely, the static pressure buildup will reduce air flow through the coolers. The result will be a marked increase in the moisture and the heat absorbed per pound of air leaving the cooler, and a reduction in the room air velocity. These effects

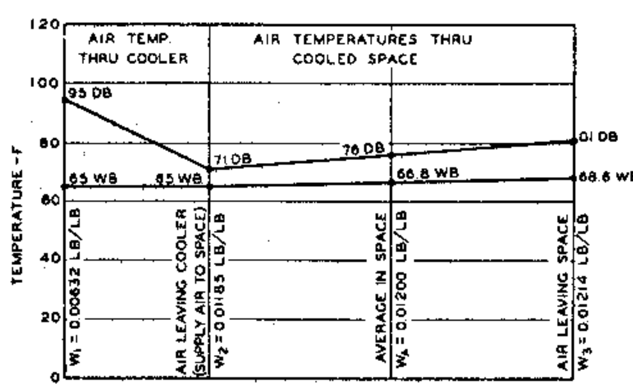


Fig. 3. . . . Conditions Within Evaporative Cooler and Cooled Space for *Example 1*

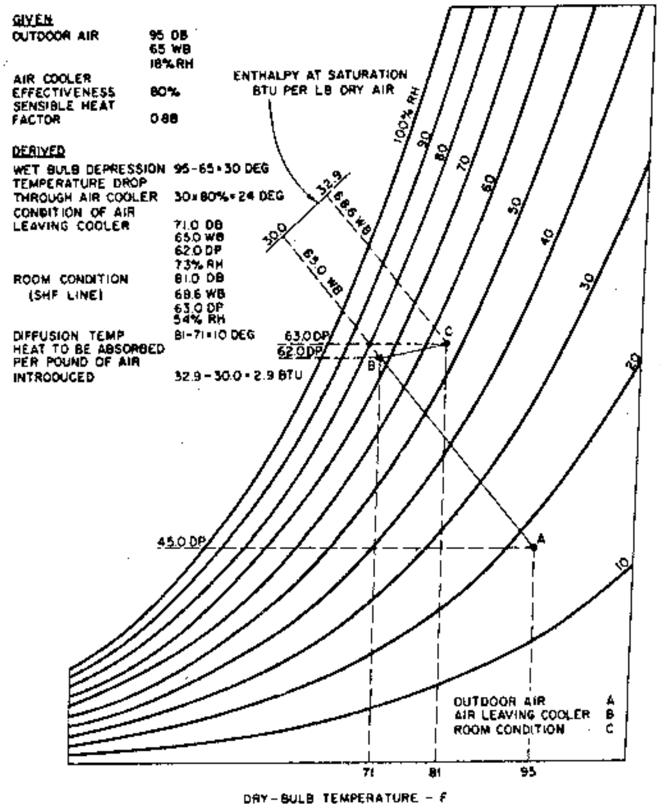


Fig. 4. . . . Solution of *Example 1* on Psychrometric Chart

combine to produce almost certain discomfort. For normal commercial systems with no internal heat emission, the exhaust quantity should approximately equal the quantity of evaporatively-cooled air introduced.

Two-Stage Cooling[7]

The effectiveness of evaporative cooling in producing comfortable conditions depends on the weather; the general limitations are related to the prevailing outdoor dry-bulb and wet-bulb temperatures. The use of two-stage systems for commercial applications can extend the range of atmospheric conditions under which comfort requirements can be met. (For the same design conditions, two-stage cooling will provide lower cool air temperatures and thereby reduce the required air flow rate.) The simplest arrangement is a combination of precooling coils using cooling tower water and evaporative cooling. Fig. 5 is a schematic arrangement of such a system.[8] The air first passes over the coil in which cool water from the cooling tower is circulated, the water and air flow being counter-current for best performance. After being cooled by the coil, the air is further cooled by the evaporative cooler. The precooling coil and tower should be of such a design and arrangement that the temperature of the supply air can be reduced to within 15 F deg of the outdoor wet-bulb temperature. The use of two-stage cooling will often reduce the temperature of the air by as much as an additional 10 F deg for given climatic conditions, and extend the usefulness of evaporative cooling systems.

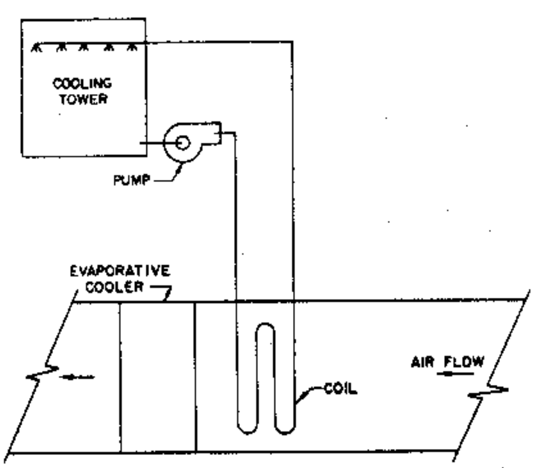
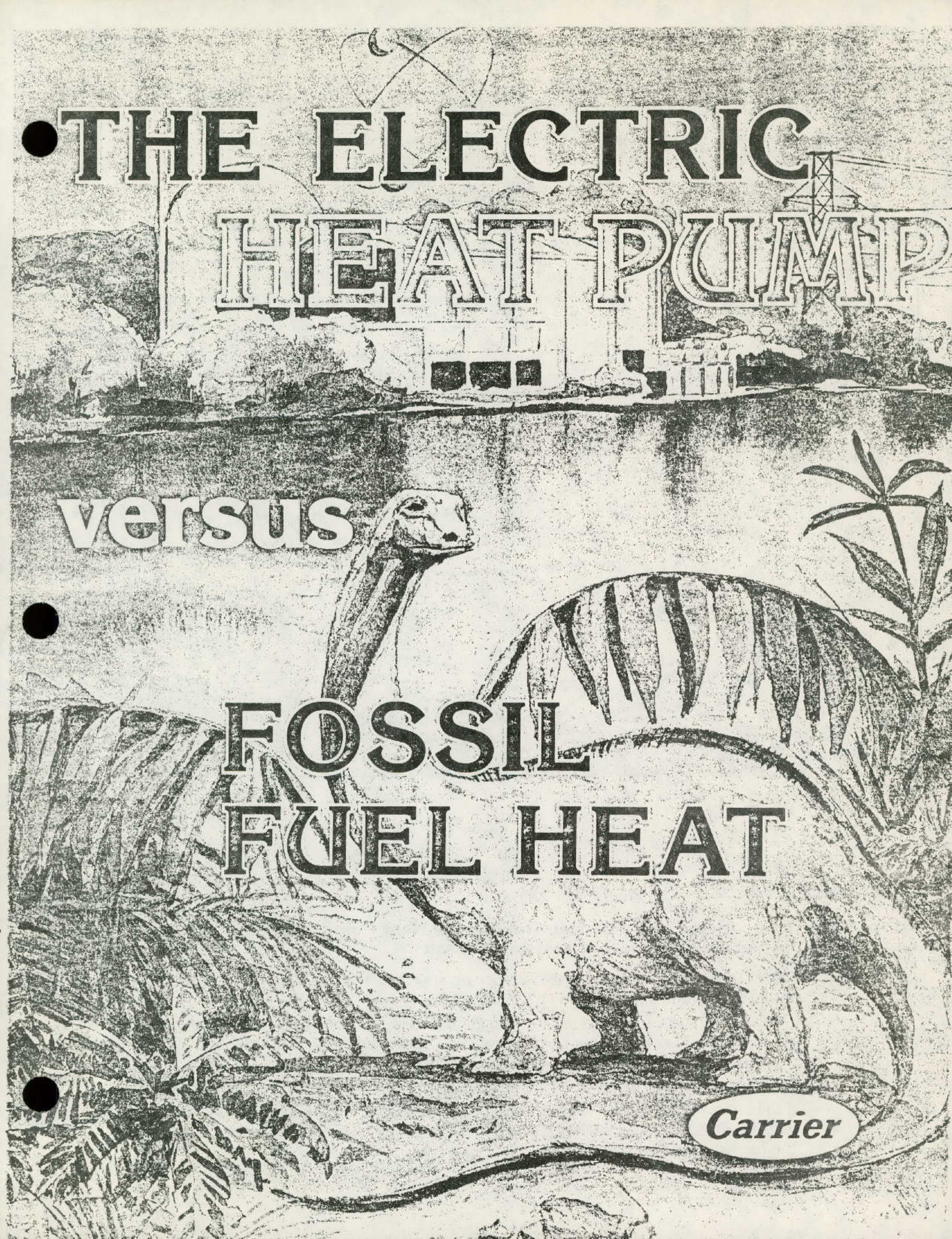


Fig. 5. . . . Two-Stage Evaporative Cooling with Precooling Coil and Cooling Tower

High Internal Load Areas

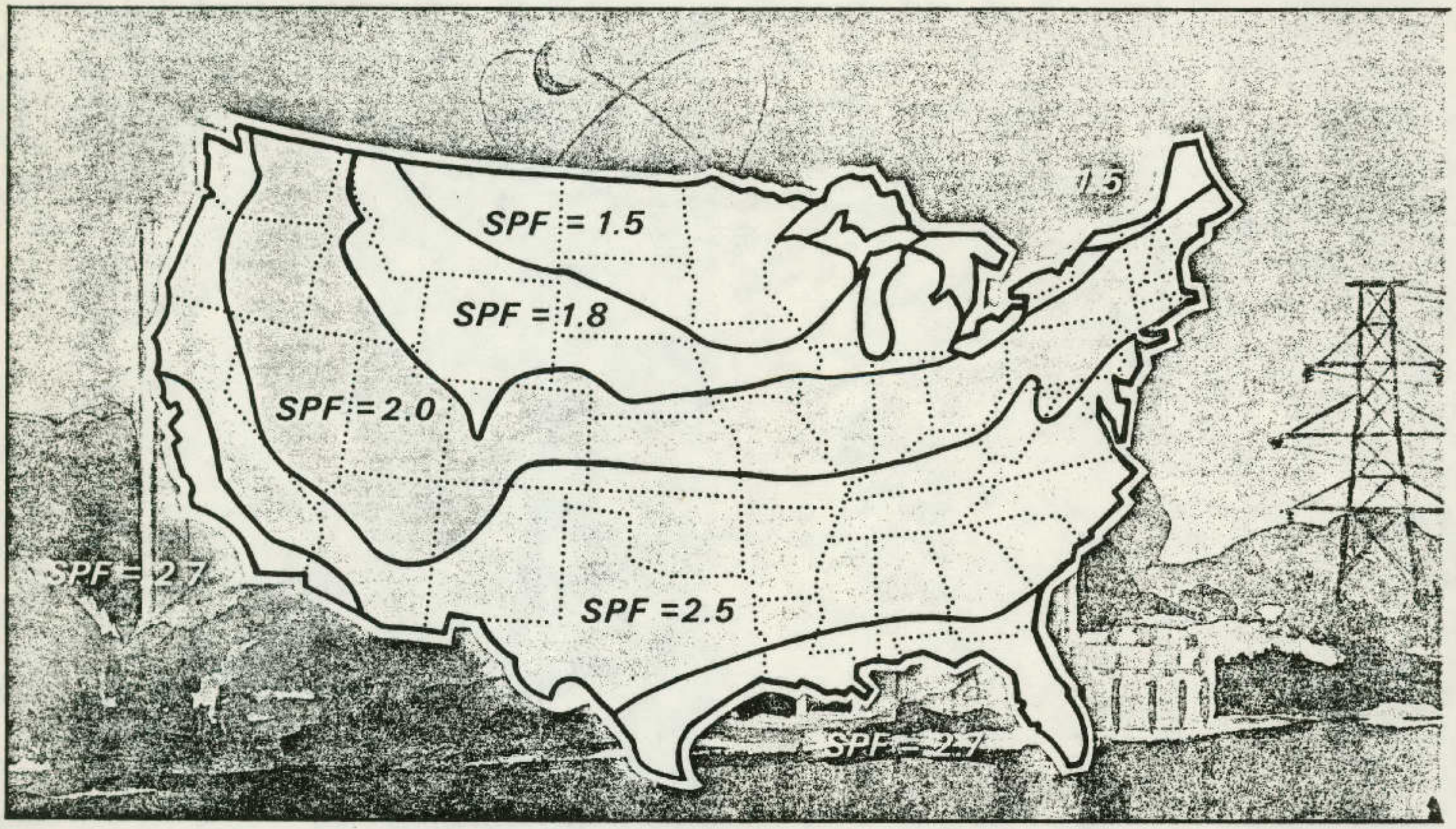
These are similar to conditions found in industrial environments and should be evaluated along the guidelines discussed for Industrial Cooling.


THE ELECTRIC
HEAT PUMP
versus
FOSSIL
FUEL HEAT
Carrier

Which fuel heats best...for less?

Every building owner wants to know, "What is the least expensive way to heat my building? Should I use a Carrier Heat Pump, gas, oil or electric resistance heat?"

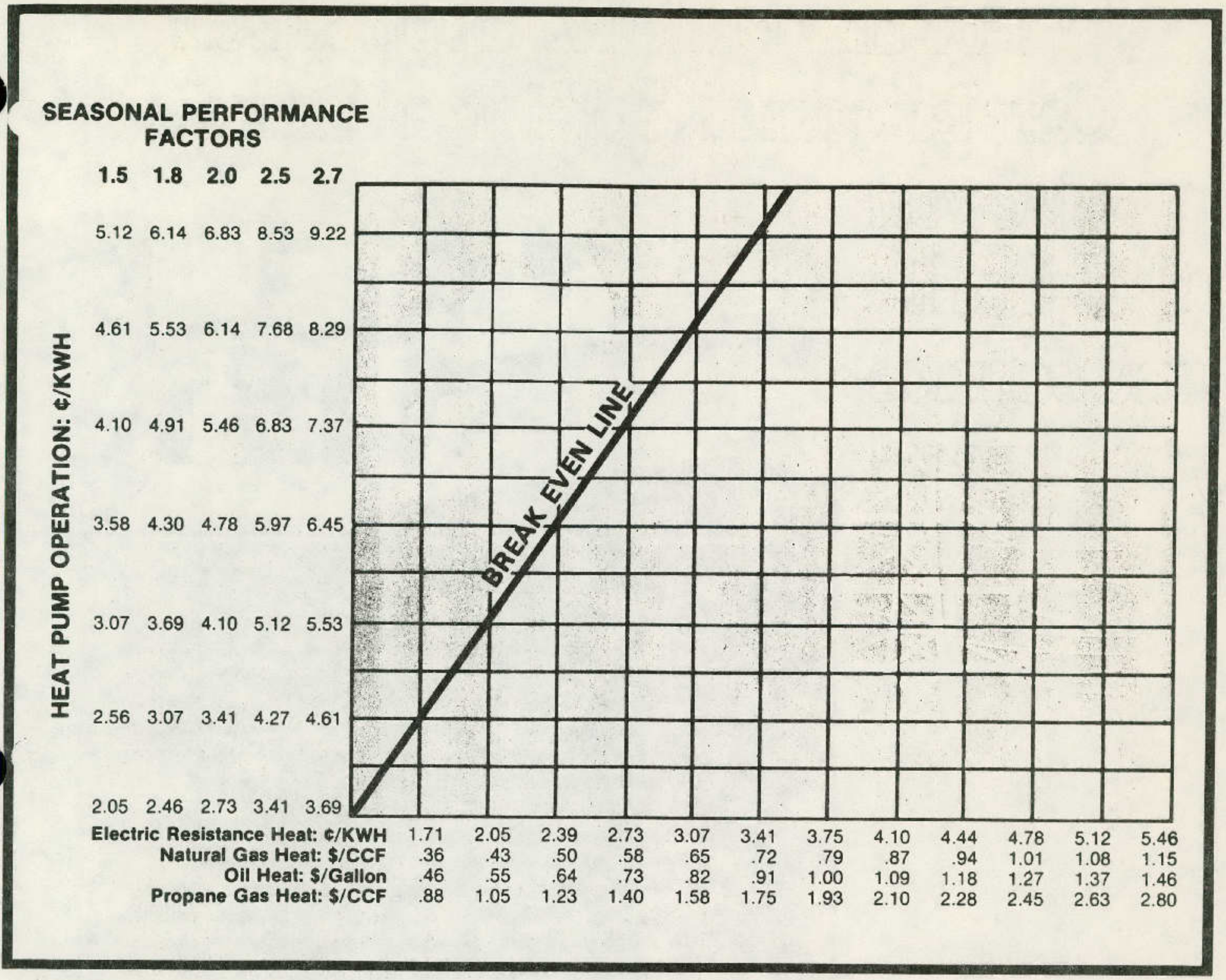
Commercial buildings are more difficult to "energy guesstimate" than homes, and consequently studies can be complex. For this reason, Carrier has developed this easy guide for determining the relative operating cost levels of gas, oil, electric resistance heat, and a Carrier Commercial Heat Pump. This guide gives you a handy working approximation only.



Directions:

To compare the economics of a Carrier Commercial Heat Pump with oil, natural gas, propane gas, or electric resistance heat:

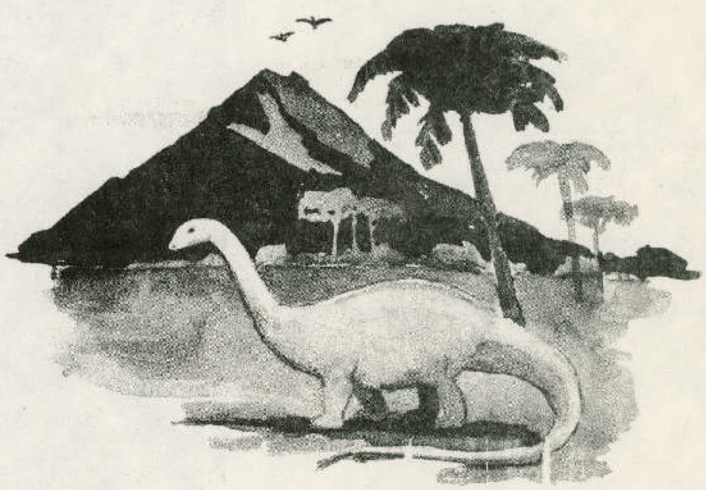
1. Check the Seasonal Performance Factor map shown on this page and find the SPF for your building's geographical area.
2. On the graph on the next page, find your local electric rate (¢/KWH) under your SPF column. From that point, draw a line horizontally on the graph.
3. Next find your local rate for the fuel you wish to compare, along the bottom of the graph. From there, draw a line vertically on the graph.
4. If the intersection of these two lines falls below the breakeven line, heating with a Carrier Commercial Heat Pump would be less expensive than using the fuel you are comparing.



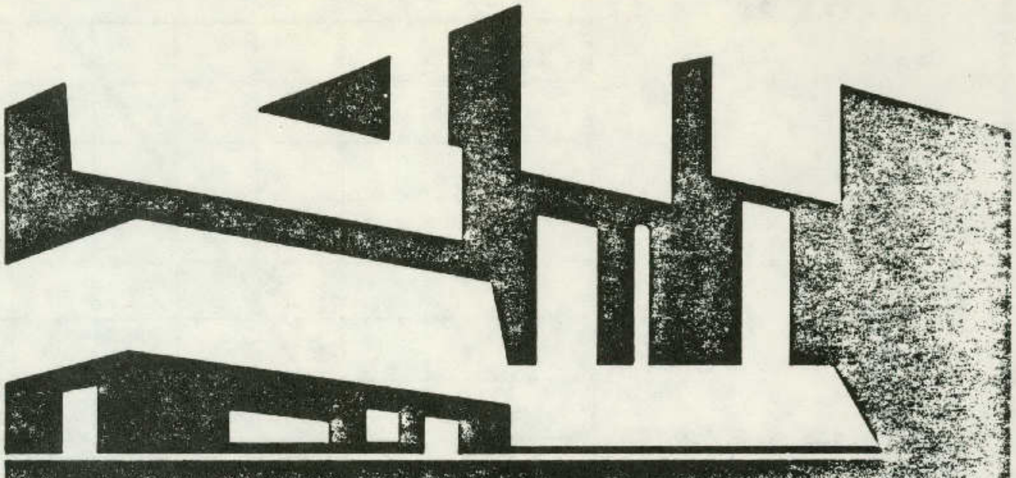
For a comparison of gas, oil and electric resistance heat...

Select any two fuels for relative cost comparison. Find the actual rate for both fuels at the bottom of the breakeven graph. Draw a line vertically from each of the rates. Whichever line intersects the breakeven line first is the least expensive fuel to heat with in your area.

This procedure does not tell you how many dollars can be saved, but it does quickly identify your one or two best energy alternatives. For a detailed actual savings study, contact your local Carrier product supplier. Be sure of your local utility's rates for quantity use, heat pump use, etc. You may qualify for a preferential rating if using electric-source heat.



For any building application, Carrier commercial heat pumps give you the quality and service you expect!



Single package units...

- 5, 7½ and 9 ton sizes.
- Curbed or uncurbed (down discharge or side supply and return).
- Factory-installed options: electric heat, economizer.
- Heat pump qualified hermetic Carrier P compressor.
- Crankcase heater.
- Accumulators.
- Chronotemp Defrost.
- High- and low-pressure switches.
- Over-current and over-temperature protection.
- Signal Loc — protects against short cycling; signals user that correction is needed. Avoids costly repair jobs and electric resistance heat usage.

Split systems...

- Combine outdoor section with indoor unit in mix-match options.
- 5 — 45 tons.
- Semi-hermetic compressors.
- High- and low-pressure switches.
- Crankcase heater.
- Over-current and over-temperature protection.
- Time Guard®, corrects short cycling.
- Accumulators.
- Chronotemp Defrost.

Number One Air Conditioning Maker

Carrier

Division of Carrier Corporation

Syracuse New York

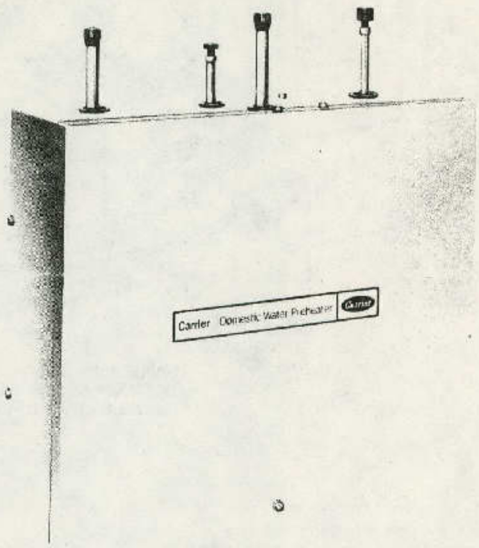
We can't control the weather.
But we can help you control its cost.

850-055 0378 Printed in U.S.A.

Carrier

38
38HQ900011
2800 – 8500 Btuh

Heat Reclaim Device
for domestic hot water systems



...provides up to 9 gallons of free hot water for each hour your air conditioning system runs*

Introducing the Hot Shot, Carrier's unique heat reclaim device that automatically recycles heat energy from your air-conditioning or heat pump system to your domestic hot water.

Reusing energy is like reusing your own money.

The Hot Shot begins paying for itself immediately because it takes heat energy that you've already paid for to air-condition your home, and instead of throwing it away, reclaims it for use in your hot water heater. Here's the basic principle: An air-conditioned home stays comfortable on summer days because heat from hot, humid indoor air is mechanically removed and dispersed outdoors. The Hot Shot takes that unwanted heat and uses it to heat your hot water. Inside the Hot Shot, superheated refrigerant is brought into contact with water (about 60 F), heating it to the desired temperature (about 140 F); then it's delivered to your hot water tank. Whenever your air-conditioning system is running, the Hot Shot adds hot water . . . so in effect, your hot water heater runs significantly less, and your hot water costs significantly less.

Installs in only minutes

The Hot Shot connects quickly, directly to the inlet and outlet lines of your hot water heater. Mounts easily on ceiling or wall.

Quality construction meets HUD requirements.

The light, compact Hot Shot (only 5-in. wide) features a double wall tube-in-tube heat exchanger and a small (1/200 HP) water pump that not only moves water, but also contributes most of its 35 watts to the water heating process as well. The cabinet is lined with thermal/acoustical insulation.

Although recommended for use with Carrier 38CE, CU, EE, GS, SE and UE cooling systems and 38CQ and HQ heat pump systems thru 4 tons (48,000 Btuh), the Hot Shot is also compatible with a wide variety of competitive systems, depending on accessibility of components. Your Carrier representative has the details.

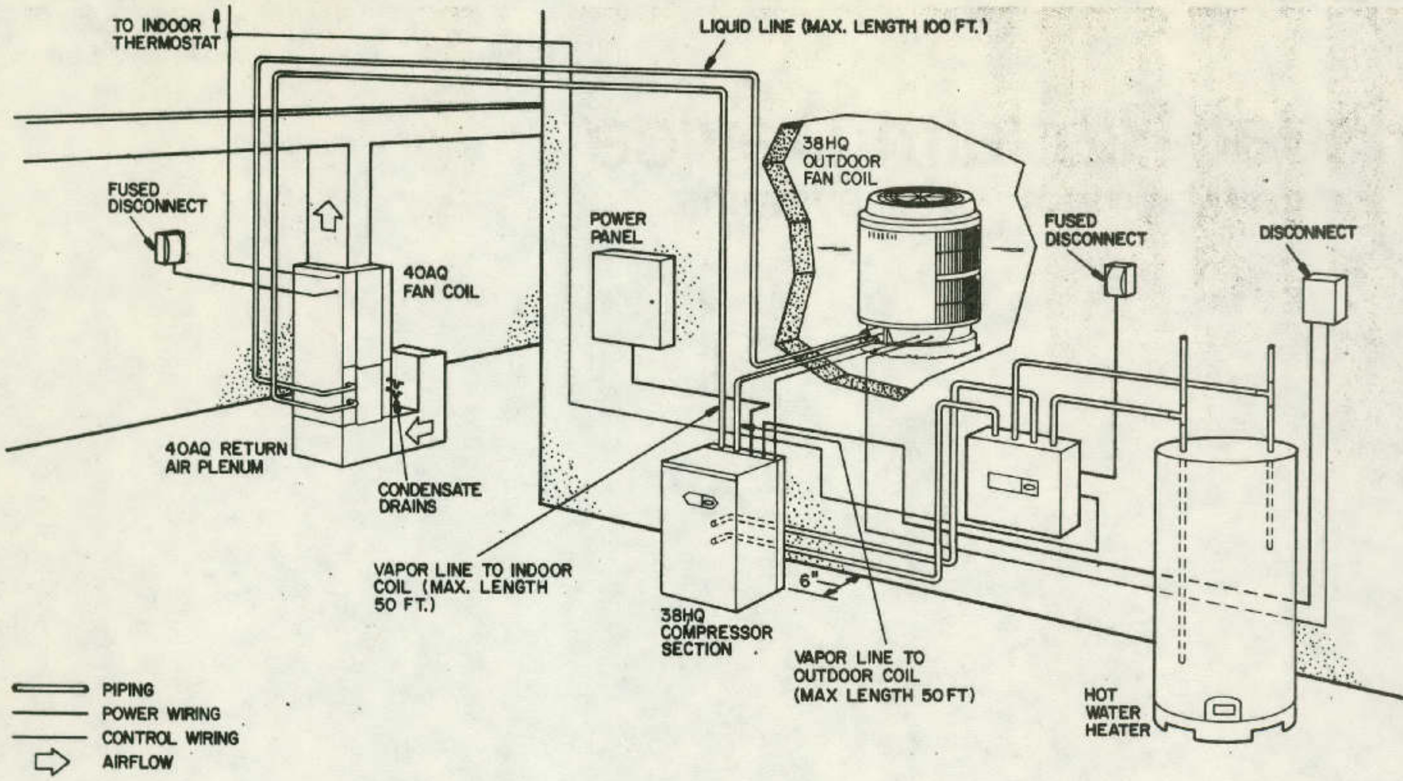
*Based on a typical 36,000 Btuh system with 60 F entering water and 140 F leaving water.

