FLORIDA SOLAR ENERGY CENTER®

Energy-Efficient Florida Home Building

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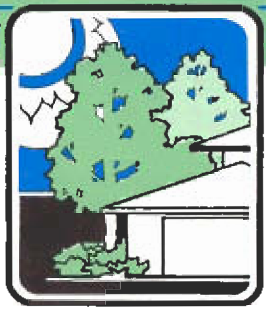
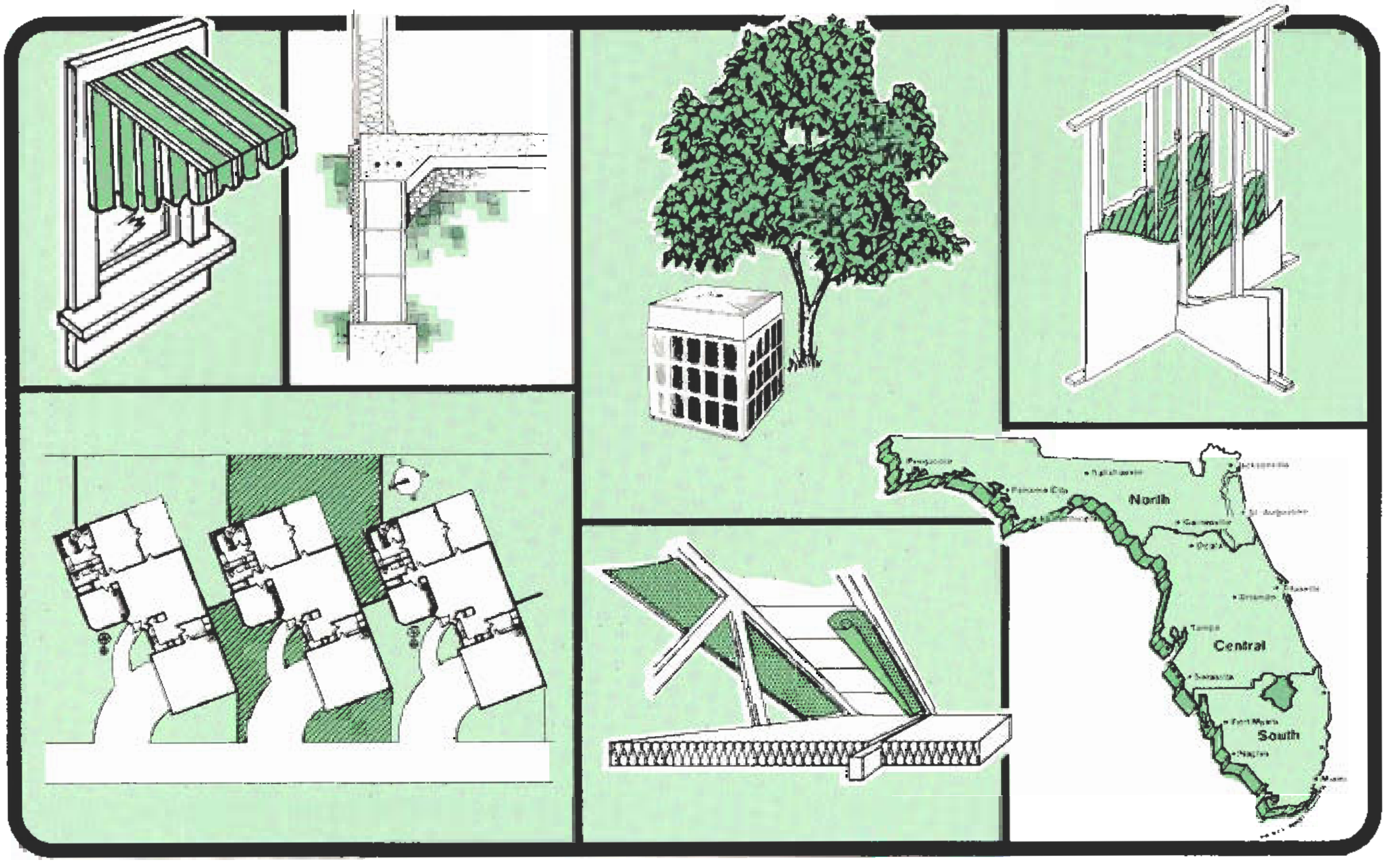


Energy-Efficient Florida Home Building



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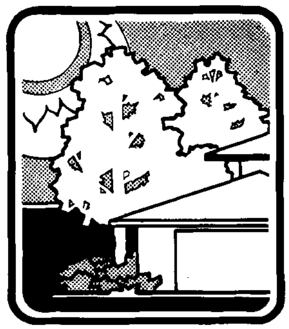
Energy-Efficient Florida Home Building



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Foreword

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS

2740 CENTERVIEW DRIVE • TALLAHASSEE, FLORIDA 32399-2100

LAWTON CHILES
Governor

LINDA LOOMIS SHELLEY
Secretary

Dear Fellow Floridians:

This book presents practical, real-life recommendations on how to design and build homes in Florida. It contains information specific to our state's climate and lifestyles, rather than the overly general information found in most residential building publications.

The book has been developed as an all-inclusive guide for anyone interested in constructing homes that are energy efficient. It is packed with information that will help you plan such homes, choose the best materials and products for the homes, and if you are a builder or developer - sell and profit from them.

The Florida Energy Office in the Department of Community Affairs is pleased to have sponsored the publication of this book by the Florida Solar Energy Center. I am confident you will enjoy its recommendations. Energy-efficient homes not only help consumers save money but benefit our state's environment and economy.

Very Truly Yours,

Linda Loomis Shelley
Secretary

EMERGENCY MANAGEMENT • HOUSING AND COMMUNITY DEVELOPMENT • RESOURCE PLANNING AND MANAGEMENT

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Thanks also to our families, who put up with us through months of working at home during evening and weekends. Finally, we gratefully acknowledge the many interested citizens of Florida who over the years asked the questions we have answered.

Sincerely,

Robin K Vieira
Kenneth G. Sheinkopf

Robin K Vieira
Kenneth G. Sheinkopf

Contents

Abbreviations

AC	Air conditioner
AEC	Annual energy cost
AFUE	Annual Fuel Utilization Efficiency
AHAM	American Home Appliance Manufacturer's Association
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
CFM	Cubic feet per minute
COP	Coefficient of Performance
CRI	Color rendering index
DE	Diatomaceous earth
EF	Energy factor
EPA	Environmental Protection Agency
FHA	Federal Housing Administration
FSEC	Florida Solar Energy Center
FTC	Federal Trade Commission
HP	Heat pump
HSPF	Heating Season Performance Factor
HVAC	Heating, Ventilation and Air-Conditioning
ICS	Integral Collector Storage
IRRI	Internal rate of return on investment
JEA	Jacksonville Electric Authority
Low-E	Low emissivity
LP, LPG	Liquid propane, liquid propane gas
NA	Not applicable
NAAMC	Net added annual mortgage cost
NFYCF	Net first year cash flow
OB	Oil base
OSHA	Occupational Safety and Health Administration
PV	Photovoltaic
R (value)	Resistance to heat flow
RE	Recovery efficiency
SC	Shading coefficient
SEER	Seasonal Energy-Efficiency Ratio
SHF	Sensible Heat Fraction
SP	Specific pressure
SPB	Simple payback
TARP	Thermal Analysis Research Program
VA	Veterans Administration

Chapter 1

Why You Should Build Energy-Efficient Houses

1. Why read this book?

Why use energy-efficient building strategies? What can you gain from building energy-efficient homes?

Consider these basic reasons:
- Your clients can anticipate more comfortable living, lower utility bills and higher home resale value.
- Selling will be easier, because of the convincing differences between your homes and those of your less aware competitors.
- Home buyers will be gratified with their purchase and will provide referrals. They will also be prospects for future purchases.
- Your company reputation and prestige will be improved by your association with better-built, more efficient homes.

This all adds up to one key point: **You will make more money by selling energy efficiency.** This book provides marketing ideas to assist you in selling energy-efficient homes. Most of the strategies (concepts and techniques) described in this book can be quickly, easily and, in many cases, inexpensively built into your homes. Individually, they are desirable features in today's houses. Putting them all together into an energy-efficiency package will give you highly marketable homes and increased profits.

2. How to use this book

This book will lead you through the various energy-efficient building strategies that have proven effective in Florida homes. It will give you marketing ideas to help sell these concepts and techniques to your clients. It tells how to design and build for energy efficiency, in easy-to-understand language with many practical illustrations.

Much of your job will be consumer education — explaining to clients what the various building practices will do for them, and helping them see why your quality-built homes offer the best buy for their money. This book will help you do that. If you want to sell more houses and make more money in today's energy-conscious world, you should read the entire book, cover-to-cover. If your only purpose in picking up this book is for information on a specific subject, the following paragraphs tell you how to find it.

Organization. The book's chapters are arranged in chronological order of the building process from site planning through amenities. Beginning with Chapter 3, *each chapter* provides you with:
- A list of recommended strategies, associated costs, and estimated savings.
- A section on how to market the recommended strategies.
- A section on how to carry through each recommendation. This includes product selection, sizing, and installation information.

An index at the back makes this book an easily-used reference source. Two recommendations: Copy appropriate sections of the book and take them to your job site. Copy the marketing suggestions and give them to your sales team.

Sales Approach. Do not exaggerate energy savings. Your clients may not believe you, and those who do believe you will be disappointed if their bills do not reflect the savings you projected.

The illustration opposite shows cooling and heating load sources for a standard, meet-the-code, 1500-square-foot wood frame Florida home. Use this figure to find the limits of potential savings from various practices. For example, if you merely add a radiant barrier to an insulated and vented roof, your clients will not save 30% on air conditioning costs since the roof constitutes only 12% of the air conditioning load.

Recommendation Lists. The recommendation list at the beginning of each chapter provides you with an estimate of savings for each suggested strategy. The listed savings reflect the benefit of the recommended strategy over the minimum practice required by code.

The same recommendation may appear in more than one chapter. For example, the site planning, house plan and window chapters contain recommendations for shading windows. The maximum saving from shading windows would be the largest estimated saving cited for one of the strategies, not the sum of all of them.

Also, many different strategies that affect the cooling load (or heating load) are related, so the percentage savings should not be added. Instead, use the following formula:

Total percent savings

$$= 100 \times \left[1 - \left(1 - \frac{\text{strategy A savings}}{100}\right) \times \left(1 - \frac{\text{strategy B savings}}{100}\right)\right]$$

For example, suppose you installed an attic radiant barrier (Chapter 8) and also chose a high efficiency (SEER=12.0) air conditioner (Chapter 9). The radiant barrier estimated savings is 8% and the high efficiency air conditioner is 20%.

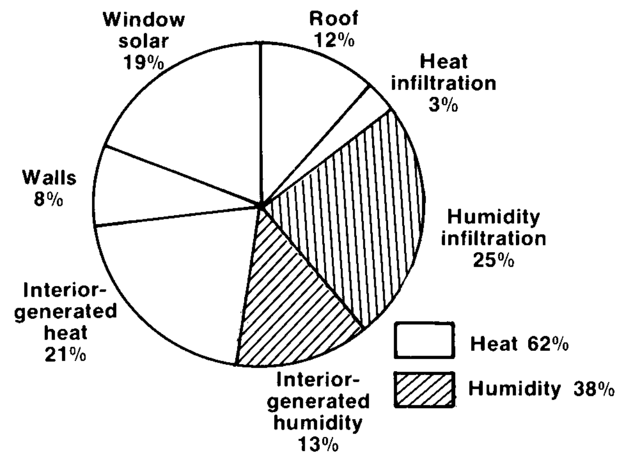
Total percent savings

$$= 100 \times \left[1 - \left(1 - \frac{8}{100}\right) \times \left(1 - \frac{20}{100}\right)\right]$$

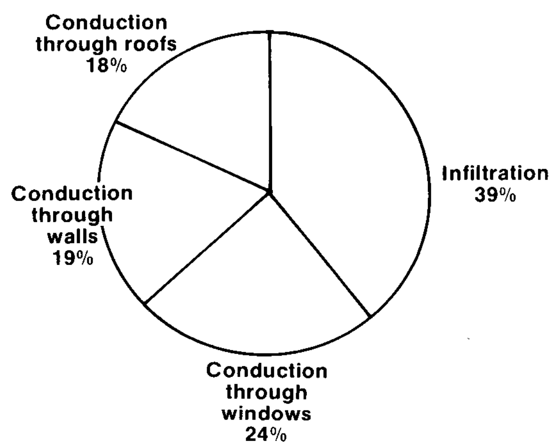
$$= 100 \times [1 - (.92) \times (.80)]$$

$$= 100 \times [1 - .74] = 100 \times .26 = 26$$

Total savings would be 26%, not the 28% you would get if you added the two numbers.



Air conditioning load sources.



Heater load sources.

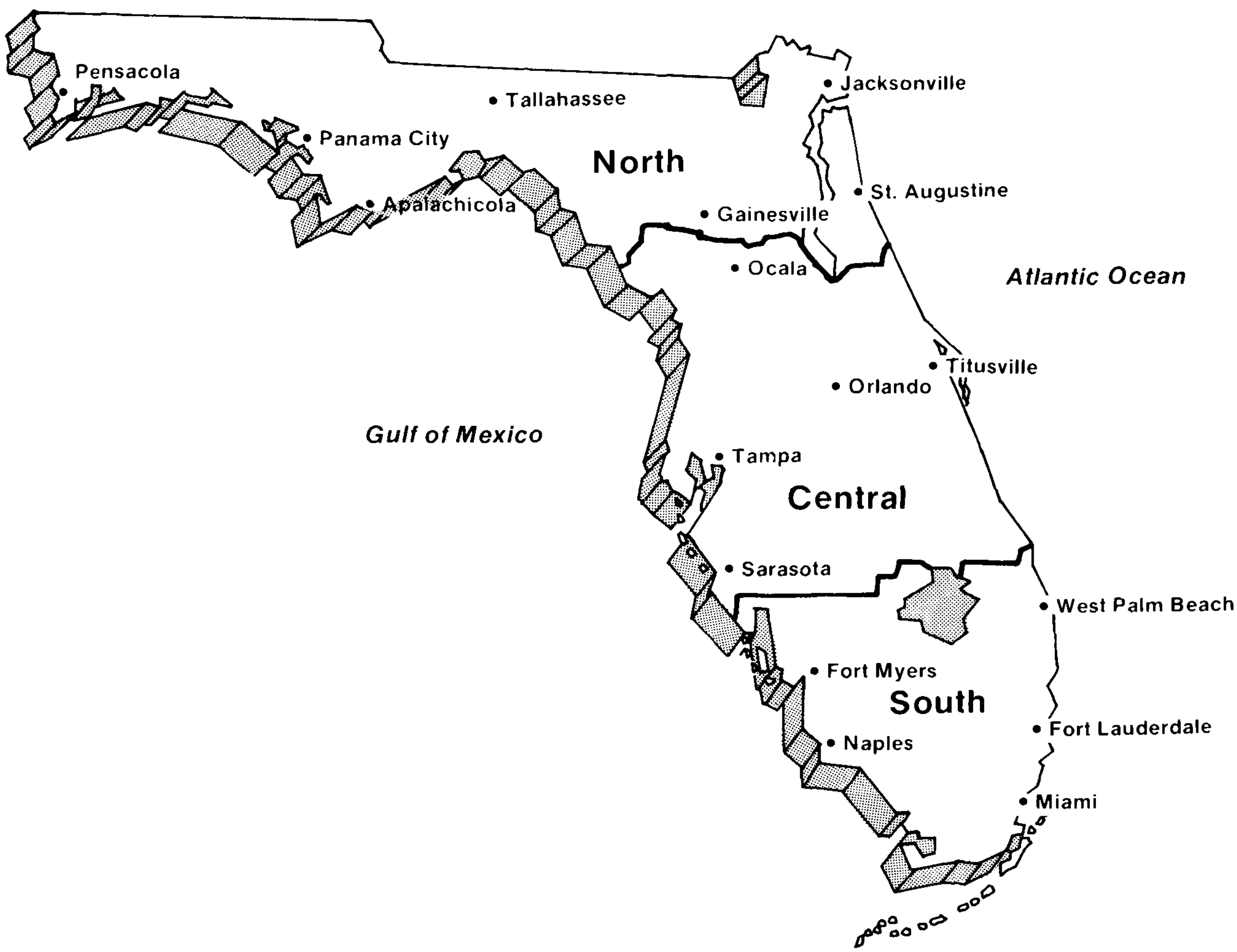
In the case of natural ventilation enhancement, the savings can increase when combined with other measures. The recommendation lists cite savings (20%) for natural ventilation enhancement that are representative of typical new homes. However, in particularly well-insulated homes that include mass features (see Chapter 4) and ceiling fans, ventilation savings can increase to 40%.

Your Location and Perspective. Although most Florida homes have fairly large cooling needs, the amount of heating they require differs substantially from North to South Florida. Because of this, some building strategies described in this book are more appropriate for certain sections of the state (see map below).

Furthermore, you may find that not all recommendations in this book apply to what you are building. Such factors as the specific site, deed restrictions, local availability of products, and your completion schedule may make some recommendations impractical. However, it is likely that you will find most of the recommendations easy to apply to your present or future homes — particularly if you plan early to include them.

3. Priority checklists

The following are quick checklists of recommended energy-efficient building practices based on factors that concern you the most: initial cost, installation/planning time, ease of selling, and long-term economics for the home owner. Each checklist recommendation is covered in detail in a later chapter. These checklists reveal that whatever your home building concerns and priorities, you can afford to build energy-efficient homes. You are left with only one question: Can you afford to build homes that are *not* energy-efficient?



Climate zones for Florida. Cities within each zone may have similar weather patterns.

Strategies That Cost Less Than Alternative Building Practices

	Chapter Discussed
• Reduce window area.	4,7
• Have simple building shapes.	4
• Choose slab-on-grade foundation.	5
• Reduce the number of framing members.	6
• Properly size the air conditioner.	9
• Locate water heater and laundry in nonconditioned space.	10
• Do not use skylights, fireplaces, pools or spas.	11

Strategies That Cost About the Same as Alternative Building Practices

	Chapter Discussed
• Plan site to minimize watering requirements.	3
• Plan site layout to maximize breezes.	3
• Have long axis east-west (long sides face north and south).	4
• Have at least half of glass on south side (Central, North Florida); consider south-facing clerestory windows.	4
• Have major rooms (kitchen, dining, family, master bedroom) cross-ventilated.	4
• Have morning rooms on west side, afternoon rooms on the east, living areas on north or south (time-of-day-layout).	4
• Run ductwork between floors in 2-story home.	5,9
• Vent crawl space.	5
• Use white or light-colored exterior wall colors (especially east and west walls).	6
• Use light-colored shingles and roofs.	8

Strategies That Are the Easiest to Sell

	Chapter Discussed
• Leaving mature shade trees on site.	3
• Avoid east and west windows.	3,4
• Providing porches.	4,11
• Time-of-day layout.	4
• Tile floors.	5
• Added attic insulation.	8
• Attic radiant barriers.	8
• High efficiency air conditioners.	9
• Timer controls on bath and kitchen exhaust fans.	9
• Ceiling fans.	9
• Whole house fans.	9
• Efficient water heaters.	10
• Water-saving bathroom fixtures.	10
• Built-in microwave ovens or shelf for microwave.	11
• Outdoor cooking areas.	11

Strategies That Have the Least Time or Labor Associated with Them

	Chapter Discussed
• Use light colored exterior wall paint.	6
• Choose reduced transmittance glass products.	7
• Choose insulated glass where cost-effective.	7
• Use light-colored shingles and roofs.	8
• Insulate the attic to R-30 instead of R-19.	8
• Choose high efficiency air conditioners.	9
• Choose efficient water heaters.	10
• Choose efficient kitchen and laundry appliances.	10
• Use efficient lighting.	10
• Install water-saving bathroom fixtures.	10

Strategies That Have the Greatest Rate of Return on Initial Investment*

	Rate of Return on Investment (%)
Low-flow showerheads	169
High efficiency outdoor lighting	130
Natural gas water heating	70
Natural gas clothes dryer	66
Natural gas heating or heat pump in N. Florida	60
Insulated hot water lines	45
High efficiency refrigerator	40
Super-insulated water tank	36
Natural gas heating or heat pump in C. Florida	35
High efficiency indoor lighting	26
High SEER air-conditioner	24
Natural gas range/oven	24
Ceiling fans	23
Attic radiant barrier (with R-19 insulation)	20
R-30 ceiling insulation	20

Strategies That Have the Greatest Net First Year Cash Flow*
(Energy Savings - Mortgage Cost - Maintenance costs)

	Net First-Year Cash Flow $/Year
Natural gas heating or heat pump in N. Florida	130
Natural gas water heating	91
High SEER air conditioner in S. Florida	80
Ceiling fans in S. Florida	73
Natural gas heating or heat pump in C. Florida	60
Natural gas clothes dryer	50
Low-flow showerheads	39
High SEER air conditioner in C. Florida	38
High efficiency outdoor lighting	32
Ceiling fans in C. Florida	32
High SEER air conditioner in N. Florida	24
Ceiling fans in N. Florida	22
Insulated hot water lines	21

* Items that cost less than or the same as alternatives should be considered first (see page 1-4). This table shows only items that have definable initial cost. See Appendix A for definitions and analysis.

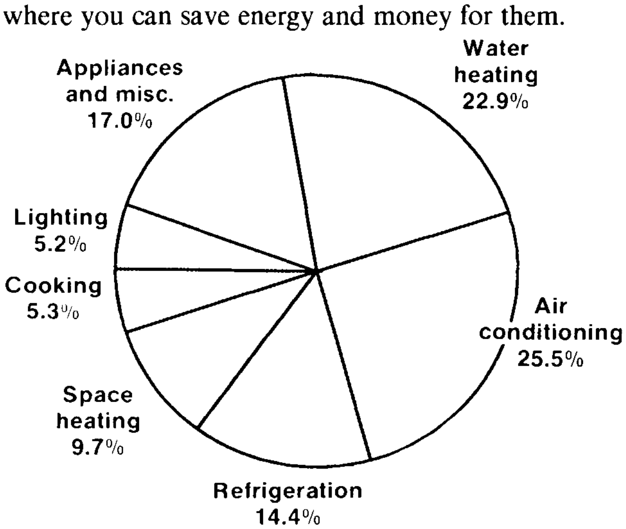
Chapter 2

How To Market Energy-Efficient Houses

1. What do home buyers want?

Ever since the oil embargo of 1973, American homeowners have been interested in energy conservation. A recent Wall Street Journal/NBC poll found that 89% of the consumers surveyed felt energy conservation was important today, and more than 75% felt there would be another energy crisis in the future. In another major study of special interest to builders — a *Professional Builder* survey of active home shoppers — almost 56% of the respondents said they would spend as much as $1000 extra on their new house to save just $100 a year in energy costs, and more than 17% said they would spend even more to have greater yearly savings.

Your clients will probably be surprised when you show them the chart below and they see just how much of their power bill goes toward air conditioning, house heating and water heating (subjects which are covered in detail in this book). It's worth taking the time to show them where energy is wasted and where you can save energy and money for them.



Breakdown of a typical Florida residential power bill.

Governor's Energy Office Annual Report to Legislature 1982

Your energy-efficient home will help reduce the occupants' dependence on mechanical air conditioning and heating equipment. **The strategies described in this book** — including cool roofs, tight houses, shaded windows and other building techniques — **will be effective in making the home comfortable as well as efficient.**

Because you have built an energy-efficient home, your clients will enjoy lower power bills. This translates into more available spending money from their paychecks every month, and into significant long-term savings as energy costs continue to increase in the future.

Energy conservation is on people's minds and gets their attention. Your customers may already be asking you about weather-tightness of the house, types of windows used, etc. They know that maintenance expenses, furniture costs, taxes and most other home expenses will keep going up, and there's little they can do about it. But they can do something to control their energy costs.

Further, many energy-related products and design features are desirable for reasons beyond dollar savings:

- Proper site selection can provide a better view and more enjoyable use of the yard and other outdoor areas.
- A well-designed house can mean many more days with open windows and fresh air.
- Well-insulated, tightly sealed houses have quieter interiors and fewer drafty areas.
- Lower ceiling and wall temperatures lessen the load on the air conditioner, and also increase the comfort of people near them.
- Tighter and energy-efficient construction makes homes look and feel better and is a tangible sign of quality.

Some of these strategic features will be evident to your clients when they see your houses. Other features are less tangible, less visually apparent, but this book suggests how you can effectively describe them to your clients. So there's no need to worry about how to sell energy efficiency — just include it as part of your total marketing effort. Remember, people don't buy energy alone, but they will give energy a high priority in making their final decision.

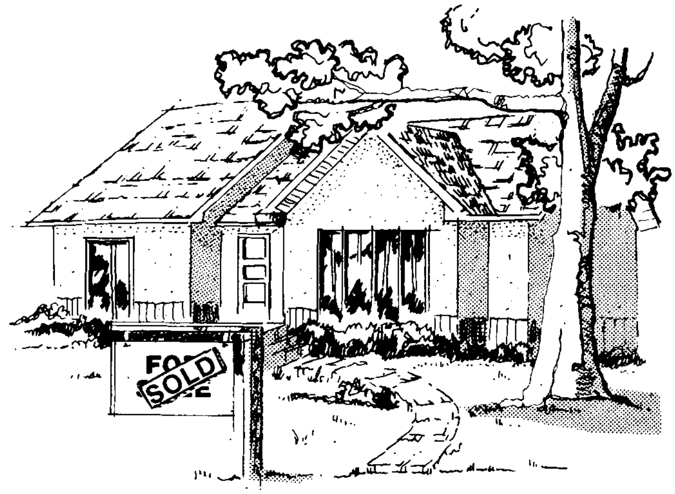
Your concern for the efficiency of kitchen appliances, the reduction of air leakage into and out of the house, shading of east and west walls and other building strategies will enhance your reputation.

Studies confirm that people with better educations and higher income levels are the most energy-conscious. They will be more likely to develop a strong bond with your company if they perceive you as being energy-aware. But regardless of the market segment you are targeting, you can use energy to talk about the clients' needs. For example, the lower fixed incomes of many senior citizens, along with their strong desire for home comfort, makes energy efficiency a sought-after feature in their choice of a new home. Other home buyers looking to move up to a larger home do not want higher power bills.

2. Sales techniques

How do you market an energy-efficient home? Use the same sales techniques, marketing strategies and promotional materials that have been successful in selling conventional houses. Talk about the location of the house, the workmanship, floor plan, aesthetics and amenities. After all, people really aren't coming to you to buy energy efficiency. They want to buy a house, and they'll base their decision largely on quality, value, size and setting. But all else being equal, a house that is built for home owner comfort and lower utility bills will be more in demand.

Successful builders know they must **sell benefits, not merely features.** People won't care about a solar water heater, extra insulation or a heat pump unless they know what it means to them. They will care about lower utility bills and more comfortable houses. You've got to educate your buyers and tell them the benefits of your houses. Advertising people have long known that you do better when you sell the "sizzle" along with the steak.



A home designed and built for comfort and lower utility bills will be more in demand.

There are some things you can do during construction to make it easier to market additional products or services later. For example, you can pre-wire the main living rooms and bedrooms for ceiling fans, which will make later fan installation much easier. This is an effective marketing strategy — another beneficial feature you can point to in your homes.

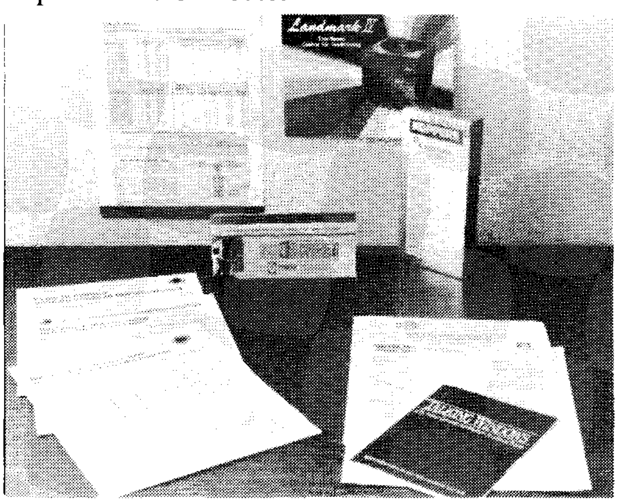
Think about using special incentives centered on energy efficiency. For example, you can tell buyers what their power bills should average, and then agree to pay 50% of any excess over the average during the first year (or even two or three years). Be very conservative and quote higher utility bills than you think will occur — not just to save incentive money, but because your buyer will be pleasantly surprised to find the house's performance is even better than promised. Buy special energy-efficient appliances for the home and feature them — along with their "Energyguide" labels and estimated savings information. Do all that you can to show that your home will save the buyer money.

One of the best things you can do — for yourself and your client — is to offer optional pre-construction "energy packages". These packages provide a solid source of extra income. They might include an upgraded, efficient water heater and refrigerator, several ceiling fans, an attic radiant barrier, and awnings on the east and west windows. The home buyer can save some money by buying the entire package, and you can install the features during home construction.

Contact your local gas and electric utilities to see if they offer builders promotional incentives to construct energy-efficient homes. If so, not only can you benefit financially, but you can send the utilities' promotional material to prospects as evidence of your home's efficiency. Suggest the utilities begin adopting programs to encourage energy-efficient homes if such programs are not currently available.