Carrier®

© Carrier Corporation 1977

Form 38-1P

Typical piping and wiring



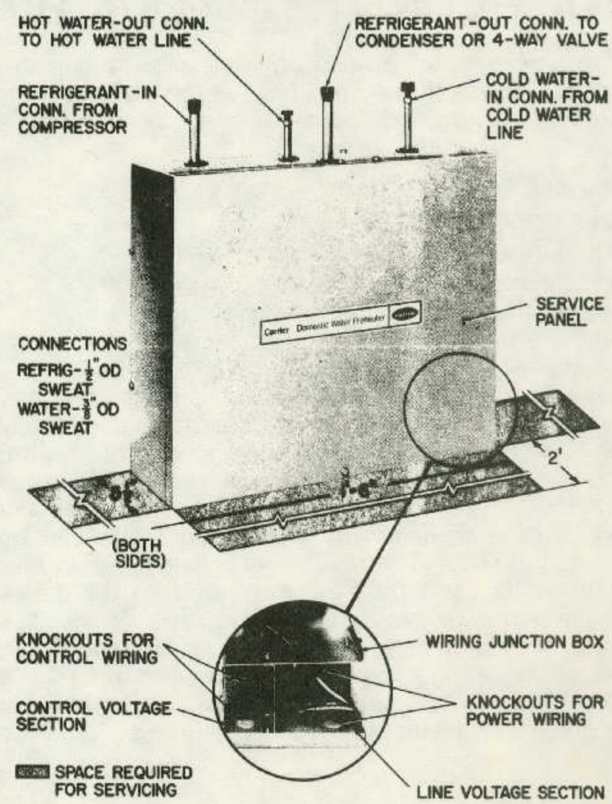
NOTE: Wiring and piping are general guides only. They are not intended for a specific installation.

TYPICAL HOT SHOT PERFORMANCE

AIR COND SYSTEM CAPACITY (Btuh)	HOT WATER SUPPLIED (gph)	UNIT OF ENERGY SAVED PER DAY
18,000	4.7	
24,000	6.0	
30,000	7.3	15.5 Kw of elec
36,000	8.9	76 cu ft of gas
42,000	11.1	.53 gal of oil
48,000	12.7	

Based on 80 F water temperature rise, family of 4 using 80 gallons of hot water per day. For gas and oil hot water heating, an efficiency of 70% is assumed.

Dimensions and connections



Number One Air Conditioning Maker

Carrier

Division of Carrier Corporation
Carrier Parkway • Syracuse, N.Y. 13221

Manufacturer reserves the right to discontinue, or change at any time, specifications or designs without notice and without incurring obligations.

How much will it cost to operate air conditioning?

Like so many other things that were accepted uncritically before the days of energy shortages and rising energy prices, methods of estimating air conditioner operating costs have been subjected to a searching analysis for the first time. Under provisions of the Federal Energy Policy and Conservation Act of 1975, the National Bureau of Standards, the Federal Trade Commission and the Department of Energy cooperated on a year-long study of the theory and practice of calculating air conditioner energy consumption and operating costs.

As a result, the Department of Energy has outlawed "EER" procedures used for many years to estimate air conditioner operating costs. Studies and tests showed that EER-based estimates of seasonal energy consumption were misleading. Use of EER's for such purposes after January 1, 1979 constitutes a deceptive business practice.

The National Bureau of Standards, one of the government's principal scientific agencies, has developed new testing methods by which air conditioner operating costs must be calculated. They correct all the errors inherent in the old EER procedures.

ACCURATE OPERATING COSTS

Instead of figuring operating costs based on an outdoor temperature of 95°F, which represents only a tiny fraction of total air conditioning hours, operating costs are now calculated on the basis of 82°F outdoor temperature. The 82°F temperature was designated as the most common air conditioning temperature for the country as a whole after a nationwide analysis of local weather patterns.

Instead of basing operating costs unrealistically on continuous operation, the new procedures take into account the fact that air conditioner compressors cycle on and off repeatedly. Until they work up to peak efficiency during each "on" cycle, air conditioners produce fewer BTU's per watt of power consumed. Real-life stop-and-go air conditioning, like stop-and-go driving, is less efficient than the purely theoretical continuous operation presumed by EER's.

The new method of calculating operating costs of air conditioning is based on SEER ratings (for "Seasonal Energy Efficiency Ratios"). Test procedures and formulas for SEER's were announced more than a year ago.

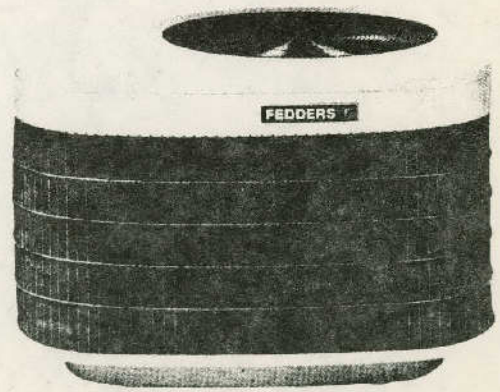
BE SURE . . . INSIST ON SEER OPERATING COSTS

1. *Many air conditioning contractors do not realize that EER-based estimates of operating costs are not legal...or that SEER's must now be used in calculating such costs. They may offer misleading estimates based on EER's because of ignorance of the new law. Be sure to ask.*

2. *Some contractors who are aware that only SEER's may be used in estimating operating costs cannot do anything about it. Many air conditioner manufacturers, strangely, enough, have not yet published SEER's for their equipment.*

3. *It is not possible to convert EER ratings into SEER's. Do not accept claims that operating costs are based on SEER's unless you see a manufacturer's statement of certified SEER's in printed form.*

4. The certified SEER's for all Fedders air conditioners (including air conditioning and heating models) are listed in an adjoining column. *They will enable you to determine accurately what it will cost to operate central air conditioning in your home for the first time.*



OPERATING COST FOR AIR CONDITIONING

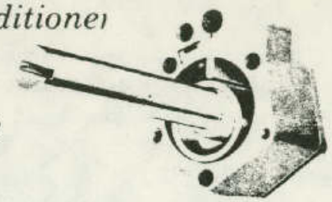
$$\text{Annual Operating Cost} = \frac{\text{BTU's}}{\text{SEER}} \times \frac{\text{Cost Kilowatt Hour}}{1000} \times \text{Hours of Operation}$$

Your Fedders contractor can provide the proper cost per kilowatt hour and the hours of operation for your area from data prepared for this purpose by U.S. Bureau of Standards.

FEDDERS AIR CONDITIONERS

Model No.	Certified BTU's	Certified SEER
Standard Efficiency — Split System		
CFC015F7A	14,100	7.2
CFC018F7A	17,300	6.7
CFC024F3A	22,600	6.8
CFC030F3A	28,600	6.6
High Efficiency — Split System		
CKC018C7A	17,600	7.8
CKC024C7A	23,000	7.7
CKC030C7A	30,400	7.5
CKC036C3A	35,000	7.0
CKC038C7A	36,500	7.8
CKC042C7/8A	40,000	7.6
CKC048C7A	47,000	7.5
CKC060C7A/8A/0A	59,000	7.3
Super High Efficiency — Split System		
CKC025E7A	23,000	9.0
CKC030E7A	29,000	9.3
CKC038E7A	35,000	9.1
CKC042E7A	40,000	8.5
CKC048E7A	48,000	8.1
Packaged Air Conditioner		
CAC024C7A	22,800	7.6
CAC030C7A	29,600	7.2
CAC036C7A/8A	35,800	7.6
CAC042C7A/8A	39,000	7.7
CAC048B3A/8A/0A	46,500	7.1
CAC060B3A	55,000	7.0
Cac060B8/0A	56,000	7.0
Package Air Conditioning/Gas Heating		
CTG024E7A/7B	23,600	7.1
CTG030E7B	28,600	7.0
CTG036E7B/7C	34,200	7.0
CTG036E8B/8C	34,200	7.0
CTG042E7C	41,000	7.6
CTG042E8C	41,000	7.6
CTG048E3C/8C/0C	48,000	7.1
CTG060E3C/3D	56,000	7.0
CTG060E8C/8D	56,000	7.0
CTG060E0D	56,000	7.0

"air conditioner designs which conserve energy"



In an industry which has lived with EER's for many years, the change to SEER's can have important consequences. These were pointed out by the Department of Energy in the Federal Register of Nov. 25, 1977.

"Some central air conditioners are capable of responding better to changing load conditions than others and hence are more efficient over a wider operating range. The industry practice of measuring the efficiency at a single point would not necessarily detect these differences in efficiency. The SEER, however, would provide a means to identify those air conditioners which are more efficient under actual operating conditions. (Data from tests conducted by NBS shows that the EER and the SEER may be significantly different even for single compressor designs.)"

This statement applies with unusual accuracy to Fedders Air Conditioners which utilize Fedders-built rotary compressors. While the new test conditions appear to result in lower SEER's for air conditioners with piston-type compressors than their EER ratings, SEER's for Fedders Air Conditioners are consistently higher than the corresponding EER's would be.

The relatively better performance of Fedders Air Conditioners becomes evident at 82°F which reflects the full range of operating conditions. The outcome was clearly predictable to engineers who studied the volumetric efficiency of rotary and piston-type compressors but could not be expressed under the former test conditions.

"By giving recognition to design innovations which improve overall efficiency, adoption of the SEER will encourage the development of air conditioning designs which conserve energy." That hope expressed by the D.O.E. has already been realized in Fedders Air Conditioners.

FPCC79559

How much will it cost to operate air conditioning

Simple answer to a complex question

The question of air conditioner operating costs involves more than the electric meter in your basement and your electric utility bill. It reflects the basic efficiency of air conditioning equipment produced by manufacturing concerns that have vast sums invested in these products. Perhaps that is the reason why the question of more accurate air conditioning operating costs, mandated in a law passed by Congress in 1975, still remains unanswered by many air conditioning manufacturers.

Here are forthright answers about the cost of operating Fedders Air Conditioners.

9

APPLIANCES

APPLIANCES AND LIGHTING

Current estimates indicate there are more than 1.25 billion appliances in use in approximately 71 million American households, which means, on the average, each home has five major and about 14 portable appliances.

Major appliances use an estimated four to seven percent of the electricity consumed annually in the U.S. Compared with the energy it takes to heat and cool homes or drive automobiles, the total may sound relatively small, but converted into barrels of oil, a 17 percent reduction in the energy consumption of major appliances could save the equivalent of nearly 200 million barrels of oil a year by 1985.

Any reduction in the amount of energy consumed by appliances is determined by two factors -- their operating efficiency and how they are used by the owner. As builders, you can't control how the buyer will operate his water heater or dishwasher, but you can build into his home energy efficient appliances, and appliances which give the owner a greater degree of control of how he uses energy.

As the public's awareness of energy increases a home's saleability increases with the options the buyer is given.

In a recent survey published by Professional Builder Magazine, 89.1 percent of prospective homebuyers indicated they would be willing to spend $600 more in added construction costs to save $100 per year in energy costs for home heating and cooling. Since 1975 the number of people willing to make such an initial outlay has increased 10 percent. While the figures refer to home heating and cooling, they indicate an increased willingness by consumers to pay for deferred gains in energy efficiency.

The same survey found that a buyer's willingness to accept greater initial cost invested in energy efficiency increased with his awareness level. In more meaningful terms, the more information salesmen pass along to the buyer, the higher upfront costs the buyer will accept.

The major energy user in a home, after space heating and cooling, is hot water heating. The Professional Builder survey indicated 87 percent of those questioned would spend $100 upfront in order to realize a yearly savings of $50 in water heating bills. After all, the $100 ends up in the mortgage.

Acceptance of higher costs due to energy saving features added to a home at construction was found to be highest among those who already owned homes and were familiar with the spiraling costs of energy. Even first-time buyers are familiar with the cost of heating, cooling, and operating major appliances. A complete breakdown of the costs of operating appliances and a comparison of relative monthly consumption of gas and electricity in Texas can be found in the appendix to this section.

Many major appliances on the market today offer some energy savings features. Most new models of dishwashers, for example, come equipped with automatic switches that turn off the electric dry cycle. And many brands of ovens come equipped with thicker insulation and improved door seals. The question, then, is which appliances are the most efficient? The easiest way to answer such a question would be to supply you with a list of brands and models classified according to their energy efficiency. Unfortunately, such a list does not exist and will not exist (except in the case of refrigerators which will be mentioned later in this text) until the federal government begins putting its appliance labelling program into effect.

In 1975 Congress passed the Energy Policy and Conservation Act, which directed the National Bureau of Standards to develop energy efficiency test procedures for each type of major home appliance and directed the Federal Trade Commission to issue mandatory labelling rules for manufacturers. The FTC established a list of 13 categories of home appliances for which the energy efficiency improvement targets were prescribed for the first ten product types during 1978. The list of 13 appliance types is:

(1) Refrigerators and refrigerator-freezers.

(2) Freezers.

(3) Dishwashers.

(4) Clothes dryers.

(5) Water heaters.

(6) Room air-conditioners.

(7) Home heating equipment, not including furnaces.

(8) Television sets.

(9) Kitchen ranges and ovens.

(10) Clothes washers.

(11) Humidifiers and dehumidifiers.

(12) Central air-conditioners.

(13) Furnaces.

At this time the consumer should begin seeing the appearance of uniform energy efficiency labelling on all appliances.

Additional explanation on this action is contained in the FTC material included at the end of this chapter.

When the labels appear on products, two types of energy consumption measurements will be prominently displayed. By law, a label must include an estimate of what it will cost to operate the appliance. Because the price per kilowatt hour differs from one area to another, some sort of chart will probably appear on the label so that consumers can determine the dollar savings in their areas. The law also requires that some other form of energy measurement be placed on the label, and this will probably be in the form of an energy efficiency ratio. The ratio is determined by how many BTU's (British Thermal Units) of heat one watt of electrical energy produces in one hour. You can figure an EER by dividing the BTU output per hour by the watts used, as with air conditioners.

$$\text{EER} = \frac{\text{BTU/hr.}}{\text{Watts}}$$

Thus, a 10,000 BTU appliance which requires 2,000 watts of power has an EER of five. EER's usually fall in the range of five to eleven. The higher the number, the more efficient the appliance. For example, a six or seven is fair; an eight or nine is good. The problem with figuring the EER's on existing appliances is that frequently the manufacturer does not supply you with the BTU's an hour of an appliance, and without this information, it is impossible to calculate an EER.

Until recently, some appliance manufacturers were voluntarily labelling their appliances with EER ratings or other forms of consumption measurements under a program sponsored by the U.S. Department of Commerce. The voluntary labelling program was especially successful with air conditioners today with EER's displayed on the nameplates. Other appliance manufacturers, however, abandoned the voluntary program after the federal government announced its new test procedures under the mandatory labelling program. Occasionally you will find an appliance labeled with energy consumption data, but these are old models that were assembled during the voluntary program.

The most important aspect of the mandatory labelling program is that you will have the opportunity to make responsible, energy saving purchases. The program will not prevent you from buying a less efficient appliance, but it will provide you with reliable information so that you can make a choice.

It is expected that Congressional action will, in time, take the most inefficient appliances off the market. A House-Senate conference committee has already agreed to grant the Department of Energy discretionary authority to set new mandatory efficiency standards for 13 major home appliances. This would wipe out the existing non-mandatory efficiency goals proposed by the FEA under the 1975 Energy Policy and Conservation Act. The overall energy consumption reduction target for major appliances was

20 percent, but the new standards are expected to set the reduction target even higher.

Uniform efficiency standards and labelling are coming, but for the present the difficulties in determining energy efficiency are manifold. The rest of this workbook section on appliances contains a great deal of information with which you are, no doubt, already familiar. However, it is presented in hopes it will give you additional consumer-oriented information which will help you sell your energy efficient homes to increasingly energy conscious homebuyers.

Water Heaters

An estimated two percent of all the energy consumed in Texas is used for residential water heating, second only to space heating and cooling as an energy user. For the homeowner, hot water requires about 17 percent of his yearly energy bill. A more complete picture of home energy use may be found in the appendix to this section.

Significant savings are possible in home water heating. The first consideration is whether to use a gas or an electric water heater. The decision is primarily a function of the cost of gas or electric energy in your locale, or whether gas is available to you.

The following table is a simple way to compare relative costs based on energy costs per unit.

Heating Water Fuel Cost Comparison Table

Fuel and Unit	No. Units to Heat 100 Gal.	Price Per Unit, Cents	Cost to Heat 100 gal. 100°, Cents	Gallons Heated Per Cent
Electricity Kilowatt Hour	24.5	1	25	4.0
		3	74	1.4
		5	123	0.8
		7	172	0.6
		9	221	0.45
Gas, natural therm° (100 cu.ft. based on 1000 BTU per cu.ft.)	1.2	10	12	8.4
		20	24	4.2
		30	36	2.8
		40	48	2.1
		50	60	1.7
		60	72	1.4*

*adapted from Consumer's Research

To use the table, determine the current local prices for gas and electricity. Circle those prices and also the figure following in the last column which indicates the gallons heated for each cent spent on fuel. Your choice would naturally be the fuel providing the most hot water per penny spent.

Once the decision to use gas or electric is made, the next consideration is the size of the heater. If the water heater is too large, energy is spent heating unneeded water. Generally, a family of four, with one full bathroom, a clothes washer and dishwasher, needs a minimum water heating capacity of 30 gallons.

When judging the efficiency of a water heater, you must look for the recovery rate (the speed with which the water heater is able to heat its holding capacity of water), the standby loss (the efficiency with which a water heater stores hot water) and the water delivery system. Water heaters that have quick recovery systems also have higher wattages than regular models and therefore use more energy. It is nearly impossible to calculate recovery rates accurately without testing a product overtime, so until the labels are issued, the only thing you can do is avoid buying those models with higher than average wattages or those that advertise higher recovery rates.

The standby loss, on the other hand, is primarily a function of the amount of insulation included in the jacket of a water heater. Select a unit with an extra two inches of insulation with an R-value of at least 11. The accompanying table graphically demonstrates the cost effectiveness of insulation for both gas and electric water heaters. Although this table is based on 1975 costs the effectiveness of the insulation thickness is still meaningful in 1979.

Insulation Thickness (cm)	Energy Savings	Added Cost (1975-$)	Payback Period [a] (yr)	Energy Savings	Added Cost (1975-$)	Payback Period [a] (Yr)
	(50 Gallon Electric)			(40 Gallon Gas)		
5.1	...	...	...	7%	4.9	1.1
7.6	4%	6.1	0.7	10%	10.9	1.9
10.7	7%	12.1	1.0	10%	17.0	2.7
12.7	7%	19.4	1.4	11%	24.2	3.6*

[a] Based on 1975 fuel prices.

* Adapted from energy and Cost Analysis of Residential Water Heaters Robert A. Hoskins, Eric Hirst, ORNL/CON10.

Some manufacturers have increased the efficiency of their water heaters by improving the dip tube. Under normal conditions, dip tubes inside water heater tanks carry cold water at the top of the tank. However, sometimes short draws of water taken in succession can activate the heating element, causing the water in the tank to "overheat" and use more energy. Some dip tubes now come with holes to match those in an outside polypropylene sleeve. When the water at the top of the tank gets too hot, the holes in the polypropylene expand to match the holes in the tube, and cold water is released into the tank. As the temperature in the tank meets the desired level, the holes in the polypropylene gradually close and the temperature stabilizes.

There are several things a builder can do to make a heater more energy efficient before installation. The most efficient water heater is useless if the pipes carrying the hot water to the bathroom or kitchen are not insulated. A one-half inch copper pipe can lose up to 40 BTU's of heat an hour per foot if it is not insulated. Reducing the pipe size will also cut down on heat loss.

Locate the water heater as close as possible to the area which will use the greatest amounts of hot water. Long pipes retain water which cools rapidly. If the bathrooms, kitchen and laundry room are far apart, it's more energy efficient to install two or three water heaters in a home. Set the thermostat for the kitchen water heater at about 130 degrees to ensure good dishwashing operation. The thermostat for the bathroom water heater can be set about 20 degrees lower. Encourage buyers to keep the thermostats at the levels you set.

If you install an electric water heater, locate it in an air-tight closet and insulate the walls. Gas water heaters must draw air, so they should be installed in vented areas. However, don't locate a gas heater where it draws on artifically cooled air in the summer months. This would lower the efficiency of the house cooling system. Instead, try to place gas water heaters in spots where outside air can be drawn in through vents in the floor, or use ducts to pull in the required air.

A few energy conservationists have suggested that timers attached to water heaters improve their efficiency. Such timers would shut off the heating element at times when hot water is not normally used, like during the night. But most experts don't recommend timers because it usually takes as much energy to re-heat the water after the shut-off period as it does to maintain a constant hot water temperature. Timers may have some future value, though, if utility companies adopt off-peak inexpensive electric power rates. Consumers could then set timers to cut off water heaters when electric rates were the highest and cut them back on when rates were the lowest. The system would not save a lot of energy, but it would help to lower consumers' electric bills.

Though primarily in the province of the homeowner, thermostat settings on water heaters offer quick results in energy savings. Tests have consistently shown that a 10 degree reduction in thermostat settings results in a five percent reduction in energy use for both gas and electric water heaters. A 20 degree reduction in the setting reduces electric consumption a significant 10 percent and gas by nine percent.

There are a few innovations in water heater design that could be available on a wide scale in the next few years. For example, it's likely that conventional gas water heaters will come equipped with standard electric igniters and flue dampers. The electric ignition system would substantially reduce the amount of gas needed to heat the tank, and flue dampers would decrease the heat loss. Manufacturers are also working on ways to preheat the water entering the water heater by capturing the waste heat from air conditioner systems. A heat exchanger, is mounted near the air conditioner compressor. The Freon line of the air conditioner is routed through the box and heat from the line is transferred to a water line that goes directly to the water heater. Thus, water entering the water heater tank is preheated and it takes less energy to bring the temperature up to the desired level. This was described in the Mechanical Systems chapter.

While solar water heating is still less economical than conventional water heaters, it deserves mentioning as a possible alternative to water heater design in the future. Present technology already exists for solar water heating, but only time and even higher electric rates will make it economically feasible.

Dishwashers

The two most important things to look for in a dishwasher are the energy saver switch, which allows the owner to turn off heaters during the drying cycle, and models which use less hot water. An average dishwasher used about 14 gallons of hot water per wash, so any model that has shorter wash or rinse cycles is more energy efficient.

When you install a built-in dishwasher, add a layer of insulation to the sides and top if there is room. The insulation will keep the water hotter during the wash, and while this will not directly affect energy usage since the water is not heated in the dishwasher, it will allow more efficient use of hot water and better cleaning at a given temperature.

More energy is used to heat the water that goes into the dishwasher than to run the machine itself. On the average the cost of heating water for the normal dishwashing cycle runs between 15 and 20 cents, and the cost of the electricity to run the machine is less than five cents.

Manufacturers make various claims about the efficiencies of their models, but it is important to note the figures refer only to energy saving rinse and dry cycles, and not to the amount of electricity needed to operate the dishwasher and the energy used to heat the hot water supply.

Ovens/Ranges

The major feature to look for in an oven is increased insulation. Self cleaning ovens generally have more insulation and more effective door seals than standard models. If the cleaning feature is used sparingly, the user should realize substantial energy savings.

There are two types of self-cleaning ovens -- "self-cleaning" and "continuous cleaning." The continuous type is coated with a rough-surface porcelain enamel containing a chemical catalyst which promotes the oxidation of oven spills whenever the oven is operated at moderately high baking temperatures. The other type utilizes a cleaning method known as pyrolytic, which in simplest terms means the decomposition of organic compounds by high temperatures. Temperatures in this type oven may reach as high as 1000^{o} during the cleaning process.

A self-cleaning gas oven works essentially the same way as an electric one. Test results indicate their energy usage for cleaning to be somewhat less than self-cleaning electric ovens.

If you plan to install a gas oven or range, look for those equipped with electric igniters. These devices replace extremely inefficient pilot lights by igniting the fuel electrically. Pilot lights can burn up to 40 percent of the energy used by gas ranges and ovens.

Another consideration is the installation of a microwave oven which is much more efficient than a conventional oven or range. A microwave oven used in conjunction with a conventional oven for tasks such as baking could save the average family about 12 percent of its annual energy used for cooking. The payoff for such an investment is relatively long, but if the family were to use the oven for half its cooking needs, the payoff could be reduced to between five and six years. Another factor to be considered is the lack of radiant heat put off by a microwave oven. During the cooling season such waste heat can put a considerable load on air conditioning equipment.

Refrigerator-Freezers

Condominium and apartment house builders are faced with the decision of what kind of refrigerator to buy for a unit. The typical refrigerator uses on the average of three kilowatt hours of electricity a day, which amounts to up to 18 percent of the electricity consumed in the home.

In the last few years refrigerator manufacturers have come a long way in improving the efficiency of their refrigerators. Some models now offer more insulation in the walls of cabinets and power saver switches that shut off tiny heaters that keep condensation from forming on refrigerator and freezer doors.

Typically, a refrigerator has approximately one and three-fourths inches of insulation in the walls of the cabinet. Look for the models that have two inches of insulation around the refrigerator section and two and one-half inches of insulation around the freezer section. Be sure that the insulation is urethane foam and not fiberglass. Foam insulation has about twice the insulation value per inch of thickness as does fiberglass.

You won't have much trouble finding out how much insulation a refrigerator has because increased insulation is usually a big sales feature. Amana, for example, boasts that its special line of energy savings models can save the buyer from $208 to $417 a year in operating costs, depending on the rate per kilowatt hour in each area of the country. The company provides the prospective buyer with charts that compare energy usage and dollars saved in the operation of every major refrigerator line presently on the market. Other companies such as General Electric and Whirlpool also provide the buyer with comparable material.

Many manufacturers are also beginning to offer power saver switches which, under optimum conditions, can save as much as 16 percent of the electricity used by a refrigerator. To minimize cabinet condensation in hot, humid weather, refrigerators come equipped with heater strips inside the doors to keep the outside from sweating. This heating element is not needed under cool conditions, and a switch will allow the owner to turn the heaters off. There are a few refrigerators now on the market that circulate waste heat from the motor to the door to prevent condensation. If the weather is hot and humid year 'round, some experts say, this method is more efficient than the heater system.

As with the water heater, be sure you select a refrigerator that is not too large for the family that will occupy a home. Also be careful not to design the kitchen so that the refrigerator will be next to the heat source, such as an oven, range or dishwasher. And check to see that there is at least one inch of air space across the back and on both sides of the refrigerator to prevent overheating.

It goes without saying that a refrigerator with a lot of "extras" will usually use more energy. Avoid the automatic ice makers and cold drink dispensers. They're nice, but energy wasteful.

Some frost-free refrigerators use up to 50 percent more energy than the regular defrost type. Until the labels come out it will be hard to tell which ones use more energy. In the meantime, use this as a rule of thumb -- stick with models that require only occasional manual defrosting in the freezer section. A total manual defrosting refrigerator will actually use more energy because as the frost rapidly collects on the evaporator coil, the unit will not cool properly and will run longer. A total automatic defrosting system will use more energy because the heating strips inside the walls to defrost the unit will cut on more frequently.

One source of information for comparing the energy usage of various refrigerator models and brands is the 1977 Directory of Certified Refrigerators and Freezers published by the Association of Home Appliances Manufacturers. The information in the book is not completely accurate because it covers only 1977 models and the association will not publish another directory until the federal labels are issued. However, the directory will give you some idea of which refrigerators have outstanding energy efficiency records. It can be ordered for $3.50 directly from AHAM, 20 North Wacker Dr., Chicago, Illinois, 60606.

Washer/Dryer

Washers and dryers use a relatively small portion of the average household's total energy consumption, but savings can be made if certain rules of operation are observed.

As is the case with dishwashers, the greatest use of energy connected with a washer is not in the actual operation of the machine, but is in the expenditure of energy to heat the water.

Except for extremely heavily soiled fabrics, hot water is not necessary for effecive cleaning. The use of warm, or even cold water in the washing cycle is the most effective energy-saving step which can be taken.

In selecting an energy-efficient washer you should be sure that the model you select has a minimum of three combinations of wash-rinse cycles. They should be hot-cold, warm-cold and cold-cold. It has been demonstrated that a cold-water rinse is just as effective as a warm or hot rinse for any kind of washing, and in the case of permanent press washing is superior.

If the user decides to use a hot or warm-water wash cycle, the most efficient washer is one which uses the least water for a given washer capacity. Several models do better than others at water conservation, which in turn means a lower water heating load and a savings in energy.

Many brands of washers offer machines with sudsaver cycles. Following the wash cycle the wash water is collected in a container and retained for the next washer load. Second-hand suds are demonstrably less effective than fresh suds, so it is up to the individual consumer to determine if the savings in detergent and the marginal energy savings realized by saving hot water which will cool considerably between loads is worth it.

An aid to increased dryer efficiency is an effective spin cycle which removes as much excess water from the clothes as possible.

In the case of selecting a dryer, once again, you must choose between a gas or electric one. The same criteria used to decide on the type of water heater to install applies to dryers.

The major savings in energy which can be realized with a dryer are almost totally dependent upon the user. Steps he can take include shortening the dryer cycle by periodically checking the clothes in the dryer and removing articles as soon as they are dry, and keeping the lint filter clean to allow a free flow of air through the tub.

Disposal

Next to a water heater and a dishwasher the most likely appliance a builder will install is a garbage disposal.

Little can or need be done to conserve energy here. A typical 500-watt unit can be operated five minutes per day with only one and one-quarter kilowatt hours of electricity each month. At the average cost of five cents per kilowatt hour the consumer can have the convenience of a garbage disposal for an energy cost of about six and one-quarter cents per month.

About the only practical conservation consideration with the disposer is the saving of water, and since most manufacturers do not recommend the use of hot water with their units, any savings in this area would be negligible.

Lighting

The typical household uses 22 percent of its total electrical consumption for lighting. A considerable savings can be realized by the judicious selection of bulbs of the proper wattage and the best fixtures, either incandescent or fluorescent.

Selecting the bulbs to be placed in fixtures is one of the easiest steps to take. Bulbs are usually selected by their wattages, a valid means in most cases, but the most accurate measure of a bulb's lighting power is the amount of light, or lumens, it produces. Any lamp which can produce more lumens using fewer watts is an energy saver.

One should avoid so-called long-life bulbs. They produce fewer lumens while using the same number of watts as standard bulbs of the same rated wattage. If you can get by with less illumination in a given application you will be much better off from an energy usage standpoint with bulbs of lesser wattage.

As a general rule, the smaller an incandescent bulb the less efficient it is. For example, a 100-watt bulb puts out more illumination than two 60-watt bulbs while using less energy.

Fluorescent lamps are the choice for greatest energy savings because they are much more efficient than incandescents. A 40-watt fluorescent lamp produces more light than a 100-watt incandescent bulb, but uses less than half the electrical energy.

Another factor to consider when choosing between fluorescent and incandescent lighting is the amount of heat produced by each. A fluorescent tube produces much less heat than an incandescent of the same illumination. Here in the Southwest, where cooling season energy loads are approximately equal to the heating season loads, the use of fluorescents to prevent the heat gain which must be removed by air conditioning equipment is a wise energy-saving decision.

Some consumers object to fluorescent lighting because of the manner in which it renders colors, particularly skin tones. Warm tone fluorescents are available which provide a color rendition closer to that of natural light than incandescents can achieve.

There are a number of other steps a builder can take to increase the energy efficiency of home lighting.

Dimmer switches which allow the regulation of lighting levels to suit the needs of the individual at a particular time should be installed. Smaller bulbs can be used in fixtures intended to provide general or fill lighting.

Security of safety lights should be controlled by electric eyes which operate the lights only during hours of darkness. Where practical, spotlight bulbs or fixtures can be used to provide more intense light for work areas or accent lighting. Another lighting measure, which, unfortunately, is at the whim of current fashion is the selection of wall and ceiling colors for their reflectivity. The color of rooms affects natural lighting. Dark colors will absorb light and create the perception of less light while light colors tend to reflect light and thereby contribute to the illumination level in a room. By proper selection of colors, one can increase the illumination level of a room by as much as 30 footcandles without any change in the source of light. Consider using colors that will give reflectances in the following range:

Ceiling finishes	--	80-90 percent
Walls	--	40-60 percent
Floors	--	21-39 percent
Furnishings	--	26-44 percent

The selection of efficient artificial lighting and effective natural lighting and careful consideration of interior finish can reduce the energy requirement for lighting.

A final note on natural lighting. As discussed in the Heat Flow section, windows are a significant source of heat loss during the winter and heat gain during the cooling season. In general, these gains and losses tend to offset the benefits of natural lighting when window area exceeds 8 to 10 percent of total wall area.

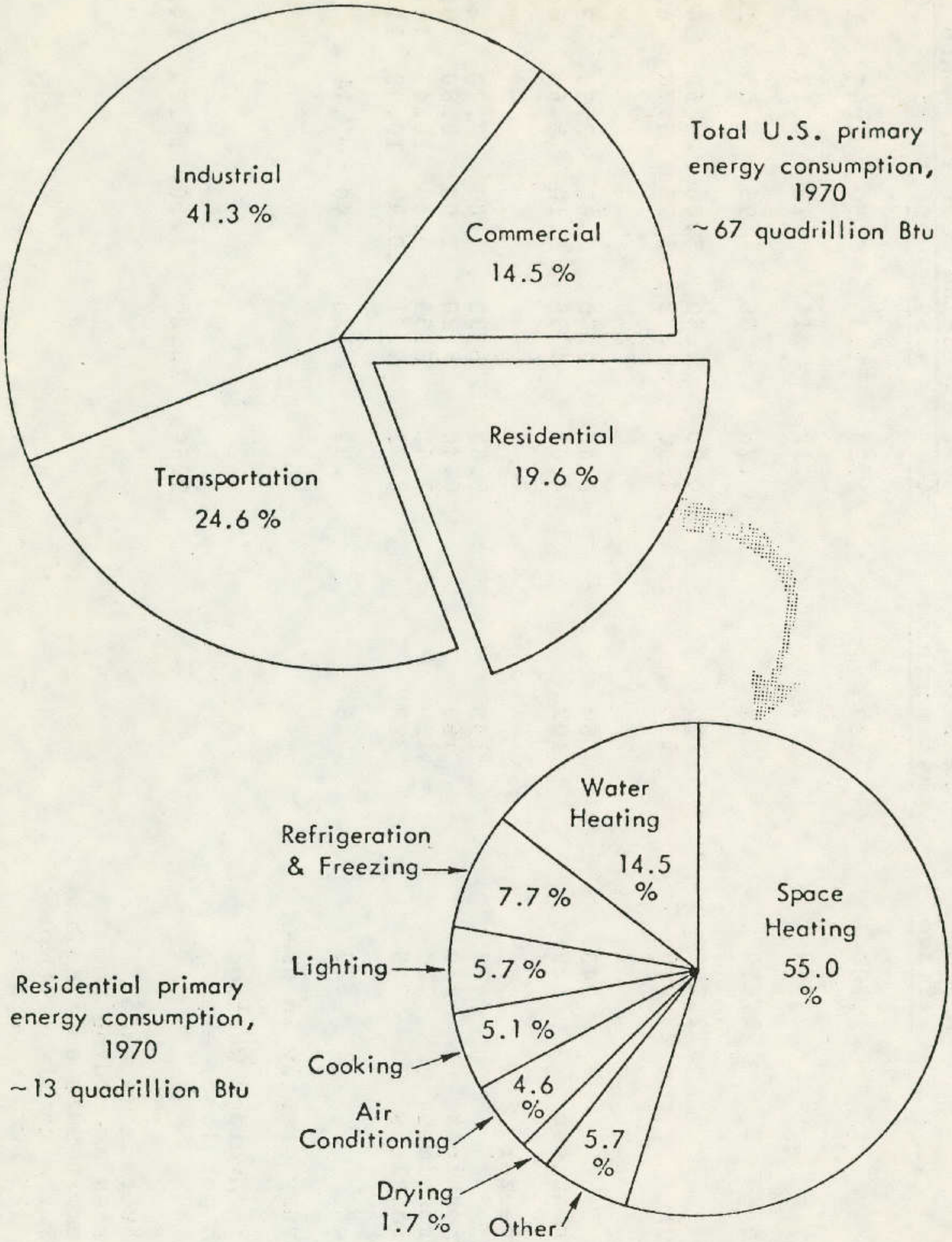
If you want to take the time, there are three other sources you can turn to for more information on the efficiency of refrigerators and all other major home appliances. The State of California has recently adopted a thorough set of appliance standards that set minimum efficiency levels for appliances sold in California. The standards outline in detail the design requirements for each appliance. Any federal appliance standards that may be adopted by Congress will probably not be much stronger than the California standards. You can get a copy of the California standards by contacting the Conservation Division of the California Energy Resources Conservation and Development Commission, 1111 Howe Avenue, Sacramento, California, 95825.

Another valuable source of information regarding the federal labeling program is the federal test procedure regulations that have been published in the Federal Register. The regulations will not rate brands according to their efficiency, but they will tell you how the appliances were tested and what the federal government considers important in evaluating their energy efficiency.

Finally, try contacting your local utility company. Most utilities have personnel that can answer questions about appliances and some will even make suggestions as to which models you should purchase.

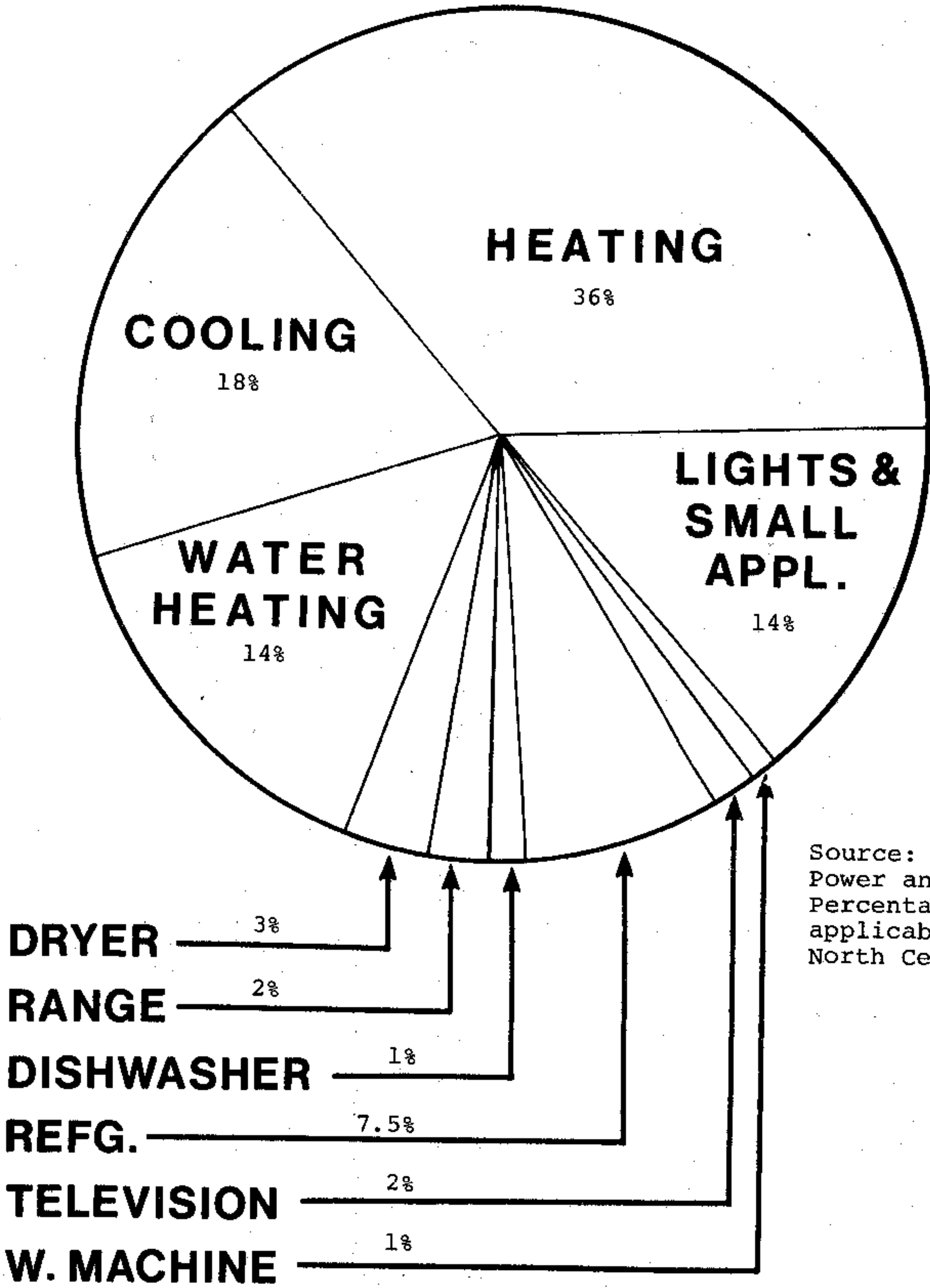
AVERAGE OPERATING COST OF ELECTRICAL APPLIANCES

Appliance	Average Wattage	Est. Ave. kwh Monthly	Ave. Operating Cost Per Month At 4¢	4.5¢	5¢	5.5¢	6¢
Dishwasher	1,200	30	1.20	1.35	1.50	1.65	1.80
Disposal	440	3	.12	.14	.15	.17	.18
Oven (Microwave)	1,450	19	.76	.86	.95	1.05	1.14
Range and Oven	12,200	100	4.00	4.50	5.00	5.50	6.00
(Self-Cleaning)	12,200	105	4.20	4.73	5.25	5.78	6.30
Refrigerators							
12 cu. ft	240	60	2.40	2.70	3.00	3.30	3.60
12 cu. ft., Frostless	320	102	4.08	4.59	5.10	5.61	6.12
Refrigerator-Freezer							
14 cu. ft.	475	140	5.60	6.30	7.00	7.70	8.40
14 cu. ft., Frostless	610	160	6.40	7.20	8.00	8.80	9.60
18 cu. ft., Frostless	720	190	7.60	8.55	9.50	10.45	11.40
21 cu. ft., Frostless	750	218	8.72	9.81	10.90	10.99	11.08
Automatic Washer	510	8	.32	.36	.40	.44	.48
The following vary greatly in use:							
Clothes Dryer - Average wattage 5,000 - 2.4 kwh per load, Ave. cost per load			9.6¢	10.8¢	12.0¢	13.20	14.40
Water Heater- Average wattage 4,500 - Use varies according to family size, temperature setting and amount used. For a family of three average use is 325 kwh. Average cost per month			$11.38	$13.00	$14.63	16.25	17.88



— Residential energy use in the United States

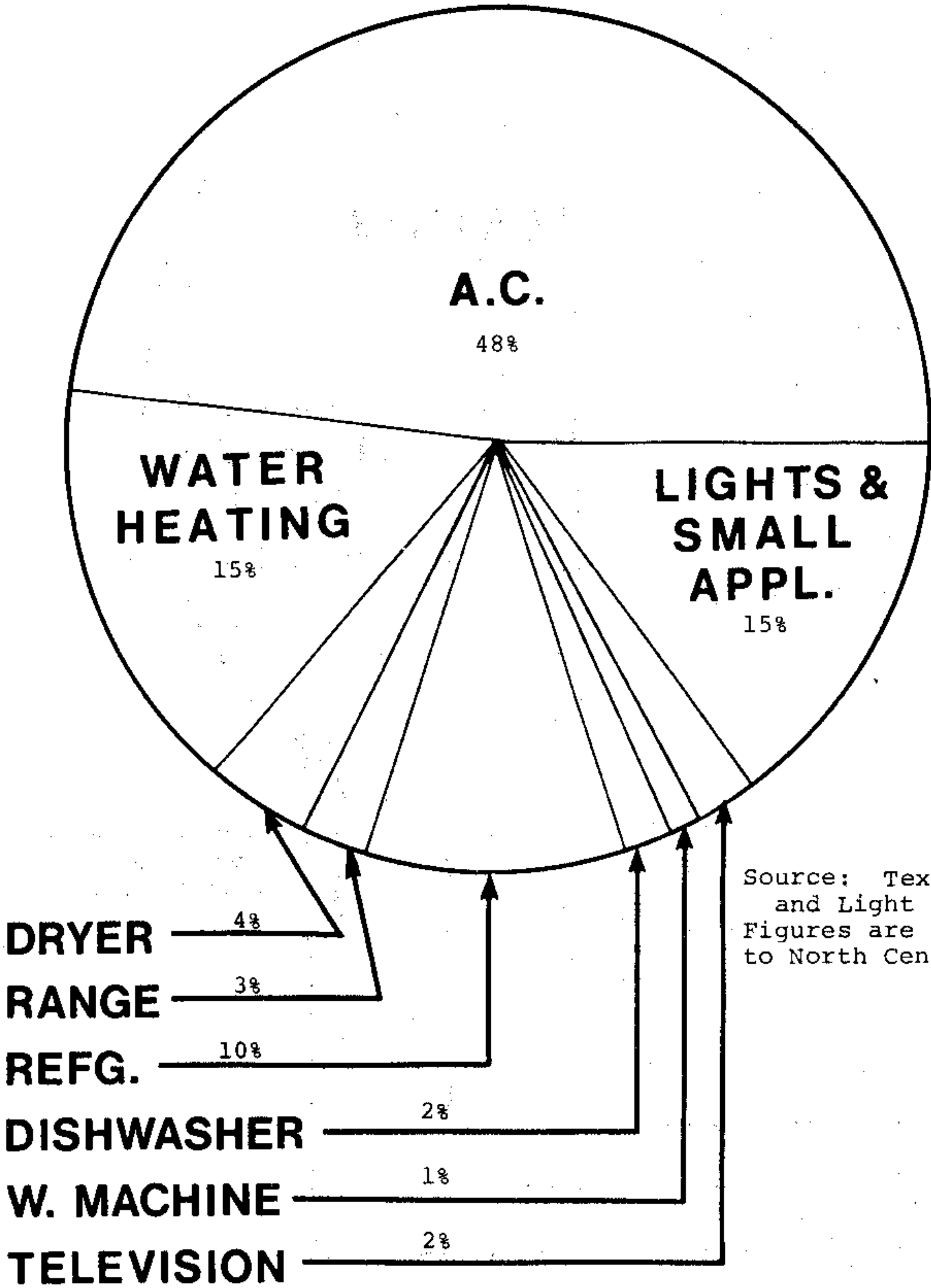
AVERAGE ANNUAL KWH BY APPLIANCE



Source: Texas Power and Light Co. Percentages are applicable to North Central Texas

AVERAGE SEASONAL KWH BY APPLIANCE SUMMER

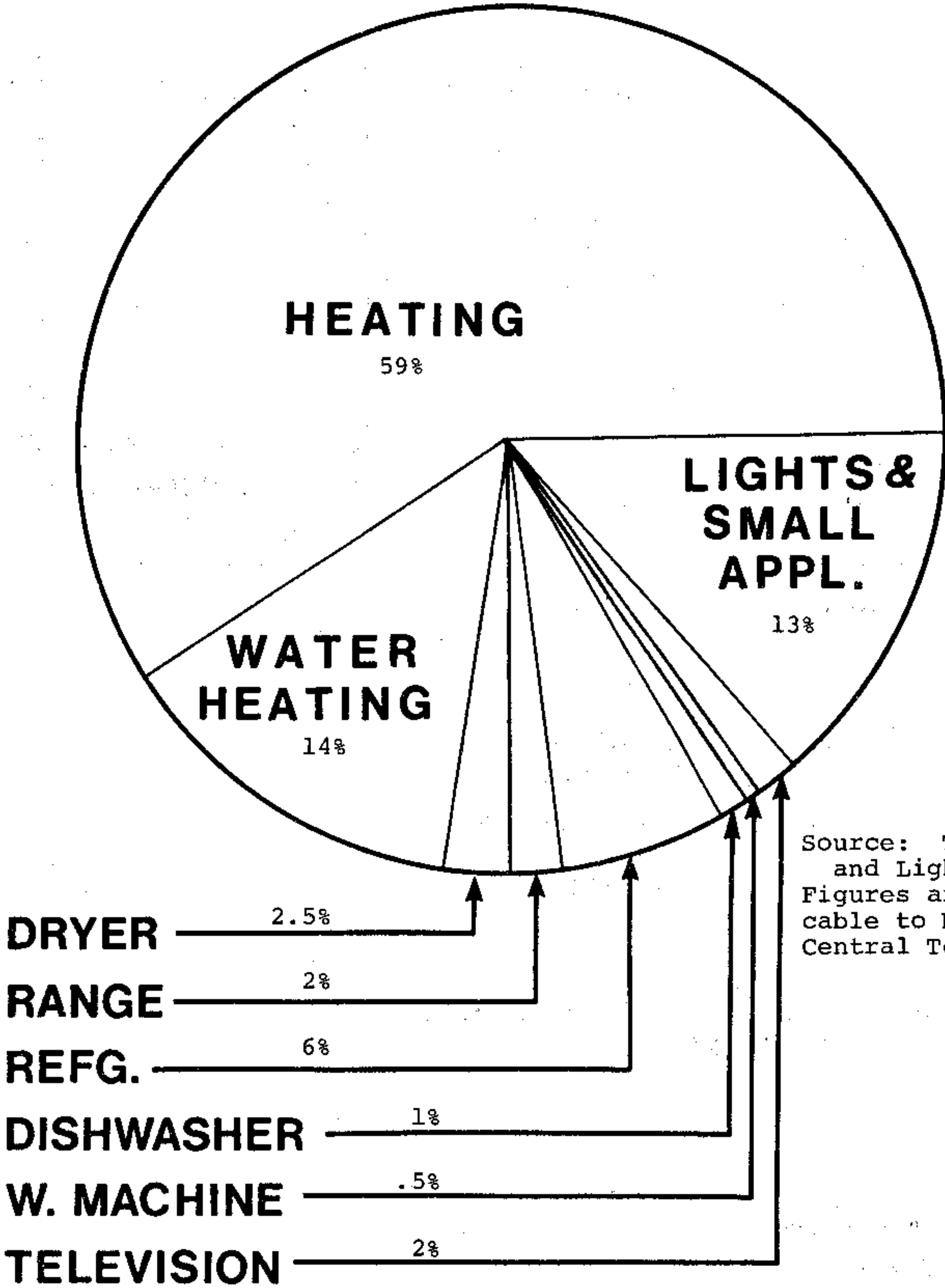
Texas All Electric Homes



Source: Texas Power and Light Co.
Figures are applicable to North Central Texas

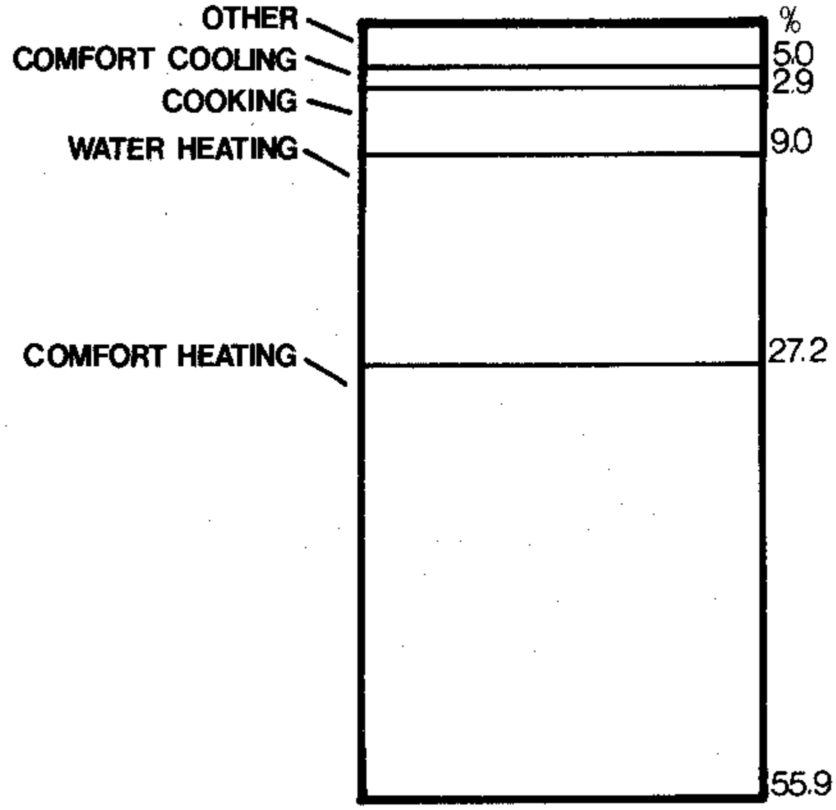
AVERAGE SEASONAL KWH BY APPLIANCE WINTER