There are a number of marketing strategies that builders have used successfully to sell energy-efficient homes. The following promotional ideas can make your model homes or presentation center stronger parts of your marketing effort:

- Line the walls of your model homes with energy awards you have won, recommendations from manufacturers of energy-efficient equipment, and photos of various energy features.
- Display copies of utility bills from clients who now live in energy-efficient homes, along with photos of their houses.



Give out fact sheets, energy notes, checklists of features, and manufacturer's literature.

- Set up a slide show to run continuously while people visit the models, emphasizing the quality of your work and the comfort of your houses.
- Put together displays with samples of the radiant barrier foil, insulation, thermostat, etc.
- Post copies of your energy code forms showing the credit your houses have been given for the above features. Display posters showing energy code ratings, especially if your homes have an Energy Performance Index (EPI) of 75 or less.
- Use models and cutaways of walls, attics and other parts of the house to show construction details and close-up views of your quality workmanship.
- Give out fact sheets, brochures and other literature from the manufacturers of windows, shingles and appliances used in your homes that show their commitment to energy efficiency. Display ads from consumer magazines featuring the products you have used.
- Hand out a checklist of your homes' energy-efficient features. Ask prospects to compare those features with the energy options offered by other builders. Go into detail about any energy-savers which are not readily apparent, including site planning, floor plan, overhangs, radiant barriers, an efficient air conditioner and insulation; and, as well, draw attention to obvious features such as ceiling fans and exterior shades.
- Put signs on the appliances, calling the attention of prospective buyers to the efficiency and savings of the water heater, refrigerator, etc.
- Contact the Florida Solar Energy Center (300 State Road 401, Cape Canaveral, 32920) and the Florida Energy Extension Service (IFAS Bldg. 664, University of Florida, Gainesville, 32611) for energy notes and fact sheets that you can hand out to clients and make available in the model homes. Most of the informative literature is available at no cost, and contains the latest energy-conserving information. This can be especially beneficial since it is information coming from a third party, not directly from your company.
- Train your salespeople to explain the benefits and features of the energy savers. Many salespeople use energy efficiency as a great close to their presentations, showing the difference between their company's and the competitors' homes. In other words, don't just tell clients that your houses are energy-efficient; every builder does that. Show them what you've done and explain how they will benefit from it.

Finally, give some thought to the basic marketing strategies you are using today, and adapt them to stress the energy efficiency of your homes. Emphasize in your advertisements the cost savings and added comfort of your homes. Develop mailing lists of people interested in energy and the environment. Keep up a public relations effort, regularly sending news stories to local real estate and business editors about your home plans, new salespeople, etc. Hold special events at your model homes and invite the media. And, again, use the basic marketing tools to point out the differences between your homes and those of your competitors. A demonstrated commitment to energy efficiency makes you different!

3. The economics of energy savings

Some buyers may perceive energy efficiency as adding to the cost of the home. Your sales team should show them how their energy savings will pay back their investment in a relatively short time and lower the cost of owning the home. Some other buyers won't be concerned about the size of their present utility bills, so you should tell this group how energy efficiency improves comfort and is a form of insurance against any rise in utility rates.

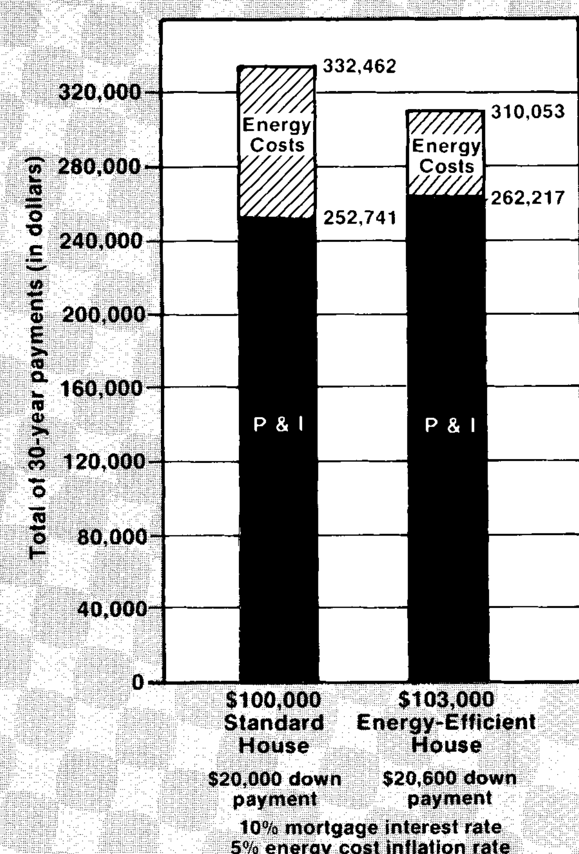
To provide enough electricity for Florida's rapidly growing population, our state's utilities may make large capital investments for new power plants. In addition, fuel prices are almost certain to rise again. As a result, energy costs may increase in the future at a rate greater than inflation. You can use this

Example

Consider an average home with minimum energy-saving features, sold for $100,000, with 20% down and 10% interest on a 30-year mortgage. Monthly payments on the $80,000 to be financed will be approximately $702, for a total 360-month payment of $252,720 (making the total cost of the house $272,720 with the $20,000 down-payment). Current Florida electricity and fuel rates might average $100 per month for a less-efficient home in this price range. Assuming an annual average escalation of 5% in fuel cost, this home owner could pay $79,721 for energy during the 30-year mortgage period. That's an *additional one-third* of the mortgage payment, just for energy costs!

But take that same home and put in the no-cost and low-cost energy-saving features described in this book, and you should be able to reduce the home owner's energy bills by as much as 40%. Suppose these features raise the selling price by $3000 — that is, $2000 to cover the costs of many of the energy-saving strategies described in this book and $1000 profit for you. The buyer now is purchasing the house for $103,000. Only $600 more is needed on the down-payment, and mortgage payments will increase only $26 monthly, to $728. However, that $3000 extra investment in the home will in many cases reduce the first year's utility costs by up to $40 per month. Total the energy savings for the entire 30 years, and your buyer could pay $47,836 — or $31,885 less in energy costs. Subtract $9400 for the higher mortgage payments, and total savings will still be more than $22,000.

Of course, savings will be lower than this if energy costs increase less than 5% per year. However, if energy costs increase at a greater rate — 10% per year, for example — the efficient house will cost the home owner $118,436 for energy over the life of the mortgage, versus $197,393 for the conventional home. This represents a savings of almost $79,000 for the owner of an energy-efficient home.



Sample comparison of 30-year costs of energy-efficient and standard home with energy costs increasing at 5% per year.

likelihood as an important selling point in terms of the direct financial savings that energy efficiency offers your home buyers.

Many mortgage lenders, including Freddie Mac, Fannie Mae and FHA, are rewarding buyers of energy-efficient homes by making it easier for them to qualify. Buyers have reported that lenders are offering greater debt-to-income ratios for energy-efficient houses, with the result that buyers can get more house by putting money they would have needed for higher utility bills toward the cost of the home itself. Because the savings on monthly utility bills will be larger than any increases in mortgage payments, people can afford the new home. In addition, appraisers are including the value of solar and passive energy features when evaluating houses. That can be a benefit to the home owner for resale, too.

Beyond benefiting the home buyer, you can save money by offering energy-efficient features. Think how much it costs you to carry a house for a month. If you can sell it two weeks sooner because energy efficiency attracted a customer, you have substantial additional profit. How much does it cost to install an efficient water heater instead of a conventional unit? How about a set-back thermostat, radiant barrier, or ceiling fans? For modest extra costs, you'll have solid marketable features that should make your homes sell faster.

For your homes to be economically attractive to buyers, energy-efficient features must provide substantial monthly utility savings. By following the strategies in this book, you will be able to give clients a number of energy-efficient features at very low initial cost, almost certainly assuring them that their monthly savings will quickly pay back the extra costs and continue reducing their expenditures for many years to come.

An example of how energy efficiency can affect a home buyer's expenses is shown on the preceding page. You may wish to reprint this on a sheet to be handed to all prospects so they can take it with them and study the numbers. You can also adapt this example to numbers specific to the homes you are building.

Be aware, though, that individual living-style differences can significantly affect the actual energy bill. You may want to provide copies of energy-efficiency tips clipped from newspapers and magazines to educate buyers toward even lower utility bills.

4. Summary

Many energy-saving features can be incorporated into your homes for little or no cost. These features can make your homes more marketable and stimulate increased sales through word-of-mouth from satisfied buyers. Even a couple of thousand dollars in extra energy-efficient building strategies can translate into hundreds of dollars in energy savings for your clients every single year. They'll also have a more comfortable home that will appreciate in value while giving them protection against future energy increases. Selling energy efficiency means you will sell more homes and sell them more quickly. You'll establish your reputation as a builder of comfortable, quality homes, and you will be distinguished from the builders of conventional homes. This book provides you with the information you need to provide, sell, and *profit* from energy-efficiently constructed homes.

5. For further information

"Enticements to Conserve Energy," S. Andrews, *Builder* (Jan. 1987, pp. 82-84).

"Selling Homeowners on Energy," S. Andrews, *Solar Age* (May 1986, pp. 28-30).

"Energy Efficiency: A Marketing Tool," G. Cook (Florida Energy Extension Service, EES-24).

"Marketing: Methods To Show Your Strength," A. House, *Progressive Builder* (Nov. 1986, p. 33).

"Selling Conservation Packages," D. Wadleigh, *Solar Age* (Jan. 1986, pp. 30-31).

"Marketing Essential to Future Sales," *Nation's Building News* (Jan. 17, 1987, p. 9).

"Energy Efficient Homes That Sell," *Solar Engineering & Contracting* (Jan./Feb. 1985, pp. 26-28).

Selling Solar Sucessfully, D. Root, K. Sheinkopf and C. Kettles, Florida Solar Energy Center, FSEC-GP-27, 1985.

Chapter 3

Site Selection and Planning

Recommendations	First Cost	% Estimated Savings on Utility Bill		
		Heating	Cooling	Water
1. Save shade trees.	N/S	—	0-30	0-30
2. Lay out subdivision or site so that major glass areas will face north or south.	N	10-50	5-20	—
3. Plan site to receive spring, summer and autumn breezes.	N	—	5-20	—
4. Create landscape design that shades walls, windows, air conditioner condenser, and adjacent areas.	S	—	10-25	—
5. Plant deciduous trees on south side of home (North and Central Florida) and evergreen or deciduous trees on other sides.	S	—	0-30	0-30
6. Use native plants that minimize need for pest control, fertilization and water.	S	—	—	20-50
7. Use vegetative ground covers, and minimize concrete and asphalt.	R/N	—	0-5	—
8. Plan site to retain rain runoff to minimize watering requirements.	N	—	—	0-30
Maximum Combined Total	H	50	55	50

Cost Codes:
R = reduced
N = negligible
S = small ($<$\$0.25/ft^2 of floor area)
M = medium ($>$\$0.25 and $<$\$1.00/ft^2 of floor area)
H = high ($>$\$1.00/ft^2 of floor area)

Marketing Energy-Efficient Sites

You have a great opportunity to impress potential home buyers simply by building on basic knowledge of the sun, breezes and trees. These are subjects most people know something about — but have not really *thought* about in terms of their being essential elements in a well-planned, energy-efficient home site. Here are some sales presentations you can use to promote efficient site planning.

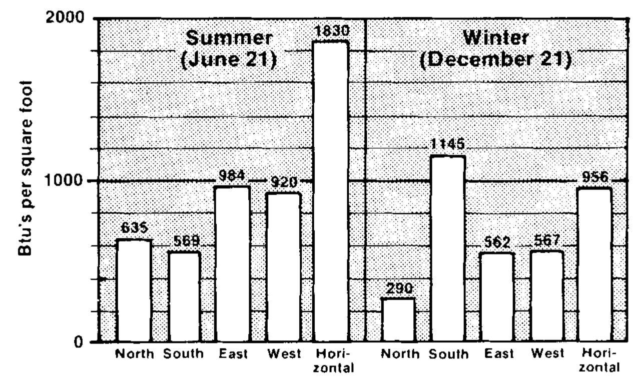
- "Did you ever have dinner in a dining room or screened porch on the west side of a house? Do you remember trying to shade yourself from the hot sun pouring in through the window and radiating from the wall?"

Just try to shade yourself from afternoon sun streaming through west-facing windows!

Many of your clients will identify with this situation. Even if they don't, the next item will still be convincing.

- "You know that the hot afternoon sun from the west is low and strikes your home directly. The morning sun also does this from the east. It so happens that in early summer about twice as much sun will strike the east or west walls and windows of a house as will strike the north or south walls and windows. In winter, however, the south side receives twice as much sun as the east or west!"

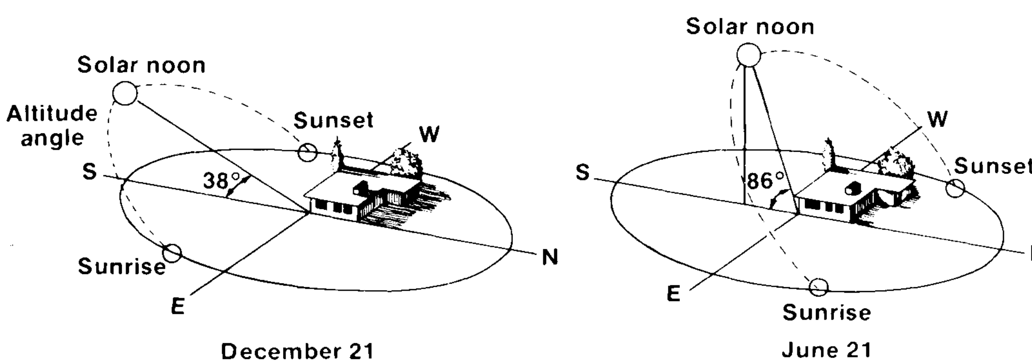
Show buyers a drawing patterned after the one below and then tell them the good things you've done to minimize problems in their houses.



The amount of heat from the sun can vary significantly with orientation.

- "We have developed this site (development) so that most house designs can fit on it with all (most) glass shaded in summer but still receive some sun during winter. (We have also situated it for breezes from the ocean, golf course, field.) You will be much more comfortable and, depending on the home, you may save 5-20% on cooling costs."

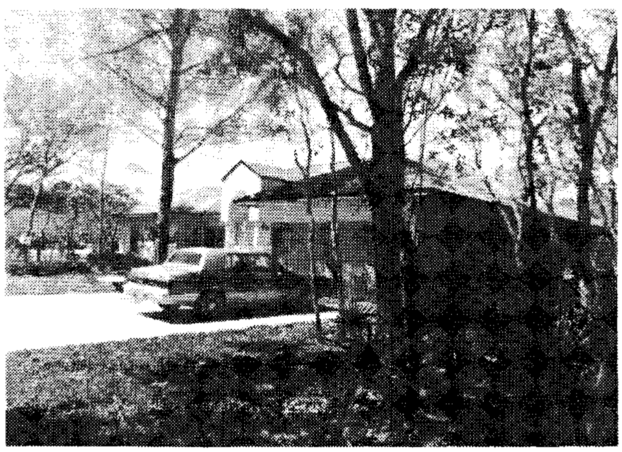
The following diagrams show the orientation and height of the sun during different times of the year. Make enlarged copies and show them to your clients. They will be impressed by your having considered the sun's path in planning the site and home design.



Winter sun is lower and more southerly than summer sun.

If you are fortunate enough to be building on a wooded site and have saved the trees, the site will usually speak for itself. However, the client may not think of the following benefits:

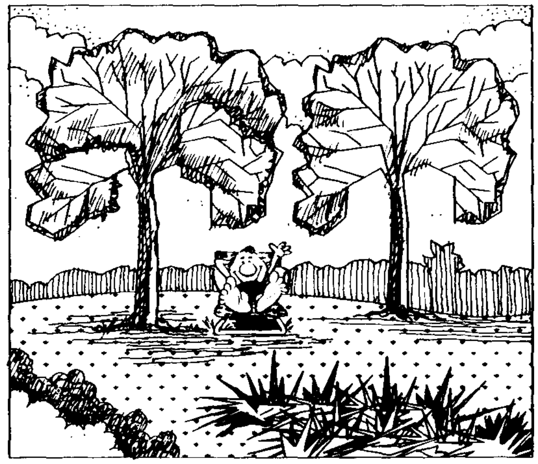
- Trees of that size cost hundreds or thousands of dollars (depending on the trees) to purchase and plant.
- Those trees will not only create nicely shaded areas outside but will lower air conditioning bills by shading the house.



Trees shade and beautify a site.

- Many people have lived in places where they had to water their lawn extensively. The shade provided by trees may greatly reduce watering needs.
- A study shows that a single mature tree gets rid of as much heat on a home site as would require removal by two residential-size central air conditioners if the site were enclosed. Trees keep surroundings cool, and cooler surroundings reduce air conditioning requirements.

Highlight the landscaping you have added. Tell how you have chosen and located native plants for minimal pest problems, watering and maintenance — so your clients can save money and spend their time enjoying their home.



By using native plants, home owners can spend more time enjoying their homes.

If you are developing each home site in a subdivision in a similar fashion — leaving trees and using native plants — point out that the subdivision should appreciate nicely in value because of the landscape not needing continuous costly attention. Emphasize that the increase in a house's value is based more on its location than on the house itself. Also, research shows that neighborhoods with tree-shaded streets can be 10°F cooler in summer than nearby unshaded neighborhoods. Thus, the entire subdivision will be a more attractive and comfortable place to live.

How To Select and Create Energy-Efficient Sites

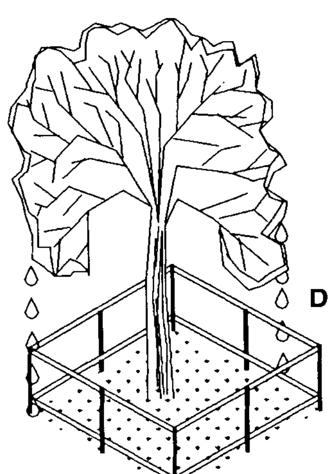
1. Save trees

"The average added value for homes with trees was 5% to 10%, but some homes showed an added value of up to 20%." This statement, the result of a Massachusetts study, appears in *Tree Protection Manual for Builders and Developers*. Much of the tree protection material in this section has been taken from that manual.

It is always more economical to prevent tree damage than to remedy it. Trees are damaged during home construction by accidental cutting, mechanical equipment, grade changes, excavation and chemical substances.

Cutting Trees. To avoid accidental cutting of trees that are to be retained, clearly mark the trees to be cut with paint at eye level and on the ground. The paint marks on the ground will be visible if unmarked trees are felled. Make sure there is a clear understanding of which trees are to be cut, and that they will not damage the remaining trees when they fall. Preferably, be on site during the clearing, since the trees you are saving may bring you thousands of dollars. You often may find a logger or firewood dealer who will pay you for the cleared trees. This is far more profitable and environmentally sound than burning the wood. Consult the Florida Division of Forestry or the Florida Energy Extension Service for advice.

Mechanical Damage. Mechanical damage can occur from trucks, bulldozers or other heavy equipment, carelessness with tools, girdling with guy wires, soil compaction, and improper cutting of roots. You should have a clear, contractual understanding of what recourse you will have if equipment operators damage trees. Protect your financial investment by constructing barricades around the trees at their dripline. Make sure the barriers are high enough and conspicuous enough to be seen by equipment operators. In some instances, barricades may go around a group of trees. To remove brush and weeds around a tree, use hand tools to avoid damage. When laying cables or piping, avoid trenching too close to the trunk.



Placing dripline barricades around trees prevents damage during construction.

Grade Changes. Grade changes frequently result in root damage and death of a tree within one or two years. The extent of injury from filling depends on the species, age, and condition of the tree, the depth and type of fill, the drainage and several other minor factors. Trees in weak condition at the time the fill is made are more susceptible to serious injury than vigorous trees.

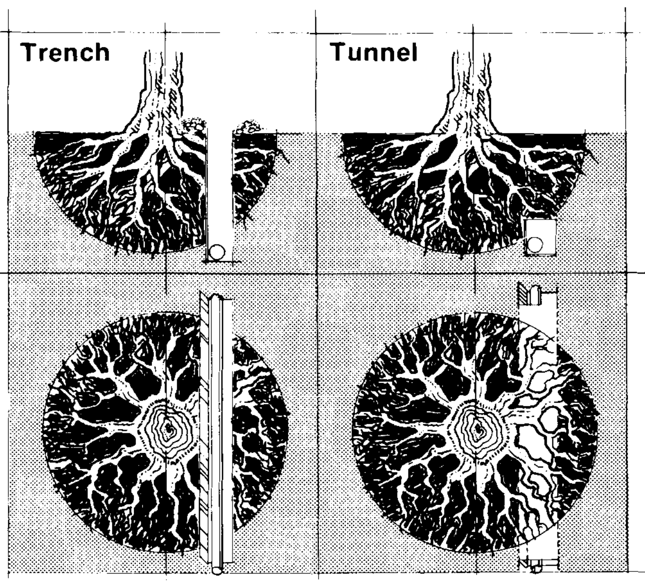
Tree wells can be used to save trees during a grade change.

A light fill of porous or gravelly material up to 6 inches in depth will *usually* do little harm. Heavier or more impervious fills such as clay and marl will harm the tree. Also, fill may raise the water table or cause surface drainage to puddle over the roots. It often has proved advantageous to install an aeration system before the fill is added, to maintain a normal balance of air and water around roots. This increases the likelihood of the tree surviving.

The basic steps in constructing an aeration system include preparing the ground, installing tile for drainage and aeration, constructing a drywell, and filling.

Consult with a tree expert or the Florida Division of Forestry for more information regarding construction of an aeration system.

To minimize damage to the roots during excavations:
- Cut roots cleanly and retrim after excavation.
- Treat cuts in larger roots (1/4 inch and up) with wound dressings.
- Refill the excavation as soon as possible or construct retaining walls.



Many roots are destroyed by trenching. Better way is to tunnel under the base of the tree.

- Avoid leaving air pockets when refilling the excavation.
- Mix peat moss with fill soil to promote new growth.
- Top-prune to aid in maintaining tree vigor.

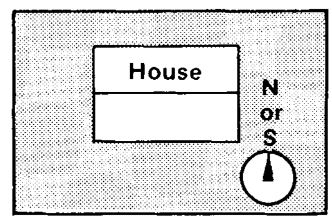
An improper excavation can drastically reduce a tree's chance for survival. Wilted or faded foliage, premature dropping of foliage, undersized leaves, excessive sprouting along the main stem and branches, and dying twigs and branches are some of the easily seen external symptoms of root injury.

Chemical Damage. Chemical injury can be avoided by keeping the soil within the dripline undisturbed and free from building materials and harmful runoffs. Toxics from paints, oils, thinners, solvents, asphalt, cement grout and treated lumber can harm trees. Therefore do not use areas near trees as dump or storage areas. Do not use herbicides or pesticides, or fertilizers containing herbicides, near any of the vegetation you are trying to preserve.

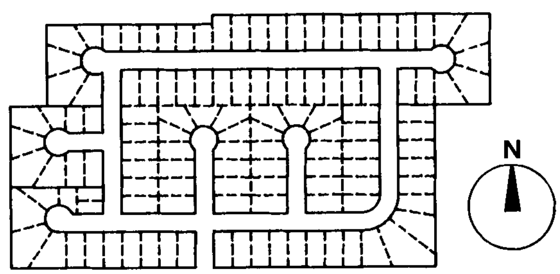
Tree Moving. A preferred alternative to clearing small trees is to move them. You may want to move a tree from one part of a lot (e.g., where the foundation will go) to another (e.g., the back yard), or to another site. Or you may want to move it temporarily to a nursery to be cared for until site construction is completed. By using a tree-spade, a tree up to about 20 feet high can be moved economically. You can save considerably on landscaping costs while still providing decent-size trees.

2. Lay out site so major glass areas face north or south

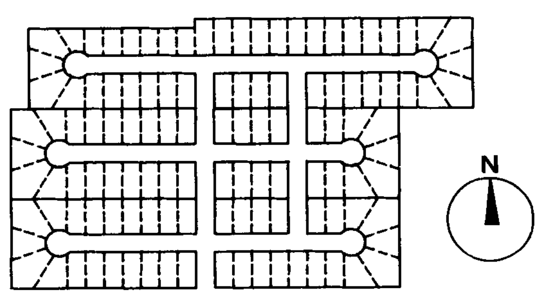
Plan your subdivision or site to minimize a home's exposure to the east and west. In other words, try to select a site where the longer sides of your house and its glass areas will face north or south.



Single-Family Lots. Single-family homes in general have longer fronts and backs and narrower sides, so lots facing north or south are preferred. However, this is partly dependent on the house plan. Chapter 4 give examples of home designs for all four major orientations.

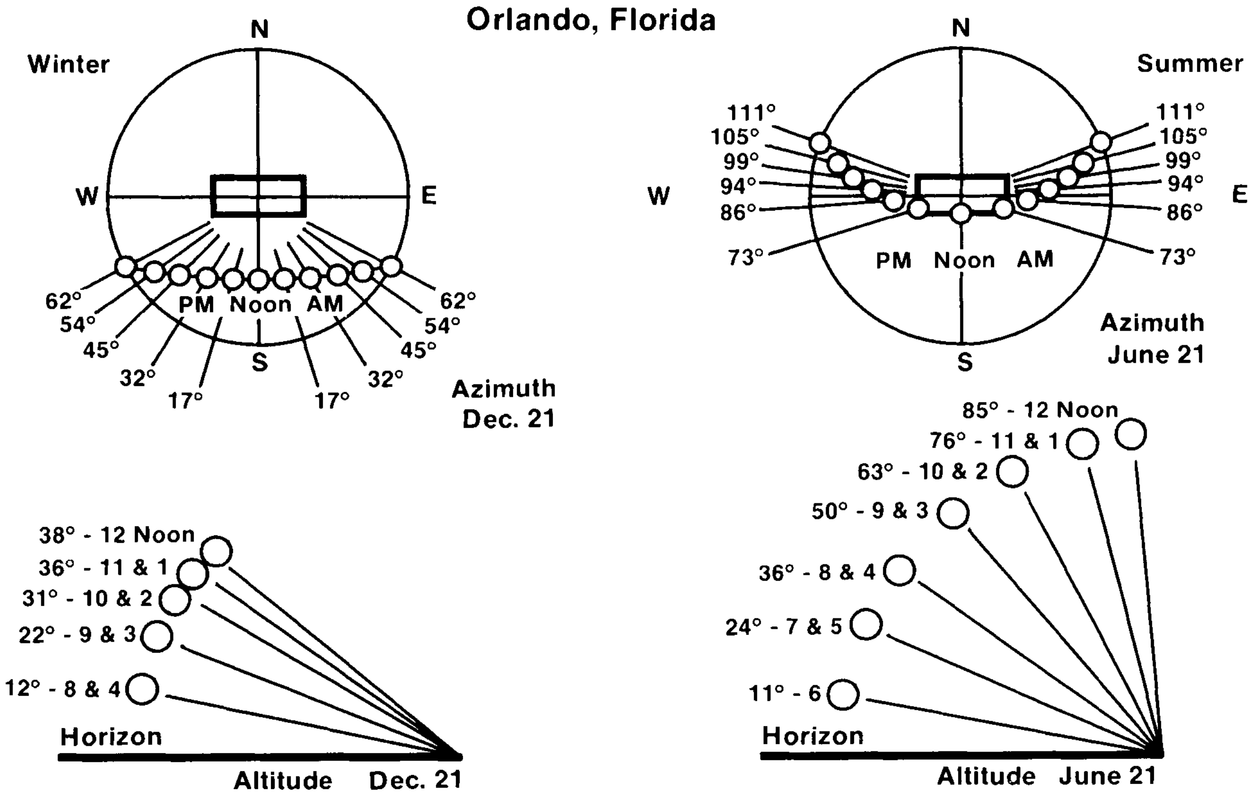


Typical subdivision.
(23.13 acres, 115 lots, 4.96 units/acre)



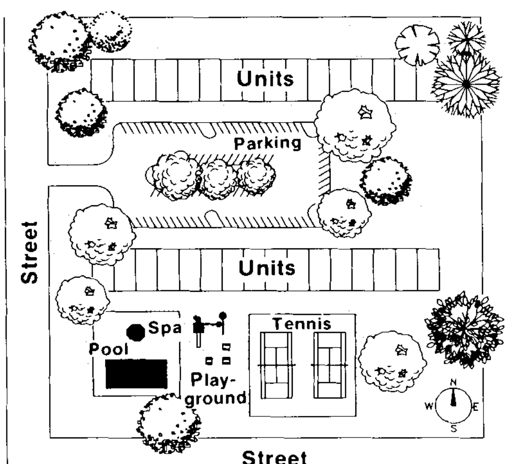
Florida oriented subdivision.
(23.13 acres, 119 lots, 5.14 units/acre)

Plan subdivision layout for predominantly north- and south-facing sites.



Sun angles from south (azimuth) and horizon (altitude) for Orlando, Fl.

Multifamily Lots. Most multifamily developments have many units with sides that lack windows. Since the sides with windows are generally the front and back, a north- or south-facing lot is also strongly preferred. Even if the street side of the site faces a different direction, multifamily lots are usually large enough for locating units on an east-west axis.