Texas All Electric Homes

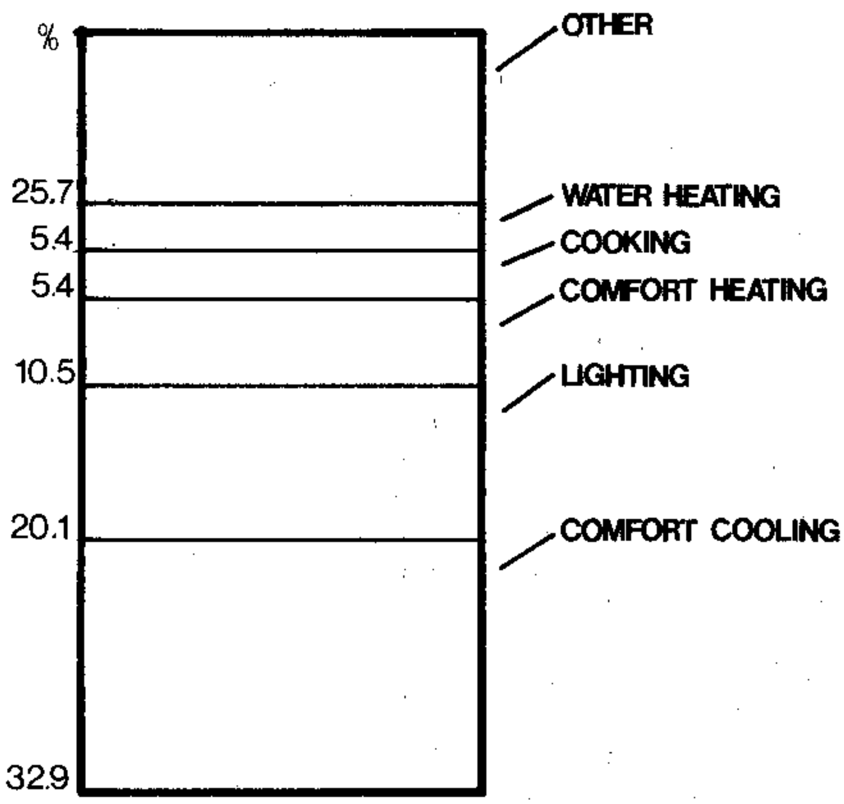


Source: Texas Power and Light Co. Figures are applicable to North Central Texas

Texas Residential Energy Use



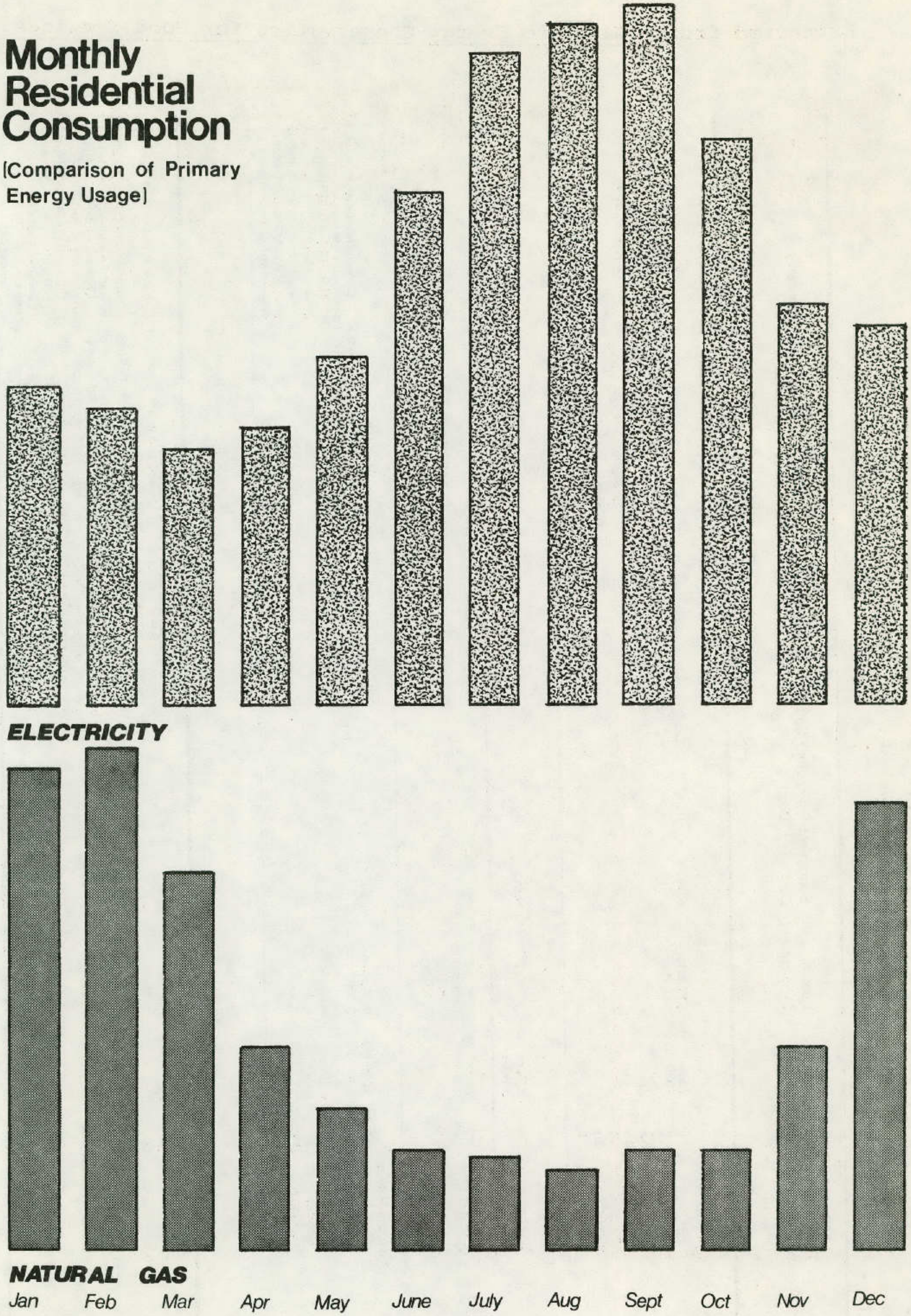
NATURAL GAS



ELECTRICITY

Monthly Residential Consumption

(Comparison of Primary Energy Usage)



Types of Lighting Compared

	Type & Wattage	Lumens Per Watt (L/W)	Lifetime	Lumen Efficiency	Equipment Cost	Operating Cost	Color Characteristics	Recommended Uses	Remarks
incandescent	Standard 15 25 40 60 75 100 250 500	 8 9 12 14 18 18 20 21	750–1000 hrs. shortest of all lamps	80% prior to failure	Low	High	· Skin tones heightened. Gives "warm" atmosphere where used.	· Where lamps are burned fewer than 6 hrs a day · Where foot-candle requirements are under 50. · Where "warm" atmosphere is desired · Where area to be lighted is small	· Efficiency is critically dependent on operating voltage. Do not operate below nameplate voltage of lamp
	Long-life 100		2, 3, or 5 years		High	High		· Only where maintenance is difficult or irregular	
	PAR 250	18.4		Reduced to 70% after 1,000 hrs.				· As narrowbeam floodlights · "Cool beam" lamps suitable for displaying food	
	Tungsten Halogen 45 100 150 200 250 Spot 500 Flood 1,000 Flood	 13 18 18 19 13 14 17	4,000 hrs. minimum for high-voltage lamps	90% after 3,000 hrs.	Low	Low	· Good color rendition: bright, white	· Where strong light is desired · Where good color is desired · In cornices and niches	· Low wattages available for single-purpose lamps · Not as flexible as standard incandescent · Significant savings in energy and costs over standard incandescent throughout life
	PAR 150			98% after 3,000 hrs.				· For floodlighting and outdoor decorative lighting	
fluorescent	40 60 75 110	66 68 73 72	20,000 hrs.	70% at 12,000–15,000 hrs.	Higher than incandescent	Lower than incandescent	· Warm white has the poorest color rendition, emphasizing the colors orange and yellow while "graying" reds, greens, and blues. Cool and deluxe warm white are better. Deluxe cool white most closely approximates natural daylight	· In sales and production areas, offices · As display and case lighting · Deluxe cool white, deluxe warm, and white can be usually used in place of incandescent bulbs	· Ballasts required for start-up reduce lamp efficiency · Some color-corrected lamps are 30% less efficient than standard · Efficiency especially affected by ambient temperature · Cool and warm white have highest outputs, followed by deluxe and color-corrected lamps · Dimmable

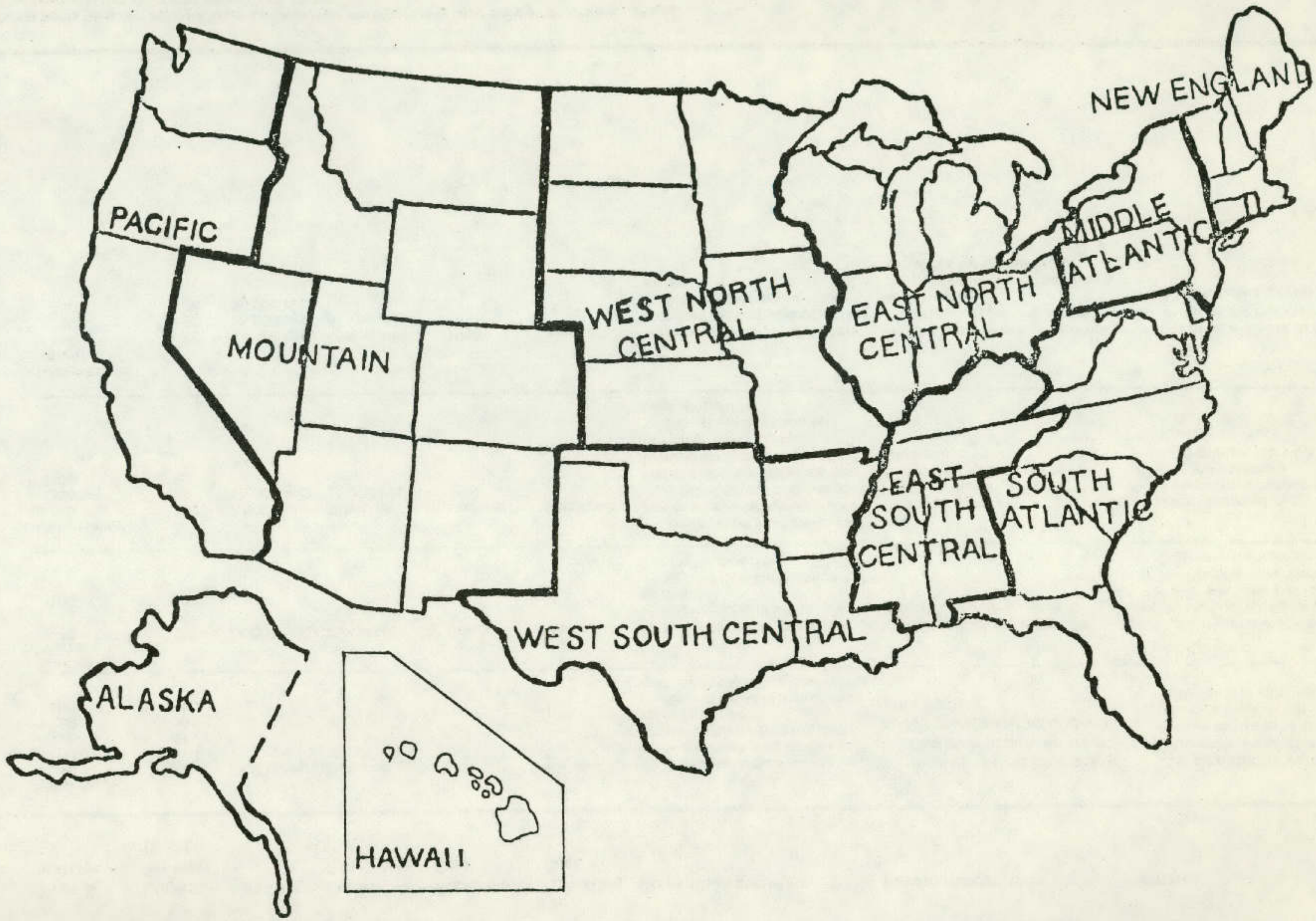
Extracted from: Guide to Energy Conservation for Food Services.

high-intensity discharge

Type & Wattage	Lumens Per Watt (L/W)	Lifetime	Lumen Efficiency	Equipment Cost	Operating Cost	Color Characteristics	Recommended Uses	Remarks
Mercury 40 100 175 250 400	 29 41 42 46 51	24,000 hrs.	75% after 16,000 hrs.	Low	Medium	· Available in clear, white, color-corrected, and deluxe white. Deluxe white has best color rendition · Deluxe white is interchangeable with cool white fluorescent	· Indoors to light large spaces · Outdoors in parking areas and as merchandising or decorative lighting	· Can be dimmed; voltage requirements are precise · Not as sensitive to frequent start-ups as fluorescent · 2-10 minute start-up time
Special Color Mercury 40 75 100	 18 36 36	24,000 hrs.	75% after 16,000 hrs.	Low	Medium	· Excellent color; preferred alternative to cool white fluorescent · Second best color choice for "warm" atmosphere	· Can replace incandescent lamps in interior fixtures	· Limited number of sizes; strictly for interior fixtures · Higher wattages and longer life than standard mercury · 2-10 minute start-up time
Metal Halide 175 250 400	 70 64 80	7,500–15,000 hrs.	60% after 11,000 hrs.	Medium	Medium	· Better color than mercury; not as good as special mercury · Color-coated bulb has good, warm color, emphasizing yellows, greens, and blues. Clear bulb less satisfactory · Best color rendition for outdoor lighting	· Parking areas · Large work spaces · Interior spaces lighted from above	· Ballast required · Higher lumen output, lower lifetime than mercury · 2-10 minute start-up time · Can be dimmed
High-pressure Sodium 150 250 400	 89 80 106	 12,000 hrs. 15,000 hrs. 20,000 hrs.	80% at end of lifetime	High	Low	Poor color rendition: grays colors of red and blue objects. Similar to warm white fluorescent	· Outdoor, where color is unimportant: in parking spaces and security uses · If illumination of building is enhanced by yellow light	· The most efficient lamp currently on the market · 2-10 minute start-up time

NOTES: Neon lights have not been included because they are commonly used only as decorative lighting.
Fluorescent lamps described are all "rapid start."
Lumen efficiencies and numbers of lumens per watt are approximations.

CENSUS REGIONS OF THE UNITED STATES



Source: FEA, "Identifying Retrofit Projects for Buildings," Office of Energy Conservation and Environment (September 1976).

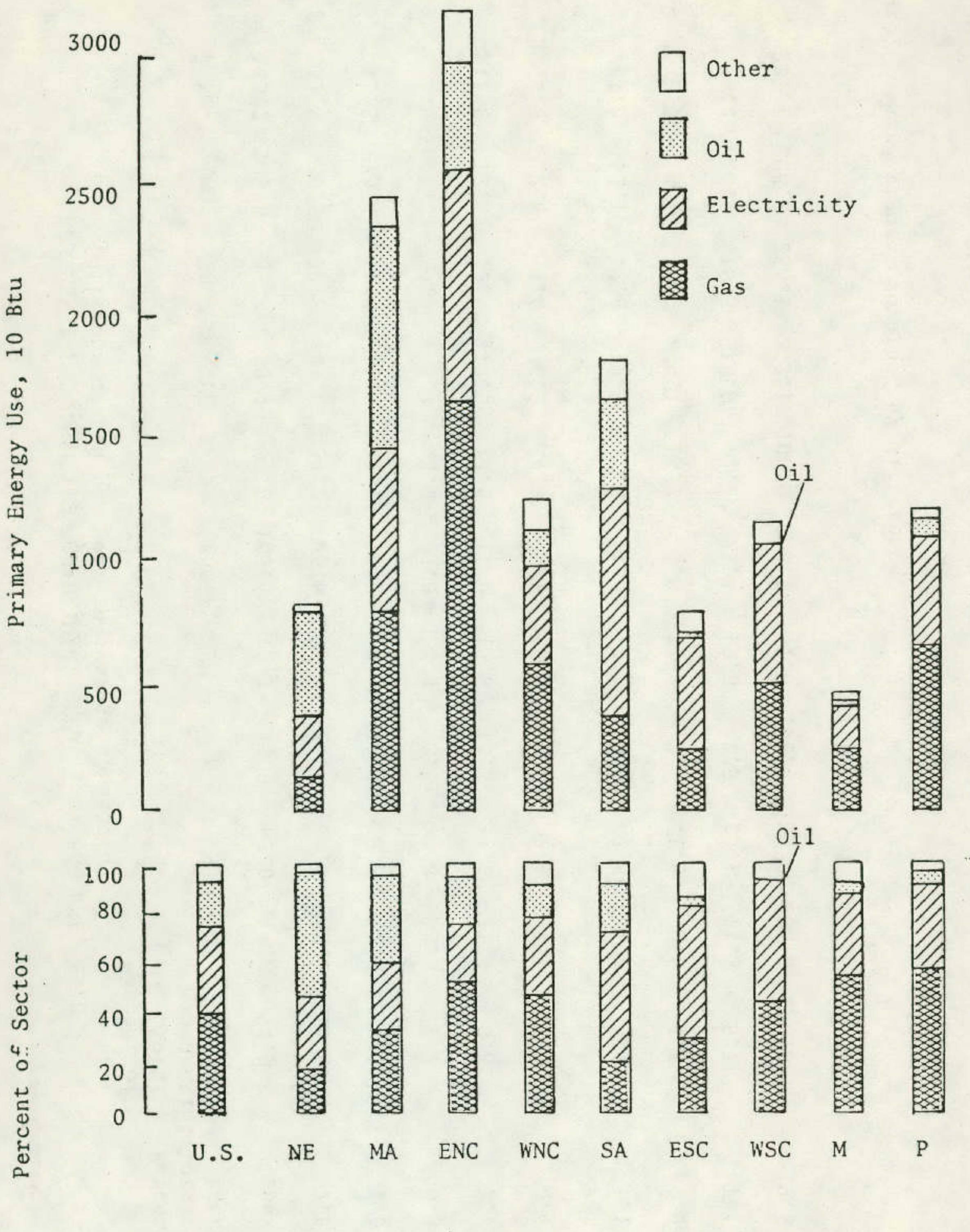
RESIDENTIAL CONSUMPTION OF PRIMARY ENERGY, BY END USE, 1970
(Millions of Btu per year in average household)

End Use	NE	MA	ENC	WNC	SA	ESC	WSC	M	P	U.S.	Percent of Total Residential Energy	Percent of Total U.S. Energy
Space Heating	143.2	123.8	155.8	138.4	97.8	105.6	70.1	111.9	63.0	113.6	54.9	10.8
Water Heating	33.8	30.3	32.8	31.0	34.2	26.8	23.4	31.0	24.9	30.1	14.5	2.8
Cooling	11.5	10.4	11.0	11.0	11.7	10.7	10.6	10.3	8.8	10.6	5.1	1.0
Clothes Drying	3.9	3.1	4.5	4.4	3.2	3.0	3.4	3.5	2.8	3.5	1.7	0.3
Refrigeration	13.0	12.2	12.8	12.5	12.6	11.0	13.3	10.5	7.6	11.8	5.8	1.1
Home Food Freezing	2.8	2.8	4.6	6.2	4.5	5.1	5.5	4.6	2.4	4.1	2.0	0.4
Lighting	13.0	12.1	12.8	12.5	12.6	11.0	13.2	10.4	7.6	11.7	5.7	1.1
Air Conditioning	1.7	5.1	5.5	9.1	15.7	14.0	33.9	3.0	1.8	9.6	4.6	0.9
Other	4.2	6.2	16.3	16.9	-1.2[a]	21.4	19.3	7.5	19.1	11.8	5.7	1.1
TOTAL	227.1	206.2	256.1	242.1	190.9	208.5	192.6	192.6	138.0	206.8	100.0	19.6

[a]Error of closure; "other" figures obtained by difference.

Source: Stephen H. Dole, "Energy Use and Conservation in the Residential Sector," National Science Foundation, R-1641-NSF (June, 1975).

RESIDENTIAL ENERGY USE BY ENERGY TYPE, 1970



Source: Stephen H. Dole, "Energy Use and Conservation in the Residential Sector," National Science Foundation, R-1641-NSF, June, 1975.

DOE/CS-0006

Lighting

Twenty percent of all electricity generated in the United States today is used for lighting homes and businesses. Yet, between 20 and 50 percent of that energy could be conserved by any home or business owner with little, if any, capital expense. Energy conservation in lighting can be achieved with little effort—sometimes it's as simple as flipping a switch. In addition, curbing energy use in lighting doesn't require a change in lifestyle or a substantial investment of funds.

Through decades of use, consumers have come to rely on the familiar incandescent bulb for all of their lighting needs, even though different tasks obviously require different lighting types and levels—from high-powered outdoor security lights to very dim night lights. A variety of light sources is available; each has characteristics that make it suitable for different lighting tasks. This fact sheet is designed to help a consumer select the most energy-efficient light source for his needs, whether he is simply replacing a bulb or remodeling a lighting system.

It begins with information on the two considerations most important in choosing home lighting, energy efficiency and color rendition. It then describes the most commonly used indoor and outdoor lighting sources and ways to increase their operating efficiency. Such simple considerations as turning off lights when not needed, replacing bulbs as they dim, and keeping fixtures clean have a surprisingly beneficial impact on energy requirements and electricity bills.

Energy Efficiency . . .

Energy efficiency for all light sources is the measure of how much light is produced—measured in ***lumens***—in relation to the amount of energy used—measured in ***watts.*** Lumens-per-watt ratings are similar to a very familiar measure of energy efficiency: ***miles per gallon.*** Just as cars have different efficiency ratings, so do lamps. Some light sources convert electricity into light much more efficiently than others, and therefore can deliver more light for the same amount of electricity. For example, a 40-watt fluorescent tube that delivers 66 lumens per watt is more than five times as efficient as a 40-watt incandescent bulb that delivers only 12 lumens per watt. The difference in the amount of light provided for each watt can have a dramatic impact on the amount of electricity required to light a house or commercial building. New, highly efficient lamps are available that produce considerably more light for every watt of electricity than older, more familiar light sources. By using these energy-efficient lamps, a homeowner can reduce energy consumption while maintaining desired lighting levels.

The efficiency of different light sources varies considerably—from less than 10 lumens per watt to over 130 lumens per watt. Table 1 on page 2 illustrates dramatically the differences in the efficiency of various light sources.

. . . and Color Rendition

Energy efficiency is only one of the factors a homeowner considers in choosing a lighting system; he also wants the light source to create a pleasant atmosphere. Color rendition is an important concern in lighting aesthetics, but it is a characteristic of light sources that is difficult to evaluate. Color is simply the effect of light waves bouncing off or passing through various objects. The color of a given object, therefore, is determined in part by the characteristics of the light source under which it is viewed. Color rendition, then, is a relative term; it refers to the extent to which the perceived color of an object under a light source matches the perceived color of that object under the familiar incandescent bulb. To say that a light source has a "good" color rendition can be translated as saying that it gives objects a familar appearance—the appearance they would have under incandescent lighting.

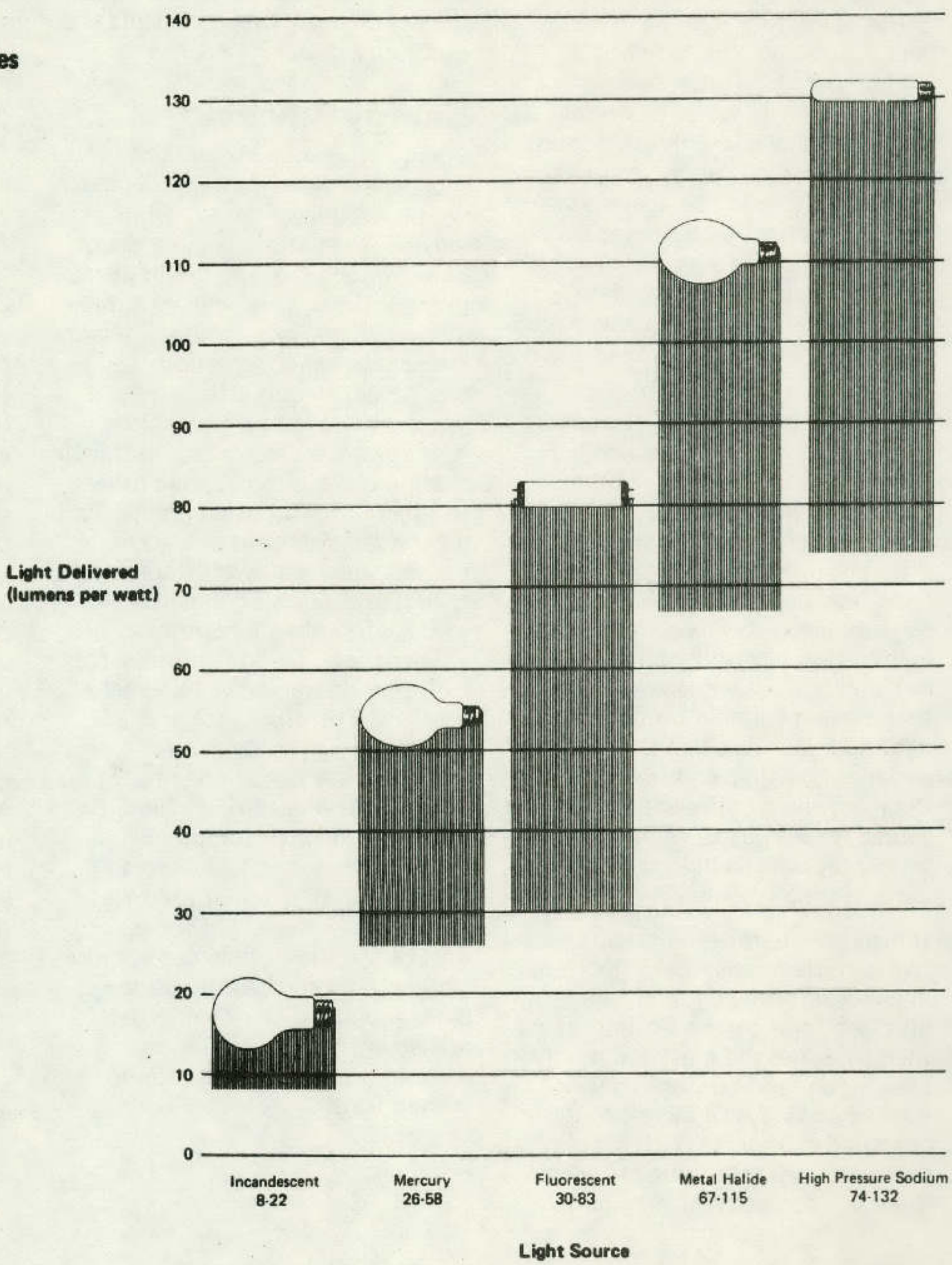
The color-rendering properties of incandescent bulbs are the standard measurement for indoor lighting because they are the most commonly used light source, and people

Copies of these Fact Sheets may be obtained from:
U.S. Department of Energy
Distribution
Washington, D.C. 20585

U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Conservation and Solar Applications
Division of Buildings and Community Systems
January 1978

Table 1

Efficiency of Various Light Sources



have become accustomed to the appearance of objects under them. Incandescent lamps accentuate warm tones—reds, oranges, yellows, while the standard fluorescent bulb used in offices and stores accentuates cool tones—blues and greens; for this reason, people have been reluctant to use fluorescent lighting in their homes.

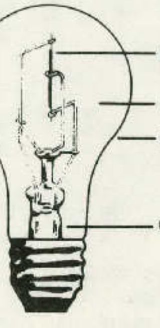
Light Sources for the Home

Residential lighting must balance more than efficiency and aesthetics; it must also be flexible—adaptive to a wide variety of activities occuring in the home, and it must be economical. How well these factors are balanced for the three major light sources for the home—incandescent, fluorescent, and high-intensity discharge lamps used for outdoor lighting—is discussed in this section.