Place: Buildings on east/west axis
Parking on north of building
Pool south of building
Tennis courts north/south
Shade trees by parking and buildings

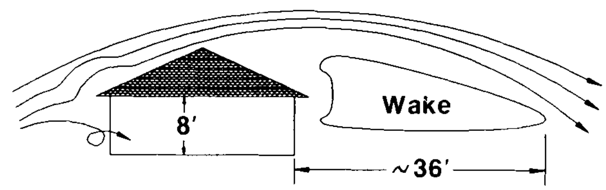
Multifamily site layout.

Zero Lot Line Sites. Due to increasing land costs and the strong market advantages of detached houses, zero-lot-line subdivisions have become common in Florida. One side of the house is on the lot boundary and has no windows, so all glass is on the front, back and opposite side. The home owner gets a larger side yard than is normal with the conventional house on a small lot (many of which are only 50 feet wide). It is desirable to orient the glassless side to the west, with the front and back facing north and south and a screen porch on the east. Some zero-lot-line house plans feature little front or back glass but a significant amount on the one side. With these, an east or west front is preferred. Natural ventilation can be enhanced by using a double zero Z-lot site plan that permits windows openings where breezes will not be significantly blocked by adjacent structures. Chapter 4 provides design examples for zero-lot-line sites.

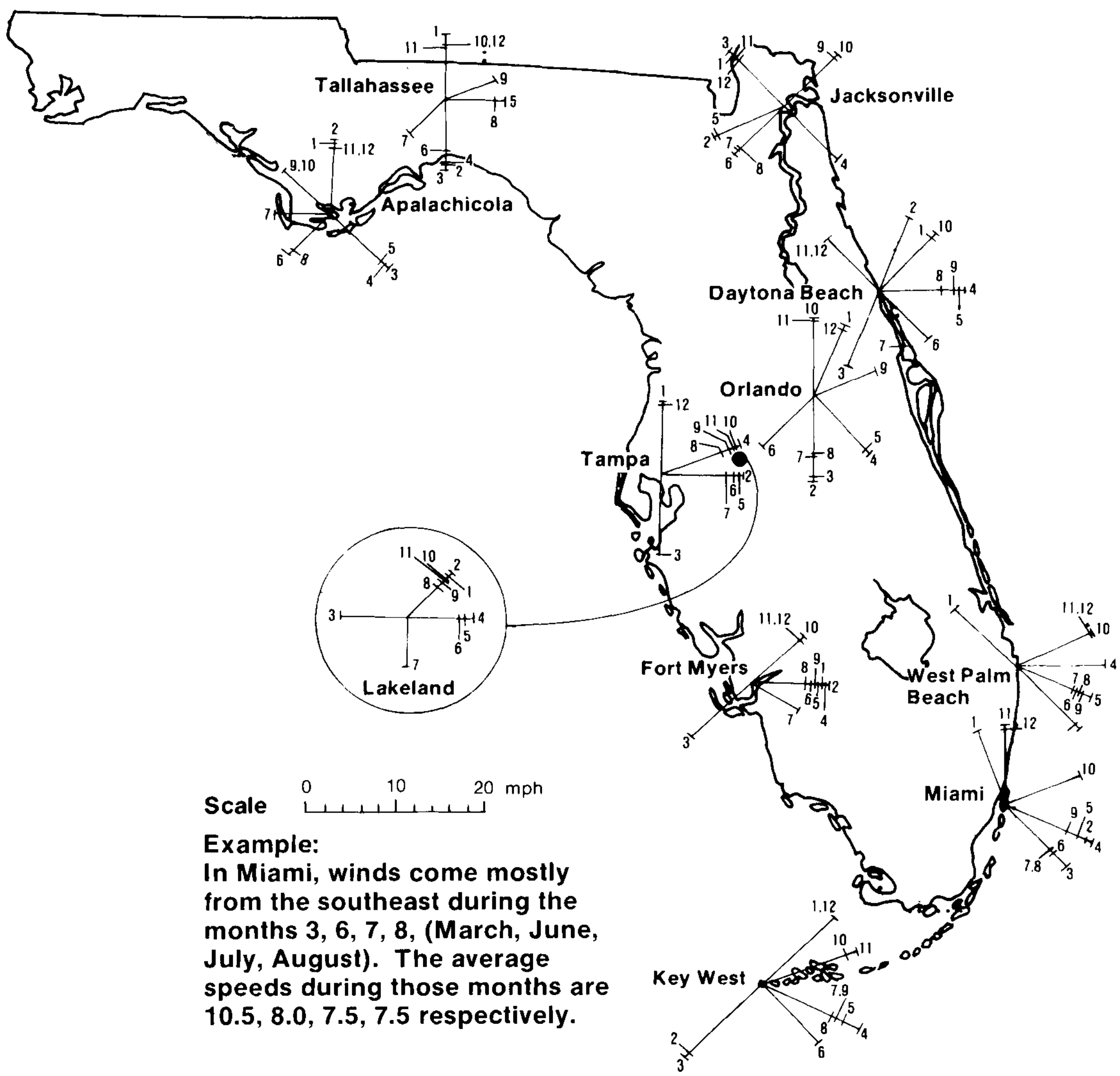
3. Plan the site for natural ventilation

Consider the direction from which breezes will be blowing in spring, summer and autumn. Careful site planning and house design can make use of those breezes for cooling. Look at the drawing below, which shows the predominant wind direction each month for various cities. Wind direction is indicated from outside the city towards its center. The length of each line indicates the average wind speed for that month, based on the scale provided. If breezes shift from the average, consider that April-June and September-November generally are ventilation months in Central and North Florida. In South Florida, March-May and October-December are ventilation months. During mid-summer, air conditioning is used extensively throughout the state.

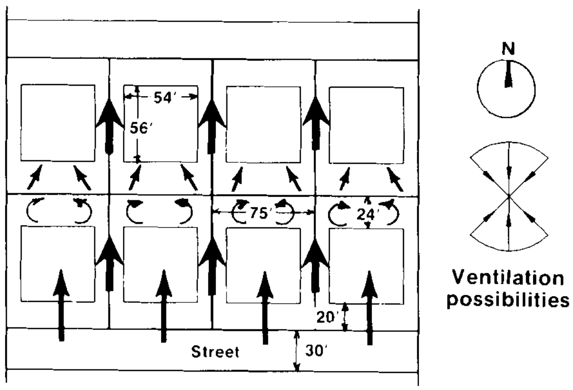
Wind conditions at any individual site may differ considerably from those on the drawing due to local geography. A body of water, open field, or golf course adjacent to a lot may be a source of breeze. In general, heavily wooded sites will produce good shade but will limit breezes; however, the energy savings from tree shade usually will outweigh the difference in breeze. Fences, tall hedges and buildings can also limit breezes. Coastal locations are almost always windier than inland regions. As stated earlier, a standard subdivision can be set up preferably for south and north window openings. However, breezes from the east or west may be disturbed



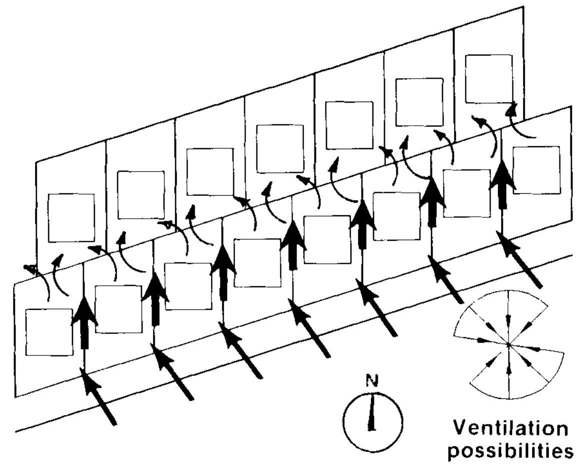
Wake of a typical house.



Florida wind roses.



Standard subdivisions can permit enough room for southerly and northerly ventilation breezes.



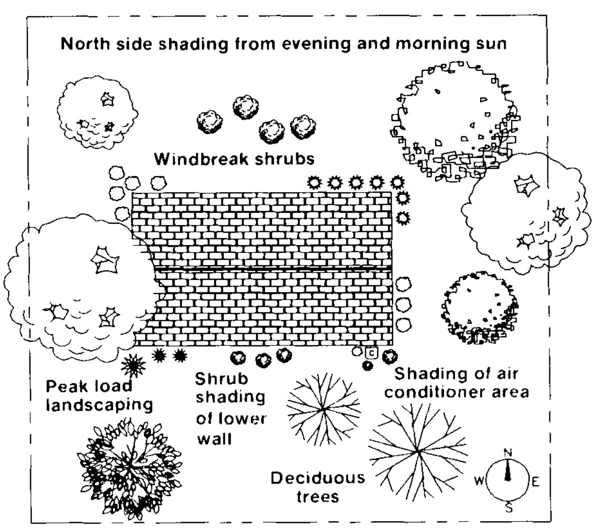
Curved or slanted streets can provide greater ventilation possiblitities.

by adjacent homes. As a general rule, the breeze disturbance in tract housing is a wake in the wind force that is four to five times the eave height. Curved streets and staggered lots can assist in preventing wind disturbance. House designs may have to be carefully selected to maintain property easements.

In high-density subdivisions, house and street layout is very important as adjacent buildings frequently block breezes.

4. Landscape for conservation

Trees and Shrubs. Use trees and tall shrubs to shade east, west, northeast and northwest sides of the house. Citrus trees, wax myrtle, Spanish bayonet, shining sumac, southern red cedar and



Energy-efficient landscape design.

youpon holly are good choices. In North and Central Florida, use full, tall-canopied deciduous trees (trees leafless during winter) on the south side. Try Florida elms, southern red maples or sweet gum. Use foundation plantings to shade lower wall areas, to keep the ground next to the house cool, and to block re-radiation from adjacent hot surfaces. Use trees to shade the air conditioner condenser.

Leave natural vegetation on the site.

Trees intended to shade east, west and north walls should be planted between 7 and 20 feet from the house (small trees 7 feet, large trees 20 feet). Plant trees even closer on south sides.

Select native plants that are correct for your area. The advantage of appropriately selected native plants is that they can minimize the need for pest control, water, and fertilizer and maintenance.

Grass and Ground Covers. Proper selection of grasses and ground covers will save money and energy. Base your selection on the expected use of the area. Foot traffic and play call for a user-tolerant turf grass. If foot traffic is not expected, you have many choices. First, think of leaving the natural vegetation on the land. This landscape saves you clearing expense, will require no maintenance (including no mowing), and can be a selling point to a client. For large clear areas, there are alternatives to grass: small-leaf confederate jasmine, bugleweed, ajuga, juniper, dwarf lantana, golden creeper, gopher-apple and dwarf lily turf. Some ground covers (e.g., ferns, partridgeberry, creeping liriope) will grow much better than grass in heavily shaded areas, and others can be much easier to maintain on slopes or in hard-to-get-at locations. Also consider using mulches as ground cover.

Ground covers such as ivy and ferns grow better than grass in heavy shade.

Water Retention. Many Florida home sites have sandy soil, which is quickly penetrated by water. However, sites which slope towards roads, driveways or sidewalks can have significant runoff even if the soil is sandy. Whenever it is possible, grade lots to retain water by having the lowest area in the center of the yard. The water so saved can be used by the vegetation. Preventing runoff also conserves fertilizers and pesticides and reduces water pollution.

Some Florida sites (including Tallahassee and other inland areas) have clay soils. Water penetrates clay soils slowly. and runoff can be a problem with even the slightest slope. Design your landscape to avoid water retention very close to the house and, also, to prevent runoff from the site. Plant appropriate vegetation in the low areas.

To keep areas cool and prevent excessive runoff, use paving or concrete sparingly. Where possible, use pervious path/deck materials such as stones or wood. In planning multiple sites or a subdivision, there are many methods of retaining water. Consult with the National Xeriscape Council and your water management district for water-saving ideas.

Irrigation. Irrigation water can be provided by using a gray-water system (also called water re-use). The water drained from showers, faucets, washing machines and sinks is used for irrigation. Consult with your building department to find out what ordinances and codes may exist in your area.

Environmental Impact. Performing all of the tree preservation and landscaping techniques described here will minimize the environmental impact of your project. Make your local government aware of your efforts, and see if they will respond by lowering your impact fees or giving you preferred zoning.

Summary

By choosing sites that will least expose the house to summer sun and make it most accessible to spring and autumn breezes, energy bills can be lowered. Saving mature trees can help keep homes cool. Landscaping should be designed to shade the house, to preserve natural vegetation, and to reduce watering requirements.

For further information

"Tree Protection Manual for Builders and Developers," Florida Department of Forestry, 1986.

"Troubled Waters," June Fletcher, *Builder*, August 1987.

Florida Native Plant Society, 1133 W. Morse Blvd., Winter Park, FL 32789, (407) 647-8839

Institute of Food and Agricultural Services/Energy Programs, Rolfs Hall, Room 220, University of Florida, Gainesville, FL 32611, (904) 392-5240.

Resetting America: Energy, Ecology & Community, Gary Coates, editor, Brick House Publishing Co.,1981.

Chapter 4

Energy-Efficient Home Design

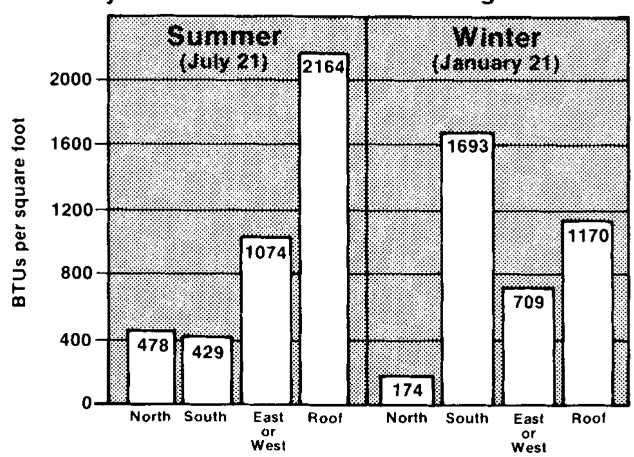
Recommendations	First Cost	% Estimated Savings		Other Benefits
		Cooling	Heating	
1. Have long axis east-west (long sides face north and south).	N	0-15	10-50	—
2. Eliminate unnecessary windows.	R	10-20	10	
3. Have few or no east or west windows.	R/N	5-15	—	Increased comfort
4. Provide porches or other structural shading.	S/M/H	5-25	—	Outdoor living areas
5. Have at least half of glass on south side (Central, North Florida); consider clerestory or dormer windows.	N	—	30-70	Improved light levels
6. Have overhangs on all sides (consider hip roofs instead of gable roofs).	S	5-10	—	Rain protection
7. Use simple building shapes.	R/N	0-5	0-20	Quicker construction
8. Cross-ventilate major rooms (kitchen, dining, family, master bedroom).	N/S	10-20	—	Improved air quality
9. Place morning rooms on west side, afternoon rooms on the east, living areas on north or south (time-of-day layout).	N	0-5	0-10	Greatly enhanced comfort
10. Locate air handler and ducts in conditioned space, laundry area and water heater in non-conditioned space.	N	0-10	0-15	—
11. Avoid fireplaces.	R	0-10	5-15	—
Maximum Combined Total	H	50	70	Increased comfort

Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft^2 of floor area)
M = medium (>$0.25 and <$1.00/ft^2 of floor area)
H = high (>$1.00/ft^2 of floor area)

Most home buyers are more concerned with the basic rooms a house contains than with its energy features. Nevertheless, you have an advantage over the competition by selling the potential buyer on the energy advantages of *your* home plans. Many energy features can be included at a negligible cost to you. Emphasize the comfort, convenience and savings they provide.

Orientation is a key energy and comfort feature. Chapter 3 on site planning illustrates the discomfort of eating an early-evening meal in a dining room with west-facing glass or a west-facing porch, because of the sun's strong rays at that time of day. Examples like that will help you market the time-of-day layout concept discussed in this chapter. The avoidance of west windows can be marketed first from a comfort viewpoint, then from an energy viewpoint.

Daily Solar Heat Gain for 1/8" Single Glass



Glass facing north or south is preferable to glass facing east, west or roofward (horizontal).

It is clear that north and south windows cause significantly fewer problems in summer than do east or west windows. Further, south windows are a benefit in winter. In North or Central Florida, you should promote the wintertime heating that the south-facing glass will provide — almost 2-1/2 times as much as the heating benefit of east or west windows. For this reason, south-facing glass should be clear, and shading should be provided by deciduous trees, overhangs (the calculation procedure in this chapter may be used to impress customers), and interior operable window treatments (shades or blinds). South-facing clerestory windows are an excellent means of providing light and winter heat to interior spaces — and in summer they receive only 20% of the heat of a horizontal skylight! Additionally, the dramatic effect of a clerestory, from inside and out, may actually sell the house.

The passive solar heating afforded by proper window orientation can be best utilized if it can be (1) distributed (via lots of openings between rooms) and (2) stored for use at night. The heat storage ability (capacity) or "thermal mass" of the house depends on the components it is made with. The following components have good heat storage ability and are referred to as being "massive":

- a quarry tile concrete slab floor
- a concrete block or brick interior partition wall
- a concrete block exterior wall insulated on the outside.

Ceramic or quarry tile flooring is the most marketable feature, particularly in a high-end home. See Chapters 5 and 6 for more details on marketing the thermal mass.

Natural ventilation is a key energy-saving strategy for Florida homes. Unfortunately, many stock house plans do not provide for cross-ventilation and will require modifications. If you have selected or modified plans that permit cross-ventilation, market them from the perspective of energy savings, "natural living" and fresh air. Combined with the effects of thermal mass and ceiling fans, the air-conditioning savings from natural ventilation can be 10-40%.

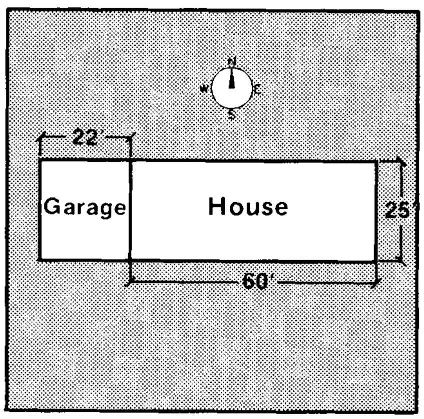
Porches are desirable to many home buyers, so why not incorporate one in your home plans from the start? This way, the porch roof can be continuous and there can be a radiant barrier and a vented attic above the porch (techniques described in Chapter 8). Point out that a porch on the east or south side provides a shaded, breezy haven during the heat of late summer afternoons and evenings. Consider more than one porch for larger homes. On starter or retirement homes, explore the market (and cost) trade-off of a porch vs. the extra bedroom — or make the porch an option. Since a porch is far better than a fireplace in terms of energy savings, encourage the choice of the porch by asking home buyers which they will use more.

Selecting and Modifying Home Plans for Energy Efficiency

The rest of this chapter describes energy-efficient features to look for in a home plan, and provides examples that will help you visualize "putting it all together."

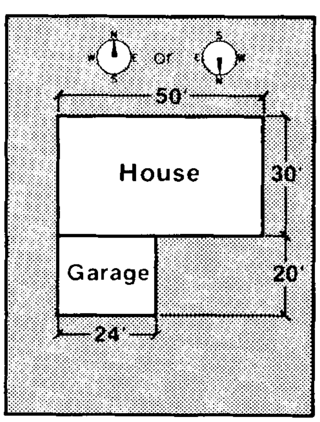
1. Have long axis east-west

The best time to start thinking of this is in the subdivision and site planning stage. However, most sites will accommodate a house oriented in this fashion — that is, with its long sides facing north and south. Suppose a 1500-square-foot house and a 500-square-foot garage were going on a site. If the site faces north or south and is a 100-foot by 100-foot lot, a conventional solution is:



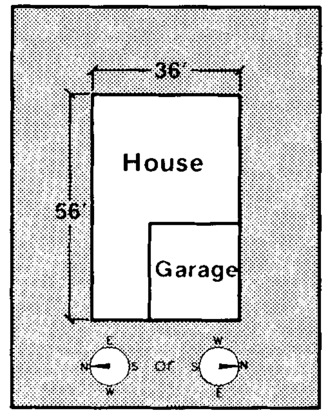
Ideal orientation of a Florida house.

Or on a 75-foot by 100-foot lot which can not have more than a 54-foot-wide footprint:



Orientation for standard size lots.

A house plan which has *a narrow front is best for a site which faces east or west.* Many zero lot line and other narrow front plans are now available.



Narrow house shape is best for east- or west-facing lots.

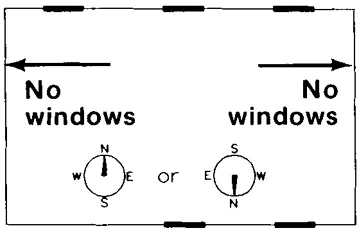
Side-entry garages can help relieve the impression of the garage dominating the street side elevation. Other specific solutions to west fronts and east fronts are covered in examples at the end of this chapter.

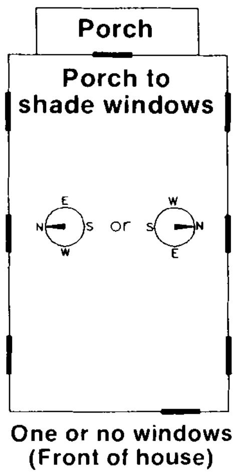
2. Eliminate unnecessary windows

Windows generally represent a source of significant heat gain in summer and significant heat loss in winter. Proper orientation of the windows and selection of appropriate glass (see Chapter 7) can partially alleviate the problem. However, excessive glass may not be adding much value to the home. As a general rule, 15% of the floor area given to well-spaced windows will provide a well-lit interior. But if you give that much or more percentage to windows, make sure the glass is well shaded and/or consider more elaborate window products (see Chapter 7). Homes can be attractive with 10% or less of floor area as window glass, and some builders are finding that the initial cost-savings of fewer windows can provide an edge on the competition. Choose plans that have a *few* well-placed windows in terms of view, appearance and energy considerations instead of many randomly placed windows.

3. Have few or no east or west windows

For a north- or south-facing lot, there are a number of plans which omit side windows that face east or west. An obvious alternative is to place a garage or carport on one of these sides of the house. For east- or west-facing lots, choose house plans that have just one front window and one or more porches (back and front).



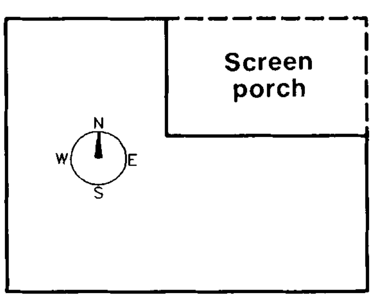


Avoid unshaded east- or west-facing windows.

4. Provide porches or other structural shading

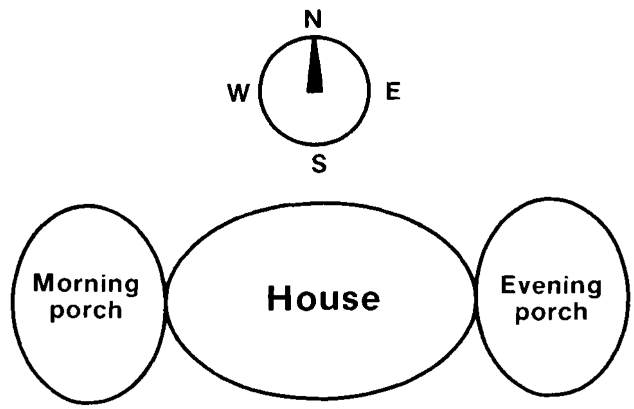
Since east and west windows have significantly more solar heat gain in summer than north or south windows, permanent window shading using porches or building shape is desired. Shading from the west sun is even more important than from the east sun, due to the time of day. Keep buffer spaces (closets, the garage, etc.) on the east and west sides.

A porch provides a place for the home's occupants to eat and even cook outdoors, assuming it is shady, breezy and insect-free. Since heat from food and bodies remains outside, a porch can be an important energy saver worth looking for in home designs. To encourage the use of the porch for outdoor dining, choose a home plan that incorporates the following design criteria.



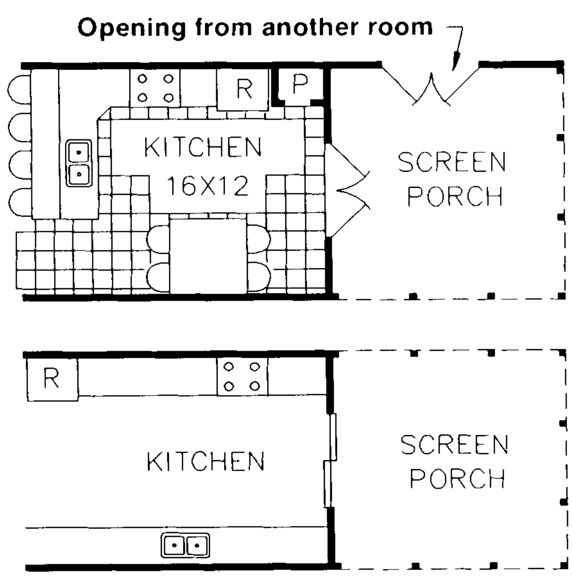
This north-facing porch will be shaded from summer evening sun.

- Orient the porch so it is shaded in the evening in summer. The east and south sides are first choices. A north-facing porch will receive direct sun from the northwest, so an "L" to the west is required for shading (see drawing). A west-facing porch can provide nice shade for the house but



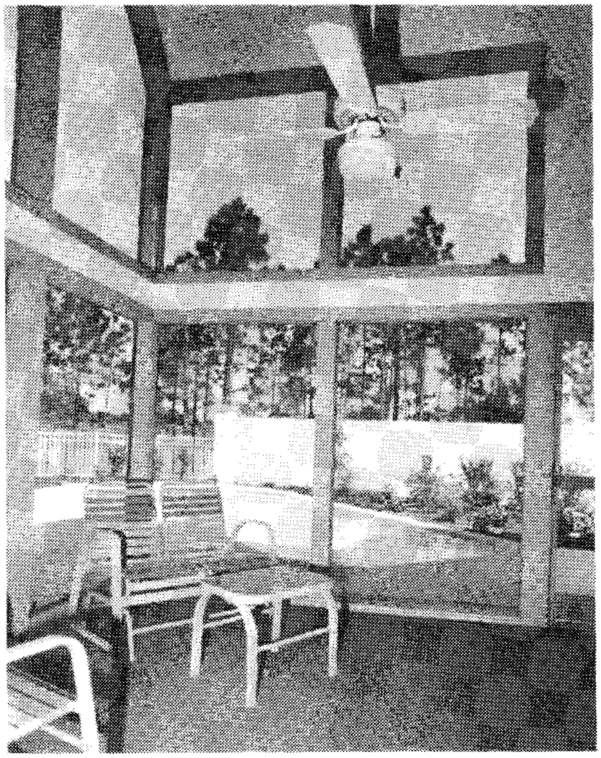
Place a porch on east and west sides.

will probably not be used in the evening. Having two porches — one on the east side and one on the west side — assures a shady porch is available all day long.
- Have direct access from the kitchen to the porch. Having to carry dishes through a dining room or family room discourages the frequent use of a porch for dining. Atrium (French) or sliding glass doors directly to the porch will provide added convenience.



Convenient access from kitchen to porch is desirable.

- Make sure the porch will be cross-ventilated. Three open sides is best. In some cases, open house windows will permit cross-ventilation of a porch. A ceiling fan can help people feel cool.



Install ceiling fans on porches.

- Keep the roof of the porch cool. Use a ventilated attic space and a radiant barrier over the porch as described in Chapter 8.

Other structural shading techniques can be provided. Overhangs (described later in this chapter) are important. In two-story homes, use designs which provide overhangs or other shading for first-floor windows. North-facing windows are best shaded by adjacent projections, such as a garage that sticks out. Recessing the windows on the north side is another good shading method.

5. Have at least half of glass on south side

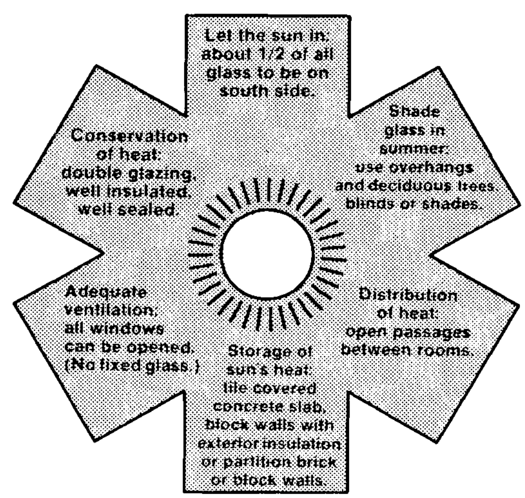
As illustrated by the chart in the marketing section, south-facing glass receives significant winter sun and much less summer sun. In North and Central Florida, use south-facing windows to provide heat in winter. Place the main living area on the south side. Provide heat storage in the house to prevent overheating. In frame houses on slabs, this can be done in two conventional ways. One is to use a good conducting material on the slab floor (tile or slate, for example) and the other is to use concrete block or brick partition walls. For every square foot of south glass, there should be 30 Btu (British Thermal Unit, a unit of energy) per °F of storage. A 4-inch slab floor has 8 Btu/°F per square foot. An 8-inch block wall has 30 Btu/°F per square foot of wall area. So, glass area (GA) = partition wall block area + (4/15 x tiled concrete slab floor area). Another way of putting that is: use 3.75 square feet of exposed slab for each square foot of south-facing glass.

For example, suppose you wanted to use a house design with 300 square feet of glass and you modified it so 200 square feet of glass was on the south side. You would then want one of the following:

- 200 square feet of 8-inch block partition wall (25 feet of 8-foot-high wall)
- 750 square feet of tiled floor (See Chapter 5 for other options)
- a combination such as 100 square feet of block wall and 375 square feet of tiled area.

Another alternative is to use containers of water as wall dividers. There are cylindrical containers designed for this purpose, and the water can be dyed for an aesthetic effect. Water provides 62 Btu per cubic foot (8 Btu/gallon = 1 Btu/pound).

Elements of successful passive solar heating for Florida



Combine all elements to use the sun's heat in winter.

With concrete block construction, use block walls with R-11 exterior insulation (see Chapter 6).

Heating Savings for a Well-Sealed Home with R11 Walls, Double Glass Windows and High Mass

	North Florida (R30 ceiling insulation)		Central Florida (R19 ceiling insulation)	
Percent Heating Savings	Required south glass as percentage of conditioned floor space	Required exposed slab floor area as percentage of conditioned floor space	Required south glass as percentage of conditioned floor space	Required exposed slab floor area as percentage of conditioned floor space
30	5.3	20	3.3	12
40	8.1	31	5.1	19
50	11.5	43	7.2	27
60	Not recommended	Not recommended	9.8	37
70	Not recommended	Not recommended	13.3	50

Also, use openable windows, not fixed glass, as a backup to prevent overheating. Position the house on the site so the south windows will not be shaded by adjacent buildings or evergreen trees.

How much energy can you save by doing this? That depends, of course, on the house itself and the number of people occupying it. For a family of four, the preceding table shows the percentage of heating saved for different fractions of glass area.

Starting in the design stage, the only extra cost of the passive solar heating is a floor finish that will permit the concrete slab to be exposed for use as a thermal mass. The energy conservation measures are the equivalent of the baseline house in the energy code (including at least Level 2 air-tightening and double-pane windows). And it is no more costly to situate glass on the south side. Trying to provide more than 50% heating savings may not be cost-effective due to the required window area.

There are also some initial cost savings in providing a passive solar heating design. You may be able to substitute electric strip heat for a heat pump. Heat will be required primarily during very cold nights (when a heat pump would rely mainly on electric resistance heat anyway) or cold overcast periods (infrequent in Florida).

In Florida, solar heating is secondary to cooling. Do not add window area for the sake of heating. Instead, shift window area from east and west sides to the south side.

Do not use attached "sunrooms" or greenhouses that have overhead glass. This glass receives too much sun in summer, is difficult to shade, and is not openable.

Clerestory or Dormer Windows. Look into designs which have north-facing or south-facing clerestory or dormer windows. These windows can provide daylight to interior spaces at a fraction of the heat gain of skylights (and with less chance of leaking rain). They can provide a dramatic effect inside and out which may help you sell the home. Clerestory windows should be operable (awning-type or hopper-type) to provide a secure ventilation outlet. If operable, they can be used to ventilate a room that otherwise would not have cross-ventilation. South-facing clerestory windows can be used to provide solar heating to rooms on the north side (see end-of-chapter examples). Moreover, because the direction of the slope of a shed roof is unlike that of a normal overhang, all south-facing clerestory windows can be used for winter heat gain and still be totally shaded in summer from the direct sun (as shown on next page).

Clerestory windows can provide shaded daylight.

6. Have roof overhangs

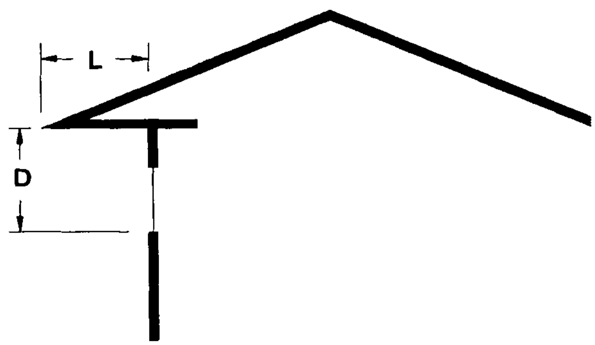
Search for house plans that provide overhangs on all sides of the house (hip roof). Make certain that the roof is oriented along an east-west axis if the plan calls for a gable roof. The resultant overhang on the south side will shade all direct sun during the summer. The ideal length of an overhang on the south side of a house is dependent on three factors:

- the latitude of the location
- the time of year shade is desired
- the distance between the soffit and the bottom of the glass.

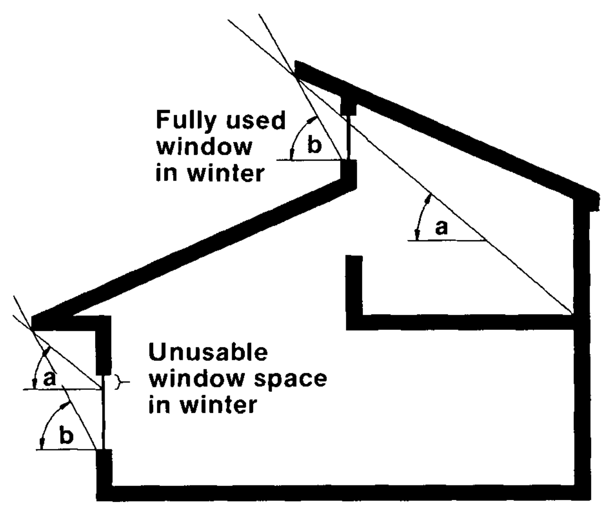
It is quite simple to calculate the ideal length of a horizontal south overhang using the table below.

For south-facing clerestory windows, the roof which will shade the window is often rising and the multiplication factors are less appropriate. Therefore, sun angles a and b are also shown for each city. The point where a and b cross is the ideal location for the end of the roof as shown. Draw the roof line, window, and angles a and b to scale to determine this point.

Although all overhang factors are for south-facing surfaces only, overhangs can be effective in shading all sides from diffuse sunlight. However, unlike the south side, "direct beam" solar heat will fall on an east, west or north side under an overhang due to the low angle of the sun. Use overhangs as wide as practical on north, east and west sides.



The length (L) of a south-facing overhang can be determined by knowing the sill-to-soffit distance (D).



Angle a is Dec. 21 sun, angle b is end of winter (see table below for dates).

Overhang Design for South-facing Windows

Latitude	Location	Sun Angles		Factor (F)	Time of Year Totally Shaded from Direct Sun	Length of Overhang (L= DxF) for Sill-to-Soffit Distance (D) of:				
		a	b			4′	5′	6′	7′	8′
25°	The Keys	41.5	52.5	.77	Feb 17 - Oct 24	3.1′	3.9′	4.6′	5.4′	6.2′
26°	Miami	40.5	54.0	.73	Feb 24 - Oct 16	2.9′	3.7′	4.4′	5.1′	5.8′
27°	Jupiter	39.5	53.5	.69	Mar 5 - Oct 7	2.8′	3.5′	4.1′	4.8′	5.5′
28°	Tampa	38.5	57.0	.65	Mar 7 - Oct 5	2.6′	3.3′	3.9′	4.6′	5.2′
29°	New Smyrna Beach	37.5	58.5	.61	Mar 16 - Sep 27	2.4′	3.1′	3.7′	4.3′	4.9′
30°	Panama City	36.5	60.0	.58	Mar 21 - Sep 21	2.3′	2.9′	3.5′	4.1′	4.6′
31°	Graceville	35.5	61.5	.54	Mar 30 - Sep 13	2.2′	2.7′	3.2′	3.8′	4.3′

7. Use simple building shapes

A rectangular-shaped home oriented on an east-west axis is the best design for energy efficiency. A square is better than a rectangle oriented north-south. Designs which have a large amount of exterior wall area should be avoided.

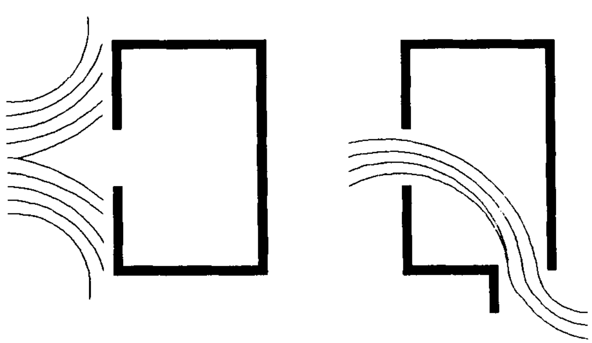
However, windows are more important than walls. An extra "jog" in the house shape to permit a window to face north or south instead of east or west will usually be a good trade-off and result in lower year-round energy use. Also, cross-ventilation of rooms lends itself nicely to spread-out, one-room-deep houses. If properly designed, the benefits of good cross-ventilation and orientation should outweigh the extra energy load imposed by slightly more wall area.

Two-story designs have more wall area and less floor and roof area than simple one-story designs. They are also more difficult to shade with landscaping. Therefore, consider using better-insulated walls on two-story designs. Two-story home designs frequently can be modified easily for adequate cross-ventilation.

8. Cross-ventilate rooms

Before vapor-compression air conditioning, natural ventilation kept homeowners cool. Florida houses were built with wide porches and large windows. The principles inherent in these older homes can be applied to contemporary ones. New homes can also be designed with massive materials to "store" the cooling provided by night-time ventilation and use it the next day to augment air conditioning.

The key to natural ventilation design is allowing openings for the air to enter and leave the home.

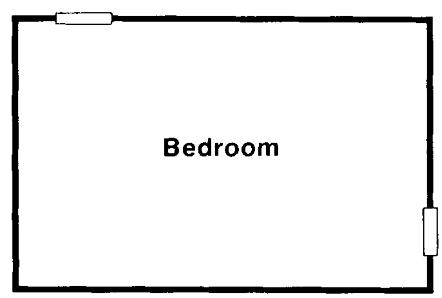


Allow openings for air to enter and leave the home.

Ideally, all rooms should be cross-ventilated. This includes bedrooms when their doors are shut. However, the major living, eating, sleeping and food preparation areas are most important. The kitchen is a source of much heat (from the refrigerator motor, dishwasher, oven, stove and microwave), so choose designs where the kitchen is well-vented.

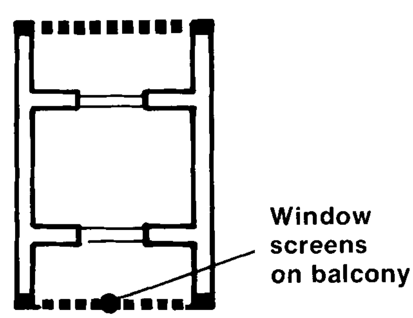
Keep the following general ventilation rules in mind when choosing or modifying plans:

- It is best to have equal inlet and outlet areas.
- Ideally, about 12% of the floor area should have screened openings. For second floors, 10% is adequate. If this is all met by sliding or single- or double-hung windows where 55-60% of the window is fixed, excessive window area would be required. To keep glass area to a minimum, use screen front doors, atrium-style doors to screened porches, and fully operable window types such as casements and awnings to provide the required openings.
- Openings on adjacent walls should be located as far away from one another as possible.

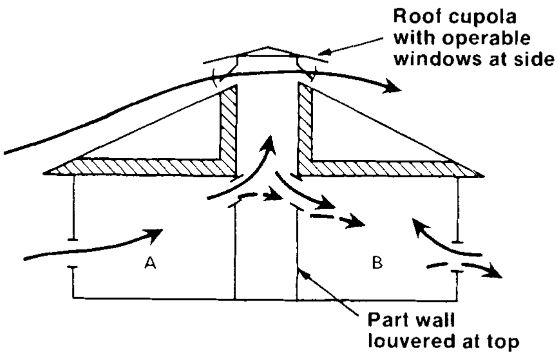


Adjacent wall openings should be at opposite ends.

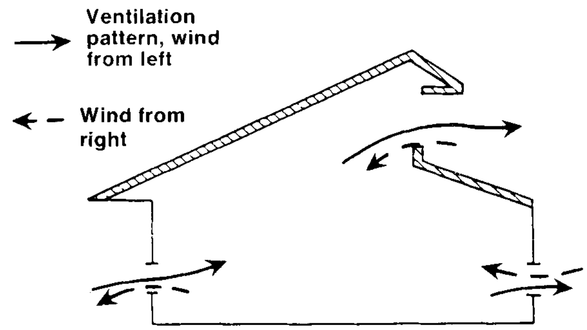
- Airflow is better with a screened balcony or porch than with window screens on the doors or windows.



Ventilation is improved by having screened porches or balconies instead of window screens.

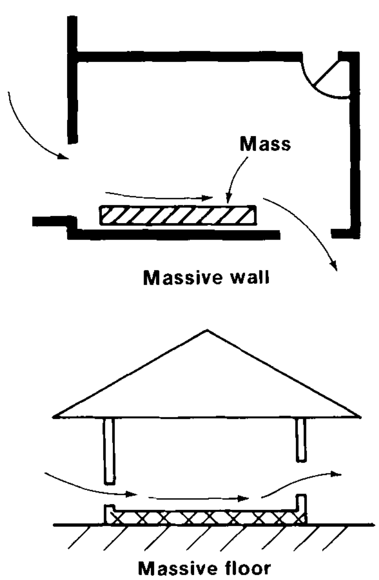


Roof cupolas can aid ventilation regardless of wind direction.

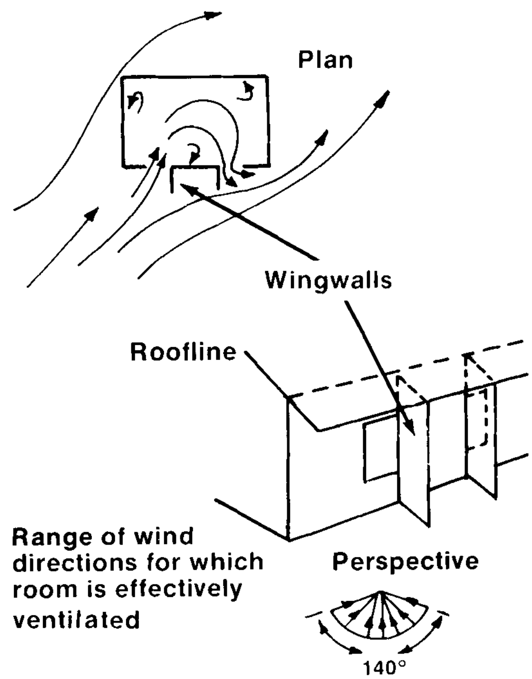


Clerestory windows can aid ventilation but may bring in hot air from the roof during the day (wind from right).

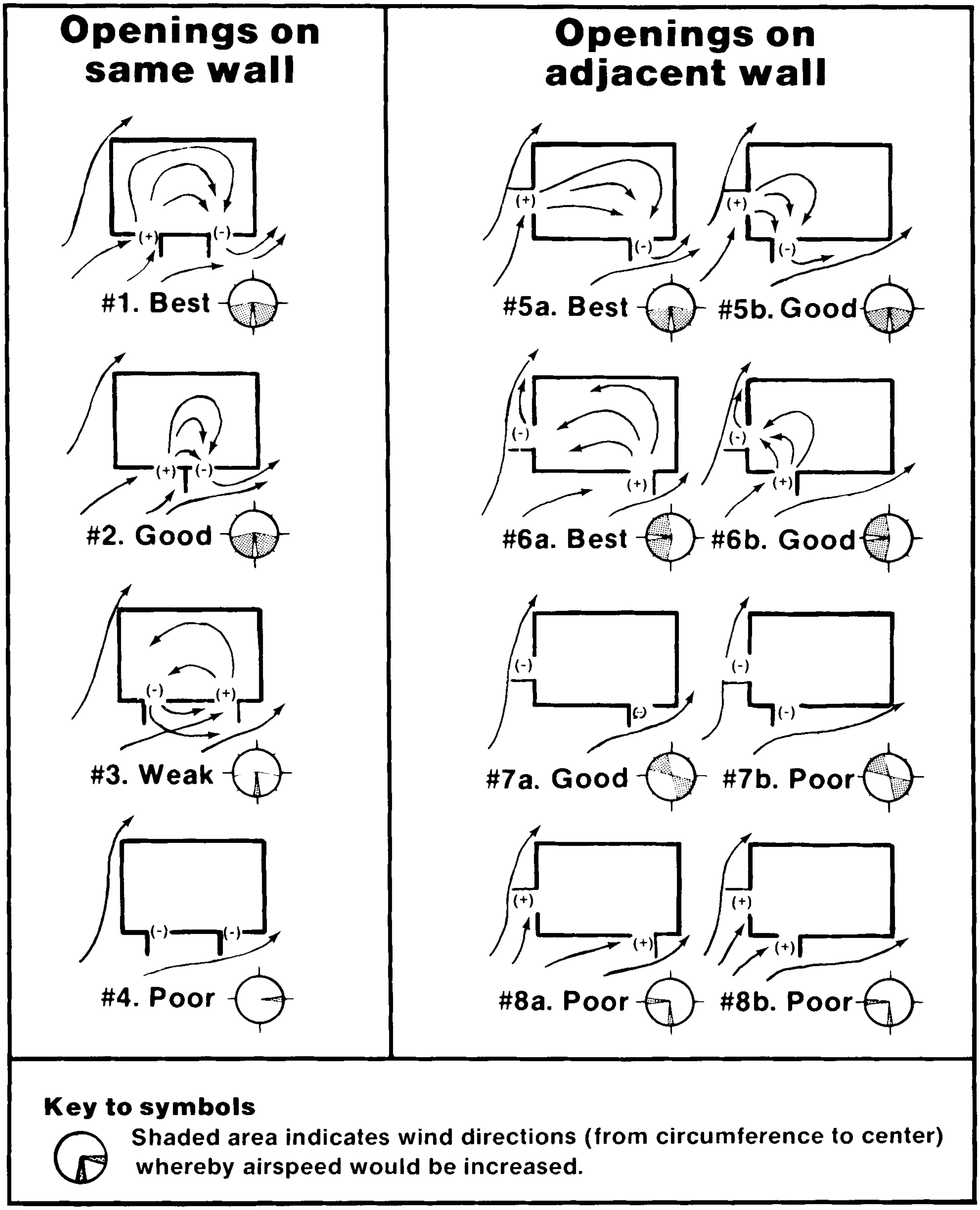
- Roof cupolas can aid ventilation, as can clerestory windows (however, clerestory windows open during the *day* may bring in hot air off the roof).
- Low inlets are preferred for occupant comfort. Therefore, screened doors and low windows are preferred from a ventilation viewpoint.
- In two- or three-story structures, there will be a slight benefit from high outlets if air is permitted to flow from the first floor up to the higher levels.
- Mass will provide daytime cooling from night venting. It is best to locate exposed (uncarpeted) floors and massive walls in living, dining and kitchen areas, leaving bedrooms with less mass so that they can be quickly cooled in the evening.
- For homes with massive walls or floors to store the heat (or coolness), inlets should be positioned close to the mass to create a wall or floor "jet."
- In rooms with one outside wall, two widely spaced windows are better than one large window.
- Wingwalls (walls that protrude out from the house, next to the window) can be used to improve ventilation. A wingwall should be as long as the window is wide. It can increase airflow, particularly in rooms with windows on only one wall. Appropriate uses of wingwalls are shown on the next page. In some instances, the space between the wingwalls can be used as indoor or outdoor closet space. Casement windows can act as wingwalls too (see Chapter 7).



Locate openings close to massive wall or floor.



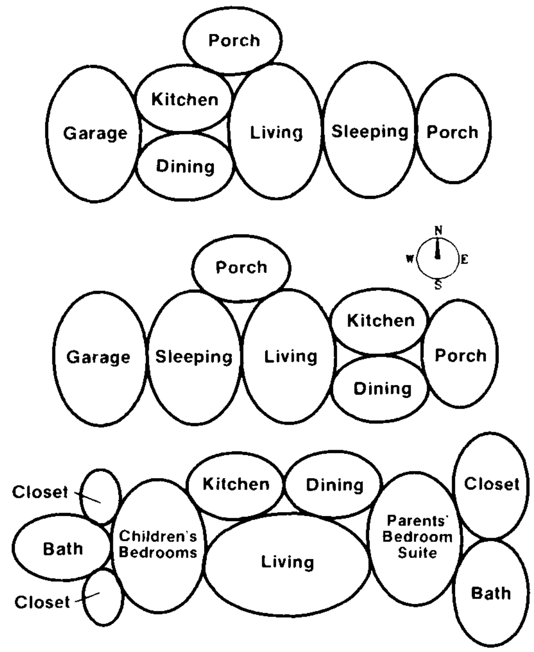
Wingwalls direct air into the house.



Wingwall examples

9. Time-of-day layout

Time-of-day layout refers to locating rooms where they will provide the most comfort when in use. Many Florida residents are hesitant about having a west-facing kitchen, dining room or porch because of the discomfort they experience while preparing and eating their evening meal. Time-of-day use can vary from one family to another, but the following table shows generally preferred locations for most rooms. Energy savings can be realized in summer, since residents will not be discomforted by hot wall surfaces or penetrating sun and therefore will not reset their air conditioner thermostat to compensate. Similarly, having the living area on the south or open to south-facing rooms will provide winter heating savings and comfort.



Room layouts designed for occupant comfort.

Time-of-Day Layout for Room Comfort						
	Preference					Comments
	1st	2nd	3rd	4th	Avoid	
Bedrooms	S	E	N	W		Base choice on direction of evening/night breezes. If late morning sleeping is anticipated, west may be better than east.
Family/Living	S	N			E,W	If family room and living room are provided, family room is more important; most living rooms are rarely used.
Kitchen	N	E	S		W	
Dining	S	E	N		W	
Garage	W	E	N	S		Provides a buffer to rest of house.
Covered porches	E	S	N	W		West should be avoided if evening meals are expected to be eaten on porch.
Baths	E	W	S	N		Provides a buffer to rest of house.
Closets	W	E	N	S		Provides a buffer to rest of house.

<table>
<tr><th colspan="5">Clock Time-of-Day When Direct Sun Strikes Unshaded House
(July corrected for Daylight Saving Time)</th></tr>
<tr><th colspan="3">Eastern Florida
(Jacksonville, Miami, Orlando)</th><th colspan="2">Western Florida</th></tr>
<tr><th></th><th>January</th><th>July</th><th>Tallahassee</th><th>Pensacola
(Central Time Zone)</th></tr>
<tr><td>North</td><td>Never</td><td>6:40-10:00
and
5:00-8:20</td><td rowspan="4">Add
15 minutes
to all times
at left</td><td rowspan="4">Subtract
30 minutes
from all times
at left</td></tr>
<tr><td>East</td><td>7:15-12:30</td><td>6:40-1:30</td></tr>
<tr><td>South</td><td>7:15-5:45</td><td>10:00-5:00</td></tr>
<tr><td>West</td><td>12:30-5:45</td><td>1:30-8:20</td></tr>
</table>

10. Locate air handler and appliances properly

Look for designs which can contain the air handler for non-combustible furnaces, together with all ductwork, in the conditioned space. This is a big asset in reducing air infiltration and duct losses. Modify designs, if necessary, to put the air handler where a coat closet or basement stairs are shown, and think of potential layouts for the ductwork in the conditioned space.

Washers, dryers and water heaters can be a source of heat and/or moisture to the house. Since air conditioning is a greater concern than heating in Florida, enlarge garages, carports, or closets off of a porch to provide non-conditioned space for these appliances. Vent the dryer to the outdoors.

11. Avoid fireplaces

Fireplaces are a source of air leakage, whether or not they are being used. It would be best to omit fireplaces from plans. If they are to be installed, see Chapter 11 for how best to install them.

Summary

The choice of home design can greatly affect the energy use and comfort of the home owner. Proper orientation, fewer window areas, and structural shading can all help keep out some of the sun's heat. Glass should face north or south unless facing a porch. Overhangs should be correctly sized for shading direct sun from south-facing glass and should be used on all sides of the house. Simple building shapes are preferred but shading and ventilation may dictate an irregular shape. All major rooms should be cross-ventilated, and located where they will provide the most comfort to occupants. Choose plans which locate laundry appliances in the garage and air handlers for non-combustible furnaces in the conditioned space. Consider the energy disadvantages of a fireplace.

House Plan Examples

Do not expect to readily find a home design that incorporates all of this chapter's recommendations and works well with the site you have selected. So that you can see how the preceding recommendations can be carried through into the house design, this section includes examples of homes for sites oriented to the north, south, east or west. If your site faces a different direction (northwest, for example), it would be best to orient the house so that the two sides with the most windows face within 15° of north or south. Two of the examples shown here, however, are site-independent — that is, most glass is well shaded regardless of orientation. Also, there are two multi-family examples, three zero-lot-line detached home examples, and eight orientation-dependent detached home designs.

Each example here is just that, an example; full plans are not available. If you would like to build one of the examples, take the drawing to an architect or residential designer. To maintain the energy aspects of the design, do not alter window or outside wall locations.

FSEC has other home designs available with full construction drawings. The designs are winners of state-wide competitions. Contact FSEC for more information.

Most single-family home designs shown here have a screened front door and a two-car garage. In most instances, a one-car garage or carport could be substituted. (A carport permits breezes to enter the home and is preferred.)

Four-inch walls are shown on most designs. Block walls could be substituted. All dimensions are rounded to the nearest foot.

Less common abbreviations and symbols used in the examples are defined below:

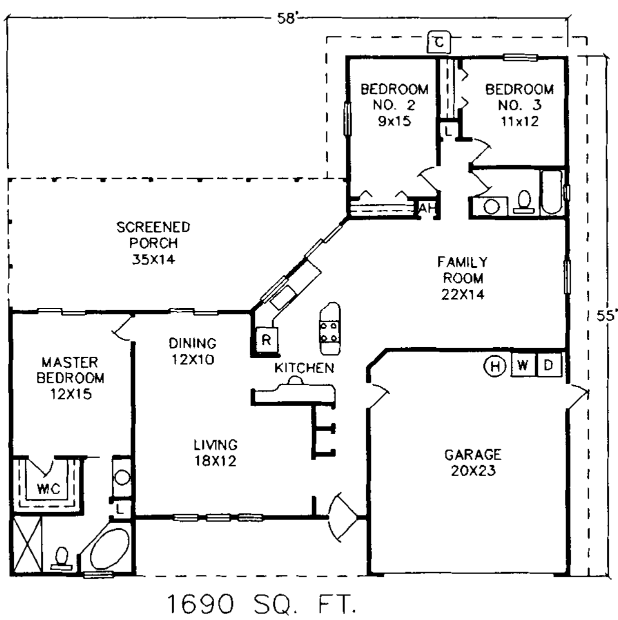
Abbr./Symbol	Meaning
AH	Air handler for cooling/ heating system
C	Air conditioner compressor
L	Linen closet
P	Pantry closet
R	Refrigerator
WIC	Walk-in closet
WO	Wall oven
—	Roof overhang or screened porch wall
//////	Fence or railing

The plans are numbered with prefix abbreviations for quick identification. For example, SF is South-Facing.

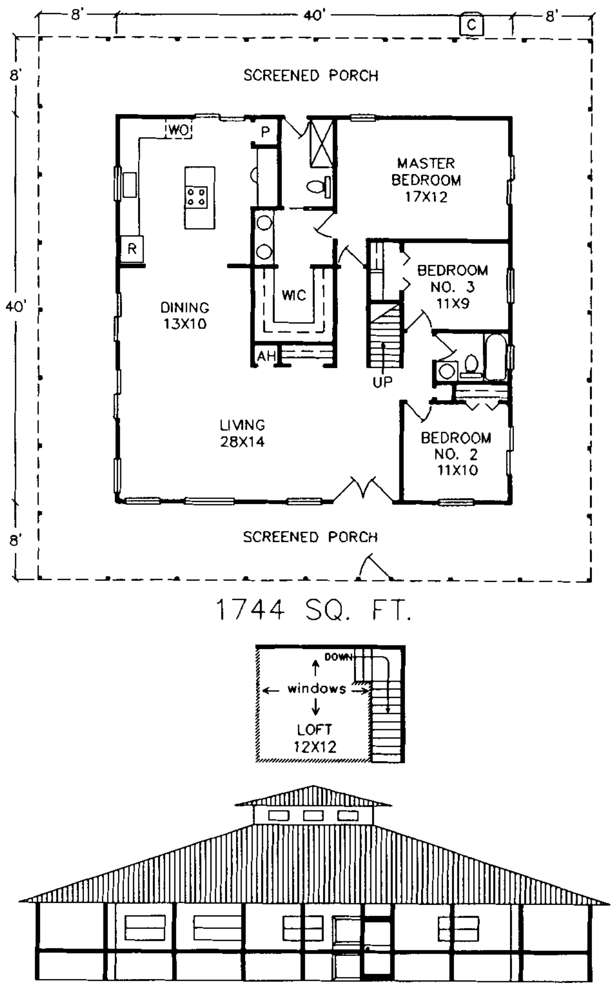
Orientation-independent plans

Home plans that are adaptable to many lots regardless of orientation should emphasize shading glass areas and avoid a disproportionate number of unshaded windows on any one side. Example OI-1 is a plan similar to many being built today, but with better shading provided. Front and back porches structurally shade most of the glass. A few unshaded windows remain — one in the front (master bath), two on one side (family room and second bath), one on the other side (bedroom 2) and one on the back (bedroom 1) — but overhangs and other shading devices (Chapter 7) can help protect them. Ventilation of the main living areas, kitchen and master bedroom is possible. Bedrooms 2 and 3 require additional openings for ventilation when the doors are closed.