Incandescent Lighting

Incandescent lamps are by far the most common source of lighting used in houses throughout the United States. They are also by far the most energy-wasteful: a full 90 percent of the energy consumed by an incandescent lamp is dissipated as heat, not light. Incandescents waste so much electricity as heat because they create light by an intermediary process: using electricity to heat a coiled tungsten filament in a vacuum bulb until it glows, rather than converting electricity directly to light.

Incandescent Bulb



Efficient Use of Incandescents

Even though incandescent lighting is not the most energy-efficient per se, efficiencies can be achieved by choosing the right type and wattage of bulb. The first thing to know is how to read and compare the information printed on the package.

An important rule of thumb in determining efficiencies of incandescents is that efficiency increases as the wattage increases. For example, one 100-watt incandescent bulb has an output of 18 lumens per watt, while a 60-watt bulb produces only 14 lumens per watt. Thus, the substitution of one 100-watt bulb (1800 lumens) for two 60-watt bulbs (1680 lumens) produces more light and uses less electricity. This type of substitution saves energy, reduces maintenance, frees circuitry, and therefore should be made wherever possible.

A factor that has a significant impact on the efficiency of incandescents is the *life span* of the bulb, which is measured in hours and printed on the package. Not only do incandescents have the shortest life span of all available lamps, but near the end of the bulb lifetime the light output has depreciated by 20 percent of its original output. Light output is reduced because, as the coiled tungsten filament in incandescent bulbs emits light, molecules of the metal burn off. These molecules become deposited on the surface of the bulb, and slowly cause the bulb to darken. As it darkens, the bulb consumes the same amount of energy as it did when new, yet it produces less light. The bulb eventually burns out when the filament ruptures. Energy and, in the long run, money can be saved by replacing darkened bulbs before they burn out. ***Long-life*** bulbs (which last from 2500 to 3500 hours) are the least efficient incandescents of all, because light output is sacrificed in favor of long life. An energy-conscious homeowner should use them only where bulbs are difficult to replace.

A comparative reading of lightbulb packages also reveals that a tinted bulb has a lower light output than a standard incandescent bulb of the same wattage. This is because the coating on the bulb inhibits the transmission of light. And the higher prices of tinted bulbs further illustrate that energy efficiency is often less expensive from the start.

To achieve energy efficiency using incandescent bulbs, the homeowner should do some comparative shopping, checking lumen output, wattages, and the bulb lifetime in hours, all of which are conveniently printed on the bulb package.

Efficient Types of Incandescents for Limited Use

Attempts to increase the efficiency of incandescent lighting while maintaining good color rendition have led to the manufacture of a number of energy-saving incandescent lamps for limited residential use.

Tungsten Halogen. These lamps vary from the standard incandescent by the addition of halogen gases to the bulb. Halogen gases keep the glass bulb from darkening by preventing the filament from evaporating, and thereby increase lifetime up to four times that of a standard bulb. The lumen-per-watt rating is approximately the same for both types of incandescents, but tungsten halogen lamps average 94-percent efficiency throughout their extended lifetime, offering significant energy and operating cost savings. However, tungsten halogen lamps require special fixtures, and during operation, the surface of the bulb reaches very high temperatures, so they are not commonly used in the home.

Reflector or R-Lamps. Reflector lamps (R-lamps) are incandescents with an interior coating of aluminum that directs the light to the front of the bulb. Certain incandescent light fixtures, such as recessed or directional fixtures, trap light inside. Reflector lamps project a cone of light out of the fixture and into the room, so that more light is delivered where it's needed. In these fixtures, a 50-watt reflector bulb will provide better lighting and use less energy when substituted for a 100-watt standard incandescent bulb.

Reflector lamps are an appropriate choice for task lighting, because they directly illuminate a work area, and for accent lighting. Reflector lamps are available in 25, 30, 50, 75, and 150 watts. While they have a lower initial efficiency (lumens per watt) than regular incandescents, they direct light more effectively, so that more light is actually delivered than with regular incandescents.

PAR Lamps. Parabolic aluminized reflector (PAR) lamps are reflector lamps with a lens of heavy, durable glass, which makes them an appropriate choice for outdoor flood and spot lighting. They are available in 75, 150, and 250 watts; they have longer lifetimes with less depreciation than standard incandescents.

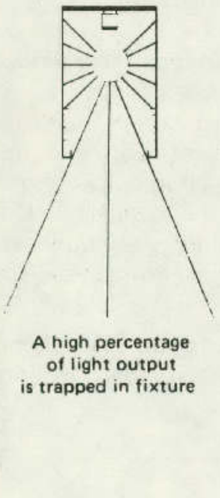
ER Lamps. Ellipsoidal reflector (ER) lamps are ideally suited for recessed fixtures, because the beam of light produced is focused two inches ahead of the lamp to reduce the amount of light trapped in the fixture. In a directional fixture, a 75-watt ellipsoidal reflector lamp delivers more light than a 150-watt R-lamp.

Fluorescent Lighting

Unlike incandescent bulbs, fluorescent lamps do not depend on the buildup of heat for light; rather, they convert energy to light by using an electric charge to "excite" gaseous atoms within the fluorescent tube. The charge is sparked in the ballast and flows through cathodes in either end of the tube. The resulting gaseous discharge causes the phosphor coating on the inside of the tube to "fluoresce," and emit strong visible light. Because the buildup of heat is not requisite to the creation of the light, the energy wasted as heat is significantly less than is wasted by incandescent lighting. The process by which fluorescent lamps

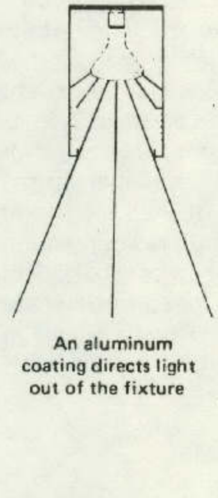
Here's why reflector lamps deliver more light than standard incandescents in directional fixtures . . .

Standard Incandescent



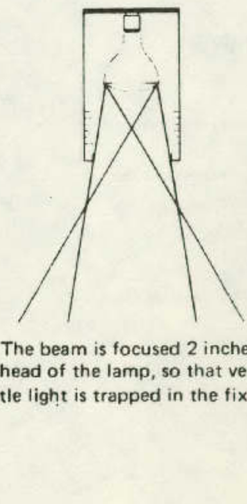
A high percentage of light output is trapped in fixture

R-Lamp



An aluminum coating directs light out of the fixture

ER Lamp

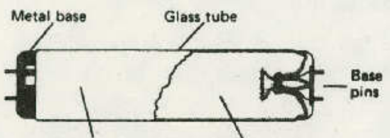


The beam is focused 2 inches ahead of the lamp, so that very little light is trapped in the fixture

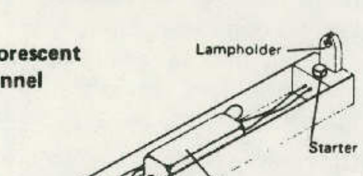
convert electricity to light is up to five times as efficient as the incandescent process.

Fluorescent lamps require a special fixture for operation. For the standard, straight fluorescent tube, this fixture consists of a metal channel that contains the ballast, which is a tiny transformer that regulates the flow of current.

Fluorescent Tube Cross Section



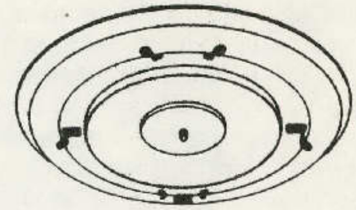
Fluorescent Channel



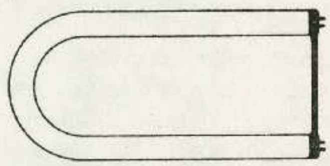
If the fluorescent tube is not the "rapid start" variety, the fixture will also have a small device that aids in starting the lamp. The start-up delay associated with fluorescent lamps is very brief; the lamp will flicker for a few moments when first turned on before achieving its full illumination. "Rapid start" fluorescent lamps that go on immediately without flickering have been available for several years.

In addition to the familiar long narrow fluorescent tubes, U-shaped and circular fluorescent tubes are available. These require different fixtures, but operate in the same way as straight fluorescent tubes. Adapters are now on the market

Circular Fluorescent Tube with Fixture



Fluorescent "U" Tube



that make it possible to use a circular fluorescent lamp without having to install special fixtures requiring such modifications as rewiring. The adapter holds the circular fluorescent tube and simply screws into a standard incandescent socket. Specially designed adapters are available for both ceiling and table lamps. Initial costs range from $15 to $45 for both the adapter and a circular fluorescent tube; however, the homeowner is reimbursed for this expense in the form of reduced operating and bulb replacement costs.

Color Rendition in Fluorescent Lighting

The color-rendering properties of fluorescent bulbs are determined by a coating applied to the inside of the bulb. Depending on the kind of coating they have, fluorescent bulbs are labeled "warm" or "cool" to indicate the effect their use creates. A consumer can choose from four kinds of commonly used fluorescent bulbs: cool white, deluxe cool white, warm white, or deluxe warm white (see Table 2). Each type has different color-rendering properties and different levels of efficiency.

To achieve energy efficiency while maintaining a pleasant atmosphere, a homeowner could use the ***deluxe*** fluorescent bulbs. The warm white deluxe bulb closely simulates incandescent lighting; the cool white deluxe bulb closely approximates natural daylight. However, the good color rendition characteristic of deluxe fluorescent bulbs also sacrifices some of the efficiency of standard fluorescent bulbs.

Table 2 summarizes the color-rendering properties of four types of fluorescent lamps.

Table 2

Fluorescent Lamp Selection Guide

	Effect on "Atmosphere"	Colors Strengthened	Colors Weakened or Grayed	Remarks
Cool white	neutral to fairly cool	orange, yellow, blue	red	blends with natural daylight
Deluxe cool white	neutral to fairly cool	all nearly equal	none appreciably	simulates natural daylight
Warm white	warm	orange, yellow	red, blue, green	blends with incandescent light
Deluxe warm white	warm	red, orange, yellow, green	blue	simulates incandescent light

Efficient Use of Fluorescents

Energy savings are to be found simply in the use of fluorescents rather than in the choice of lamps or wattages, because the efficiency rating and lifespan of fluorescents remain consistently high over a range of wattages. However, the efficiency of a fluorescent lamp will increase as the length of the tube increases. Therefore, wherever practical, large fixtures should be used to save energy.

The ballast consumes a small but constant amount of energy, even when a tube has been removed. Disconnecting the ballast or unplugging a fixture not in use is a good way to conserve electricity. As one ballast is often shared by two or more lamps where fluorescent lights are arranged in strips, removing one lamp will cause the others activated by the same ballast to go out. An electrician can make the simple adjustments required to prevent this.

While turning off incandescent lamps not in use is a commonly recognized way to achieve energy savings, misunderstandings abound as to the efficiencies of turning on and off fluorescent lamps. Like incandescents, fluorescent lamps should be turned off when not in use, even if only for a few minutes. No energy is required to turn a light off, and the initial charge required to turn a fluorescent back on does not use a significant amount of energy unless the switch is flipped back and forth in rapid succession. Fluorescent lamp life is rated according to the number of hours of operation per start, and while it was once true that the greater the number of hours operated per start, the longer the lamp life, recent technology has increased lamp life ratings to an extent that makes the number of starts far less important than they were 10 or 20 years ago. As a rule, if a space is to remain unoccupied for more than 15 minutes, fluorescent lamps should be turned off.

Outdoor HID Lighting

Because outdoor security and safety lights burn for long hours—sometimes from dusk to dawn—the potential for energy savings is great. This is especially true for outdoor home lighting, which commonly uses incandescent floodlights instead of more energy-efficient High Intensity Discharge (HID) lamps.

The greater efficiency of HID lamps can be seen from the lumen-per-watt information given in Table 1. Considering the higher wattages needed for outdoor security lamps and the long hours they burn, the higher initial investment required for energy-efficient HID lamps makes sense.

Three types of HID lamps are on the market: mercury, metal halide, and high pressure sodium. All three are more energy-efficient than the standard incandescent bulbs, and are commonly used in business and industry for lighting large areas, such as parking lots, arenas, and lobbies. Each type requires a ballast designed specifically for it.

Mercury. Of the three, mercury lamps are the most commonly used outdoor lighting source. They have the lowest installation cost and a very long life. They are available in 40, 50, 75, 100, and 250 watts, and while comparable in size to incandescent lamps of the same wattage, produce twice as much light. Clear mercury lamps have poor color rendition—they accentuate blue tones—but color-corrected deluxe cool white or deluxe warm white lamps give objects a more familiar appearance. For long-burning outdoor safety lighting, where efficiency is generally more important than color rendition, mercury lamps are a good choice.

Metal Halide. Metal halide lamps are more efficient and have a better color rendition than mercury lamps. They are widely used for general commercial interior and exterior lighting, but because the lowest wattage available is 175 watts, they provide greater levels of illumination than ordinarily required by a homeowner.

High Pressure Sodium. These are the most energy-efficient light source currently on the market. Homeowners generally would use them only for outdoor lighting, however, because the lowest wattage is 70 watts, and its high lumen output is generally too bright for interior home use. In addition, the color produced by these lamps is golden-white, which grays the color red and blue objects. However, they are excellent sources for lighting large outdoor areas.

Apart from color rendition, HID lamps pose one potential drawback—a start-up delay of from 1 to 7 minutes from the time they are switched on until they fully illuminate. However, the continued refinement of HID lamps, particularly the metal halide and the high pressure sodium lamps, is expected to make them practical alternatives to the use of less efficient light sources.

Ways to Increase Lighting Efficiency

Whatever the light source, correct placement, regular maintenance, efficient operation, and the installation of timing and dimming devices all contribute to increasing lighting efficiency and saving energy.

Placement

How light fixtures are placed in relation to the objects that surround them and the activities to be illuminated can significantly affect their efficiency. Two lamps incorrectly placed may be needed to adequately illuminate a room or work area where only one is actually required. Factors to consider are:

- Light-colored walls and bright surfaces reflect more light than do dark surfaces.
- Perimeter lighting usually gives more brightness to a room than does central lighting.
- A directional lamp used above a work area gives more illumination for the same wattage than does more general diffused lighting.
- The balance of lighting in a room should be evenly maintained. Especially in a room having both general lighting and task lighting over work areas such as kitchen counters or desks, balance is important to consider where the two types of lighting meet. If the various sources of light do not "reach" far enough to meet, excessive shadows and contrasts between light and dark areas may cause eye fatigue. Adding another lamp or increasing the wattages of the existing ones is both expensive and energy wasteful. Instead, lamps should be repositioned to spread the light and distribute it more evenly. It is also a good idea to periodically survey the way in which rooms are used to determine whether the efficiency of lighting can be increased.

Maintenance

Once installed, the efficiency of a light source depends to a large extent on how well the fixtures are maintained. A lamp that produces 20 lumens per watt when installed may actually distribute only 10 when covered with dust. The reflecting value of fluorescent fixtures is important to their illuminating ability, and their tendency to collect dust may be countered by frequent cleaning.

Bulbs should be replaced when they first begin to dim, before they completely burn out.

Operation

Significant energy savings can be achieved simply by using light sources efficiently. The following checklist suggests ways to increase lighting efficiency.

- Lower wattages, eliminate unnecessary light, and rely on daylight whenever possible.
- Replace two bulbs with one having a comparable number of lumens.
- Substitute a 4-watt night light for the standard 7-watt night light. These 4-watt bulbs have a clear finish, and are almost as bright as a 7-watt bulb; yet they use only about half as much energy. This can be a worthwhile substitution, considering the long hours night lights burn.
- Place fixtures on separate switches so they can be operated independently of each other.
- Convert decorative outdoor gas lamps to standard incandescent or mercury lamps. If the lamp cannot be converted, limit its use but maintain safety and security by using other sources to light the area.

Timing Devices, Photocells, and Dimmers

The practice of inadvertently leaving lights burning when they are not needed can be eliminated by installing small timing devices or photocells to indoor and outdoor lighting. For vacationers who want to give their homes the appearance of being occupied, and for homeowners who prefer a light on when they return home in the evening, installing timing devices or photocells provides an alternative to leaving a light burning all day.

Timing devices can be set to automatically turn lights off and on at predetermined times, for example, on at dusk and off at dawn. Timers can be purchased in most hardware or department stores for prices ranging from $10.00 to $20.00.

Photocells offer an automatic way to turn lights on and off in direct response to the amount of natural light available. Photocells are small photoelectric cells, sometimes less than an inch in diameter, that are sensitive to sunlight. When light strikes a photocell, it is converted to electrical energy. The brighter the light, the stronger the resulting electrical charge. Photocells are designed so that when a certain amount of natural daylight strikes them, the electrical charge created by the light triggers a mechanism that switches lights off; when daylight wanes, on stormy days, or when clouds temporarily decrease the amount of natural light available, the photocell switches lights on again. The reliability and low initial cost of photocells make them an excellent tool for conserving energy.

Nearly all types of light sources can be dimmed by controlling the amount of power applied to them. **Dimmer controls** permit the occupant to adjust the level of light in a room over the full range, from off to the highest illumination level, in response to the varying light levels required at different times of the day, in different rooms of a building, and by different activities in a room. Dimmers can achieve energy savings if they are used regularly.

Two types of energy-saving dimmer controls are currently on the market for home use: solid state and variable automatic transformers. Both save energy by reducing the amount of electricity delivered to the light. In addition, because bulbs are operating on reduced voltage, the life of the bulb is extended. Dimmer fixtures replace standard light switches, and are inexpensive and easy to install. New models on the market can be attached to table lamps as well.

Dimmers for fluorescent lamps must be used with a special dimmer ballast, which replaces the standard ballast. Because the use of fluorescent lamps in itself provides energy savings, the use of dimmers with fluorescent lamps is not as widespread as with incandescent bulbs. Currently, dimming equipment is available for only 30-watt and 40-watt rapid-start fluorescent lamps.

The precursor of photocells and dimmers is a dimming mechanism still sold occasionally, called a rheostat. Because it works by transforming into heat that portion of the electrical energy not used for light, it does not save energy and thus is not recommended for use.

As an alternative to full-range dimmers, there are "hi-lo" switches on the market that provide two settings for overhead lamps. While they do not provide the flexibility of a full-range dimmer, they do achieve energy savings, and are comparable to the three-way bulbs used in table lamps.

When used regularly, the costs of these lighting controls are more than offset by the electricity saved from the lower levels of illumination they make possible.

For Further Information

Although lighting is not the single largest consumer of energy in homes and commercial buildings, the percentage of energy wasted by inefficient light sources is high. Consumers who take steps to improve the efficiency of the lighting in homes and commercial buildings are helping conserve valuable energy while saving money on electricity bills.

This fact sheet was designed to give the consumer a base of information on which to develop a lighting system that provides adequate levels of light at the lowest expenditure of energy. For more information on lighting efficiency, contact your local electrical utility, bulb manufacturers, or the associations listed below:

American Home Lighting Institute
230 North Michigan Avenue
Chicago, Illinois 60601
(312) 236-3816

Illuminating Engineering Society of
North America
345 East 47th Street
New York, New York
(212) 644-7917

How much does it cost to run your appliances?

Everybody is energy-conscious. But so far there hasn't been a simple way for consumers to figure their household energy costs. Now, under a new law, the Federal Trade Commission staff is proposing that 13 categories of appliances be sold with labels giving consumers the estimated annual energy cost for an item — *before* they buy. Equally important, the labels would also give the range of estimated costs for comparable items.

If the FTC adopts the staff's recommendations, the next refrigerator you buy could carry a yellow and black label that looks like this example. It would give you:

Appliances to be sold with Energy Labels

- Refrigerators and refrigerator-freezers
- Freezers
- Dishwashers
- Clothes dryers
- Water heaters
- Room air conditioners
- Home heating equipment (other than furnaces)
- Television sets
- Kitchen ranges and ovens
- Clothes washers
- Humidifiers and dehumidifiers
- Central air conditioners
- Furnaces

1 A description of the model.

2 The estimated energy cost of the model.

3 The range of energy costs for comparable models.

4 Other useful information that will enable you to estimate costs even more precisely.

Before Buying

Compare Energy Costs

Name of Corporation

Refrigerator/Freezer
Model: AH503
Capacity: 23 cubic feet

Check Energy Cost

How much will your yearly energy cost be with this model? How does it compare with other models? Check the figures and spend less on energy

Help the nation conserve energy

Estimated Yearly Energy Cost of this Model

$84

Compare Energy Costs

This model has 23 cubic feet of inside space. All brands and models with 21.5 to 24.5 cubic feet have about the same space inside

These brands and models have different yearly energy costs

Model with lowest energy cost		Model with highest energy cost
$63	**$84** **This Model**	**$122**

More Cost Information

The $84 estimate for this model is based on the 1977 national average electric rate of 3.8¢ per kilowatt hour

Check this table to estimate your yearly cost.

Cost per kilowatt hour

2¢	4¢	6¢	8¢	10¢
$44	$88	$132	$176	$220

Warning

Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

Source of Cost Information

Estimates are based on U.S. Government standard tests. Your cost will depend on your utility rate and how you use the product

Source: Federal Trade Commission

FTC news

Federal Trade Commission *Washington, D.C. 20580*

FOR RELEASE Wednesday, June 28, 1978

FTC PROPOSES ENERGY-COST LABELS FOR APPLIANCES

The Federal Trade Commission today proposed a rule to require that labels be placed on home appliances disclosing their annual energy cost. The labels would also contain information on the range of energy costs of comparable products.

The Commission voted unanimously to begin the rulemaking proceeding. Congress directed the Commission to develop energy cost labels for 13 major appliance categories in the Energy Policy ConservationAct of 1975 (EPCA).

Following a period for public comment, including hearings sometime in September, the Commission anticipates publishing its final rule early in 1979. From then on, the yellow-and-black labels in the form finally approved by the FTC will be required to appear on every new freezer, refrigerator and refrigerator-freezer, dishwasher, clothes washer, clothes dryer, television set, kitchen range and kitchen oven, humidifier and dehumidifier, room air conditioner, çentral air conditioner, furnace or other home heating equipment, and water heater.

Home appliances in Canada and some western European countries already carry energy useage labels for some home appliances. The FTC's action today, however, marks the first American step to involve consumers in energy conservation right at the point of purchase.

Under EPCA, the Department of Energy and the National Bureau of Standards of the Department of Commerce developed the standards for manufacturers to measure the energy consumption of their products. The Act gives the FTC the responsibility for developing product disclosure labels. The FTC has also been assigned enforcement authority to ensure that all appliances in the 13 categories are correctly labeled, reflecting as nearly as possible their actual energy costs.

The proposed rule, plus sample labels, will shortly be published in the Federal Register. All aspects of the proposed rule--including the label design--are subjects for public comment.

(MORE)

F025/ENERGY

:RAL TRADE COMMISSION
WASHINGTON, D. C. 20580

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

POSTAGE AND FEES PAID
U. S. FEDERAL TRADE COMMISSION
FIRST CLASS

U.S. MAIL

›u no longer wish to receive
:ailings, check here ______
·eturn this sheet to the

A typical label discloses, for example, that the estimated yearly energy cost for a particular refrigerator-freezer with 23 cubic feet of inside space is $84. For comparison purposes, the range of yearly energy costs for all brands and models with about the same inside space is shown; the lowest is $63 and the highest $122. The $84 estimate is based on the 1977 national average electric rate of 3.8 cents per kilowatt hour. A grid shows what the figure would be if the customer pays a different cost per kilowatt hour.

The FTC in cooperation with the Department of Energy is also launching a national education program directed to consumers, retailers, distributors, and appliance manufacturers. The objective is to promote energy awareness among appliance purchasers, as well as the understanding and cooperation of the industry.

In announcing the proposal, Chairman Michael Pertschuk noted that "fully 25% of the energy we use in this country is consumed in our homes, primarily by home appliances. These proposals are designed to aid consumers' purchase decisions by providing much needed information on what it costs to operate major appliances. At the same time, these new rules should stimulate manufacturers to develop appliances that are more energy efficient. The benefits should be significant: consumers will be able to purchase energy efficient appliances that cost them less over the long run and save significant amounts of energy."

# # #

PRESS CONTACT: Office of Public Information (202) 523-3830

THE FEDERAL TRADE COMMISSION'S

Proposed Energy Rule

The United States has about six percent of the world's population. Yet it consumes about one-third of all energy used. Approximately one-fourth of the energy consumed in this country is used in residences: about 70 percent for climate control, 20 percent for heating water, and the rest for lighting and other appliances.

Now, under a recent Congressional enactment, the Federal Trade Commission staff is proposing that 13 categories of appliances be sold with labels giving consumers the estimated yearly energy cost for an item -- before they buy. Equally important, the labels would also give the range of estimated costs for comparable items.

The staff's proposal resulted from extensive consultation with the Department of Energy and the National Bureau of Standards. Recommendations for label formats are based on results of a major consumer experiment that measured responses to and understanding of a variety of labels.

EPCA

Q. Where does the FTC get the power to create an appliance labeling rule?

A. The Energy Policy and Conservation Act (EPCA), passed by Congress in December, 1975, requires the Federal Trade Commission to issue labeling rules for disclosure of energy costs to operate at least 13 categories of home appliances:

- Refrigerators and refrigerator-freezers
- Freezers
- Dishwashers
- Clothes dryers
- Water heaters
- Room air conditioners
- Home heating equipment, not including furnaces
- Television sets
- Kitchen ranges and ovens
- Clothes washers
- Humidifiers and dehumidifiers
- Central air conditioners
- Furnaces

Q. Why have these 13 appliances been earmarked for labeling?

A. Most studies have shown that the energy used by small appliances (can openers, pencil sharpeners, mixers, toasters, etc.) is insignificant and that if an energy conservation program is to succeed, efforts must concentrate on the large energy users -- major appliances.

Q. Who decided what information should appear on the labels?

A. Consumers themselves decided. Each consumer in the testing sample was interviewed at home. The test included showing the consumer a proposed label and asking a series of questions designed to measure (1) the attention-getting quality of the label, (2) consumer attitude to energy-cost labeling, and (3) consumer understanding of the information on the label.

WHAT THE LABEL SAYS

Q. What type of information will the labels have to provide?

A. Labels would have to provide six types of information:

1. A section called "Check Energy Cost" would let consumers know they can save money by considering energy cost when purchasing an appliance.

2. A warning that the label should be removed only after purchase by the consumer.

3. An explanation of the estimated yearly energy cost to the consumer and of the range of energy costs for comparable models.

4. The source of the cost information.

5. Other useful information that would enable the consumer to estimate energy costs even more precisely.

6. A table, or grid, showing energy cost based on a variety of utility rates and, when applicable, consumer use patterns.

Q. Will the consumer be able to understand all that information?

A. The rule provides for an extensive education program that will alert consumers, state and local energy and consumer affairs offices, manufacturers, and retailers to the significance of estimating yearly energy costs. The program will include instruction for the consumer on how to use the data on the appliance label to save money and energy when comparison shopping. The educational program is an important way of carrying out the rule's intention to make the American public aware of the economic benefits of energy conservation.