Example OI-2 is reminiscent of older Florida homes, with a porch or veranda on all sides. High, narrow loft windows provide light and good ventilation.



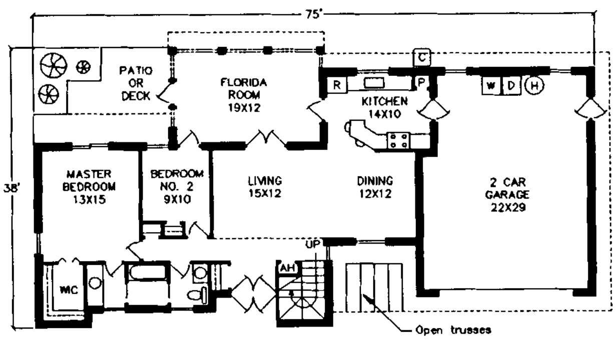
Plan OI-1



Plan OI-2

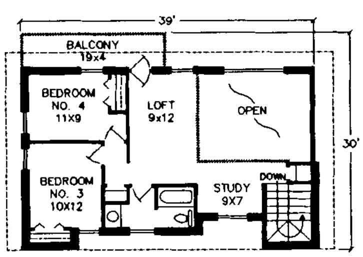
North-facing single family home plans

North-facing sites may be the best orientation for an energy-efficient, comfortable home. Example NF-1 shows a two-story plan with thick block walls indicating space for exterior insulation. Note that the overhanging second floor balcony shades the first-floor south-facing glass. There is no unshaded west glass. The Florida room should remain unconditioned and can serve as a screened porch in summer. North-facing glass is shaded from direct sun by the projections. Walls create wingwall effects for ventilation in bedrooms 2 and 3. All rooms have good ventilation potential.



1290 SQ. FT.+
240 SQ. FT. Florida room

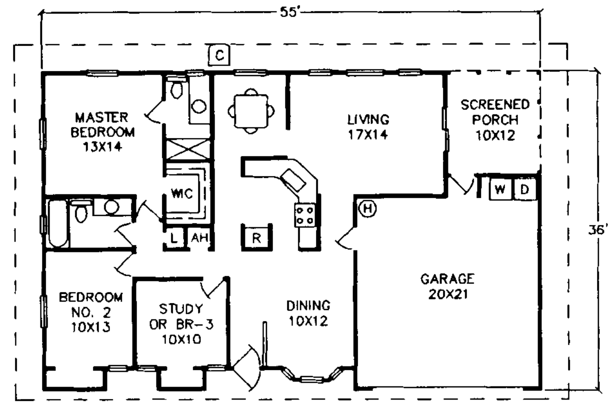
Plan NF-1, 1st floor



680 SQ. FT.

Plan NF-1, 2nd floor

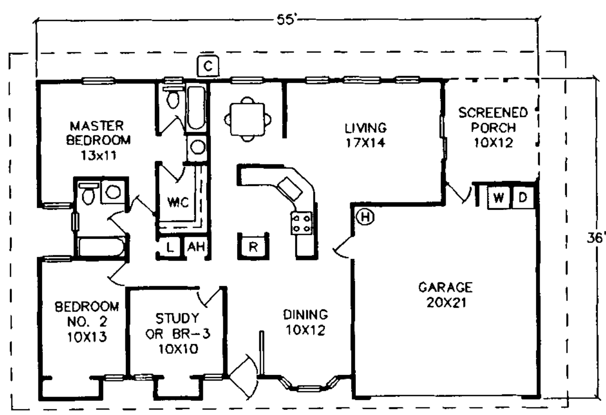
Plan NF-2a is a simple, small rectangular plan with a hip roof and two-car garage that will fit on most lots. Shading on the west side is provided by the garage and a screened porch. Tinted glass or an alternate shading method should be used on the three small east windows. Closets in bedrooms 2 and 3 act as wingwalls. Cross-ventilation potential for each room is good.



1275 SQ. FT.

Plan NF-2a

Plan NF-2b varies slightly from NF-2a. It adds wall area but reduces shading problems for the east windows, while maintaining reasonable cross-ventilation potential. A different interior layout is shown in the south-facing plan SF-2, which would also be effective on north-facing lots.



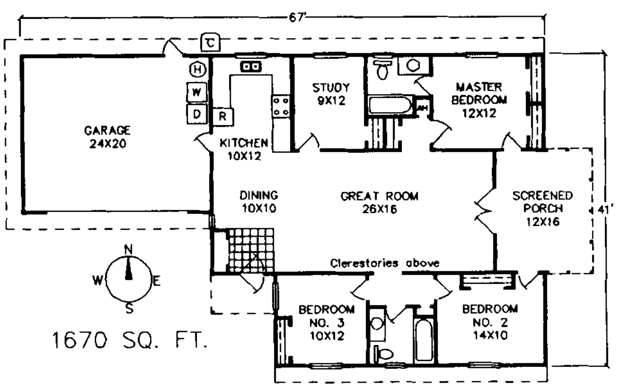
1275 SQ. FT.

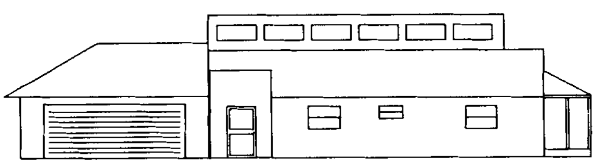
Plan NF-2b

South-facing single family home plans

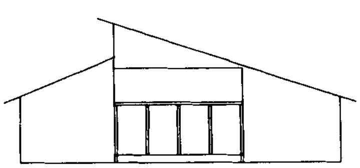
Energy-efficient designs are easily adapted to south-facing home sites. A front overhang is recommended with few or no side windows. Example SF-1 shows east and west windows, but they are shaded by long overhangs on the west and a screened porch on the east. All rooms have good ventilation potential. The south-facing clerestory windows provide light, winter heat and ventilation to the main living area.

Plan SF-2 is the same as NF-2b except that an alternate room arrangement is shown. There is direct access from the kitchen to the porch. The mirror image of this plan would also be effective for south-facing lots.



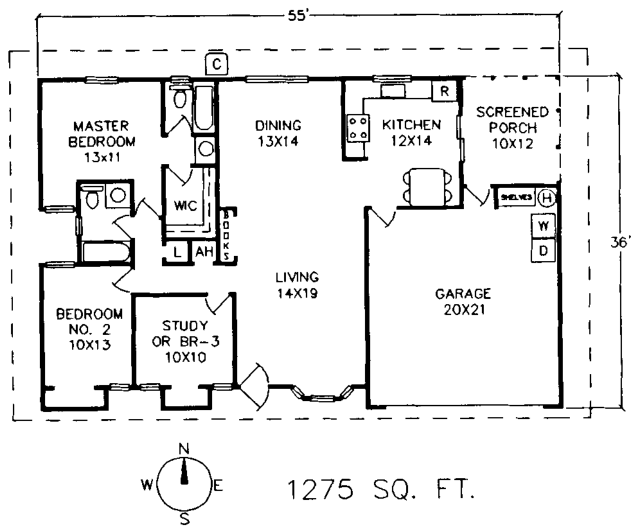


SOUTH ELEVATION



EAST ELEVATION

Plan SF-1

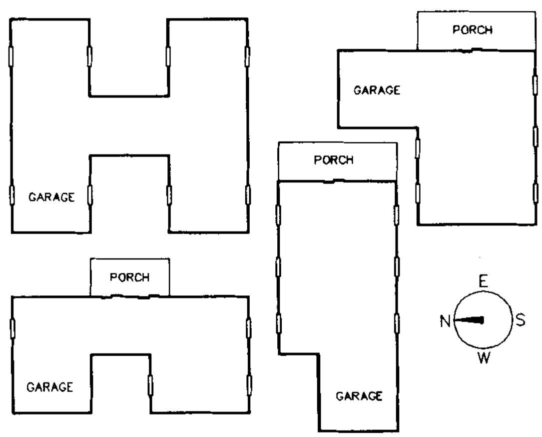


Plan SF-2

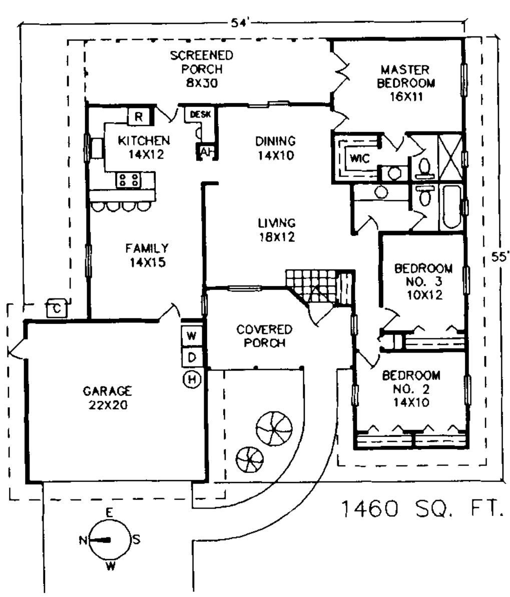
West-facing home plans

As previously discussed, the west is the worst side for glass. Choose designs which have one or no front windows, and which have a long porch on the back to shade the house from the morning sun. Finding an energy-efficient west-facing plan is a challenge, but many design options are available — although they may require modifications to an existing plan.

- Keep house oriented on east-west axis. Put design emphasis on roof elevation and consider side-entry garages.
- Consider a house shape other than a simple rectangle to permit north- and south-facing glass and adequate ventilation. Examples: a 7-shape, U-shape, H-shape.



Choose shapes with most windows on side.

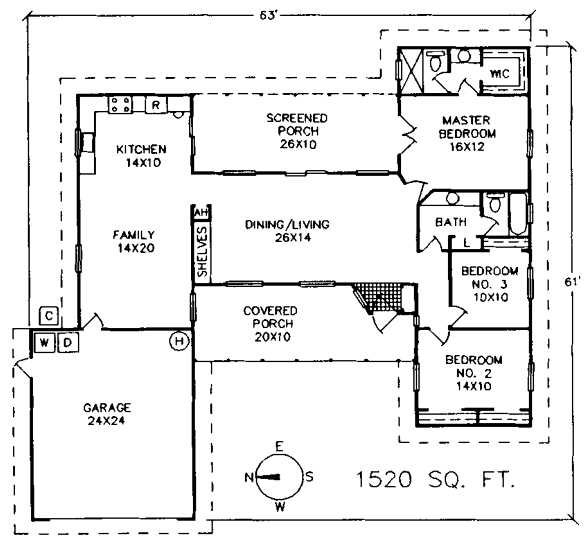


Plan WF-1a

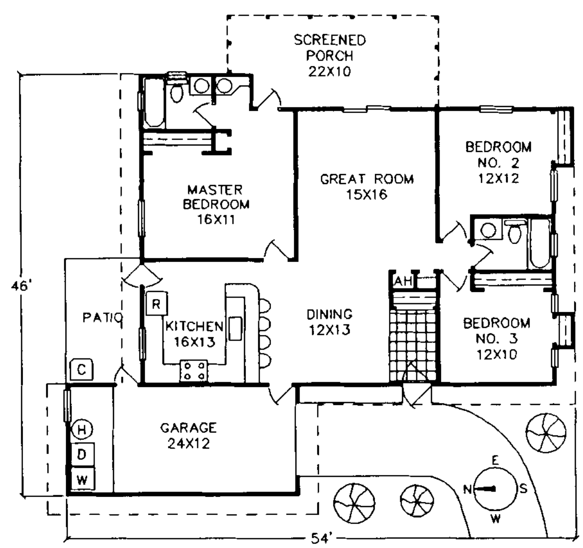
- Use a large, covered front porch to shade windows. Consider a Victorian or country design to make the front porch a marketing feature.

Plan WF-1a is a U-shaped plan that uses the garage and front porch to shade the house from the sun. The shape permits cross-ventilation for every room. If a longer front elevation is desired, a larger front and back porch can provide the needed shade, as shown in plan WF-1b.

Plan WF-2 has no front windows and will provide excellent cross-ventilation to each room with southeast winds (a predominant wind direction in many parts of the state).



Plan WF-1b



1360 SQ. FT.

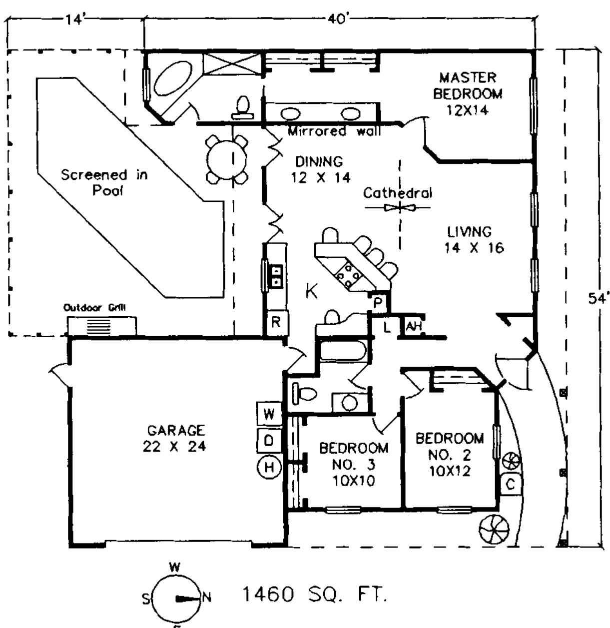
Plan WF-2

East-facing home plans

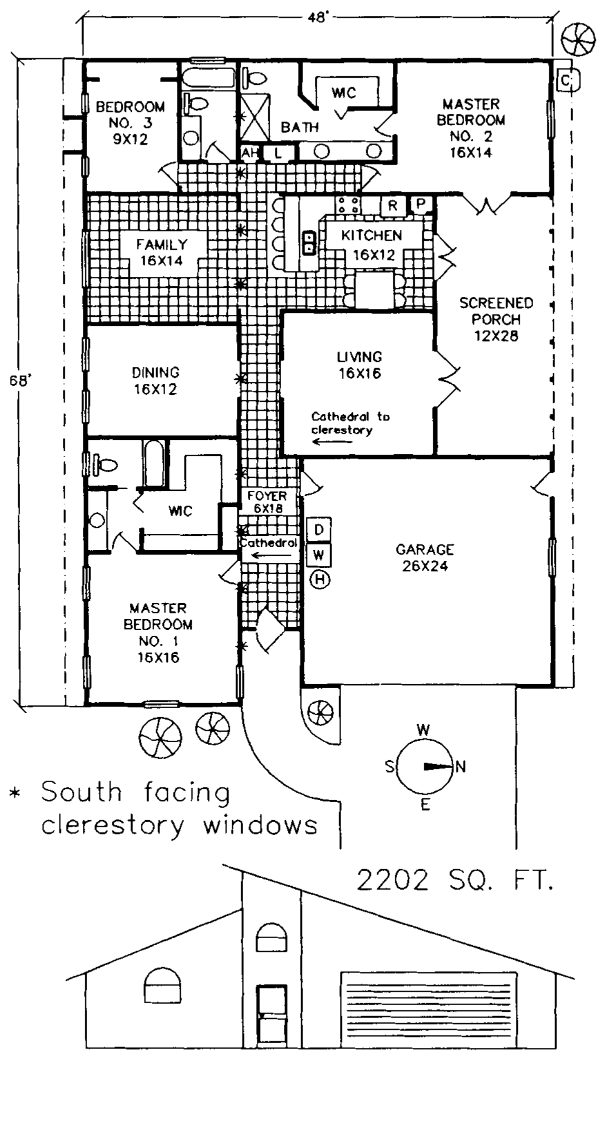
The design criteria listed for west-facing plans will be energy-efficient on east plans also. However, east-facing lots present the most difficult challenge in selecting comfortable and energy-efficient floor plans. Not only does the back of the house have to be shaded, but the ideal focal point of the property should be shifted from the traditional back yard to a side yard to avoid the afternoon heat. A C-shape (or reverse C-shape) house with most glass on its sides, but not in front or back, will create a pleasant outdoor area, as shown in examples EF-1 and EF-2.

Plan EF-1 succeeds in having no windows on the back of the house and an outdoor focal point on the south side. Due to the projection of the master bath wing, occupants can eat in the shade in the screened area during late afternoon and early evening in summer. The south side is also the best location for a pool. The south glass will help heat the home in winter. Every room except bedroom 3 has cross-ventilation potential, although the garage may block southeast breezes.

Plan EF-2 maximizes cross-ventilation potential and the use of south glass, for an energy-efficient plan. There is one front-facing east window and one small (4 square-foot) west window. The south-facing clerestory windows provide light and winter heat for the kitchen, living room, foyer and one bath. A north porch allows outdoor living/eating off the kitchen and living room, and either the north or south side can serve as an outdoor focal point. Tile flooring provides thermal mass for ventilation and passive solar heating.



Plan EF-1

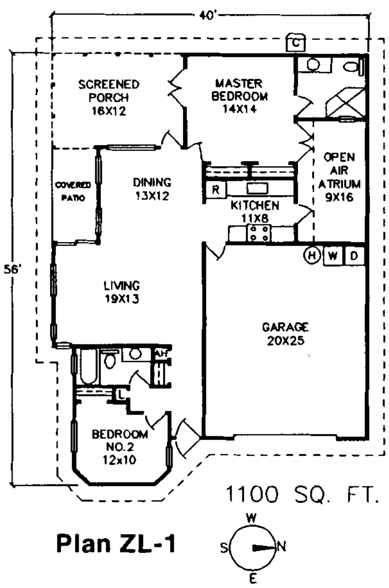


Plan EF-2

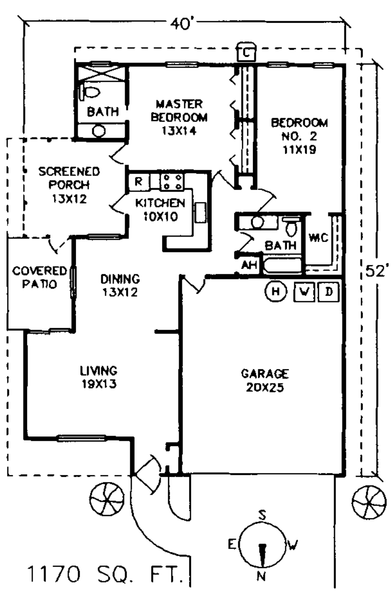
Zero lot line plans

In areas where land costs are high, many builders use high-density detached house zoning. A typical lot size is 50 by 100 foot. Usually one side of the house is built on the lot line and is without windows. Glass is provided on the other three sides.

Plan ZL-1 is best for east- or west-facing lots. Most of the glass is concentrated on the south side. Cross-ventilation potential is excellent. The open-air atrium (screened roof) helps provide ventilation and light to the kitchen and master bath, and the screened porch and covered patio help shade other glass.

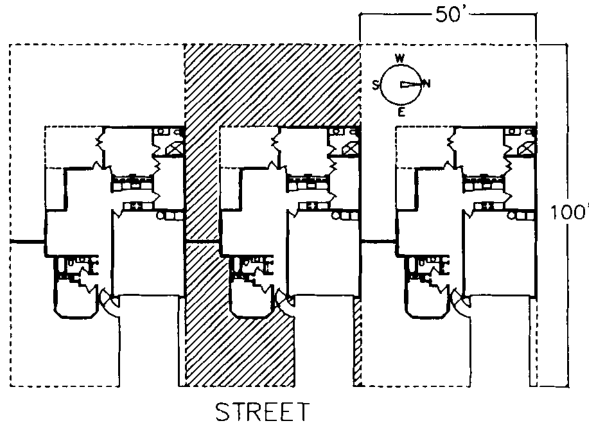


Plan ZL-1

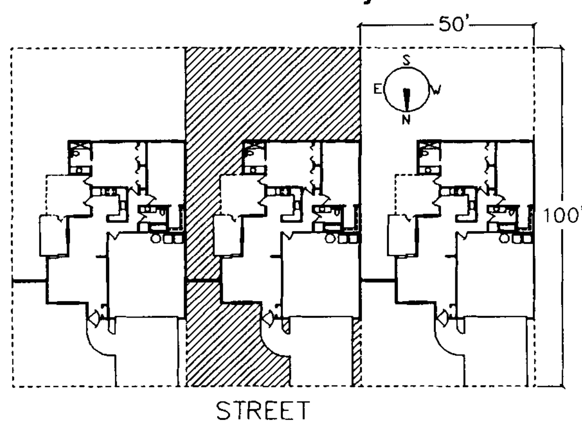


Plan ZL-2

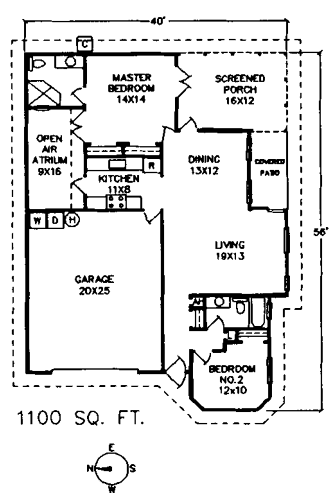
Plan ZL-2 is better than ZL-1 if the lot faces north or south. The west side should always be the side without windows. Cross-ventilation potential is available to all rooms except bedroom 2. East windows are shaded by the porch and patio.



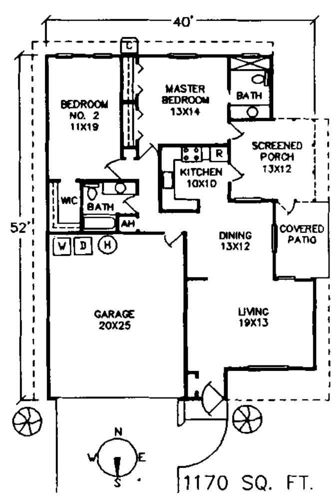
Plan ZL-1 site layout



Plan ZL-2 site layout

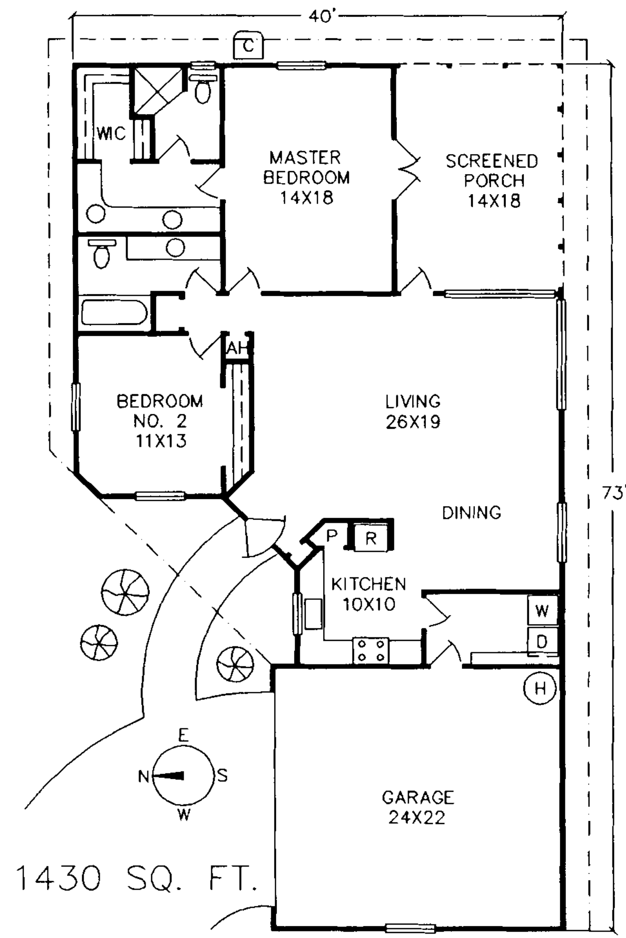


Mirror image of ZL-1 would be effective on west-facing lots.

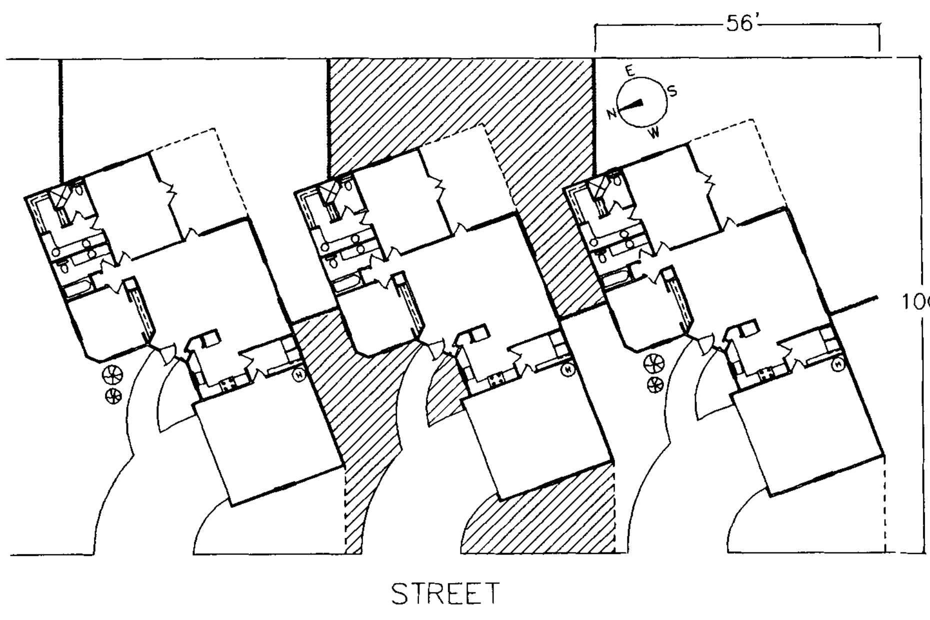


Mirror image of ZL-2 would be effective on south-facing lots.

Plan ZL-3 is for double-zero lot line sites. There are windows in the front part of one side and the back part of the other side. The house is usually tilted on the lot, creating a wider elevation when viewed from the street. Since the garage has to occupy a fair portion of the front of the house, and the narrow width almost dictates that a porch go on the back of the house, east- or west-facing sites are preferred. Plan ZL-3 is an example of such a case. A solid fence (shown in the site layout) may act like a partial wingwall and aid in cross-ventilating the dining room and kitchen. A screened front door is essential for cross-ventilation of the living room.



Plan ZL-3



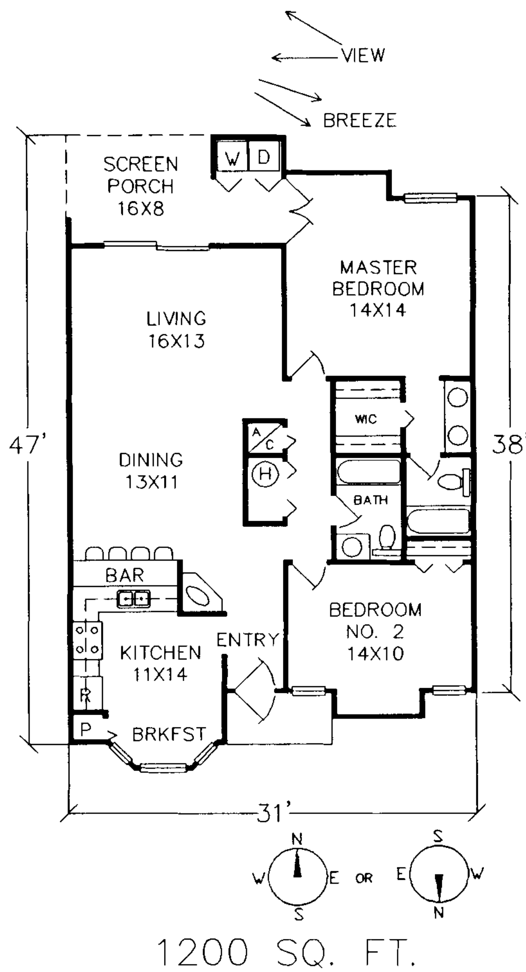
Plan ZL-3 site layout

Multifamily plans

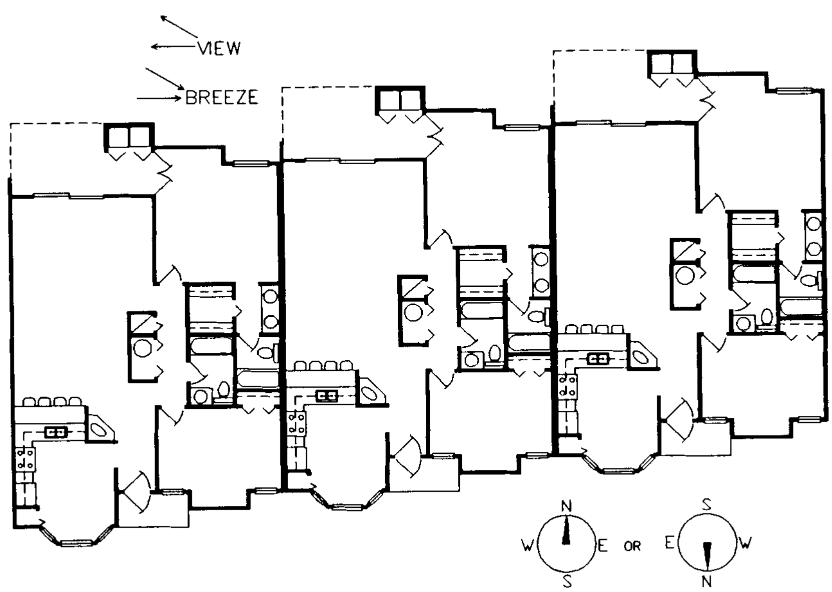
Multifamily buildings frequently contain identical units side by side and, sometimes, above and below. In many multifamily buildings, windows are limited to front and back. Due to staircases, most units in a multistory, multifamily building have some shading of front glass. A porch on the back can provide further shading. North- or south-facing sites are preferred.