Q. Why do the appliance labels give energy cost data rather than comparative efficiency ratings?

A. Experts from industry and other groups have pointed out that efficiency labeling might be appropriate for some appliances but not for others. The description of efficiency would have to vary from product to product and would give consumers virtually no guide to meaningful comparison of purchase prices. Only energy cost data can tell consumers whether a particular purchase is likely to save them money over the life of a product.

ENERGY COSTS

Q. How reliable are the estimated yearly energy costs provided by the label?

A. The yearly energy costs are based on information obtained from testing procedures developed by the federal government and the manufacturers of appliances. The estimated yearly energy costs printed on the label represent only the amount of money that could be saved by the purchase of energy-efficient household appliances and are to be used only as tools for comparison shopping. The labels do not guarantee the consumer a specific yearly energy cost.

Q. Won't the information on the label encourage the purchase of more expensive appliances?

A. In some cases, the most energy-efficient appliance, the one with the relatively lowest yearly energy cost, will have a higher purchase price. However, a few dollars extra on the initial payment could be balanced, or even outweighed, by long run savings on utility bills.

Furthermore, once the energy cost disclosure program is in full force, manufacturers should realize that consumers are considering energy costs in their purchase decisions. Competitive forces should then cause many manufacturers to redesign their products with an emphasis on energy efficiency at competitive prices. This concept is known as "life cycle costing."

Q. Will the labels be updated to account for changes in energy costs?

A. If the representative average unit cost changes, or if the efficiencies of the products within the range change in a way that alters the upper or lower estimated costs for the range, then the ranges of estimated yearly energy costs may be changed -- but no more than once a year. Then, within 60 days after a range is revised and published, each manufacturer must modify all information on the labels to conform with the revised range.

Q. Where will the consumer find the label?

A. It must be attached to the appliance in a place that is clearly visible. Also, it should be attached in such a way that the consumer can remove it easily, in one piece, without the use of tools or liquids. No adhesive should remain on the product after removal.

Q. Can the manufacturer use hang-tags instead of pressure sensitive labels?

A. A hang-tag may be used in place of an adhesive label, provided the manufacturer can prove its use is necessary. A hang-tag should be attached so that the consumer can read it easily while standing in front of the product as it is displayed for sale.

Q. Will the appliance labeling rule cover catalog sales of products?

A. Yes. Any manufacturer, distributer, retailer, or private labeler who advertises a covered product for sale in a catalog must disclose in the catalog the same types of information provided by a label: the capacity of the model (if applicable), the estimated yearly energy cost, the range of energy costs for comparable models, and the range of estimated yearly energy costs. In addition, on each page that offers a covered product, the "Check Energy Cost" and "Source of Cost Information" sections of the label must be included.

Q. Will imported appliances be subject to the rule?

A. All covered products imported for use in the United States must bear the yearly cost label as specified by the FTC.

EFFECT ON THE MANUFACTURER

Q. Who will bear the cost of the labeling program?

A. Manufacturers will assume the cost of testing and labeling appliances. The label will be produced and displayed according to detailed specifications provided by the FTC.

Q. Will manufacturers have to label appliances that were produced before the effective date of this rule?

A. The rule doesn't apply to any covered product manufactured prior to the effective date of the rule, nor to a catalog distributed prior to the effective date of the rule.

RETAILER'S ROLE

Q. What responsibilities will the appliance retailer have?

A. Energy cost labeling will not burden the retailer. Yearly energy costs will be determined by information developed by federal agencies, manufacturers, and private labelers. Because estimated yearly energy costs are meant only to be a guide to the amount of money that could be saved by the purchase of energy-efficient household products, the failure of any energy cost estimate to predict accurately an individual's actual costs does not create a cause of action for rescission, reformation, or refund of a contract or sale, unless the disclosure was made in a fraudulent manner. The retailer may inform the customer that estimates for yearly energy costs are based on average patterns of use and should not be construed as exact calculations of consumer cost.

Of course, the retailer must not, under penalty of federal law, remove the label attached to an appliance.

Q. What will happen to existing state laws on appliance labeling?

A. One of the strongest arguments for a mandatory national energy cost labeling program is the appliance manufacturer's and consumer's need to work with a uniform national rule. Many states have already enacted appliance labeling programs and more have such programs under study. As a result, conflicting labeling requirements may confuse the consumer and can cause unnecessary expense for the manufacturer.

To remedy this situation, the federal appliance labeling rule contains a strong preemption clause that will enable the federal rule to supersede all state and local laws that provide for the disclosure of energy consumption, efficiency, or operating cost of any product covered by the rule.

LABEL'S EFFECT ON CONSUMERS

Q. How many consumers will be affected by the appliance labeling rule?

A. In 1974, nearly 55 million major home appliances were sold with a retail value of over $1.3 billion. Current indications are that appliance sales and appliance energy demands have grown and will continue to grow in the future.

The American home relies heavily on a wide range of appliances. Almost all homes have heating and hot water heating equipment. At least 99 percent of all homes have refrigerators, at least 99 percent of all homes have black and white television, at least 60 percent have color TVs, at least 46 percent have air-conditioning, and at least 32 percent have dishwashers. The percentage of American homes having each one of these major appliances is rising every year. All Americans at some time in their lives will purchase a major appliance that will entail not only an initial purchase price but a long-run cost in energy consumption.

Q. What will this rule do for consumers?

A. Disclosures of yearly energy cost data on appliance labels and in catalogs from which appliances may be purchased will enable consumers to compare the relative costs and benefits of competing major energy-consuming appliances. Consequently, consumers will be able to take long-run energy costs of appliance operation into consideration as a major factor in their purchasing decisions. In so doing, they can choose on the basis of energy costs rather than purchase price alone.

With these disclosures, the consumer has tools that can save him money in the long run and that can help to promote the national goal of energy conservation.

# # #

FEDERAL TRADE COMMISSION
OFFICE OF PUBLIC INFORMATION

June 28, 1978

10

CASE STUDIES

Energy Efficiency Rating

the Burns co

11831 Radium, San Antonio, Texas 78216, (512) 349-1471

BASIC DESIGN ITEMS	POINT VALUE	BURNS	BUILDER A	BUILDER B
1. Orientation (Wall Exposure)				
Long Axis Facing 5°–15°	60			
Long Axis Facing 350°–5° 25° Range @ North	50			
Long Axis Facing 185°–195°	45			
Long Axis Facing 170°–185° 25° Range @ South	40			
Long Axis Facing generally West (250°–310°)	−30			
Long Axis Facing generally East (80°–140°)	−50			
2. Solar Conversion Feasibility				
Sun Rights Protected (Min. 45′ open)	25			
Adequate roof (s.f.) faced 160°–200°	*			
Roof pitch of South roof plane 7½/12 min.	*			
Additional Roof Framing	*			
3. Type and Shape				
A. Basic style				
1. Two story	40			
2. Split level	20			
3. One story	0			
B. Shape				
1. Rectangular (approx. 2:3 dimension)	20			
2. L Shape	10			
3. U Shape	0			
4. H Shape	−20			
4. Maximum Use of Minimum Glass				
A. Percent of glass area to floor area				
Less than 10%	40			
10% to less than 12%	24			
12% to less than 15%	0			
15% to less than 20%	−24			
Greater than 20%	−40			
B. Shading of Glass				
100% shaded	48			
Less than 100%, more than 90%	32			
Less than 90%, more than 75%	16			
Less than 75%, more than 60%	0			
Less than 60%, more than 40%	−32			
Less than 40%	−48			
INTEGRAL THERMAL PROTECTION				
1. Shell Insulation				
A. Outside walls				
R-22 insulation installed	15			
R-19 insulation installed	10			
R-13 insulation installed	3			
OVE corner system	3			
Wiring run at 48″ height or at plate	3			
R-11 insulation installed	0			

*no value to heat gain or loss calculations.

	POINT VALUE	BURNS	BUILDER A	BUILDER B
B. Ceilings over conditioned areas				
R-30 insulation installed	15			
R-26 insulation installed	10			
R-22 insulation installed	5			
R-19 insulation installed	0			
C. Fenestration				
Storm windows on 100% glass area	12			
80% to less than 100%	10			
60% to less than 80%	8			
40% to less than 60%	6			
Less than 40%	0			
D. Exterior Doors				
Insulated metal	3			
Wood	0			
E. Light Shade of Roofing	3			
2. Infiltration of Unconditioned Air				
A. Soleplates sealed at slab	12			
B. Soleplates sealed at sub floor	12			
C. No plumbing drain/vents in ext. walls	12			
D. Mechanical chases/knockouts sealed	12			
E. Ext. doors and windows weatherstripped	3			
F. Ext. doors and windows caulked	6			
G. Attic scuttle weatherstripped	3			
H. Polyethylene film installed on ext. walls	8			
I. Subfloor joints glued PL400	3			
J. Duct end plates taped to ceiling or subfloor	3			
K. No ceiling lights on rough-in boxes	3			
L. No ext. wall outlets on 2nd floor	3			
M. No recessed light/mech. equipment in ceiling	5			
N. 100% stucco exterior	10			
3. Exfiltration of Conditioned Air				
A. All electric: No combustion venting required	25			
B. Fireplace with:				
Damper, combustion air intake and glass screen	20			
Damper, combustion air intake	10			
Locking damper	0			
Standard damper	−15			
C. Attic Ventilation				
Soffit vents 48" o.c. or continuous	3			
Ductboard baffles at vent locations	6			
Continuous ridge vent at 6/12 or less roof pitch	3			
Turtle vents 48" o.c. 12" below ridge on 7/12 or over roof pitch (Locate out of sight)	3			
D. Ventless Range Hood	3			
E. Bathroom Venting (where required)				
4" fresh air intake 8" off floor	3			

	POINT VALUE	BURNS	BUILDER A	BUILDER B
Weatherstrip door @ bath	3			
F. Inside utility room Double reverse 4″ vents	6			
Weatherstrip door	3			
MECHANICAL SYSTEMS				
1. **Air Handler or Heating Unit Location**				
Centrally located	8			
Conditioned Space	8			
Unconditioned Space	3			
Attic Space	0			
2. **Duct System**				
One level for 2 stories (cavity between floors)	8			
Conditioned Space	8			
2 return air grills (filter grills)	3			
Unconditioned Space	2			
Attic Space: R-7 Insulating; sealed joints	0			
3. **Cooling Efficiencies at 95° Outdoor Temperature, 78° Indoor Temperature**				
9.5 EER or greater	13			
9.0 to 9.5 EER	10			
8.5 to 9.0 EER	8			
8.0 to 8.5 EER	5			
7.5 to 8.0 EER	3			
7.0 to 7.5 EER	0			
6.9 EER or less	−15			
4. **Heating Efficiencies at 47° Outdoor Temperature, 68° Indoor Temperature**				
3.5 SPF or greater	12			
3.0 to 3.5 SPF	10			
2.5 to 3.0 SPF	8			
2.0 to 2.5 SPF	6			
1.0 to 2.0 SPF	4			
1.0 SPF or less	0			
5. **Water Heating System/Hot Water conservation**				
Heat recovery equipment	8			
Located within 20′ of kitchen/utility areas	2			
Water lines insulated	3			
3 GPM flow restriction at faucets and shower heads	2			
TOTAL				

the Burns co

11831 Radium, San Antonio, Texas 78216, (512) 349-1471

A LOOK AT

ENERGY CONSERVATION

IN
RESIDENTIAL CONSTRUCTION
FOR THE GULF COAST

BY

HERMAN H. QUINTON

THE QUINTON COMPANY
AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

SPECIFICATIONS FOR CONSTRUCTION OF ENERGY EFFICIENT HOMES

I. Air Conditioning and Heating

A. High efficiency heat pump for air conditioning with a high coefficiency of performance (COP). It should have an EER of 7.5 or better at 95° and a COP of 2.5 or better at 17°.

B. Rectangular duct system of fiber board with a minimum 4# density run in attic or through furr down system.

C. When construction design will permit, locate indoor air handler in closet in conditioned space.

II. Attic Ventilation

Garages and porches and other attic space not above conditioned space should have same ventilation as over conditioned space. Attic should have 1.5 sq. in. of ventilation per sq. ft. of ceiling area. This can be accomplished with ridge vent or power vents. A 14" power vent moving 1050 cubic feet of air per minute will normally ventilate 1800 sq. ft. of attic space.

To accommodate 10¼ R-30 insulation it is necessary to install air baffles at each eave vent opening to allow air passage into attic and insulation to be installed to outer plate levels.

III. Attic Insulation

Open attic area where blown insulation can be installed should have an R-30 installed. R-30 may be obtained by the following manufacturer's recommendations:

Rockwool	10¼" equals R-30	
Glass fiber	13 3/4"	"
Wood fiber	7½"	"

Manufacturer's specifications for coverage is printed on each bag of insulation.

Where vaulted ceiling occurs, framing should be designed to accommodate a 6" R-19 and a 3" R-11 batt to accomplish an R-30. As an alternate when framing will not permit it, a 6" R-19 and a 1" TG styrofoam may be applied to bottom of framing then stripped and sheet rocked. Where vaulted ceilings are used and knee walls or attic walls are created, the attic side of these walls should receive styrofoam insulation board or equal as well as R-11 batts.

IV. Exterior Wall Framing

All exterior walls that are adjacent to the conditioned space should be constructed to receive insulated sheathing (TG styrofoam, R-value of 5.5) applied full height of stud wall. Immediately following application of styrofoam all exterior walls should be wrapped with 6 mil polyethylene on outside of styrofoam allowing polyethylene to come down and partially cover brick ledge. Polyethylene should be applied before window installation and exterior door installation. All lap joints of polyethylene should be a minimum of 24".

V. Caulking

A polymetric foam should be used for caulking in the following manner. After all plumbing and electrical work is roughed in and all windows and exterior doors are in place the following caulking should be done. Caulk all exterior plates to concrete on interior of house. Caulk all openings made by plumber and electrician on exterior and interior walls through upper plates and the exterior of building. Caulk window and door frames to structure. Caulk any loose joints or other openings in exterior sheathing. After all caulking is completed, install a minimum of R-11 batt insulation in all exterior walls of conditioned space.

VI. Ventilation

A. Fireplaces - A fresh air vent from exterior or attic of house should be installed to provide combustion air into fireplace. This can be accomplished with ducting air from attic to hearth area or from exterior of building to hearth area.

B. Clothes dryer - Where clothes dryer is located in conditioned space a 4" fresh air vent with back draft damper should be installed from exterior of building to the back of area where dryer will be located, therefore, permitting fresh air to be drawn in to the room where dryer is being used.

C. Kitchen vent-a-hood should be vented to exterior of structure with back draft damper in vent.

D. Bathroom vent should be vented to attic space.

VII. Windows

In designing, where possible, keep all windows to minimum size. Windows should be double glazed thermopane type or storm sash.

XI. Doors

All doors to conditioned space should be insulated doors with particular care in regard to full weather stripping of doors.

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Riveroak #9 Builder Jesse Waller - Rouse Job

Square feet of living area 1906 Square feet of glass 204 ( ) Insulated (X) Non Insulated

Number of occupants 2 Square feet of doors 38 ( ) Insulated (X) Non Insulated

BTU Cooling required at 95° outdoor temperature 27,420 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 45,416 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	1275	44.56		
November 77	815	29.90		
December 77	1371	43.47		
January 78	1803	55.88		
February 78	1796	59.42		
March 78	398	19.53		
Total Heating Season Usage	7458	252.76		
April 77	1062	35.19		
May 77	2079	67.89		
June 77	496	21.03		
July 77	1017	39.15		
August 77	1622	57.15		
September 77	1466	53.68		
Total Cooling Season Usage	7742	274.09		
Total Annual Usage	15,200	526.85		

Total Electric Usage 526.85 Average Cost Per Month 43.90

Total Heating and Cooling not sub metered Average Cost Per Month

ENERGY MANAGEMENT SPECIALISTS

3 TON Hi-KE-LI WESTINGHOUSE HEAT PUMP.
10 KW EMERGENCY HEAT

Second Year

Page #1

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location ~~Bevil Oaks~~ River Oaks #9 Builder Jesse Waller-Rousegol

Square feet of living area 1906 Square feet of glass 204 ( ) Insulated (✓) Non Insulated

Number of occupants 2 Square feet of doors 38 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 27,420 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 45,416 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	623	$31 - 22.29		
November 78	1037	35.11		
December 77	1803	55.88		
January 78	1796	59.42		
February 78	398	19.53		
March 78	2500	80.09		
Total Heating Season Usage	8157	$272.32 / $261.52		
April 78	682	$29.26		
May 78	1371	52.14		
June 78	1787	65.74		
July 78	1648	68.40		
August 78	1869	71.44		
September 78	1160	42.04		
Total Cooling Season Usage	8517	$329.02 / $291.72		
Total Annual Usage 16,674		$601.34 / $553.24		

Total Electric Usage $601.34 / $553.24 Average Cost Per Month $50.11

Total Heating and Cooling NOT SUB-METERED Average Cost Per Month —

ENERGY MANAGEMENT SPECIALISTS

Rouse Job

Air conditioning and heating equipment used; HOUSE # 1

Brand Westinghouse Type Hi-Re-Li Heat Pump - 3 ton

BTU's Cooling 36,000 EER: 7.1 BTU's Heating 41,000 C.O.P. 2.7

Emergency heating, KW. strip 10 KW XXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (x) Concrete Slab

Wall Consturction: (X) Brick Veneer
(X) Vapor Ba-rier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(x) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(x) Power vent

Fresh Air Vent:

( ) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(x) R-30

Duct System:

(x) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #2

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location River Oaks Builder Jesse Waller

Square feet of living area 2416 Square feet of glass 280 (X) Insulated ( ) Non Insulated

Number of occupants 5 Square feet of doors 38 ( ) Insulated (X) Non Insulated

BTU Cooling required at 95° outdoor temperature 29,665 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 50,474 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	2707	86.58	1070	34.22
November 77	2112	61.67	343	10.02
December 77	2367	67.46	282	9.04
January 78	2914	83.62	766	21.90
February 78	3382	102.46	1254	37.99
March 78	2986	100.86	952	32.08
Total Heating Season Usage	16,468	502.65	4667	144.25
April 77	2019	57.74	238	6.81
May 77	2243	72.06	282	9.02
June 77	2700	88.73	900	28.80
July 77	3902	130.80	1619	55.01
August 77	2917	96.74	1591	52.82
September 77	3243	109.92	1417	48.04
Total Cooling Season Usage	17,024	555.99	6046	200.50
Total Annual Usage	33,492	1,058.64	10,713	344.75

Total Electric Usage 1,058.64 Average Cost Per Month 88.22

Total Heating and Cooling 344.75 Average Cost Per Month 28.73

ENERGY MANAGEMENT SPECIALISTS

4 ton Hi-Rchi Westinghouse Heat Pump with 20 KW Emergency Heat

Page #2

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location ~~Best Oaks~~ River Oaks Builder Jesse Waller

Square feet of living area 2416 Square feet of glass 280 ( ) Insulated (✓) Non Insulated

Number of occupants 5 Square feet of doors 38 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 29,665 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 50,474 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	1860	$\$58^{92}$	322	$\$9^{66}$
November 78	2197	70^{10}	323	9^{69}
December 77	2914	83^{62}	766	22^{98}
January 78	3382	102^{46}	1254	37^{62}
February 78	2986	100^{86}	952	28^{56}
March 78	2506	79^{50}	332	9^{96}
Total Heating Season Usage	15,845 / 17,181	$\$495^{46}$ / $\$488^{25}$	3,949 / 4669	$\$118^{41}$ / $\$141^{60}$
April 78	2184	$\$78^{84}$	348	$\$13^{92}$
May 78	3216	112^{61}	1165	46^{60}
June 78	3107	109^{62}	1393	55^{72}
July 78	3349	135^{74}	1490	56^{60}
August 78	2584	97^{71}	1215	48^{60}
September 78	3053	105^{25}	1129	33^{87}
Total Cooling Season Usage	17,493 / 17,024	$\$639^{83}$ / $\$555^{99}$	6740 / 6046	$\$255^{31}$ / $\$208^{11}$
Total Annual Usage	33,338 / 24,205	$\$1,135^{29}$ / $\$1,044^{24}$	10,689 / 10,715	$\$373^{78}$ / $\$349^{71}$

Total Electric Usage $\$1,135^{29}$ / $\$1,044^{24}$ Average Cost Per Month $\$94^{61}$ / $\$87^{02}$

Total Heating and Cooling $\$373^{78}$ / $\$349^{71}$ Average Cost Per Month $\$31^{15}$ / $\$29^{14}$

ENERGY MANAGEMENT SPECIALISTS

1977 IN RED

Waller Job

HOUSE #2

Air conditioning and heating equipment used;

Brand Westinghouse Type Hi-Re-Li Heat Pump - 4 ton

BTU's Cooling 50,000 EER: 7.3 BTU's Heating 56,000 C.O.P. 2.9

Emergency heating, KW. strip 20 KW XXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (X) Concrete Slab

Wall Consturction: (X) Brick Veneer
(X) Vapor Barrier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(X) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(X) Power vent

Fresh Air Vent:

(X) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(X) R-30

Duct System:

(X) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Silsbee Builder Owner - Calk Job

Square feet of living area 3378 Square feet of glass 181 (X) Insulated ( ) Non Insulated

Number of occupants 4 Square feet of doors 88 ( ) Insulated (X) Non Insulated

BTU Cooling required at 95° outdoor temperature 32,678 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 61,637 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	1956	64.94		
November 77	3091	86.70		
December 77	2718	76.80		
January 78	3195	91.65		
February 78	3489	106.42		
March 78	2444	85.07		
Total Heating Season Usage	16,893	511.58		
April 77	2292	64.88		
May 77	2729	87.12		
June 77	3655	119.01		
July 77	3436	117.06		
August 77	3120	104.03		
September	3798	128.88		
Total Cooling Season Usage	19,030	620.98		
Total Annual Usage 35,923		1,132.56		

Total Electric Usage 1,132.56 Average Cost Per Month 94.38

Total Heating and Cooling Not sub metered Average Cost Per Month

ENERGY MANAGEMENT SPECIALISTS

Upstairs - 2 1/2 ton outdoor condensing unit with 10 KW electric furnance

Downstairs - 2 1/2 ton Hi-Re-Li Westinghouse Heat Pump with 10 KW emergency Heat

Page #3

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Silsbee Builder Owner - Calk Job

Square feet of living area 3378 Square feet of glass 181 ( ) Insulated (✓) Non Insulated

Number of occupants 4 Square feet of doors 88 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 16,293 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 24,673 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	2689	$84.47		
November 77	2718	76.80		
December 77	3195	91.65		
January 78	3489	106.42		
February 78	2444	85.07		
March 78	2398	77.22		
Total Heating Season Usage	16,933 / 13,174	$521.63 / $371.82		
April 78	2357	$85.40		
May 78	3083	109.25		
June 78	3621	127.92		
July 78	3308	136.74		
August 78	3657	138.71		
September 78	3301	114.69		
Total Cooling Season Usage	19,327 / 19,030	712.71 / $620.98		
Total Annual Usage	36,260 / 32,204	$1,234.34 / $992.80		

Total Electric Usage $1,234.34 / $992.80 Average Cost Per Month $102.86 / $82.73

Total Heating and Cooling NOT SUB-METERED Average Cost Per Month —

ENERGY MANAGEMENT SPECIALISTS

J. L. Calk Job

Air conditioning and heating equipment used; HOUSE #3

Brand Westinghouse Type Upstairs-2½ ton cooling-10 KW elect. furnace / Downstairs-Hi-Re-Li Heat Pump - 2½ ton

BTU's Cooling up-30,000 / dn-31,000 EER: up- 7.1 / dn- 7.3 BTU's Heating up-34,130 / dn-31,500 C.O.P. up- 1-1 / dn- 3

Emergency heating, KW. strip 10 KW XXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (X) Concrete Slab

Wall Consturction: (X) Brick Veneer
(X) Vapor Barrier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(X) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(X) Power vent

Fresh Air Vent:

(X) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(X) R-30

Duct System:

(X) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #4

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Lumberton Builder Hugh Haley - Bradley Job

Square feet of living area 1524 Square feet of glass 141 ( ) Insulated (XX Non Insulated

Number of occupants 5 Square feet of doors 56 ( ) Insulated (X) Non Insulated

BTU Cooling required at 95° outdoor temperature 22,369 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 39,334 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	1650	55.26	708	23.64
November 77	1037	35.10	190	6.43
December 77	1138	37.35	38	1.25
January 78	1511	47.91	176	5.58
February 78	1730	57.03	701	23.10
March 78	1369	51.37	387	14.51
Total Heating Season Usage	8435	284.02	2,200	74.51
April 77	1033	34.16	26	.85
May 77	1278	43.78	239	8.12
June 77	1753	59.84	803	27.30
July 77	2065	72.21	1108	38.75
August 77	2214	74.95	1194	40.42
September 77	1867	65.97	970	34.27
Total Cooling Season Usage	10,210	350.91	4340	149.71
Total Annual Usage	18,645	634.93	6540	224.22

Total Electric Usage 634.93 Average Cost Per Month 52.91

Total Heating and Cooling 224.22 Average Cost Per Month 18.69

ENERGY MANAGEMENT SPECIALISTS

2½ ton WESTINGHOUSE HEAT PUMP + 10 KW EMERGENCY HEAT

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location LUMBERTON Builder Haley Homes, Inc. - Bradley Joi

Square feet of living area 1524 Square feet of glass 141 ( ) Insulated (✓) Non Insulated

Number of occupants 5 Square feet of doors 56 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 22,369 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 39,334 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	955	# 32.13	45	# 1.35
November 77	1138	37.35	38	1.14
December 77	1511	47.91	176	5.28
January 78	1730	57.03	701	21.03
February 78	1369	51.37	387	15.48
March 78	1010	37.69	61	2.44
Total Heating Season Usage	7,713 / 10,603	$263.48 / #309.44	1,408 / 2,448	#46.73 / #71.12
April 78	984	# 39.01	180	# 7.20
May 78	1709	62.81	733	29.32
June 78	1973	74.87	-0-	-0-
July 78	1729	72.09	1772 (2 MONTHS)	70.88
August 78	1859	71.06	840	33.60
September 78	1323	47.40	423	16.92
Total Cooling Season Usage	9,577 / 9,567	$367.24 / #306.92	3,948 / 3102	$157.92 / #98.87
Total Annual Usage	17,290 / 20,170	#630.72 / #616.37	5,356 / 5,550	$204.64 / #169.99

Total Electric Usage #630.72 / $616.37 Average Cost Per Month $52.56 / $51.36

Total Heating and Cooling #204.64 / #169.99 Average Cost Per Month #17.05 / #14.17

ENERGY MANAGEMENT SPECIALISTS

1977 IN RED

Air conditioning and heating equipment used; HOUSE #4

Brand Westinghouse Type Hi-Re-Li Heat Pump 2½ ton

BTU's Cooling 28,000 EER: 6.1 BTU's Heating 30,000 C.O.P. 2.4

Emergency heating, KW. strip 10 KW XXXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (x) Concrete Slab

Wall Consturction:
- (x) Brick Veneer
- (x) Vapor Barrier-6 mil Polyethelene
- (x) Styrofoam Sheathing
- (x) 2 x 4 studs
- (x) R-11 insulation batts
- ( ) Caulking-Polycel One
- (x) Caulking-Other