Two-story units are best if situated side by side with openings front and back — for cross-ventilation and so that all windows can be facing north or south.

Plan MF-1 demonstrates an open floor plan that permits cross-ventilation of the kitchen/dining/living areas. A sitting area in the master bedroom protrudes to act as a wingwall for better cross-ventilation in that bedroom. The ventilation potential of a multifamily building will depend on the site, the spacing between buildings, and the way the units are connected. Shown is a method for connecting the units to allow angled breezes to each. Additionally, each unit could have a view of a special feature of the site (river, lake, ocean, golf course, etc.). Note that the washer and dryer are located on the porch and the dryer can easily be vented to the outdoors.

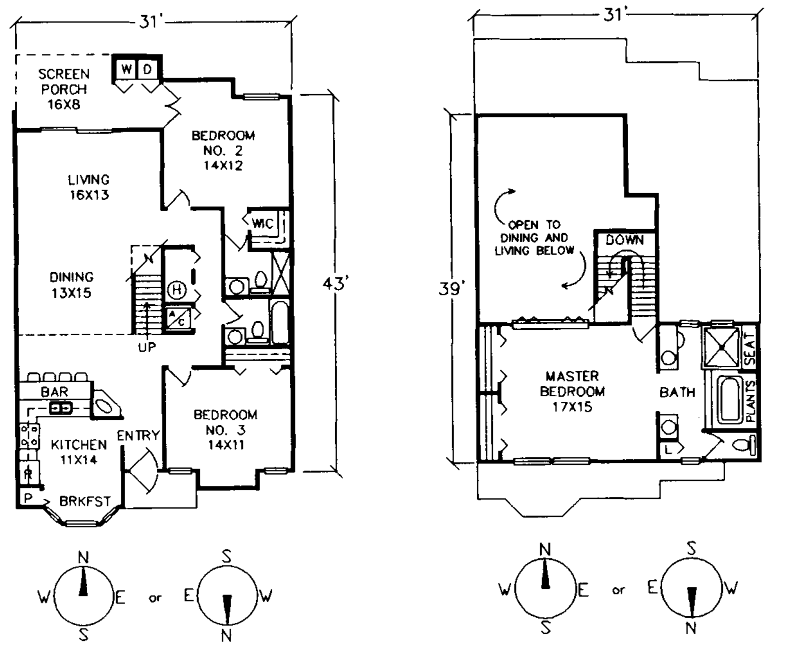


Plan MF-1



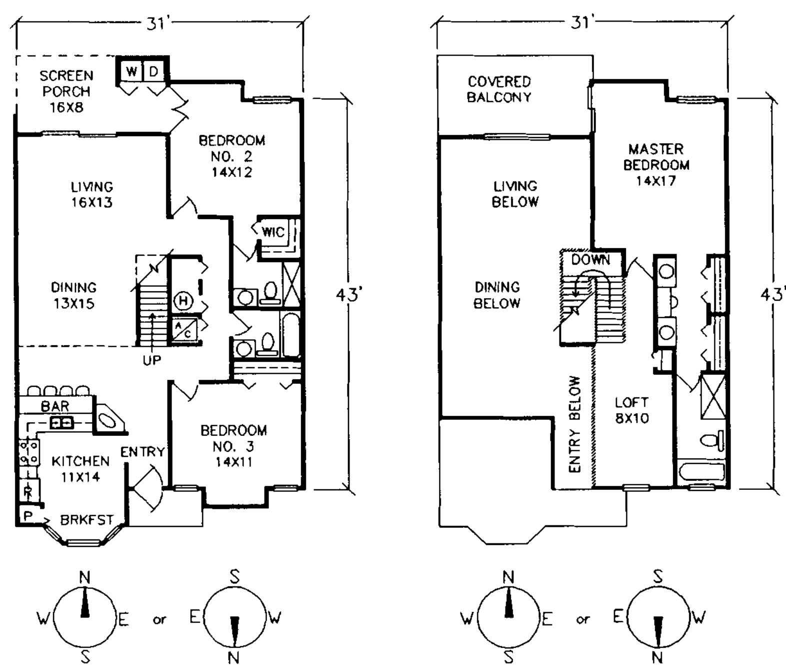
Connect units so that breezes reach each one.

Plan MF-2a is a two-story plan. Cross-ventilation of the second floor is possible by the opening from the first-floor dining room to the second-floor master bedroom. Plan MF-2b shows an alternative cross-ventilation design where the windows in the loft and master bath are at the opposite end of the master bedroom windows.



1st Floor 1200 SQ. FT. 2nd Floor 600 SQ. FT.

Plan MF-2a



1st Floor 1200 SQ. FT. 2nd Floor 600 SQ. FT.

Plan MF-2b

For further information

"A Passive Solar Home Program for Florida," T. Wayne Waldron, *Concrete Masonry Solar Architecture,* Vol. 6, No. 3, August 1986.

"Guidelines for Energy-Efficient Multi-Family Housing Design," Mike Nicklas, *Concrete Masonry Solar Architecture*, Vol. 6, No. 3, August 1986.

"Solar Homes Design Portfolio," Tennessee Valley Authority (TVA), 1985.

"Passive Solar Design Considerations for North Central Florida," Florida Region III Energy Action Committee and Gainesville Regional Utilities (also reprinted by Jacksonville Electric Authority).

Cooling with Ventilation, Subrato Chandra, Philip W. Fairey III, Michael M. Houston, Solar Energy Research Institute — Sp-273-2966, Golden, Colorado, 1986.

Climate Design, Donald Watson, Kenneth Labs, McGraw-Hill, Inc., New York, 1983.

Chapter 5

Energy-Efficient Foundations and Floors

Recommendations	First Cost	% Estimated Savings		Radon Prevention Measure
		Cooling	Heating	
1. Choose slab-on-grade foundation, not crawl space foundation.	R	0-10	0-10	—
2. Follow standard recommended slab construction practices, including: wire mesh layer or control joints, gravel/polyethylene/ sand layers, isolation joint at footing, ground sloped away from slab, cured slab.	N	—	—	Yes
3. Seal all penetrations.	S	—	—	Yes
4. Use foundation plantings to shade slab perimeter.	S	0-2	—	—
5. Consider using perimeter insulation.	M	0-2	0-10	—
6. Select tile or stamped concrete finish.	H	0-10	0-10	—
7. Seal and insulate crawl space ceiling.	S/M	—	—	Yes
8. Vent crawl space.	N	—	—	Yes
9. Insulate floors over garages or other nonconditioned spaces to R-11.	S/M	0-5	0-10	—
10. Leave space for ductwork in floor of second story.	R/N	0-10	0-10	—
11. Seal sill plate.	S	5	5	Yes
Maximum Combined Total	H	25	25	

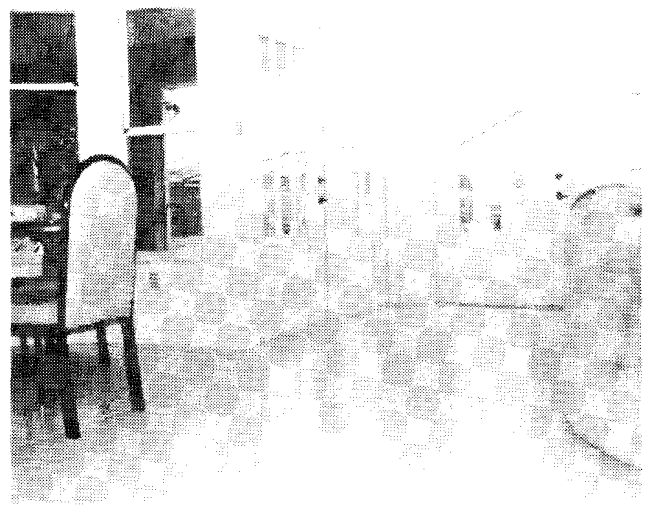
Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft² of floor area)
M = medium (>$0.25 and <$1.00/ft² of floor area)
H = high (>$1.00/ft² of floor area)

Marketing Energy-Efficient Foundations and Floors

The foundation of a house appears to be an unlikely source of energy savings. However, this chapter offers construction recommendations that are cost-effective for both saving energy and preventing migration of radon or other gases from the soil. Most of these measures already are established practices. Unfortunately, too many builders and subcontractors overlook them. They should be used throughout Florida but are most important where higher radon levels exist.

This chapter also contains information on floor finishes and second-floor construction that can contribute to an energy-efficient home — together with the following tips on how to educate home buyers on the desirability of these features.

Explain to your clients the steps you have taken to minimize the chance of water, heat and cold infiltrating through cracks in and around the foundation. Show photos of other job sites where slabs have cracked or sill plates are not properly caulked, and then show photos of the foundations you built that incorporate the recommendations in this chapter. Clients will grasp the differences and view you as both an energy-conscious home builder and a quality builder.

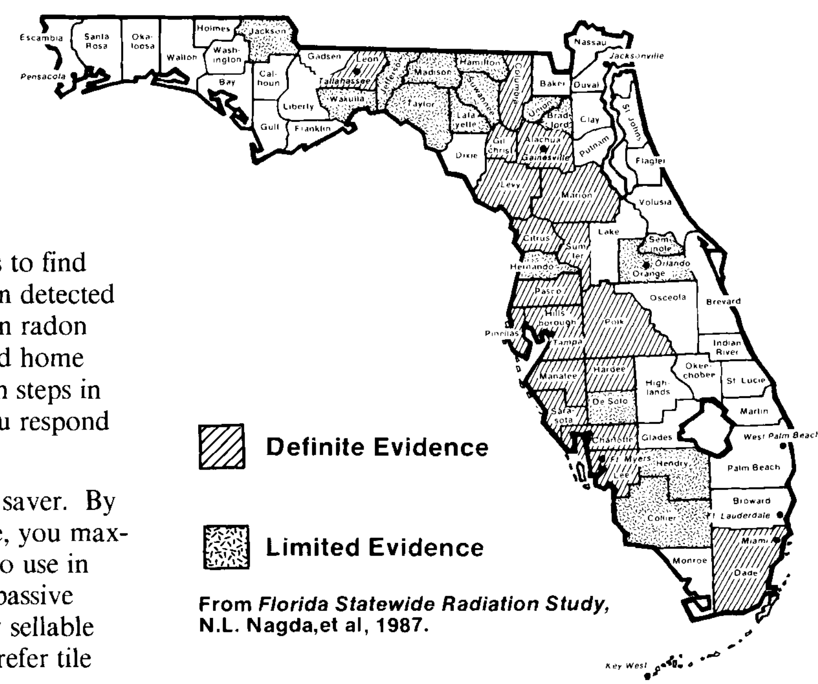


A ceramic tile floor can help sell houses.

One of this chapter's recommended strategies is to plan the construction of the second floor in two-story homes with space for ductwork. Depending on the home layout, the quantity of ducting may be reduced, with an overall cost savings that can give you an edge on a competitor. Moreover, you can inform potential home buyers that you may have saved them 10% on their heating and cooling bills!

In certain parts of the state, the concentration of radon in the ground is high enough that harmful gases can migrate through cracks in the foundation into the house. The adjacent map shows areas where soil tests indicate potentially harmful levels. However, you should contact local and state health departments to find out if high radon concentrations have been detected near your building site. News coverage on radon has raised the concern of home buyers and home owners. By following the radon-reduction steps in this chapter, you can show clients that you respond to their concern.

You can market a slab floor as an energy saver. By choosing stamped concrete or ceramic tile, you maximize the use of the slab for heat storage to use in conjunction with natural ventilation and passive solar heating. Moreover, you have a very sellable floor: A survey showed that Floridians prefer tile floors to wood ones.

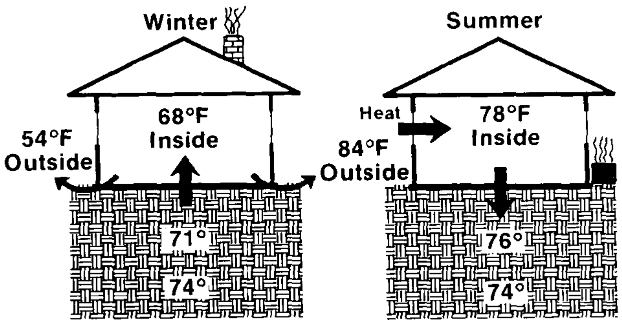


Florida counties with evidence of elevated radon potential.

1. Choose slab-on-grade foundations

Slab-on-grade foundations are usually more energy-efficient than raised (crawl space) foundation systems. Heat flow between the ground and slab varies — depending on the type of soil, amount of rain or shade at site, etc. — but a slab-on-grade foundation may reduce home space conditioning costs by as much as 10%.

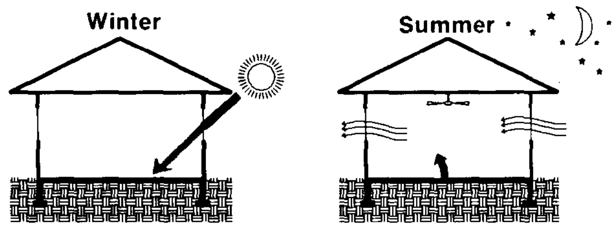
In South Florida, slabs can reduce heating requirements by 10% and cooling requirements by 0-3%. Conversely, in North Florida, slabs can reduce cooling requirements by about 10% and heating requirements by 0-3%. This cost savings derives from the fact that year-round deep earth temperature stays constant. In Florida it ranges from 70°F (north end of Florida) to 78°F (south end of Florida).



In winter, heat flows in from the earth and out through the slab perimeter. In spring and summer, the ground helps remove heat.

In summer, if occupants keep their house at 78°-82°F, the cooler ground can take heat away from the house. In winter, if occupants keep their house at 65°-70°F, the warmer ground can be a benefit (see drawing above). However, the perimeter of the slab (outside edges) loses heat to the cold outdoors. Unless the perimeter is insulated the slab may not help much in heating the home. But crawl spaces lose heat to the cold outdoors in winter and provide no summer benefit.

Concrete slab floors also can be used to store heat. During the summer, daytime heat can be stored for removal at night by ventilation. During the winter, passive solar heat (see Chapter 4) can be stored during the day to keep the occupants comfortable through the evening and night.



Slab floors can store the sun's heat in winter and the coolness from night-vented air in spring, fall and summer.

2. Follow recommended slab construction procedures

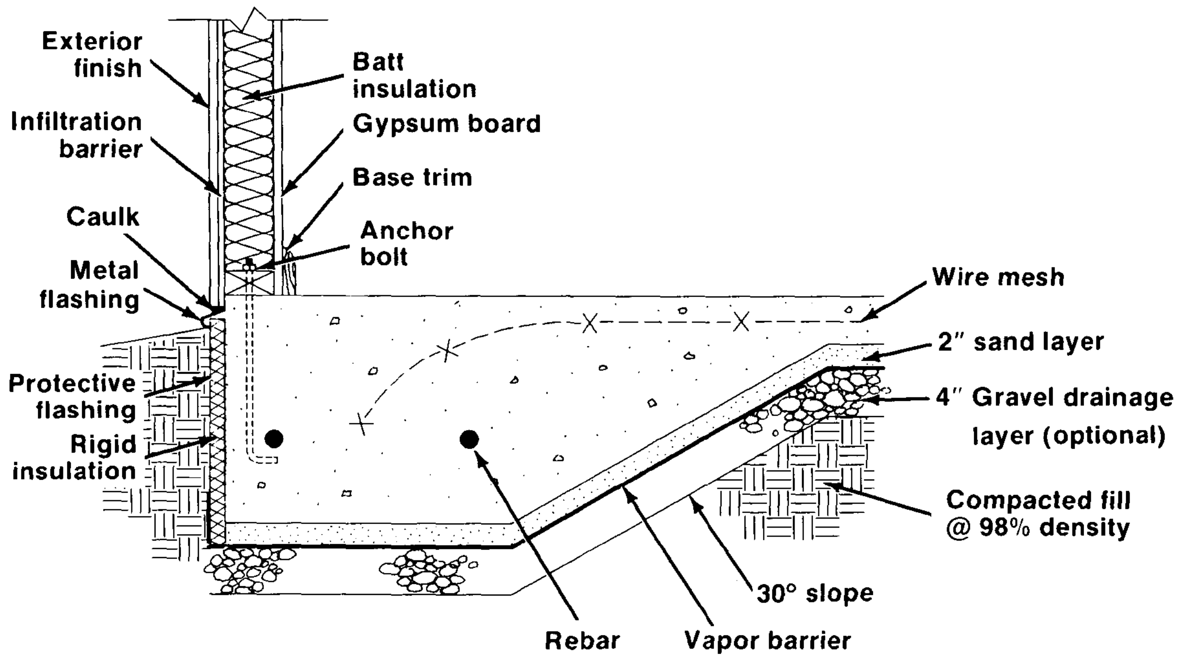
For durability of the slab foundation, a number of standard measures should be followed. (See drawings on next page.) They will reduce moisture migration from the ground to the house and keep the air conditioner from working as hard. More important, they may deter the leakage of dangerous gases such as radon or pesticides from the soil into the house.

Radon. Despite uncertainties about the causes and effects of radon concentration in houses, there is general agreement that:

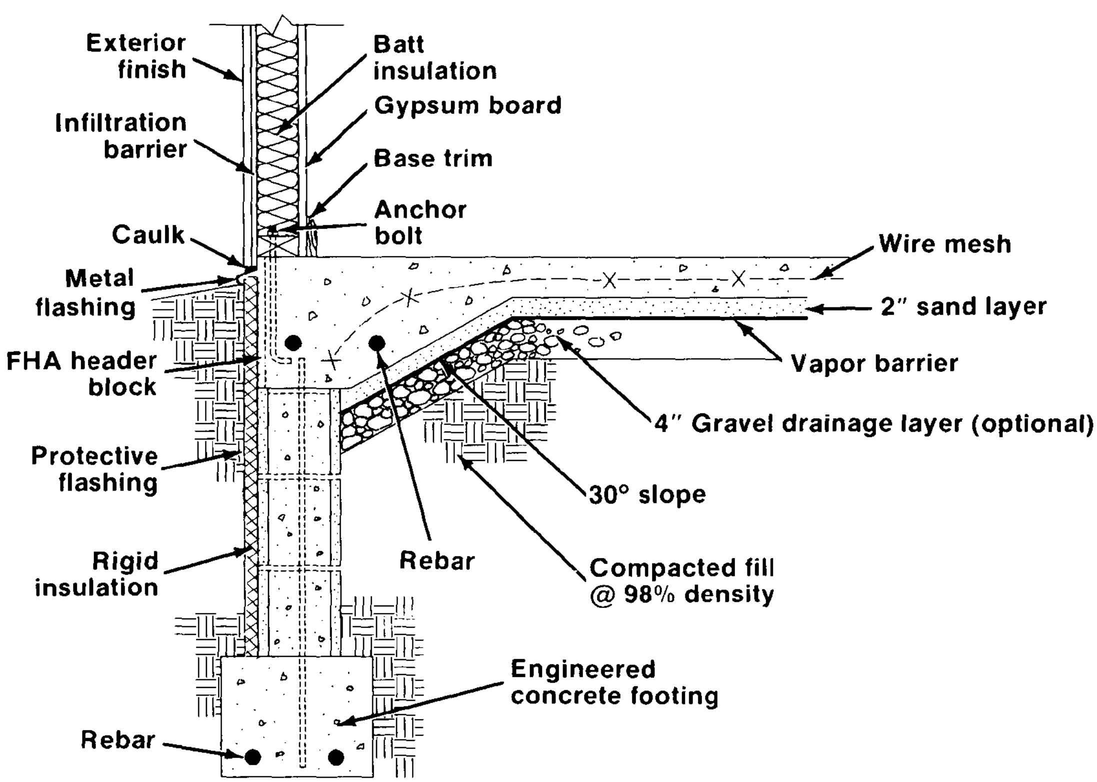
- Dangerous levels of naturally occurring radon can be found in some homes.
- Radon usually gets into the home from cracks in or around the foundation.

The following radon-reducing steps are suggested measures at this time. The State of Florida may come out with standards in the near future that would supercede any recommendations given here.

- Place wire-mesh reinforcement in the concrete floor slab to minimize cracking. Support the mesh while the concrete is being poured so that it is embedded at the mid-height of the slab.
- Pour the floor slab on 2 inches of sand over a 6-mil polyethylene sheet. The 2-inch sand layer helps cure the concrete to minimize shrinkage cracking, and it also reduces the risk of damage to the gas barrier during the pouring of the concrete. The 6-mil polyethylene sheet is a barrier for



Recommended monolithic slab-on-grade construction.



Recommended stem wall construction.

vapor and radon gas. Lap and seal the barrier at all seams and penetrations. Some authorities recommend a 4-inch gravel drainage layer underneath the gas barrier, but it is questionable whether there is any benefit from the gravel in Florida.

- Seal the joint between the concrete floor slab and foundation wall or grade beam. If expansion joint material is placed along the slab edge, pour a liquid sealant into the joint over a foam backing rod.
- Remove all grade and plumbing support stakes as soon as possible during the slab pour, so that they will not create a passageway for radon.
- Completely seal around all pipes, drains and ducts that penetrate the concrete floor. Use a product designed to seal weather-exposed concrete joints.

Cracks. To reduce or eliminate cracks in the foundation, consider these construction practices for any slab:

- For stem wall construction, the floor slab should not rest directly on the footing. Instead, provide an isolation joint to permit vertical movement without cracking. Seal the joint to prevent radon gas entry.
- After the slab has been poured, use proper wet curing practices for reduced cracking and improved strength (a slab allowed to air dry will have only 55% of its rated strength). Other methods to reduce cracking include the use of: air-entrained concrete; the maximum practical aggregate size (the largest dimension should not exceed one-third of the slab thickness); a low water-to-cement ratio; post-tensioning of the slab.
- Make sure the concrete brought to the job site already has the right mix of water. Do not add water on site.
- In radon-prone areas, a wire mesh layer placed 2 inches below the top surface of a 4-inch concrete slab is strongly recommended. In other areas, the use of control joints (saw cuts, etc.) direct any cracks to predictable locations and, unlike random cracks, can be sealed. The control joint is formed by reducing the slab thickness by 25% at the joint location. Control joints should be used at intervals not exceeding 10 to 15 feet in each direction according to the Portland Cement Association.

Non-rectangular slabs should have contraction joints across the slab perpendicular to and at points of offset that exceed 10 feet.

Drainage. Proper drainage is important to prevent moisture migration into the house. In addition to the gravel/polyethylene/sand layer described under radon control, the following practices should be followed:

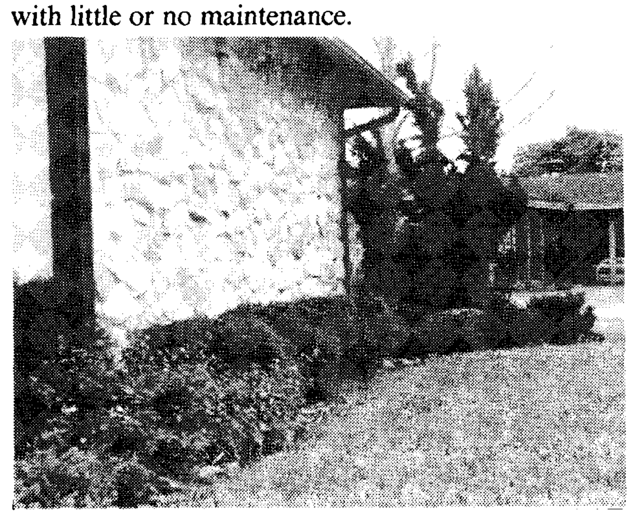
- Slope the ground surface downward at least 6 inches over the first 10 feet surrounding the foundation, to direct surface water run-off away from the house.
- Use long (3-foot) overhangs, or downspouts and gutters, to direct roof water run-off away from the foundation.
- Place the top of the slab and sill plate at least 8 inches above grade, or higher if local officials specify it.

3. Seal all penetrations

The area around all pipe, drain, or other slab penetrations should be well sealed. To prevent tears in the vapor barrier, instruct concrete laborers not to puncture holes in it as they pull up on the wire mesh. Repair any punctures in the vapor barrier prior to pouring concrete. Seal the vapor barrier around conduit and piping penetrations with asphaltic-based sealant. All grade and plumbing support stakes should be removed prior to setting, and the holes should be plugged with wet cement.

4. Shade the slab perimeter

Use foundation plantings to shade the perimeter of the slab and the soil near the house. This can prevent most of the sun's heat from being conducted into the house through the slab. Consult the Florida Native Plant Society (see the "For further information" section of Chapter 3) for plants which are well adapted to your climate and soil so they will survive with little or no maintenance.



Plant shrubs to shade slab perimeter.

5. Consider using perimeter insulation

To make the slab more energy-efficient, insulation can be placed around the perimeter. This will reduce winter heating requirements, and it may reduce summer cooling requirements if the perimeter is exposed to significant sunlight. Note, however, that perimeter insulation is not highly cost-effective, particularly where heating requirements are small (South and South Central Florida) and where the slab perimeter is at least partially shaded. Covering perimeter insulation with siding or stucco to make it blend with your wall treatment adds significantly to the cost of installing the insulation.

Perimeter insulation may be cost-effective for a North or North Central Florida home when:
- the perimeter will be exposed to sun, or
- the finish treatment will not be an additional cost (in brick veneer homes, for example).

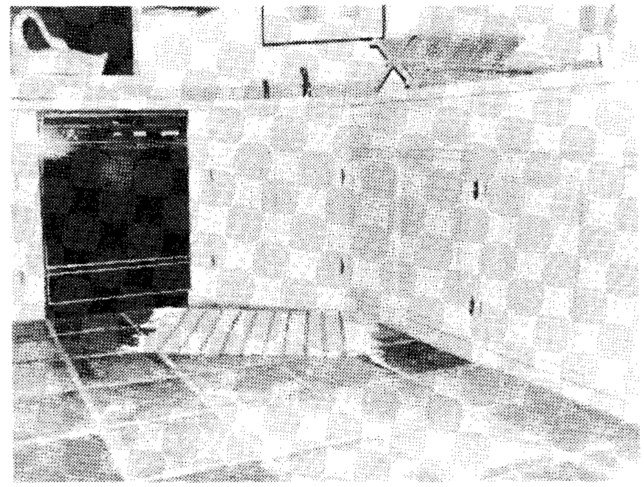
If you decide to insulate, use extruded polystyrene because of its low water-absorbing characteristics. Attach the insulation both with adhesives and mechanical fasteners. Tape all seams with a long-lasting tape which adheres to plastic. The detail drawings on page 5-4 show the preferred location for installing insulation.

6. Select conductive slab floor finish

A highly conductive floor finish such as tile or concrete is desired for slabs for these reasons:
- to make use of the slab's thermal mass (see Chapter 4) for passive heating or cooling
- to permit the greatest flow of heat from the house to the ground in early summer
- to enhance summer comfort by reducing the average "radiant" temperature of the room and by cooling through direct physical contact.

A highly conductive floor will feel cool to the feet because it is cooler than skin temperature (around 90°F). In Florida, that is a benefit for the barefooted home occupant during most of the year. Although cold floors can be a discomfort in winter, their overall comfort and energy benefits outweigh that disadvantage.

There are two finishes that provide a highly conductive slab surface. The most common is ceramic tile, which has one drawback: It is expensive. Some builders are using stamped and dyed concrete as a less costly alternative to tile. It is better than tile for conducting heat, and provides the option of a larger pattern size. Use either of these finishes throughout the house.



Tile and stamped concrete are attractive finishes for providing thermal mass.

Carpeting is undesirable as a slab finish since it restricts the interaction of the slab and the living space. Vinyl and wood floor treatments rank between ceramic tile and carpeting in terms of effectively using the slab for its thermal mass.