Roof Constuction:
- (x) Composition shingles

Attic Ventilation: 1-5 square inches per square feet attic area
- (x) Eave vents
- ( ) Gable Louvers
- ( ) Ridgerow
- ( ) Wind turbine
- (x) Power vent

Fresh Air Vent:
- (x) Fire Place
- (x) Clothes Dryer
- (x) Bathroom Vents
- (x) Kitchen Vent A Hood Vent

Attic Insulation:
- ( ) R-19
- (x) R-30

Duct System:
- (x) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #5

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Beaumont - Eldridge Dr. Builder Owner - Glazener

Square feet of living area 1594 Square feet of glass 150 ( ) Insulated (X) Non Insulated

Number of occupants 4 Square feet of doors 74 ( ) Insulated (X) Non Insulated

BTU Cooling required at 95° outdoor temperature 26,712 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 46,310 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77		122.40		
November 77		100.46		
December 77		60.47		
January 78		89.48		
February 78		80.12		
March 78		109.29		
Total Heating Season Usage		562.22		
April 78		98.58		
May 77		68.41		
June 77		66.19		
July 77		99.39		
August 77		111.01		
September 77		127.03		
Total Cooling Season Usage		560.61		
Total Annual Usage		1,122.83		

Total Electric Usage______ Average Cost Per Month 93.57

Total Heating and Cooling______ Average Cost Per Month______

ENERGY MANAGEMENT SPECIALISTS

Glazener Job

HOUSE #5

Air conditioning and heating equipment used;

Brand Bryant Type Electric Cooling/Gas Heating

BTU's Cooling 36,000 EER: ? BTU's Heating 80,000 C.O.P. ---------

Emergency heating, KW. strip ----------- XXXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (X) Concrete Slab

Wall Consturction: (X) Brick Veneer
( ) Vapor Barrier-6 mil Polyethelene
( ) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
( ) Caulking-Polycel One
( ) Caulking-Other
(X) A - I Sheathing

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1-5 square inches per square feet attic area

(X) Eave vents
(X) Gable Louvers
( ) Ridgerow
(X) Wind turbine
( ) Power vent

Fresh Air Vent:

( ) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

(X) R-19
( ) R-30

Duct System:

( ) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #6

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Lumberton Builder Hugh Haley

Square feet of living area 1186 Square feet of glass 67 ( ) Insulated (x) Non Insulated

Number of occupants 1 Square feet of doors 74 ( ) Insulated (x) Non Insulated

BTU Cooling required at 95° outdoor temperature 12,558 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 28,804 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 76	720	26.[illegible]	151	5.59
November 76	548	21.32	13	.51
December 76	550	20.18	148	5.42
January 77	997	33.03	366	12.11
February 77	961	32.70	358	12.17
March 77	677	27.10	74	2.96
Total Heating Season Usage	4453	$161.21		$38.76
April 77	542	21.76	-	-
May 77	697	26.78	50	1.92
June 77	881	33.28	248	9.35
July 77	1038	39.46	438	16.64
August 77	1147	41.89	489	17.86
September 77	1118	42.06	482	18.12
Total Cooling Season Usage	5423	$205.73		$63.89
Total Annual Usage	9875	$366.44		$102.65

Total Electric Usage $366.44 Average Cost Per Month $30.54

Total Heating and Cooling $102.65 Average Cost Per Month $8.55

2 ton Westinghouse Package Heat Pump

Page #6

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Lumberton Builder Haley Homes Inc

Square feet of living area 1186 Square feet of glass 67 ( ) Insulated (✓) Non Insulated

Number of occupants 1 Square feet of doors 74 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 12,558 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 28,804 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	897	$33.34	284	$10.56
November 77	507	20.92	12	.50
December 77	670	25.89	47	1.82
January 78	987	34.58	291	10.19
February 78	1,058	38.56	557	20.28
March 78	326	16.31	557	27.85
Total Heating Season Usage	4,445 / 4677	$169.60 / $166.67	1,748 / 1270	$71.20 / $43.84
April 78	529	23.44	— 0 —	— 0 —
May 78	590	25.86	— 0 —	— 0 —
June 78	821	33.48	237	9.67
July 78	1094	43.82	486	19.49
August 78	969	42.06	419	18.19
September 78	1210	47.58	475	18.67
Total Cooling Season Usage	5,213 / 5423	$216.24 / $205.31	1,618 / 1707	$66.06 / $63.90
Total Annual Usage	9658 / 10,100	$385.84 / $371.88	3,365 / 2977	$137.22 / $107.44

Total Electric Usage $385.84 / $371.88 Average Cost Per Month $32.15 / $30.99

Total Heating and Cooling $137.22 / $107.44 Average Cost Per Month $13.72 / $8.95

ENERGY MANAGEMENT SPECIALISTS

1977 in RED

Chilton Job

Air conditioning and heating equipment used; HOUSE #6

Brand Westinghouse Type Standard Heat Pump - Package Unit - 2 ton

BTU's Cooling 22,000 EER: 6.9 BTU's Heating 21,000 C.O.P. 2.3

Emergency heating, KW. strip 10 KW XXXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (x) Concrete Slab

Wall Consturction: (x) Brick Veneer
(x) Vapor Barrier-6 mil Polyethelene
(x) Styrofoam Sheathing
(x) 2 x 4 studs
(x) R-11 insulation batts
(x) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(x) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(x) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(x) Power vent

Fresh Air Vent:

( ) Fire Place
(x) Clothes Dryer
(x) Bathroom Vents
(x) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(x) R-30

Duct System:

(x) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #7

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Beaumont Builder Jesse Waller - Ebner Job

Square feet of living area 2328 Square feet of glass 145 (X) Insulated ( ) Non Insulated

Number of occupants 3 Square feet of doors 76 ( ) Insulated (x) Non Insulated

BTU Cooling required at 95° outdoor temperature 22,442 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 49,428 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	1711	57.06		
November 77	1085	36.30		
December 77	1011	34.24		
January 78	1693	52.54		
February 78	2124	67.86		
March 78	1978	70.00		
Total Heating Season Usage	9602	318.00		
April 77	993	33.21		
May 77	1073	37.78		
June 77	1593	54.95		
July 77	2235	77.64		
August 77	2571	86.03		
September 77	2171	75.69		
Total Cooling Season Usage	10,636	365.30		
Total Annual Usage	20,238	683.30		

Total Electric Usage 683.30 Average Cost Per Month 56.94

Total Heating and Cooling Not sub metered Average Cost Per Month

3 ton Hi-Re-Li Westinghouse Heat Pump with 10 KW Emergency Heat

Page #7

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713-842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Beaumont Builder Jesse Waller-Ebner Job

Square feet of living area 2328 Square feet of glass 145 ( ) Insulated (✓) Non Insulated

Number of occupants 3 Square feet of doors 76 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 22,442 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 49,428 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 78	613	$21.99		
November 77	1011	$34.24		
December 77	1693	52.54		
January 78	2124	67.86		
February 78	1978	70.00		
March 78	1283	45.31		
Total Heating Season Usage	8,102	$291.94		
April 78	850	$34.56		
May 78	783	32.22		
June 78	616	26.84		
July 78	1511	63.46		
August 78	1154	45.54		
September 78	1110	40.37		
Total Cooling Season Usage	6024	$242.99		
Total Annual Usage	14,726	$534.93		

Total Electric Usage $534.93 Average Cost Per Month $44.58

Total Heating and Cooling NOT Sub-Metered Average Cost Per Month ——

ENERGY MANAGEMENT SPECIALISTS

Ebner Job

Air conditioning and heating equipment used;

Brand Westinghouse Type Hi-Re-Li Heat Pump - 3 ton

BTU's Cooling 36,000 EER: 7.3 BTU's Heating 40,500 C.O.P. 2.9

Emergency heating, KW. strip 10 KW XXXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (XX) Concrete Slab

Wall Consturction: (XX) Brick Veneer
(X) Vapor Barrier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(X) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(X) Power vent

Fresh Air Vent:

( ) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(X) R-30

Duct System:

(X) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Rolling Hills Builder Jesse Waller

Square feet of living area 1776 Square feet of glass 142 ( ) Insulated (x) Non Insulated

Number of occupants 4 Square feet of doors 47 ( ) Insulated (x) Non Insulated

BTU Cooling required at 95° outdoor temperature 20,192 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 40,540 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost Elect.	Monthly Cost Gas	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 76	1813	$58.62	12.22		
November 76	679	25.13	22.23		
December 76	863	27.43	28.04		
January 77	652	25.12	37.81		
February 77	787	30.26	30.74		
March 77	797	28.80	17.71		
Total Heating Season Usage	5591	$195.36	148.82		
April 77	1009	36.25	12.66		
May 77	1598	55.64	9.66		
June 77	2363	82.51	10.25		
July 77	2413	82.48	9.06		
August 77	2056	72.70	9.06		
September 76	1845	57.35	12.29		
Total Cooling Season Usage	11302	$386.93	62.98		
Total Annual Usage	16,893				

Total Electric Usage & Gas $794.09 Average Cost Per Month $66.17

Total Heating and Cooling not sub metered Average Cost Per Month -

ENERGY MANAGEMENT SPECIALISTS

2½ ton Westinghouse Outdoor Condensing Unit with 3 ton Coil
80,000 BTU Gas Furnace

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

Page #8

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location ~~Bevil Oaks~~ Rolling Hills Builder Jesse Waller

Square feet of living area 1776 Square feet of glass 142 ( ) Insulated (✓) Non Insulated

Number of occupants 4 Square feet of doors 47 ( ) Insulated (✓) Non Insulated

BTU Cooling required at 95° outdoor temperature 20,192 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 40,540 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	~~Submeter for heating & Cooling kilowatt used~~ Gas Used	Monthly Cost	~~Submeter Monthly cost~~ Total Utility Cost
October 78	1425	$46.04	18	$10.55	$56.59
November 77	1141	37.78	68	22.38	60.16
December 77	1017	35.69	30	28.04	63.73
January 78	903	34.62	94	31.96	66.58
February 78	943	38.69	116	40.76	79.45
March 78	1093	40.39	76	28.51	68.90
Total Heating Season Usage	6522	$233.21	402	$162.20	$395.41
April. 78	1224	$47.43	34	$15.72	$63.15
May 78	2122	77.19	28	13.76	$90.95
June 78	2772	98.48	20	10.98	109.46
July 78	2591	105.64	18	10.29	115.93
August 78	2710	102.42	22	12.00	114.42
September 78	2319	80.50	22	12.00	92.50
Total Cooling Season Usage	13,738	$511.66	144	$74.75	$586.41
Total Annual Usage 20,260	$744.87 / $582.29	546	$236.95 / $211.80	$981.83 / $794.09	

Total Electric & Gas Usage $981.83 / $794.09 Average Cost Per Month $81.83 / $66.17

Total Heating and Cooling NOT SUB-METERED Average Cost Per Month —

ENERGY MANAGEMENT SPECIALISTS

©1977 IN REO

Franklin Joh

Air conditioning and heating equipment used;

Brand Westinghouse Type Electric Cooling / Gas Heating

BTU's Cooling 30,000 EER: 7.1 BTU's Heating 80,000 C.O.P. -------

Emergency heating, KW. strip --------- XXXXXXXXXX

Type of construction used to obtain above operating cost (items checked)

Foundation: (XX) Concrete Slab

Wall Consturction: (X) Brick Veneer
(X) Vapor Barrier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1-5 square inches per square feet attic area

(X) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(x) Power vent

Fresh Air Vent:

( ) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(X) R-30

Duct System:

(x) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

HOUSE #9

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report

Location Beaumont - Longwood Builder Enery Homes - Christopher Joh

Square feet of living area 3445 Square feet of glass 338* (X) Insulated ( ) Non Insulated

Number of occupants 5 Square feet of doors 80 (XX) Insulated ( ) Non Insulated

BTU Cooling required at 95° outdoor temperature 42,756 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 73,452 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	2437	79.33		
November 77	1918	57.42		
December 77	2428	69.63		
January 78	2696	78.83		
February 78	4331	129.79		
March 78	2842	97.38		
Total Heating Season Usage	16,652	512.38		
April				
May				
June				
July				
August 77	2162	74.06		
September 77	3827	129.81		
Total Cooling Season Usage	5989	203.87		
8 MONTHS ONLY Total Annual Usage	22,641	716.25		

Total Electric Usage 716.25 8 MONTHS ONLY Average Cost Per Month 89.53

Total Heating and Cooling Not sub metered Average Cost Per Month

ENERGY MANAGEMENT SPECIALISTS

* ADDITIONAL 30 SQ. FT. OF INSULATED SKY LIGHTS

2 - 2½ ton Westinghouse Heat Pumps
with 20 KW emergency Heat

Page #9

THE QUINTON COMPANY

AIR CONDITIONING HEATING INSULATION
1215 LINDBERGH DRIVE
BEAUMONT, TEXAS 77707
713 - 842-0115

ENERGY EFFICIENT HOMES
Heating and Cooling
One Year Cost of Operation Report Christopher Job

Location Beaumont - Longwood Builder Energy Homes One

Square feet of living area 3445 Square feet of glass 338* (✓) Insulated ( ) Non Insulated

Number of occupants 5 Square feet of doors 80 (✓) Insulated ( ) Non Insulated

BTU Cooling required at 95° outdoor temperature 42,756 (4000 degree hours)

BTU Heating required at 20° outdoor temperature 73,452 (1500 degree days)

Month	Total kilowatt Used	Monthly Cost	Submeter for heating & Cooling kilowatt used	Submeter Monthly cost
October 77	1918	$57.42		
November 77	2428	69.63		
December 77	2696	78.83		
January 78	4331	129.79		
February 78	2842	97.38		
March 78	2224	72.29		
Total Heating Season Usage	16,439	$505.34		
April 78	2519	$90.83		
May 78	3177	$112.38		
June 78	3353	$121.41		
July 78	3252	$134.47		
August 78	3418	$129.81		
September 78	2278	$79.88		
Total Cooling Season Usage	17,997	$668.78		
Total Annual Usage 34,436		$1,174.12		

Total Electric Usage $1,174.12 Average Cost Per Month $93.84

Total Heating and Cooling NOT SUB-METERED Average Cost Per Month —

ENERGY MANAGEMENT SPECIALISTS

* ADDITIONAL 30 sq. ft. of insulated sky lights

HOUSE #9

Christopher Joh

Air conditioning and heating equipment used;

Brand Westinghouse Type 2 Hi-Re-Li Heat Pumps - 2½ tons each

BTU's Cooling 32,000 ea. EER: 7.3 BTU's Heating 35,500 ea. C.O.P. 2.9

Emergency heating, KW. strip 20 KW xxxxxxxxxx

Type of construction used to obtain above operating cost (items checked)

Foundation: (XX) Concrete Slab

Wall Consturction: (X) Brick Veneer
(X) Vapor Barrier-6 mil Polyethelene
(X) Styrofoam Sheathing
(X) 2 x 4 studs
(X) R-11 insulation batts
(X) Caulking-Polycel One
( ) Caulking-Other

Roof Constuction:

(X) Composition shingles

Attic Ventilation: 1.5 square inches per square feet attic area

(XX) Eave vents
( ) Gable Louvers
( ) Ridgerow
( ) Wind turbine
(X) Power vent

Fresh Air Vent:

(X) Fire Place
(X) Clothes Dryer
(X) Bathroom Vents
(X) Kitchen Vent A Hood Vent

Attic Insulation:

( ) R-19
(X) R-30

Duct System:

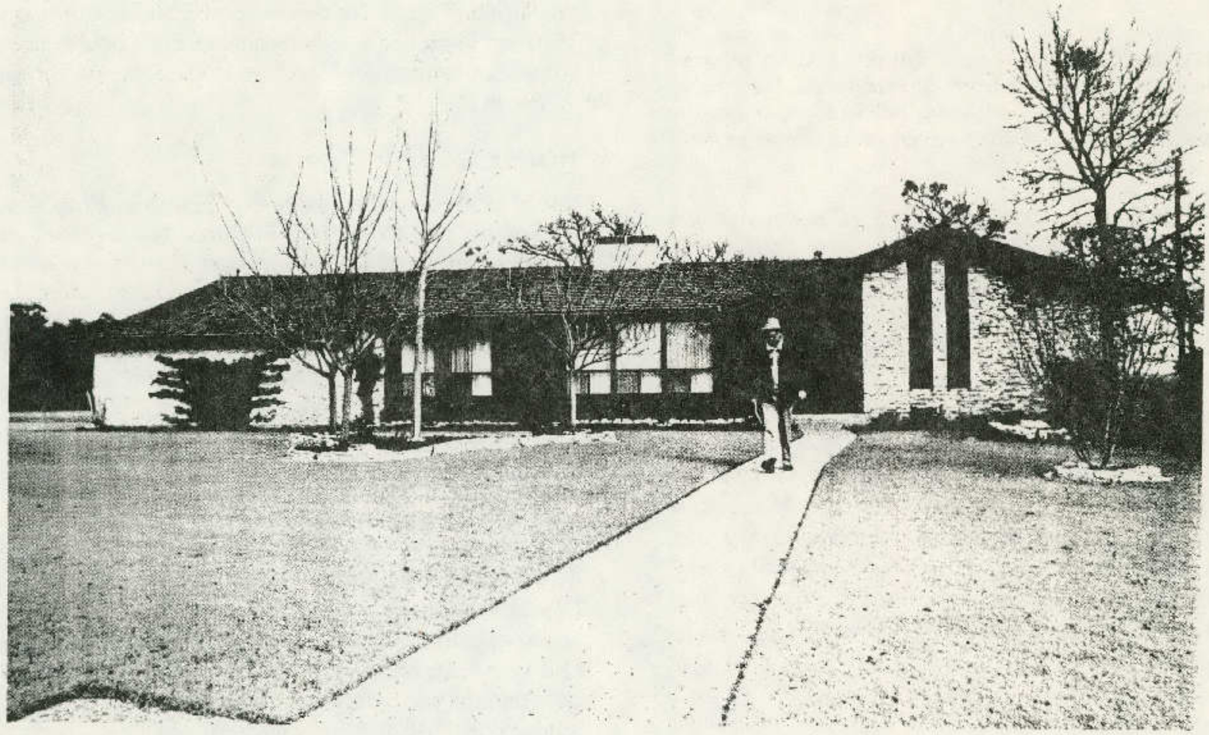
(X) 1" rectangular glass fiber, 4½ lbs. density duct board sized at .08 static pressure.

BUILD YOUR OWN ENERGY-SAVER HOME

OR

UPGRADE YOUR EXISTING HOME

By Roy L. Wilson



ENERGY-SAVER HOMES CO.
P.O. BOX 10083
AUSTIN, TEXAS 78766

Section 7

Dollar Benefits of Energy-Saving Construction

GENERAL

As previously mentioned and repeated for emphasis, a recent pamphlet by the American Institute of Architects said in part:

> "In existing buildings, fuel consumption could be reduced by as much as 50 percent from current levels. New buildings initially designed to be energy efficient could save as much as 80% of the fuel they would consume at present levels."

The last figure seems extreme—"an 80% savings on fuel costs." Yet, the figure is true—an 80% savings is possible as to heating and cooling costs over an identical building that is not properly insulated, contains single-glazed windows and which was not built to the "new" standards of draft prevention.

Most houses built today conform to FHA Minimum Property Standards of insulation and general construction techniques as related to energy efficiency. In relation to the energy crisis, these standards are much too low and will surely be increased in the near future. Very large savings in energy use can be gained by houses that are built to a higher level of insulation and energy-saving construction than that now specified by the FHA. This is illustrated by the following study of four houses in the Austin, Texas area during 1976.

HOUSE COMPARISON—CONSTRUCTION FACTS

The energy-saving comparison to follow was made against four houses, all on the same street and all observed during construction by the author. Basic house facts are:

HOUSES A & B

Insulated to FHA Min. Prop. Stds. on an uninsulated slab foundation. Features single-glazed windows (covered with storm windows in mid 1976). Have dark-colored shingles, with attic ventilated by two turbine ventilators in conjunction with gable-end and eave vents. House A has wood front door, with rear door and door into garage being metal clad. House B has all-wood outer doors. Extra attention paid by owners to improving weatherstripping. Screen doors installed to use natural ventilation during moderate-summer period. Both houses are all-electric, use electric-strip heating and have a stone-faced fireplace built into an outer wall. Both installed storm windows in 1976 and improved weatherstripping. Both houses are rated at somewhat better than FHA Min. Prop. Stds. Two occupants in A, five in B.

HOUSE C

Insulated to somewhat better than FHA Min. Prop. Stds. on an uninsulated slab foundation. Features double-glazed windows, brown-colored asphalt shingles and an attic ventilated with a power-drive roof ventilator and gable-end vents. All outer doors are solid wood and a stone-faced fireplace is built into an outer wall. House is all-electric, using a heat pump for both heating and cooling. Extra care was taken to reduce drafts. Two occupants.

HOUSE D

Built by author and insulated to better than FHA Min. Prop. Stds. (R13 walls, R38 ceiling and R13 under floor). Built on an insulated crawl-space foundation. Features wood shingles, double-glazed windows and a fireplace built into an inner wall. Uses a free-standing fireplace in winter. Attic ventilated by a power-driven fan and gable-end vents. All outer doors are metal-clad with magnetic weatherstripping. Uses a screen door on front door to gain natural ventilation. *Extreme* care was taken to reduce drafts. All-electric home and uses a heat pump for both heating and cooling. Two occupants. For additional details, refer to page 7-5.

HOUSE COMPARISON—DOLLAR BENEFITS

The four-house comparison to follow illustrates the energy (and dollar) savings that can be realized by building an energy-saver home. The comparison is not exact and does not give precise answers for the following reasons:

- The air conditioning units are not on separate meters thus the actual electrical power (KWH's) used by each house for heating and cooling cannot be precisely identified.

Table 7-1. Electrical Power Consumption - 1976

Month	House A	House B	House C	House D	Remarks
Jan.	3371 KWH	2572 KWH	1810 KWH	1341 KWH	very cold
Feb.	1701	1562	*1200	782	moderate
March	1469	1744	*1200	896	moderate
April	1063	1221	830	633	mild
May	1200	1071	1130	624	mild
June	1999	1725	1280	820	warmer
July	1994	1989	1510	794	warmer
August	2344	2663	1880	*1449	hottest
Sept.	1975	1447	1560	* 569	cooler
Oct.	1781	1402	980	854	cool
Nov.	2104	2283	1680	1467	cold
Dec.	3326 KWH	2794 KWH	1710 KWH	1632 KWH	very cold
	24,327 KWH	22,474 KWH	16,770 KWH	11,861 KWH	

December 1976 averaged 1.5 times colder than Dec. 1975
*Vacation time correction

- House C and D enjoyed excellent natural ventilation, with House D being designed to optimize cross ventilation through the bedrooms and family-room-kitchen area. Houses A and B, each equipped with a front door screen door, are somewhat blocked from the prevailing wind and thus did not enjoy natural ventilation to the degree related to Houses C and D.
- Houses A, C and D all have two occupants whereas House B has five occupants.
- The comparison will be made assuming each house used essentially the same amount of electricity for all purposes other than air conditioning. That is, an equal amount for hot-water heating, cooking, lights, etc. This should be very close to correct for Houses A, C and D.
- Vacation periods for all houses somewhat balance out except for Houses C and D which averaged about 14 days greater than Houses A and B—this is compensated for in the comparison.

Table 7-1 above lists the electrical power (KWH) used by the four houses of the comparison study.

While the energy-saved and dollar-saved figures to follow may not be exact, it is felt that they are within 20% or less of actual. The savings are in close accord with those given under "Energy-Saver Home Examples," Section 9.

To arrive at a more accurate cost comparison for heating and cooling between the four houses, the electrical power (KWH) used by Houses A, B and C are now adjusted to that related to the smallest house (House D). This will make the air conditioning costs for all houses effectively equal. (See table 7-2 below.)

The monthly KWH figures given by Table 7-1 reveal that Houses C and D, each equipped with a heat pump, achieved their highest (greatest) KWH savings over Houses A and B during the winter months. The excellent summer-time savings of Houses C and D over Houses A and B are directly attributable to their double-glazed windows, extra insulation and draft prevention excellence. The figures for the coldest and warmest months of the year (1976) are as follows:

Heating Cost—Coldest Month

December - House A	3326 KWH	December - House C	1710 KWH
December - House B	+2795 KWH	December - House D	+1632 KWH
	6121 KWH		3342 KWH

House A + House B = 6121/2 = 3060 KWH average
House C + House D = 3342/2 = -1671 KWH average
Difference = 1389 KWH

1389 KWH's at 4.7 cents per KWH = $65.28 savings for December

The heating cost for Houses A & B averaged 1.83 times that of Houses C & D as averaged. The heat pump thus delivered $1.83 worth of heat per electrical dollar spent.

Table 7-2. Houses Averaged to 1944 Sq. Ft.

House	Sq. Ft.	KWH Used Yearly	KWH Yearly Per Sq Ft	Miltiplied by 1944	KWH Av. Per Month	Monthly Cost @ 4.7¢
A	2040	24,327	11.925	23,182	1,932	$90.80
B	2100	22,474	10.702	20,805	1,734	$81.50
C	2390	16,770	7.017	13,641	1,137	$53.44
D	1944	11,861	6.101	11,861	988	$46.44

The heating cost for Houses A & B averaged 1.83 times that of Houses C & D as averaged. The heat pump thus delivered $1.83 worth of heat per electrical dollar spent.

Cooling Cost—Warmest Month

August - House A	2344 KWH	August - House C	1880 KWH
August - House B	+2663 KWH	August - House D	+1449 KWH
	5007 KWH		3329 KWH

House A + House B = 5007/2 = 2503 KWH average
House C + House D = 3329/2 = -1664 KWH average
Difference = 839 KWH

839 KWH's at 4.7 cents per KWH = $39.43 savings for August

The cooling cost for Houses A & B averaged 1.5 times that of Houses C & D as averaged.

Using the 1944-square feet averaged figures from Table 7-2, the heating and cooling electrical bills of Houses A and B and then Houses C and D can be averaged and used to develop some interesting facts.

Table 7-3. Energy Efficiency vs Energy Bills

House A + B average = $90.80 + $81.50 = $172.30/2 = $86.15 per mo.
House C + D average = $53.44 + $46.44 = $ 99.88/2 = -49.94 per mo.
Difference = $36.21 per mo.

Monthly heating and cooling costs for A & B averaged 1.73 times the average of C & D. House C & D costs thus averaged to be only 58% that of A & B.

Average yearly savings of C & D over A & B is then $36.21 x 12 = $434.52 per year. For a 30-year period, based on 1976's KWH rate of 4.7¢, the total savings would be $434.52 x 30 = $13,035.60.

And note—these savings are based on 1976's KWH rate average of 4.7 cents. In 1975, here in Austin, Texas, the average yearly KWH rate was 3.83 cents—a difference of 0.87 cents in one year. This is an increase rate of 22.7% per year. What will the KWH rate be in 1977, 1980, etc. Higher, that's for certain—thus, the savings listed above will grow, year after year, as the electrical rates rise.

EXTRA OUTLAY VS. ENERGY SAVINGS

The grand question now is: How much extra capital outlay was required to raise the energy efficiency of House C and D over that of House A and B to realize such excellent energy and dollar savings?

Here is the most wonderful part of the whole energy-saving story—the cost *is not high*—it is, in fact, *very low* for the dollar savings gained. The extra cost to raise the energy efficiency of House C can only be estimated, being taken somewhat high at $2,000.00 at 1975 cost levels. For House D, the figure was taken directly from building records and also totals about $2,000.00. These figures cover the extra cost to install a heat pump over a "standard" air conditioner, install double-glazed windows, metal-clad doors, extra insulation and tightly seal the house. In each case, the extra cost is what a contractor would normally charge and thus contains a standard profit margin.

Table 7-4. Pertinent Facts on House D

$2,000.00 extra outlay/$434.52 yearly savings = 4.6 years payback time at a 4.7¢ KWH rate

Extra cost per sq ft.	= $2,000.00/1944	= $1.03
Bldg cost per sq ft.	= $45,000.00/1944	= $23.15 per sq ft
Bldg cost less extra	= $45,000.00-$2,000.00	= $43,000.00
Sq ft cost at FHA Min. Prop. Stds.	= $43,000.00/1944	= $22.12 per sq ft
Extra cost as a percentage	= $23.15 vs $22.12	= 4.7% greater

It should be noted here that Houses A and B were upgraded by the owners during 1976 to achieve a higher energy efficiency as to heating and cooling as compared to that related to houses built to strict FHA Minimum Property Standards. Thus, the cost comparison between the average of Houses C and D versus that of Houses A and B would have resulted in a higher savings by Houses C and D if Houses A and B had not been upgraded as to energy efficiency. A payback time of less than four years is thus clearly indicated if the comparison had been made against houses built to FHA Minimum Property Standards only.

The extra cost to raise the energy-efficiency level of House D calculates out to about five percent (4.7 actually). This figure can be considered very close and can be used to develop a close estimate of the extra outlay that will be required to raise a house from FHA Minimum Property Standards energy-efficiency to that related to the minimum energy-efficiency level needed today because of the energy crisis.

ENERGY EFFICIENCY UPGRADING

As mentioned above, Houses A and B were upgraded as to energy efficiency during 1976. That is, Houses A and B installed storm windows (in mid year) over their single-glazed windows and improved the caulking and weather-stripping around doors, windows and the house envelope. House A also replaced two wood outer doors with metal-clad units. Both houses also installed a screen door on the front door and used natural ventilation to the maximum degree possible to avoid using the air conditioner.

The 1976 November and December temperatures in the area (Austin, Texas) *were markedly cooler than normal* while the summer temperatures and humidity levels were about the same for both years. Even so, Houses A & B used considerably less electricity for 1976 as compared to 1975. The facts are given by Table 7-5.

SUMMARY

The dollar savings detailed by Table 7-3 (and those given in Section 9) illustrate the extreme dollar savings that can be realized for a comparatively moderate extra

Table 7-5. Energy Efficiency Upgrading Savings

House A

1975 KWH Usage =	27,572	
1976 KWH Usage =	- 24,327	
	3,245	KWH
	x 0.047	per KWH
	$152.52	

House B

1975 KWH Usage =	25,646	
1976 KWH Usage =	- 22,474	
	3,172	KWH
	x 0.047	
	$149.08	

The dollar savings gains are such that the extra outlay (about $500.00 per house) will be paid back in less than 4 years. Thereafter, the savings are total and will be enjoyed for the life of the house. Also, as the KWH rate goes up, the savings increase.

And, the comfort level of both houses was noticeably increased plus the outside noise level was greatly reduced.

outlay to raise the energy-efficiency level of a house. In a pamphlet recently issued by the American Institute of Architects, the following was said:

> "In some instances, it may be possible to achieve energy efficiency without additional capital costs. On the whole, however, energy efficient buildings will tend to cost more than traditionally designed and constructed projects . . . about 10 to 20 per cent above usual construction costs."
>
> "It is especially significant that the payback period for capital expenditures for energy efficient buildings might range from 10 to 15 years."

The figures given are somewhat general and cover all types of buildings—offices, factories, schools, homes, etc. The cost figures given by various manufacturers of energy-efficient windows, doors, insulation, etc. generally indicate payback times of from only a few months to perhaps as high as 10 years. The actual energy saved (and thus the dollars saved) will be individual for each house. The actual savings realized is always difficult to establish precisely since one must know exactly what the comparison is made against. That is, do the figures relate to a rather well insulated house, an uninsulated, poorly-built house, etc.

When computing the payback period for a particular energy-saving feature (double-glazed windows versus single-glazed windows, for example), one must consider the future. That is, the cost of electricity here in Austin, Texas rose about 22% during 1976 over 1975 and will be higher on the average during 1977. In brief, the cost of energy (electricity and gas, mainly) will rise on a year-by-year basis. Thus, a payback time of 5 years at 1976 energy rates, may be reduced to a total of 3 years by increasing energy costs in the next two or three years.

ENERGY COSTS VS. HOUSE SIZE

The energy costs for Houses A, B, C and D (as factored to 1944 square feet) are listed by Table 7-2 on a monthly-dollar-basis. These figures, divided by 1944, give energy costs for each house on a square-foot basis as follows:

House A - $90.80/1944 = 4.67 cents
House B - $81.50/1944 = 4.19 cents
House C - $53.44/1944 = 2.75 cents
House D - $46.44/1944 = 2.39 cents

These figures can be used to develop a table (Table 7-6) of estimated energy costs for houses of various sized living areas on a monthly basis and for the four levels of energy efficiency demonstrated by Houses A, B, C and D.

Table 7-6. Estimated Energy Costs vs. House Size

Living Area	House A 4.67¢	House B 4.19¢	House C 2.75¢	House D 2.39¢
1200	$ 56.04	$ 50.28	$33.00	$28.68
1300	$ 60.71	$ 54.47	$35.75	$31.07
1400	$ 65.38	$ 58.66	$38.50	$33.46
*1500	$ 70.05	$ 62.85	$41.25	$35.85
1600	$ 74.72	$ 67.04	$44.00	$38.24
1700	$ 79.39	$ 71.23	$46.75	$40.63
1800	$ 84.06	$ 75.42	$49.50	$43.02
1900	$ 88.73	$ 79.61	$52.25	$45.41
2000	$ 93.40	$ 83.80	$55.00	$47.80
2500	$116.75	$104.75	$68.75	$59.75
3000	$140.10	$125.70	$82.50	$71.70

*Example house

The figures given by Table 7-6 are, of course, only approximates and will differ (even widely) for other climatic areas, different construction standards, different living habits, etc. Yet, the figures are useful and can serve as guidelines. In a practical sense, a larger house will always be less efficient energy-wise because it usually houses a larger family, more children, more windows, etc. Further, large homes usually feature vaulted or cathederal ceilings and thus will have a larger cubic-foot total per square-foot of living space. And, it is the cubic feet that actually count as related to heating and cooling a house.

The figures given by Table 7-6 relate to homes in the Austin, Texas area where mild to moderate winters and moderate to hot summers are normal. The figures given by Table 7-6 can be factored to produce meaningful figures for houses in other climatic areas. This factoring can be accomplished by use of the Degree Days (Heating and Cooling) values obtained from Figures 6-1 and 6-2, Section 6. The Degree Days factors for certain cities are given below bv Table 7-7.

Table 7-7. Degree Day Figures - Factored

City	Degree Days Winter	Summer	Winter-Summer Totals	Ratio to Austin Figures
Austin, Tx	1800	2850	4650	
Los Angeles	1900	500	2400	2400/4650 = 0.52
Miami, Florida	125	4000	4125	4125/4650 = 0.89
Oklahoma City	3500	2000	5500	5500/4650 = 1.18
Seattle, Wash.	5800	250	6050	6050/4650 = 1.30
Chicago, Ill.	6300	800	7100	7100/4650 = 1.53
Duluth, Minn.	9400	250	9650	9650/4650 = 2.08

The Austin figure, for example, if used for a house in Seattle would have to be multiplied by 1.30. For the Los Angeles area, the figures from Table 7-6 would have to be multiplied by 0.52 to convert them to be approximates for a house in the Los Angeles area. Of course, this figuring can be made only against an all-electric home, with houses using electric-strip heating using House A and B values and with houses using heat pumps taking the House C and D values.

SUMMARY—AUTHOR'S HOUSE

Our house was the first one known in our area (or even in the Austin Tx area as far as I knew) to be built to the "new" standards of energy-use efficiency. Using standard energy-use formulas, I calculated the possible energy load on both a summer and winter basis and was hopeful of achieving the "35% savings" then stated to be possible by an energy-saver home against a home built to the "old" standards, those of FHA Minimum Property Standards.

After the house was completed and had been lived in for six months, I checked the actual energy load versus the predicted load. To my suprise and delight, I found our actual savings to be much higher. Nearer to 50% savings being achieved over other houses of comparable size in our immediate area. Our energy use (all-electric) was so low, in fact, that the electricity supplier (Pedernales Electrical Cooperative) later told me they had checked our meter on several occasions since their computer identified us as having "suspiciously low" energy bills.

What made our house so wonderfully efficient of energy use? To best knowledge, the following accounts for our low energy usage.

- House construction—extra insulation over FHA minimum, double-glazed windows, metal-clad insulating doors, ventilated attic, use of a heat pump, etc *and* with extreme care taken to eliminate any and all potential draft sources. This later point is one that is not generally understood to be so extremely important whereas it can actually make the difference between excellent energy bills and "less than expected" energy bills.
- House design—floor plan and window placement optimized use of natural ventilation. This feature provided cross ventilation in each bedroom and for a full flow of air through the house. On many days when nearby homes were using their air conditioners, cross ventilation alone sufficed to keep our house comfortably cool.
- Conservative outlook—energy conservation was practiced at all times consistent with maintaining a comfortable atmosphere. In brief, we did not "freeze" in the winter nor "swelter" in the summer—we just kept the doors and windows closed or opened as needed. Hot-water usage was studied and reduced by careful use since considerable savings can be so gained. We also reduced the hot water temperature to about 125°F. Also, we planted fast-growing trees to shade the front (North-facing) windows and used a roll-up blind to shade the rear (South-facing) windows in the summer. Lastly, we followed all applicable energy-saving hints detailed in Section 21.
- The floor plan for our home is illustrated by figure 9-1. Though not shown, each bedroom is equipped with two windows to optimize cross ventilation. The house is illustrated on the fly leaf and contains an equal amount of windows at the rear.

THE STORY -- THE BOOK

Planning to retire in 1973 from my technical writer position with Lockheed, Sunnyvale, Ca., started in mid 1972 to research on home construction with the object in mind to design and build a house to realize an absolute minimum of energy usage. In 1974, as a retiree, moved to Austin, Texas and built our home to the best standards of energy-use efficiency known at that time. Since I could not find a contractor who was enthusiastic about building an energy-saver home, acted as my own contractor and personnaly worked on the house through all phases. The house is built all above ground and no solar energy is used. Moved in October 1, 1974.

The energy savings were remarkable -- for an all-electric home of 1944 square feet, two adults -- our electric bills average just over $43.00 per month for the first six months. As of December 31, 1978 our monthly bills over a 48-month period average just over $47.00 per month -- this relating to an average usage of 1104 kilowatts (KWs) per month. About one-half that of comparably-sized homes in our immediate area (all built at the same time).

When our first six months of energy bills revealed the extreme energy-use efficiency of our home, contacted Pedernales Electric Cooperative -- our electric-power supplier. Our energy-use figures aroused their great interest, so much so that they quietly checked and double-checked our electric meter. Finding it correct, Pedernales informed the Texas Electric Cooperatives office here in Austin, Texas of the facts. (The TEC acts as a governing office over the 80 rural electric cooperatives operating in Texas.) The TEC visited our home, took pictures, got the facts and wrote the "story" of our house in their monthly magazine -- sent out to some 280,000 homes in Texas. Also, our home became much talked about locally and was written up in Austin papers.

As a result of this unsolicited publicity, many people phoned, wrote or visited us to request advice on how to build an energy-saver home. All whom I talked with (without fee) seemed to gain a great deal from the consulations and all urged me to "write a book, putting down just what you told me". Because of my personal building experience, my continuing research as to energy-saving home construction and upgrading and the wide experience gained from many energy consultations, felt I was uniquely qualified to write a book on the subject. So, being a retired technical writer, did the "what comes naturally".

The book material reflects all my research, my personal experience and the insight gained from many energy-saving consultations. Much of my material had appeared in newspapers and magazines, again and again. Yet, when talking with interested persons, I found few had gained much from the articles -- few seemed to understand or believe the extreme energy savings that can be realized for a small capital outlay. Something more seemed to be needed.

After much thought, concluded that what was needed was a basic education -- one that would lead the reader, in easy steps, to a clearer understanding of heat transfer, the purpose and need of insulation, the need for prevention of drafts, etc. This ground work, it was considered, would make the remainder of the book material more meaningful and thus more useful.

First published in November 1977, the book has sold some 7,000 copies as of December 31, 1978. The book, according to all reports I have received, satisfies the dual need of basic education and practical information on all phases of energy-saving home construction and upgrading. The book is now being stocked by public libraries within the 50 States and Canada and is being handled by some of the major book stores of the country.

OUR ELECTRIC BILLS

MONTH	TOTAL KWH USED	KWH RATE	COST	MONTH	TOTAL KWH USED	KWH RATE	COST
Jan. 75	1382	3.568¢	$49.31	Jan. 77	1519	4.526¢	$68.75
Feb.	1396	3.601¢	$50.03	Feb.	1029	4.669¢	$48.01
Mar.	1108	3.594¢	$39.83	Mar.	832	4.165¢	$34.65
Apr.	875	3.969¢	$34.73	Apr.	608	3.957¢	$24.06
May	463	4.440¢	$20.56	May	780	3.905¢	$30.46
June	1160	3.540¢	$41.05	June	579	4.363¢	$25.26
July	1313	3.430¢	$45.10	July	1586	4.352¢	$69.02
Aug.	1508	3.890¢	$58.73	Aug.	1709	4.283¢	$73.20
Sept.	849	4.130¢	$37.47	Sept.	1556	4.693¢	$73.02
Oct.	747	4.300¢	$32.12	Oct.	650	5.400¢	$35.10
Nov.	1073	4.266¢	$45.35	Nov.	829	4.865¢	$40.33
Dec. 75	1179	4.207¢	$49.60	Dec. 77	1078	4.506¢	$48.57
Jan. 76	1341	4.278¢	$57.37	Jan. 78	1401	4.706¢	$65.93
Feb.	782	4.603¢	$36.21	Feb.	1544	4.697¢	$72.51
Mar.	898	4.524¢	$40.63	Mar.	1067	5.176¢	$55.23
Apr.	633	5.316¢	$33.65	Apr.	538	4.461¢	$24.00
May	624	4.840¢	$30.20	May	736	4.974¢	$36.61
June	820	4.580¢	$37.55	June	1427	4.427¢	$63.18
July	794	4.402¢	$34.95	July	1840	4.465¢	$82.16 ← (A)
Aug.	1449	4.463¢	$64.67	Aug.	1457	4.397¢	$64.07
Sept.	569	3.845¢	$21.88	Sept.	955	4.959¢	$47.36
Oct.	854	5.033¢	$42.98	Oct.	649	4.853¢	$31.50
Nov.	1467	4.426¢	$64.93	Nov.	759	4.682¢	$35.54
Dec. 76	1632	4.633¢	$75.61 (B)	Dec. 78	1312	4.673¢	$61.32

YEAR	KWH USED YEARLY	KWH USED MONTHLY	KWH COST AVERAGE	MONTHLY COST AVERAGE
1975	13,053	1088	3.911¢	$42.55
1976	11,863	989	4.581¢	$45.30
1977	12,755	1063	4.474¢	$47.56
1978	13,685	1140	4.706¢	$53.65

48-Month Averages

Monthly cost = $47.27
KWH Used Monthly = 1070

All-electric home -- 1944 square feet -- two adults -- no solar, not underground.

(A) Highest summer-time bill = 1840 KWH

(B) Highest winter-time bill = 1632 KWH

11

APPENDIX

GLOSSARY

1 BTU	= British Thermal Unit = energy required to raise temperature 1 lb. H_2O by 1°F (from 59 to 60 F)
	= 350 calories
	= 1 wooden kitchen match burned end to end
BUILDING ENVELOPE	= the shell of a building which encloses air conditioned spaces and includes both opaque and transparent materials through which thermal energy is transferred
C	= Thermal Conductivity: measure of heat flow through actual thickness of material used
	= C-Value = $\frac{K}{\text{thickness}}$
COP	= Coefficient of Performance the ratio of the rate of net heat removal or output to the rate of total energy (KWH) input.
COOLING DESIGN TEMPERATURE	= the difference between the interior conditioned space thermostat setting and the outdoor dry bulb design temperature. (See Outdoor Design Temperature Table.)
COOLING HOURS	= For estimating Cooling consumption
	= the number of hours in the cooling season when the temperature is over 80°F (N.A.H.B.)
	= Varies with location

DEGREE DAYS = For estimating Heating consumption:

= For any one day, when the mean temperature is less than 65°F, there exists as many degree days as there are °F difference between the mean temperature for the day and 65° F . . . such degree days total for a heating season.

= Varies with location

EER = Energy Efficiency Ratio

= the ratio of net cooling capacity in BTU per hour to total rate of electrical input in watts under designated operating conditions

$$= \frac{\text{BTU/hour}}{\text{Watts/hour}}$$

= EER = 6.1 min. Model Code . . . EER = 8 to 9 = Good

ENERGY = The capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt-hours (KWH) or British thermal units (BTU); in international system (SI) units (metric), measured in joules (J) where 1 joule = 1 watt-second

ENERGY CONSUMPTION = Generally considered as the energy consumed or used by energy consuming devices and/or equipment. Expressed in terms of BTUH, KWH of electricity, and cubic feet of natural gas.

HEAT PUMP = A refrigeration system designed so that the heat extracted at a low temperature and the heat rejected at a higher temperature may be utilized alternately for cooling and heating functions respectively.

HVAC	=	Heating, ventilating and air conditioning
HVAC SYSTEM	=	A system that provides either collectively and/or individually the processes of comfort heating, ventilating, or air conditioning within or associated with a building.
INFILTRATION	=	The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.
K	=	Thermal Conductance: measure of heat flow through 1 sq.ft., 1 inch thick, in 1 hour, 1° F diff. between 2 faces of homogeneous material
KWH (Kilowatt-hour)	=	One thousand watt-hours of electrical energy. (Equal to 3412 BTU/Hr)
LATENT HEAT	=	The heat required to change a liquid to a vapor, or vice versa.
LOAD	=	Expressed in terms of BTU per hour, BTU per month, or BTU per year indicating a rate of flow of energy for either a heating or cooling requirement or a total of both.
NON-DEPLETABLE ENERGY SOURCES	=	Sources of energy (excluding minerals) derived from incoming solar radiation, including photosynthetic processes; from phenomena resulting therefrom including wind, waves and tides, lake or pond thermal differences; and energy derived from the internal heat of the earth, including nocturnal thermal changes.

OPAQUE AREAS = All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems

OPERATING HOURS = Actual hours of operation of heating or cooling equipment

OUTSIDE AIR = Air introduced into an air conditioning, heating, or ventilation system from the outdoors, and therefore not previously circulated through the system. Refer to ventilation air.

OVERHANG = A roof extension or other horizontal device above a window to intercept the rays of the sun, to provide protection from the elements, or for aesthetics.

R = Thermal Resistance: measure of ability to retard heat flow

= Reciprocal of C = $\frac{1}{C}$

R is additive: R5 + R11 = R16

: Higher R = higher insulating value

RECOVERED ENERGY = Energy utilized which would otherwise be wasted from an energy utilization system.

REHEAT = The application of heat to air after it has been cooled.

RESET CONTROL = A control device used to adjust the set point of another control device to a higher or lower value automatically or manually

SPF = Seasonal Performance Factor
Used in reference to the heating efficiency of Heat Pump systems only. Defined the same as COP but obtained by calculating actual performance of the system at 5 outdoor temperature increments. SPF = 2.25 = Good (varies with location)

SERVICE WATER HEATING = Supply of hot water for domestic or commercial purposes other than comfort heating.

SHADING DEVICE = A device positioned to intercept the rays of the sun. Some examples are roof overhangs, vertical fins, metal screens, venetian blinds and draperies.

SOLAR ENERGY = Thermal, chemical or electric energy derived directly from conversion of incident solar radiation

TEMPERATURE DRY BULB (DB) = Ambient air temperature as indicated by a thermometer in degrees Fahrenheit or Centigrade.

TEMPERATURE WET BULB (WB) = If a thermometer bulb is covered with absorbent material, e.g. linen, wet with distilled water and exposed to the atmosphere, evaporation will cool the water and thermometer bulb to the Wet-Bulb Temperature (Tw).

U = Overall coefficient of heat transmission rating of a total building section
No. BTUs/1 sq.ft. of wall (etc.)/1 hour/1° F
Reciprocal of R_{total} ; $U = \frac{1}{R_{total}}$
Lower U = higher insulating value

VENTILATION AIR = That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space, expressed in C.F.M. (cubic feet per minute)

ZONE = A space or group of spaces within heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

BIBLIOGRAPHY

Consumers Guide to Home Insulation

Texas Department of Community Affairs
Housing Divison
611 South Congress
P.O. Box 13166, Capital Station
Austin, Texas 78711

Price: Single Copy-Free

Designing, Building and Selling Energy Conserving Homes (this publication includes the Insulation Manual, Homes/Apartments listed below.)

National Association of Home Builders
and the NAHB Research Foudation, Inc.
P.O. Box 1627
Rockville, Maryland 20850

NAHB Publication 560.01

Price: Single Copy $30.00

Insulation Manual-Homes/Apartments

National Association of Home Builders
and the NAHB Research Foundation, Inc.
P.O. Box 1627
Rockville, Maryland 20508

Price: Single Copy $4.00

Energy Savers Catalog (by the editors of Consumers Guide)

G.P. Putnam's Sons, Publishers
200 Madison Avenue
New York, New York 10016

Price: Single Copy $6.95

Guide to Constructing an Energy Efficient Home

Owens-Corning Fiberglass Corp.
Insulation Operation Division
Fiberglass Tower
Toledo, Ohio 43659

Publication No. 5-BL-8033

Price: Single Copy $1.50

Is Your Air Conditioner Blowing Colder or Blowing Money?

By Gene Elwell
818 Fontana Avenue
Richardson, Texas 75080

Thermal Performance Guidelines for One and Two Family Dwellings

National Association of Home Builders
and the NAHB Research Foundation, Inc.
15th and M. Streets, N.W.
Washington, D. C, 20005

Publication No. 560.02

A Clipbook of Energy Saving Ideas in Home Building

United States League of Savings Associations
111 E. Wacker Dr.
Chicago, Illinois 60601

Manual K-Equipment Selection and System Design Procedures

National Environmental Systems Contractors Association
1501 Wilson Blvd.
Arlington, Va. 22209

State of Texas Energy Conservation Manual, Part I

State Building Commission
P.O. Box 12427
Austin, Texas 78711

Manual No. 113SBC607

Price: Single Copy-$3.00

Natural Solar Architecture, A Passive Primer

David Wright, AIA
Van Nostrand Reinhold Company
135 West 50th Street
New York City, N.Y. 10020

Regional Guidelines for Building Passive Energy Conserving Homes

AIA Research Corporation for HUD/DOE
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Concepts in Thermal Comfort

M. David Egan
Prentice-Hall, Inc.
Englewood Cliffs, N.J.

The Atlas of Texas

Arbingast, et.al.
Bureau of Business Research
University of Texas at Austin, Texas 78712

Energy Conservation in New Building Construction, Series 100 & 200

Texas Engineering Extension Service and
College of Architecture & Environmental Design
Texas A&M University
College Station, TX 77843

Building Your Own Energy-Saver Home or Upgrade Your Existing Home

Roy L. Wilson
Energy-Saver Homes Company
P.O. Box 10083
Austin, Texas 78766

In the Bank . . . or Up the Chimney, 2nd Edition

U.S. Department of Housing and Urban Development
Superintendent of Documents,
U.S. Government Printing Office
Washington, DC 20402

Progressive Architecture (magazine)

Reinholt Publishing Co., Inc.
Stamford, Connecticut 06904

Architectural Record (magazine)

McGraw-Hill, Inc.
1221 Avenue of the Americas
New York, N.Y. 10020

Professional Builder (magazine)

Cahners Publishing Company
270 St. Paul St.
Denver, CO 80206

ASHRAE Standard 90-75: Energy Conservation in New Building Design, 1975

American Society of Heating, Refrigerating, and
Air Conditioning Engineers, Inc.
345 East 47th Street
New York, N.Y. 10017

Code for Energy Conservation in New Building Construction

Building Officials and Code Administrators International, Inc.
1313 East 60th Street
Chicago, Illinios 60637

NAHB Thermal Performance Guidelines for One and Two Family Dwellings

National Association of Home Builders
15th and M Streets, N.W.
Washington, DC 20005

Minimum Property Standards for One and Two Family Dwellings

U.S. Department of Housing and Urban Development
Assistant Secretary for Housing
Federal Housing Commissioner
Washington, DC 20410

Energy Conservation in New Building Design; An Impact Assessment of ASHRAE Standard 90-75

U.S. Department of Energy
Conservation and Environment
Washington, DC 20461

An Energy and Economic Impact Assessment of HUD's Minimum Property Standards

U.S. Department of Energy
Conservation and Environment
Washington, DC 20461

WORKSHOP EVALUATION SHEET

Thank you for attending this workshop. We would appreciate you taking the time to give us your thoughts on the following questions.

1. Do you feel this workshop was helpful in providing you with new information about energy conservation measures?

2. Do you feel this workshop provided you with energy conservation information which will be useful in your business?

3. Will you consider incorporating some of the energy conserving construction and/or marketing ideas present in this workshop in your business? If so, which ones?

4. On what additional topics would you like to have information?

5. Would you like to get together with workshop participants in about a year to find out how the ideas presented in this workshop have been put to use and to obtain additional updated energy conservation information?

6. What part of this workshop did you find most beneficial?

7. Should any part of this workshop be revised or deleted?

____

8. Can you suggest additional written materials to be included in the workshop notebook?

____

____

9. What materials should be deleted from the notebook?

____

____

10. Did you find the videotaped presentation useful?

____

11. Was ample opportunity provided for questions and discussion?

____

12. What is your overall rating of this workshop?

____

____

13. Other comments. ______________________________

____

____

Name ______________________

Title ______________________

Firm ______________________

Address ______________________

____

Presented by the
Governor's Office of Energy Resources
7703 North Lamar Boulevard
Fifth Floor
Austin, Texas 78752
512/475-5407

WILLIAM P. CLEMENTS, Jr.,
Governor

David B. Marks, Director

RETAIL BUSINESS
OFFICE BUILDINGS
HOTEL/MOTEL/ RESTAURANTS
CHURCHES
FAST FOOD RESTAURANTS
LOCAL GOVERNMENTS
NEW RESIDENTIAL
SCHOOLS
HOSPITALS
SUPERMARKETS
SHOPPING CENTERS
RIDE SHARING
APPRAISERS AND REALTORS

Graphics prepared by PLANERGY, Inc., Austin, Texas