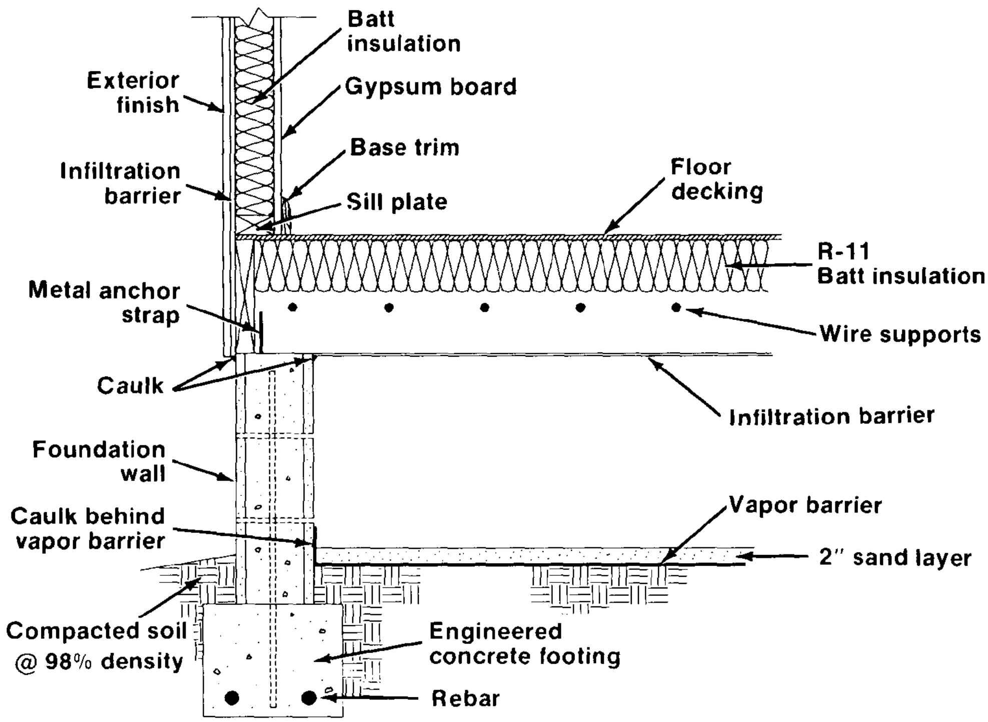
7. Seal and insulate crawl space ceiling

If you are using an off-grade (crawl space or pier type) foundation, it is important that seams, joints and penetrations through the crawl space ceiling (house floor) are all sealed. It is also important that the house be insulated from the air beneath it.

Sealing. Use sealant adhesives to prevent air leakage at the seams and joints of the off-grade floor. Use foam caulking to seal all plumbing, wiring and other penetrations through the floor.

Seal off-grade floors in the following manner: Using tongue-and-groove plywood for the subflooring, fill each groove completely with a 1/4-inch bead of sealant and mate and nail the panels immediately; where two panels abut at a joist, place a separate bead of adhesive under each panel.

Insulation. Insulate spaces between the floor joists to reduce heat loss in winter and heat gain in summer. Place insulation up against the subfloor, making sure it is snug but not compressed. An insulation level of R-11 is recommended for off-grade floors in Florida.



Recommended crawl space construction.

Moisture and Radon. To prevent unwanted moisture migration, and to reduce potential radon gas seepage from the ground, place a 6-mil polyethylene vapor barrier over the entire crawl space floor and extend it up over the foundation wall on the interior. Overlap polyethylene sheets 4 to 6 inches. Place a 2-inch layer of sand over the polyethylene to protect and hold it in place. (See diagram above.) Important: Make sure the crawl space is well vented, as discussed in the following section.

8. Vent the crawl space

Vented crawl space construction is recommended in Florida to reduce problems of moisture and, where applicable, radon gas. Place vents on all four sides of the crawl space, no farther than 3 feet from the corners, and as high on the walls as possible.

For crawl spaces with vapor barriers, there should be one square foot of total free-vent area for each 1000 to 1500 square feet of floor area. For example, a crawl space that covers 3000 square feet in area should have at least 2 to 3 square feet of total *free-vent* area. The free-vent area is the unrestricted opening; the total opening is much larger, as shown in the following table for two different vent openings. Note that if a ground cover (6 mil polyethelene) is not used under the crawl space, the required vent area increases tenfold.

Crawl Space Vent Area Requirements

Divide gross floor area by 1500 (for more vent area, divide by 1000), then multiply by appropriate number below to determine total openings required.

Obstruction in Vent	Multiplication Factor: Without polyethylene soil cover	Multiplication Factor: With soil cover*
1/4-inch mesh hardware screen	10	1.0
Louvers + 1/4-inch hardware cloth	20	2.0

* Use at least four vents.

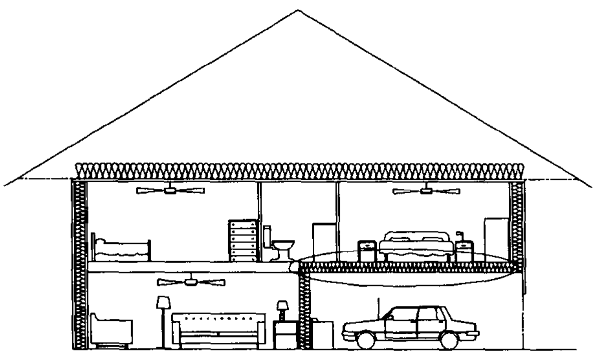
Insulate all ducts and, in North Florida, pipes that are located in the crawl space. (Ductwork located in the crawl space requires a means of access and a minimum of 24 inches of space under the joists.)

An alternative to venting is used in some parts of the country and calls for insulating and air-tightening the perimeter of the crawl space. This method is not recommended in Florida. Its use would require moisture-resistant insulation and would entail greater difficulty in blocking moisture and radon gas.

Further, the Southern Building Code requires venting of crawl spaces.

9. Insulate all floors over nonconditioned spaces

Some house designs have a second-floor room over a garage, porch or other nonconditioned first-floor area. It is important to insulate those floors to reduce summer heat gain and winter heat loss. An insulation level of R-11 is recommended.



Insulate floors over garages.

10. Leave space for ductwork between floors

The space between floors in a two-story home is ideal for ductwork. Locating ducts inside the conditioned space eliminates the heating and air conditioning losses associated with ducts in attics or crawl spaces (see Chapter 9). Duct runs can typically be shorter when ductwork is located between floors. Air can be distributed to first-floor rooms by putting grilles on the ceiling. The grilles for the second floor can be put in the floor or part way up a wall (but preferably not where a bed or other furniture is likely to block them).

11. Seal the sill plate

The sill plate is framing lumber laid horizontally on the foundation (slab or crawl space) upon which the walls are built. The sill plate is also referred to as a sole plate or bottom plate (all are used interchangeably in this book). It is responsible for 10-50% of the air leakage inside a home. Take special care when attaching it. Have a dedicated, quality-conscious worker perform this task routinely. Use an oil-based acoustical sealant between the bottom plate and the foundation wall, and apply it generously but uniformly from the outside. An alternative for wood frame walls only is sealing the air infiltration barrier or sheathing directly to the foundation wall (see Chapter 6).

Summary

Energy-efficient foundations and floors can be constructed by observing most standard practices and using long-lasting materials. Steps taken to prevent cracks will reduce moisture and radon problems. A tile or stamped concrete floor can provide the thermal mass needed to maximize savings from natural ventilation and passive solar heating. Insulation should be placed over a well-vented crawl space and between conditioned and unconditioned spaces such as a garage. Sill plates should be inspected before proceeding with wall construction to make sure a good seal was made with a durable sealant.

For further information

EPA Regional Office #4 , 345 Courtland Street, NE, Atlanta, GA 30365; (404)347-2904.

Florida Statewide Radiation Study, Final Report to the Florida Institute of Phosphate Research, N. L. Nagda, M. D. Koontz, R. C. Fortmann, W. A. Schoenborn, L. L. Mehegan, 1987.

Radon Reduction in New Construction: An Interim Guide, NAHB Research Foundation, Inc., EPA document OPA-87-009, 1987.

"Slab Treatments to Inhibit the Passage of Radon," Philip Wemhoff, Jacksonville Electric Authority, March 1988.

"Radon in Buildings," NCMA-TEK 153, National Concrete Masonry Association, 1985.

"Residential Concrete Reinforcement", *Concrete Construction,* January 1986.

Building Foundation Design Handbook, Kenneth Labs, John Carmody, Raymond Sterling, Lester Shen, Yu Joe Huang, Danny Parker, ORNL/Sub/86-72143/1, 1988.

Design and Control of Concrete Mixtures, Portland Cement Association, 12th Edition 1979.

"Treatment of Joints and Embedded Items", *Concrete Construction*, June 1986.

Chapter 6

Energy-Efficient Walls

Recommendations	First Cost	% Potential Savings	
		Cooling	Heating
1. Reduce the number of framing members.	R	0-2	0-5
2. Fill gaps with insulation.	N/S	0-5	0-10
3. Prevent insulation compression.	S	0-2	0-5
4. Use wall details designed for energy efficiency.	S/M/H	0-5	0-10
5. Air-tighten walls and minimize the use of potentially harmful building materials.	M	0-10	0-10
6. Apply light-colored exterior finishes.	N	2-10	—
Maximum Combined Total	H	15	20

Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft² of floor area)
M = medium (>$0.25 and <$1.00/ft² of floor area)
H = high (>$1.00/ft² of floor area)

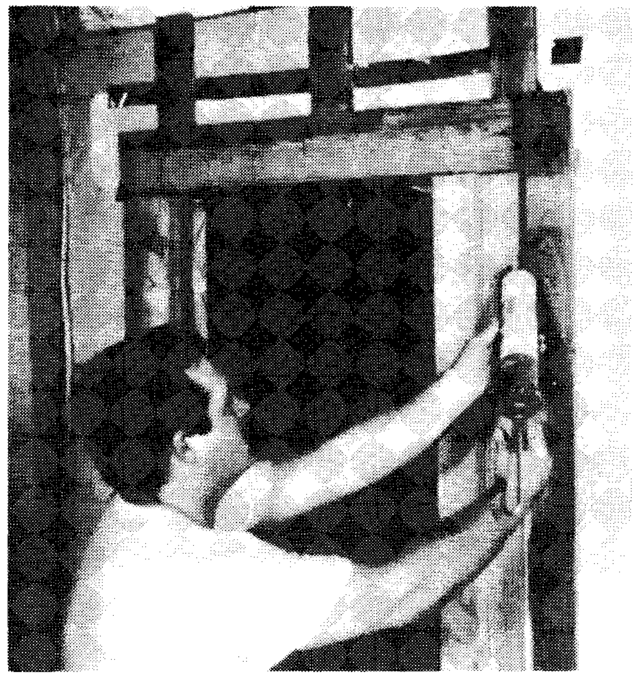
Marketing Energy-Efficient Walls

To sell the energy benefits of walls built to include the recommendations in this chapter, let buyers know how your walls are constructed differently than those of other builders. Inform them that many locations often are not insulated when walls are built, but you have made sure these locations are insulated in your homes. Show photos you have taken of exterior wall corners and partition wall tees during construction of your house and make comparisons with other builders' homes. Explain that many builders leave 2- to 4-inch uninsulated gaps the entire height of the wall at corners and tees, and that more heat can escape or enter through those gaps than through the rest of the wall.

Point out that most homes have wiring in the center of the wall, causing insulation around the wiring to be compressed and lose effectiveness. Show photos of what you have done to prevent that problem. When it comes to walls, time-of-construction photos can be your best sales tool. The photographs will help buyers see what they're getting. Most of them will associate these energy-efficient construction details with quality.

Tell your clients that humid summer air leaking into the house accounts for one-fourth of the air conditioning energy bill. They will react favorably to your attempts to block the entrance of moisture. Again, show photographs of air infiltration barriers (defined later in this chapter), caulking or other measures you have used to reduce air leakage through floors, ceilings and walls.

You may also need to explain that an infiltration barrier blocks the moisture-laden air that increases their home's humidity, whereas a vapor barrier is designed to protect the wall material in cold climates. Point out that research shows vapor barriers are unnecessary in Florida



Show clients photos of the efforts you take to construct energy-efficient homes.

because of our mild winters. And give them a dollar estimate of how much this fact has saved them.

If you are using concrete block construction and have insulated it to more than the minimum levels usual in your area, be sure to say so, and explain the difference in terms of R-value. If you have applied a stucco finish or sealer on the block, point out that the finish seals the block against air leakage.

Wood-frame and concrete-block walls account for more than 95% of Florida home construction. Other wall types — brick, log, post-and-beam, etc. — are too infrequently used to include in this discussion. A recurring question is: Which is more energy-efficient — concrete block or wood frame? Wood-frame walls generally are better insulated but tend to have greater air leakage than concrete block walls. Concrete block can absorb and store more heat and therefore may prevent rapid temperature changes in the house. So the question has no simple answer. It is more important to construct wood-frame or concrete block walls *well* than to speculate about which one may perform better.

Wood-Frame Walls. There are six key ways to improve the energy-conservation aspect of wood-frame walls:

- Reduce the amount of wood in the walls.
- Reduce or eliminate any gaps in wall insulation.
- Prevent compression of insulation around wiring.
- Choose walls designed for higher R-value levels of insulation.
- Air-tighten the wall.
- Use a light-colored exterior finish or use wall radiant barriers with brick veneer.

Concrete Block Walls. To improve the energy efficiency of concrete block walls:

- Use insulation with high R-values.
- Prevent compression of insulation around wiring.
- Prevent or reduce gaps in the insulation.
- Properly apply a light-colored, good-quality exterior stucco or sealer paint.

These methods are discussed in the following sections.

1. Reduce quantity of wood

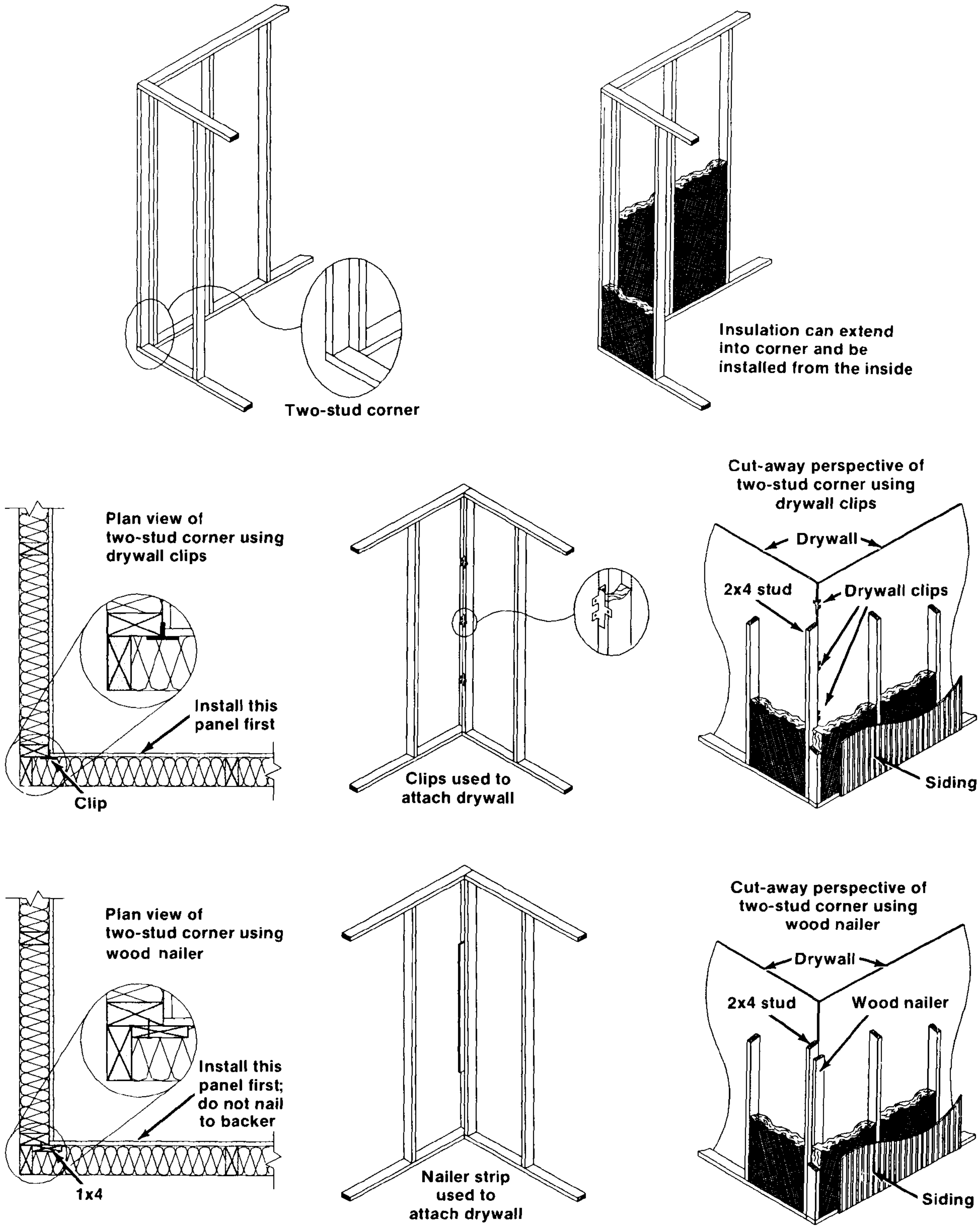
Using less wood saves not only money, but energy too. The resistance of wood to heat flow is only about one-third that of insulation. For example, a 2x4 has an R-value of about 4.4, while a 3½-inch fiberglass batt has an R-value of 11 or 13. There are many opportunities to reduce the use of wood without jeopardizing the stability or quality of your homes.

Framing. There are well-engineered and tested methods for reducing the number of framing members. Excellent resource books are available from the Department of Housing and Urban Development and The National Forest Products Association. (See the "For further information" section at the end of this chapter.)

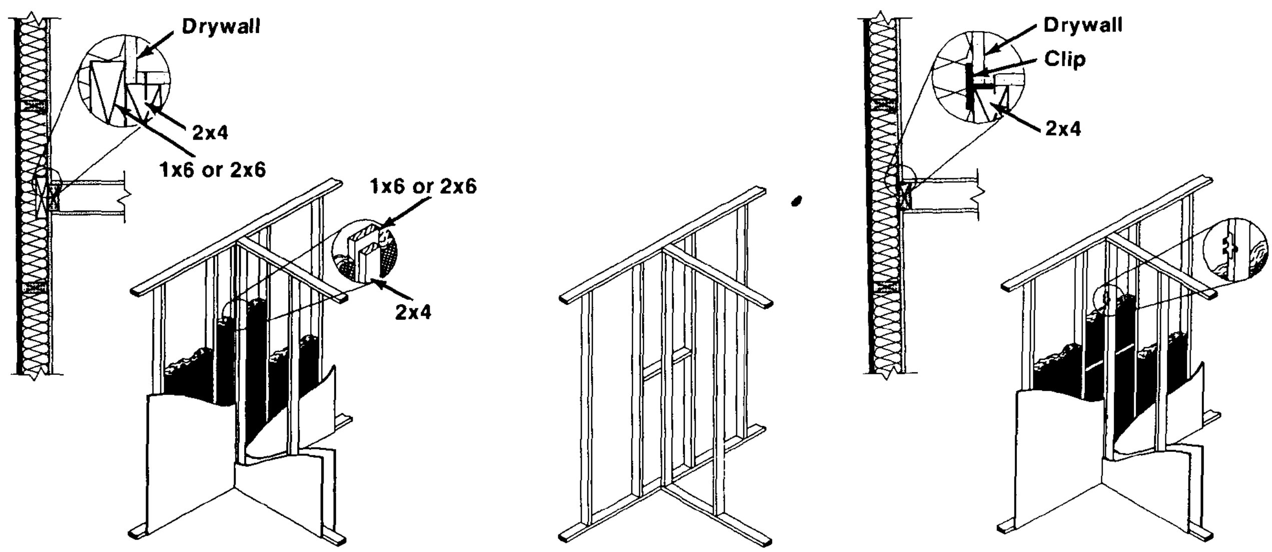
By using 24-inch-on-center rather than 16-inch-on-center framing, you can reduce the number of framing members by approximately 30%. Your costs can be further reduced by 2-foot and 4-foot-wide windows so that extra framing members are not necessary. If you use wood siding, refer to the manufacturer's recommendations for stud spacing. In some instances, wood siding may warp if supported only every 24 inches. Most gypsum manufacturers also recommend 5/8-inch gypsum with 24-inch-on-center studs.

Corners. Most corners in exterior walls are made with three studs, leaving a U-shaped channel facing the outside. This channel should be filled with insulation. However, because the wall sheathing normally is installed before the insulation, this void is often not filled. A desired alternative, illustrated on the next page, is a two-stud corner which permits the insulation to be installed from the inside. Further, since there is insulation where there otherwise would be a stud, the cost of a stud is saved. Note there are two methods of connecting drywall: Either clips or a 1x4 nailer can be used.

Tees. A typical tee for joining a partition wall to the exterior frame uses three studs, leaving a 3½-inch-wide U-shaped channel facing the exterior. The channel usually goes uninsulated. Instead, the partition wall can be attached to the exterior frame with the use of only two studs. A better alternative is the one-stud tee, consisting of the leading stud of the partition wall plus a 1x6 or two 1x4s used as drywall nailers. Drywall clips can also be used to join drywall pieces where there is no exterior framing member. See details on page 6-5.



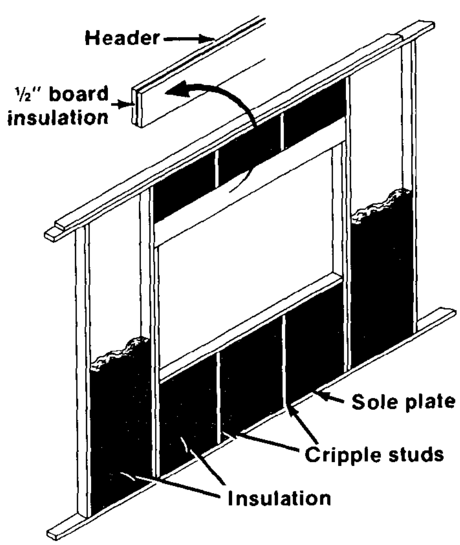
An energy-efficient corner is constructed using two studs. Drywall can be attached using drywall clips or nailer strip.



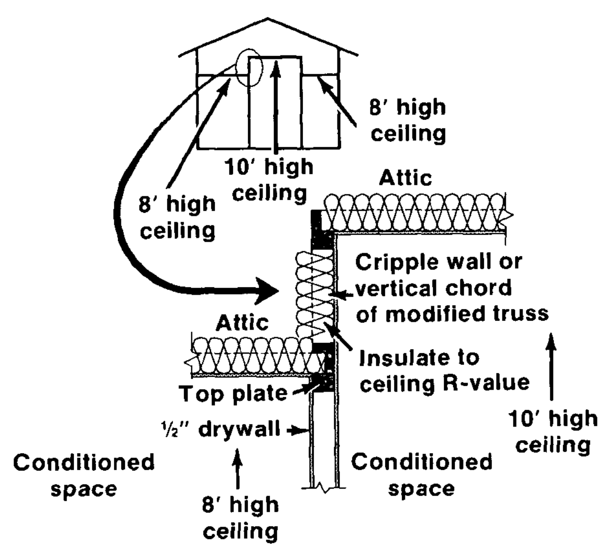
An energy-efficient partition wall is constructed by toe-nailing the leading stud to the frame. Insulation fills wall area. Drywall is attached using a nailer or drywall clip.

2. Fill gaps in wall insulation

In addition to insulating at tees and corners, it is important that insulation is provided around and above window frames and doors. If you are building a home with 9-foot or higher ceilings, be sure to install insulation the full height of the wall. Any wall section that adjoins an attic space should be insulated to the same R-value as the ceiling. Staple the insulation so it will not fall out. Also, always use blocking between studs at the ceiling height to prevent air leakage from the attic into the wall and then into the house via electrical outlets. In a kitchen, treat the drop wall above cabinets in a similar manner.



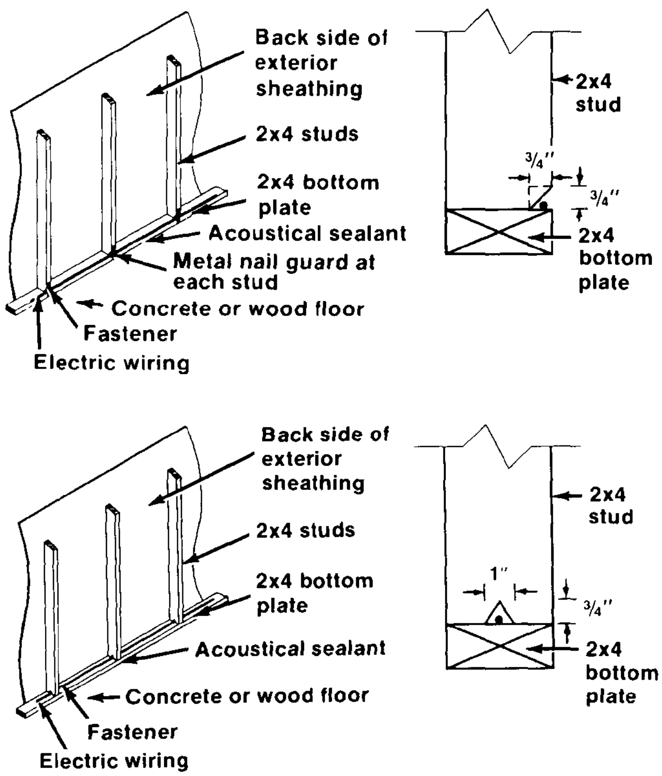
Insulate below, above and around window frames.



Insulate walls between attic and conditioned space.

3. Prevent compression around wiring

Insulation that is compressed is less effective than if allowed to expand to its recommended thickness. For example, a 3½-inch fiberglass batt with an R-value of 11 at full thickness has only an R-value of 7 at a thickness of 2 inches. Unfortunately, in a typical situation the electrician drills his holes and runs wire through the center of the stud thickness, and the insulating contractor places the insulation on one side of the wiring so that it is compressed to half its thickness. To overcome this problem:



Use notches for wiring to prevent insulation from being compressed.

- Have the electrician place the wire in a notch at the bottom inside corner of the wall (make sure nails used on baseboard trim go into floor or stud), or through a notch at the bottom center of the studs (see drawing).
- Have the insulating contractor tear apart the insulation and place it behind and in front of the wiring.
- Place patches of insulation behind the wiring; put the insulation batt in front of the wiring.

4. Use wall details designed for energy-efficiency

There are many methods of improving the insulation characteristics of walls. By using larger dimensioned lumber or different types of insulation, the R-value of the wall can be increased. The illustration on the next page shows seven different types of wood-frame wall construction.

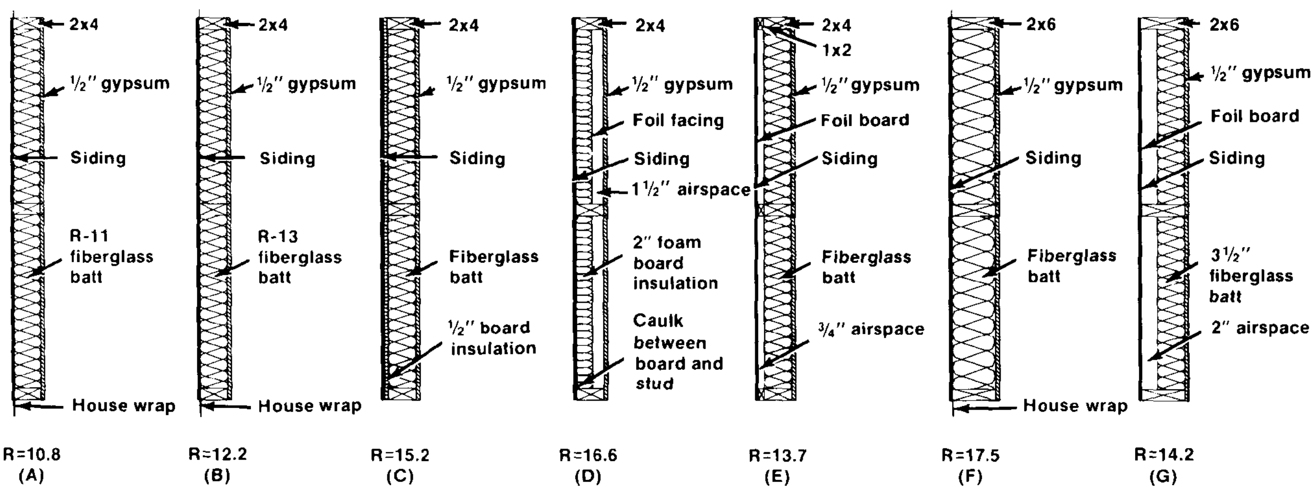
What kind of barrier is it?

Three types of barrier materials for walls are available to home builders: air infiltration barriers, radiant barriers and vapor barriers. Each has a distinct function.

An *air infiltration barrier*, if properly installed and sealed, reduces the quantity of air passing through a wall. It is highly recommended for wood frame homes to reduce the 20% to 30% of air conditioning and heating loads caused by air infiltration. It can be a wood or foam board sheathing or a plastic wrap. Some plastic wraps (generally white in color) reduce the passage of air while permitting water vapor to pass through, thus avoiding moisture problems. Other products, such as polyethelene, prevent the passage of both air and moisture (see vapor barriers below). A layer of stucco can act as an infiltration barrier when properly applied and is commonly used on concrete block homes.

A *radiant barrier* is an aluminum-foil material next to an airspace. It is used to reduce the transfer of radiated heat. Although radiant barriers would be beneficial for walls in Florida, the cost of providing the airspace is usually too high to make the system economical (unless an air-space is already present, as in a brick wall). A radiant barrier system for attics is covered in Chapter 8.

A *vapor barrier*, generally polyethylene or aluminum foil, is used in northern climates on the inside of insulated walls (behind gypsum) to prevent moisture from condensing in the wall in winter. However, experts say **a vapor barrier is not needed in walls in Florida** and, if used at all, should go on the outside of the wall. All vapor barriers are also air infiltration barriers.



Plan views of energy-efficient stud wall construction.

Wall A - Standard. This wall includes an air infiltration barrier (see the next section of this chapter). It uses faced or unfaced R-11 batt insulation. Generally, unfaced is less expensive than faced insulation and can be used whenever the drywallers will be following closely behind. Some builders experience problems with unfaced insulation falling or blowing out of the wall before the drywall is installed. To minimize problems, select friction-fit unfaced batts. The walls B-G are improvements over typical wall construction.

Wall B - R-13 Batts. You can purchase R-13 batts for 2x4 walls. This creates a wall with a higher R-value (compare wall B with wall A).

Wall C - Exterior Insulation Board. Many codes require some type of wall bracing. Usually a simple diaphragm panel (for example, wood sheathing or ⅛-inch foil-faced laminated paper sheathing) is used. However, a ½-, ¾- or 1-inch board insulation with a structural rating provides bracing and does a better job of insulating at the same labor cost. Insulation boards that are not rated as structural may be used in conjunction with plywood bracing to achieve the same R-value. Foil-faced board insulation that is properly caulked can serve also as an infiltration barrier — as can foil-faced laminated paper sheathing. Foil-faced products that are sealed also create a vapor barrier.

Wall D - Board Insulation in Wall. Most board insulations reduce the heat transfer through a wall twice as well as fiberglass insulation for any given thickness. (See the next page for characteristics of many types of insulation.) Wall D above, shows board insulation used instead of fiberglass batts. Foil-faced board insulation can gain added R-value by having an airspace next to it. Wall D obtains an R-value of 10.8 for the insulation (if phenolic type) and an R-value of 3.3 for a 1½-inch airspace that serves as a channel for wiring. Caulk the foil-faced board insulation to the 2x4 studs to form an infiltration barrier. Use an insulation product not degradeable by moisture.

Wall E - Radiant Barrier Walls. Foil facing an enclosed airspace is referred to as a radiant barrier. In wall E an airspace has been created especially for that purpose. It is most appropriate for east- and west-facing walls heated by the summer sun.

Wall F - 2x6 Construction. To enable greater thickness of insulation, walls can be constructed with 2x6s instead of 2x4s. That permits 57% additional insulation.

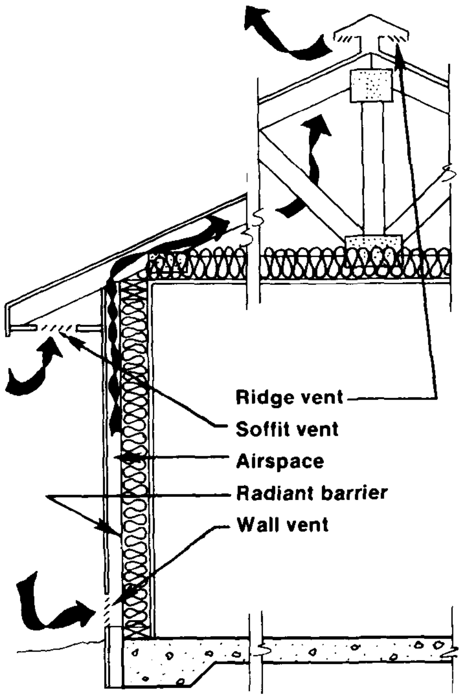
Wall G - 2x6 With a Radiant Barrier. For the southern areas of the state where winter is of little concern, a radiant barrier on unshaded walls may be about as effective as an extra thickness of insulation. Wall G shows the use of 2x6 construction with normal 3½-inch fiberglass insulation and foil-board on the outside to obtain a 2-inch airspace as a radiant barrier. This is an alternative to wall type E. In South Florida, it is best to vent radiant-barrier walls by providing an inlet vent at the bottom of the wall and a screened outlet into the

Generic Building Insulation Comparison

Generic insulation	R/inch	lb/ft³	Advantages	Disadvantages
Batts and blankets				
Fiber glass	3.2	0.6-1.0	Low cost, noncombustible without facings, stable	Facings may be combustible
Rock wool	3.6-3.7	1.5-2.5	Low cost, noncombustible without facings, stable	Facings may be combustible
Boards				
Cellular glass	2.63	8.5	High compressive strength, noncombustible, impermeable to moisture, stable	High cost, low R per inch, freeze-thaw damage possible when in contact with water
Mineral fiber with binder	3.45	15	Provides structural support, fire resistant, stable	Moderate cost, modest R per inch
Polyurethane and polyisocyanurate foam	Unfaced: 6.2-5.8 Faced: 7.1-7.7	2.0	High R per inch, may provide infiltration seal, low moisture absorption, stable	Moderate cost, combustible (polyisocyanurate less so than polyurethane), nonstructural
Phenolic foam	Faced: 8.3	2.5	High R per inch, may provide infiltration seal, low moisture absorption, stable	Combustible
Fiber glass	4.25	3.0	Good R per inch, low combustibility, good acoustical absorption, stable	High cost, binders may burn out
Expanded polystyrene foam	Extruded: 5.0; Molded: 3.9-4.4	0.8-3.0	Good R per inch, may provide infiltration seal, low moisture absorption, stable	Combustible, nonstructural
Perlite	2.8	11	Low combustibility, stable	Low R per inch
Mineral fiber with foam	3.7-7.3	N/A	Mineral board acts as fire barrier to protect foam, can provide structural support, stable	Foam is combustible
Wood fiber	2.1-2.4	25	Availability, can provide structural support, stable	Combustible
Insulating concrete	0.8-2.0	20-40	Noncombustible, can provide structural support, stable	Low R per inch
Loose fill				
Cellulose	3.2-3.7	2.2-3.0	Low cost, good R per inch, availability	May settle 0-20% if installed at too low a density
Fiber glass	2.2	0.6-1.0	Low cost, noncumbustible	Low R per inch
Rock wool	2.9	1.5-2.5	Low cost, noncombustible	Modest R per inch, may settle
Perlite	2.5-3.7	2-11	Low cost, noncombustible, stable	
Vermiculite	2.4-3.0	4-10	Low cost, noncombustible, stable	
Foam in place				
Polyurethane/ polyisocyanurate	5.8-6.2	2	High R per inch, may provide infiltration seal, low moisture absorption	Moderate cost, combustible (polyisocyanurate less so than polyurethane), may shrink
Urea-based mixtures	4.2	0.6-0.9	High R per inch, may provide infiltration seal	Moderate cost, combustible, improperly installed foam may shrink significantly and/or cause lingering formaldehyde vapors
Reflective insulation				
Two-layer Three-layer	R-5 R-7.5	N/A	Low cost, noncombustible, can provide infiltration seal, very effective as a radiant heat barrier	Dust on reflective surfaces may reduce performance, best when used with conventional insulation, best when vented

Adapted from U.S. Navy's Building Insulation Material Compilation, 1980.

attic space, as shown below. Check building codes for fire safety standards of vented airspaces.



Vented radiant barrier wall section.

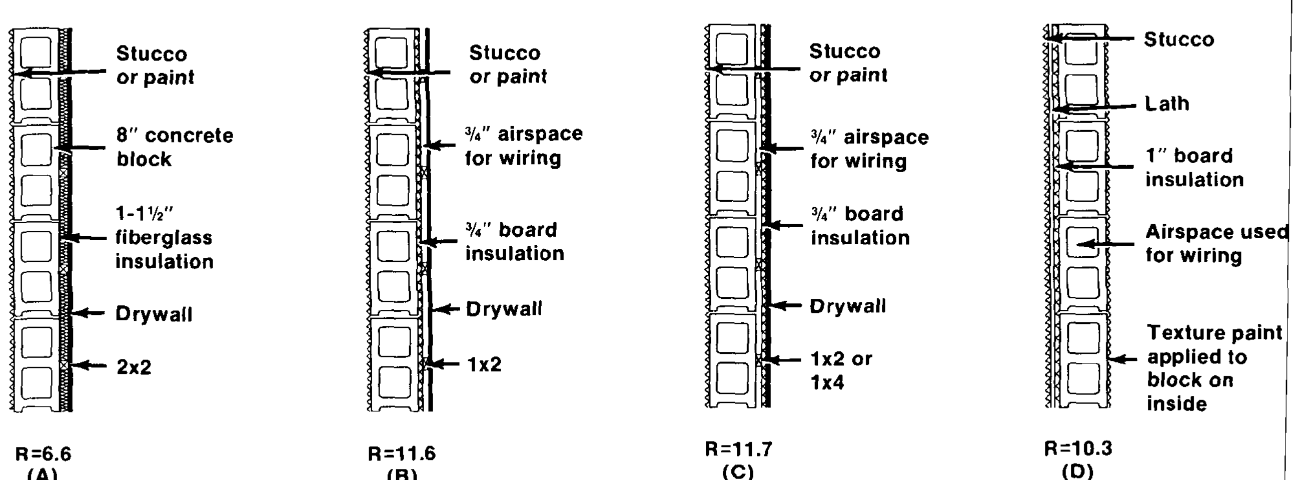
Concrete Block Walls. Concrete block walls are typically constructed with less insulation than wood-frame walls. Energy-efficient block wall construction requires more insulation than the traditional ¾ inch of fiberglass. A sealer or sealing paint or stucco finish serves as an air infiltration barrier; house wraps are not necessary.

Wall A in the drawing below shows 1½ inches of fiberglass batt being inserted between 2x2s. All conventional block construction techniques apply.

Wall B shows one of two methods of using a board insulation product on the inside surface of the block. Here, board insulation goes up first, next to the block, and furring strips are then nailed through the insulation into the block. Wall B is no thicker than wall A but has a much higher R-value.

Wall C shows a similar wall, but the furring strips go up first, followed by the insulation board. The drywall is attached with fasteners pressing through the insulation into the furring strips. Since the insulation is not in contact with the block, it tends to stay drier and may be less affected by mortar chemicals. Dryness is of more concern with brick construction, where you should use wall C and not wall B.

Wall D displays a method for making concrete block walls work as the thermal mass for passive heating and cooling (see Chapter 4 for details). In this wall, insulation is attached to the outside of the wall, and building paper, lath and stucco are applied over the insulation. Use insulation products that are highly resistant to moisture absorption, such as extruded polystyrene. The block can be painted on the inside with a texture paint for maximum contact between room air and the concrete block. Run wiring in conduits through the holes in the block or limit wiring to interior partition walls. As an alternative, furring strips and drywall can be used, but this will reduce the effectiveness of the thermal mass.



Plan views of energy-efficient block wall construction.

5. Air-tighten the wall

Air leakage is a major factor in air-conditioning and heating costs. Infiltration is air leakage into or out of a building by non-purposeful means, such as through cracks in the floor, walls or ceiling. When the heat and humidity of outside air are not desirable, the infiltration of this air into the building is unwanted and can produce discomfort, energy waste, or both.

To prevent significant air infiltration, seal all points of potential leakage. Leakage frequently occurs at the sole plate and at the ceiling. Chapters 5 and 8 cite the locations that require sealing.

Concrete block walls can be effectively sealed against air infiltration by a uniform application of exterior stucco or sealer and paint.

Wood-frame walls can be sealed in one of four ways:
- sealing the exterior sheathing
- using continuous house wrap
- sealing the drywall
- applying a layer of stucco.

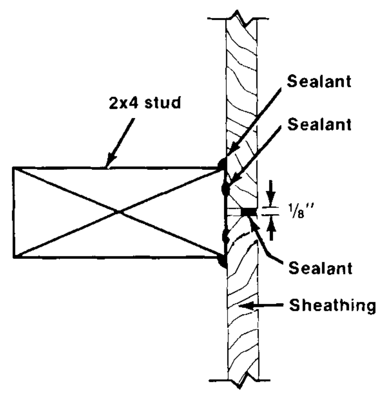
Frequently it is least expensive to seal the sheathing. House wraps can be installed quickly on many wall sections but care must be taken to obtain a proper seal at windows, doors and exterior electrical and plumbing outlets. These first two methods should not be interchanged on a given house and there is no proven advantage to doing both. Air-tightening the drywall may prove to be more difficult or costly, as it may require a skilled drywaller with knowledge of the method. However, this method is appropriate for ceilings and garage (or other nonconditioned) partition walls. The following details of how to air-tighten frame walls to reduce air infiltration are adapted from a checklist developed by the Jacksonville Electric Authority. Air infiltration barriers are required by the energy code for practice No. 2.

Wall Sheathing Techniques. Seal:
- the sheathing directly to the foundation wall or
- the sheathing to the bottom plate and the bottom plate to the foundation wall.

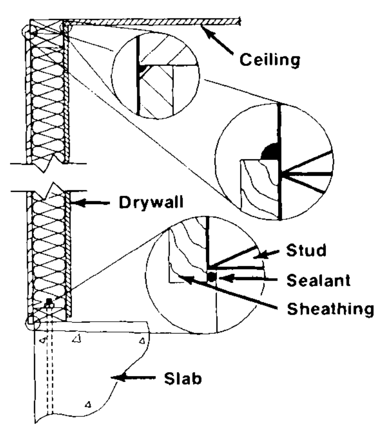
The energy code requires that suitable long-life materials be used when installing infiltration barriers for practice No. 2 houses. JEA recommends oil-based (OB) acoustical sealant for most circumstances. Where the sealant is used in conjunction with gypsum board, JEA recommends a water-based acoustical sealant. Information on which sealants are best with which materials can be obtained from manufacturers and distributors.

Apply the sealant on the outside. For off-grade floors, seal the sheathing directly to the floor deck. Seal the sheathing to the top plate.

Seal the joints of the sheathing (where two panels of sheathing meet) using one of the following methods for plywood, waferboard or foamboard sheathing:
- From the wall cavity side, seal the sheathing to both sides of the framing member at joints between panels.
- After the sheathing has been placed, seal the joint between the side of the stud and the sheathing.
- Seal the joint between the two sheathing boards.



Sealant locations for sheathing joints.



Seal sheathing to top and bottom plates and air-tighten drywall at the ceiling.

In one-story buildings the joints will occur most frequently at studs. In two- or three-story buildings, the joints will occur most frequently at studs, plates, joints and truss members. It is difficult to obtain a good seal for wood panel sheathing on multistory buildings; therefore use the house wrap method of air-tightening when using wood panel sheathing.

Seal the sheathing at post corners, using the appropriate method:

- Foam sheathing: Seal the sheathing joints at the corners.
- Wood panel sheathing: From the wall cavity side, seal the sheathing to the two corner studs which contact the sheathing, then seal the accessible joints between the studs and nailers of the corner. For three-stud corners and two-stud corners there will be a total of three seals; for "California" corners (two studs plus a one-by nailer), a total of four seals.

Seal the wall sheathing to the window frames using the appropriate method:

- Foam sheathing: Seal the mounting fins to the sheathing or seal the window casement directly to the sheathing.
- Wood panel sheathing: Seal the window casement or mounting fins directly to the sheathing, using sealant or a nonhardening foam caulking.

House Wrap Sealing Techniques. Use acoustical or other appropriate sealant to seal (a) the house wrap directly to the foundation wall or (b) the house wrap to the bottom plate and the bottom plate to the foundation wall. Apply the sealant on the outside. For off-grade floors, seal the house wrap directly to the floor deck.

Seal the house wrap to the top plate.

Seal the seams of the house wrap by lapping and either (a) taping with a recommended tape or (b) using sealant between the two pieces being lapped.

Seal the house wrap to the window frames. Seal the mounting fins to the house wrap using a recommended tape, or seal the window casement directly to the house wrap using a sealant or a nonhardening foam caulking. Note: Install flashings around windows and doors when a house wrap is used.

Sealing the Drywall. Another sealing method is referred to as the *airtight drywall approach* (ADA). In this method the gypsum board should be sealed to top and bottom plates and door and window frames, using water-based acoustical sealant. To allow acess for applying sealant at the top plate, install the wall gypsum board before the ceiling gypsum board. Seal the bottom of the drywall to the bottom plate and the bottom plate to the slab.

If garage partition walls are the only walls being air-tightened in this manner, the air barrier has to be connected between the drywall and the sheathing or house wrap used on the rest of the house. To do this, seal the gypsum board to the outer nailers of the end tees of the partition. Then use sealant to seal these nailers to the exposed sheathing.

Indoor Pollution and Fresh Air. Much of what you read in the book relates to reducing air infiltration — the flow of unwanted unconditioned air into the house during periods of heating or cooling. A separate question arises: Can a well-sealed house be harmful to the occupants' health? Unfortunately, there is no certain answer. On the other hand, the following findings are well documented:

- Many commonly used building materials are made with substances that may increase the risk of cancer or respiratory ailments or induce allergic reactions in some people.
- Many preservatives and pest control treatments used for foundations, wood and carpeting may have similar effects.
- Chemicals in household cleaners and tobacco products may make the air in the house unhealthy.

These problems have surfaced in recent years because (a) the use of chemicals in building products and household products has dramatically increased, and (b) the effects of such use were not discovered until recently. A possible third reason is that houses are now tightly constructed and, as a result, less outside air is exchanged with the house air.

Some authorities recommend that the volume of air in a home should be replaced about every two to three hours to minimize potential problems. This translates to a desired air change rate per hour (ach) of 0.33 to 0.5 when the house is not being ventilated. How tight is the average home? Recent tests indicate many of Florida's concrete block

Healthy Building Materials

(condensed from Practical Homeowner, February 1987, brand names omitted)

Wood Products

Problem	*Solution*
Formaldehyde outgassing from particleboard, hardboard, paneling plywood, and other manufactured wood products. Particleboard is used in factory-built kitchen cabinets, shelves, and furniture.	Use solid wood where possible or plywood made with exterior-grade glue.
	Purchase products containing formaldehyde far in advance of use and store them for several months in a warm, ventilated space.

Wall Finishes and Wall Coverings

Problem	*Solution*
Vinyl wall coverings may have outgassing from plasticizers.	Use wall coverings made of pure paper, linen, or genuine metallic.
Some wallpaper glues contain fungicides and mildewcides.	Use low-toxic wallpaper glues.
Plaster or drywall walls are generally OK, but drywall joint compound used to fill and smooth the surface may contain mildewcides, preservatives, asbestos, or formaldehyde.	Use low-toxic drywall joint compounds.

Floors and Floor Coverings

Problem	*Solution*
Formaldehyde and solvents in carpets and rugs.	Use a carpet sealer; consider untreated natural fiber carpets (nylon is the least toxic synthetic).
Particleboard with formaldehyde resins used for carpet or tile underlayment.	Use formaldehyde-free underlayments, a lightweight water-resistant concrete board reinforced with fiberglass (cover only with hard surface materials).
Solvents and reactive chemicals are usually present in adhesives for all types of floorings.	Use adhesives that are water-based (such as acrylics) and have low solvent content; see also "Adhesives".
Solvents in sealers and finishes for wood floors.	Provide adequate ventilation while finish is drying; use natural oil finishes (tung, linseed) with low solvent content; use special non-toxic cleaners, waxes, and polishes.
Asbestos in floor tiles.	Hazardous when drilled or sawed; use an effective respirator.
Plasticizers in vinyl flooring materials.	Use hard vinyl tiles instead of soft (hard vinyl contains less plasticizer).

Paints, Stains and Finishes

Problem	*Solution*
Oil-based or alkyd paint contains toxic hydrocarbon solvents; stains, varnishes, shellac, and most other finishes pose the same hazard.	Allow plenty of time to dry before inhabiting the space; wear OSHA-approved face mask for protection against solvent vapor; use a large fan for ventilation; use low-solvent water-based latex paint or stain.
	Select a low- or non-toxic product.
Wood preservatives (fungicides and mildewcides).	Use naturally rot-resistant woods such as redwood, cedar, or cypress; or use low-toxic wood preservatives.

Adhesives, Glues and Mastics

Problem	*Solution*
Many adhesives contain toxic hydrocarbon solvents.	Epoxy-type adhesives are relatively non-toxic when fully cured.
	White glue (polyvinyl acetate) and carpenter's glue (yellow aliphatic resin) are safe when dry.
	Use alternative adhesives made from natural and non-toxic materials, such as a water-based synthetic rubber sealant or a liquid copolymer used as a sealer and waterproofing membrane.

Insulation Materials

Problem	*Solution*
Fiberglass insulation sheds fiberglass fibers during installation, causing lung irritation.	Wear a particle filter mask.

Furniture and Fabrics

Problem	*Solution*
Frequently constructed of particleboard or other wood products containing formaldehyde.	Choose furniture made with solid wood, metal, or natural materials such as bamboo, wicker, rattan, etc. Apply a sealant, low-toxic paint, or a vapor barrier to all accessible areas of particleboard furniture.
Upholstery fabrics may contain formaldehyde, plasticizers, dye residues, and fungicides; synthetic fabrics pose the greatest problem, but even natural fabrics may contain some of these chemicals.	Choose furniture with untreated natural fiber fabrics (cotton, wool, linen, jute, etc.).

homes, dating back to even the 1960s, have average air change rates of less than 0.5. The three levels of air-tightening for wood-frame houses cited in the Florida energy code are designed to create 1.0, 0.7 and 0.4 air changes per hour. There have been few actual measurements.

The best solution to home air pollution is to minimize the use of materials reported to be potentially harmful and to maintain maximum house ventilation during construction and until occupancy. Practical Homeowner magazine (335 E. Minor St., Emmaus, PA 18049; 215/967-5171) has a regular column and frequent articles on building materials for a "healthy" home. See the "For further information" section at the end of the chapter for specific references that name builders and the products they used in building non-toxic homes.

A second solution is to air-tighten the house as much as possible and then force ventilation through it by using an air-to-air heat exchanger. As conditioned air leaves the house it pre-cools or pre-heats the incoming air. In summer in Florida it is best to use a type of heat exchanger called an enthalpy exchanger. It exchanges heat and humidity with incoming air. That means your air conditioner will not have to remove as much moisture as it would with a standard heat exchanger. In winter, a standard air-to-air heat exchanger will reduce the potential for window condensation better than an enthalpy exchanger because the drier air is outdoors. However, most enthalpy exchangers can be converted each season to perform like a standard air-to-air heat exchanger.

The third solution is to try to reduce the use of possibly harmful materials while also not overly air-tightening all structural components of the house. What airtightening measures should be left out? Let's examine what we know. Radon and possibly other harmful gases may come up from the soil and enter the house through cracks in the foundation and floor, as described in Chapter 5. Clearly, air-tightening the floor and sill plate is in the best interest of a healthful and energy-efficient home. Attic air is hotter and more humid than outdoor air during summer days, so air-tightening the ceiling (Chapter 8) is important. That leaves windows, doors and walls. Concrete block walls are fairly air-tight, so in concrete block homes it is less necessary to use extreme air-tightening measures on windows and doors. Wood-frame walls tend to leak more air and should be air-tightened. However, if *all* the foundation and ceiling air-tightening measures in Chapters 5 and 8 have been taken, it may not be necessary to go to extremes on the walls; or, if you find it easier to air-tighten the walls, do not go to extremes on the windows or doors.

Window Glass Condensation. Another potential disadvantage of tight houses is increased condensation on the inside of window glass in winter. When the temperature is low outside and warm inside, the moisture produced by people and their activities raises the humidity level to a point where water condenses on the inside of the glass. This occurs mostly in the coldest weather and will be greatest at night on windows not well protected by deep overhangs, and during the day on windows that face northerly. To reduce potential problems, insulated glass can be used. With an outdoor temperature of 30°F and indoor temperature of 70°F, condensation will occur on a single-pane window if the indoor relative humidity is greater than 30%, whereas it won't occur on an insulated glass window unless the indoor relative humidity is higher than 50%.

There still is much to be learned about air infiltration rates and healthy homes. Keep up with building publications for the latest news.

6. Choose light-colored exterior finishes

Everyone knows that white paint reflects more of the sun's heat than other colors. The table on the next page gives the properties of various paint colors. Note that light-colored stucco finishes tend to absorb more heat than light-colored smooth finishes. Obviously, wall color is less significant if the wall is well-shaded by trees or porches. However, air conditioning costs for a typical one-story home with unshaded white walls will be about 8% lower than for a home with dark unshaded walls. Therefore, choose light-colored finishes for your block or frame homes. Light colors also tend to make the home appear larger.

Measured Solar Absorptance of Wall Surfaces

Paints	
White on plywood	.15
White on wood siding	.25
White stucco	.25
Flesh color stucco	.40
Cream color	.45
White/gray aluminum siding	.45
Light gray color	.50
Medium gray/blue color	.65
Tan/brown color	.80
Brick	
Light colored	.35-.50
Light red	.50-.60
Burnt red	.65-.70

Summary

There are a number of designs for insulating frame and block walls that can improve their thermal performance. Measures should be taken to eliminate gaps in the wall insulation. Block walls should have at least R-5 insulation, and frame walls should be air-tightened. The desired level of fresh air required for a healthy home is unknown. As a precaution, low toxic or non-toxic materials should be used where and when possible. Exterior walls should be painted white or other light color to reflect the sun's heat.

For further information

Reducing Home Building Costs with OVE Design and Construction — Guideline 5, NAHB Research Foundation, Inc., prepared for the Department of Housing and Urban Development, 1977.

National Forest Products Association, 1619 Massachusetts Ave., NW, Washington, DC 20036, (202)463-2700.

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

"Allergy Free in Ottawa," John R. Hughes, *Fine Homebuilding,* April/May 1988.

"Healthy Building," Mark Alvarez, *Practical Homeowner,* February 1987.

The Nontoxic Home, Debra Lynn Dadd, Jeremy P. Tarcher, Inc., Los Angeles, CA, 1986.

"Air infiltration control package," Jacksonville Electric Authority, 1987.

Chapter 7

Energy-Efficient Windows and Doors

Recommendations	First Cost	% Potential Savings	
		Cooling	Heating
1. Minimize glass area.	R	5-10	5-10
2. Shade glass areas using porches, trees awnings, sunscreens, shutters, sun control films, interior shades or blinds.	S/M/H	5-15	—
3. Choose reduced transmittance glass products with low shading coefficients.	M	5-15	—
4. Base glass and shading choices in large part on compass orientation.	N	0-10	—
5. Choose windows with low infiltration ratings and durable hardware. Choose well-weather-stripped doors.	N/S	5	5-10
6. Choose windows and doors with maximum *openable* area for improved ventilation (casements; awning type; pocket or swinging glass doors to porches).	S/M/H	5	—
7. Choose casement windows for rooms with only one outside wall to create a wingwall effect for improved ventilation.	M/H	0-5	—
8. Use screen doors for ventilation.	S	0-5	—
9. Consider using insulated glass.	M	0-5	15-20
Maximum Combined Total	H	30	30

Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft² of floor area)
M = medium (>$0.25 and <$1.00/ft² of floor area)
H = high (>$1.00/ft² of floor area)

Marketing Energy-Efficient Windows and Doors

View, daylight, ventilation. These have been the functions of windows for centuries. But since the energy crisis, possibly no other house component has come under as much scrutiny. That is because the window is the weak link in the building envelope. It admits solar heat, tends to leak, and is a poor insulator relative to the rest of the building. More than one unhappy home owner call their windows "holes in the insulation."

But manufacturers are responding almost daily with new window products claiming greater energy efficiency. As a result, knowing what window features to look for can be confusing for the builder. This is particularly true in Florida because many of the energy-efficient features promoted by national window manufacturers save heating energy, but not necessarily cooling energy.

This chapter discusses windows and doors for Florida homes. After reading it you will know not only what to look for in currently available window products but also which features are desirable so that you can evaluate future products. Your knowledge of windows, as demonstrated in your homes, will be one of your best selling tools.

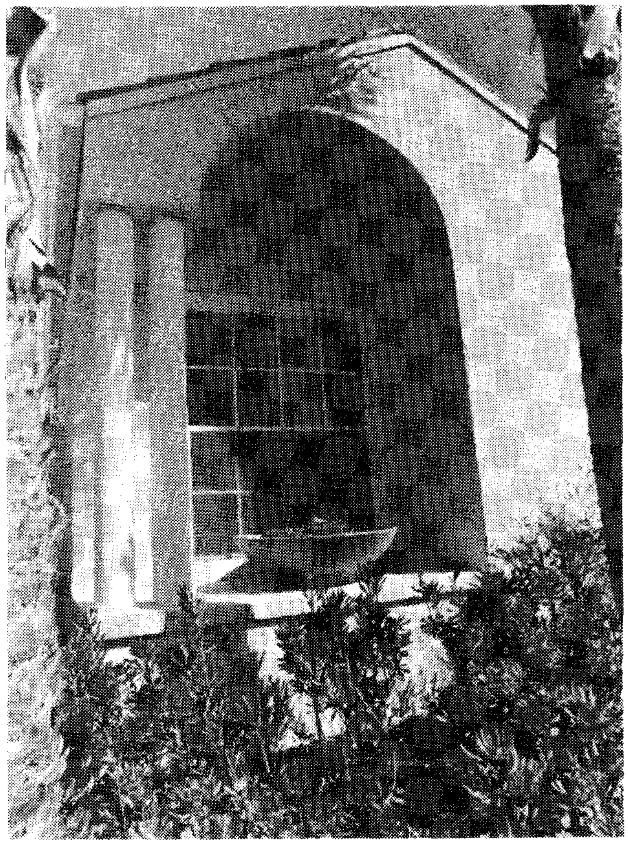
Keep in mind that there are four key items that can significantly affect the home owner's utility bills:

- solar heat passing through the glass
- air leakage through and around the window
- heat flow outward through the window in winter
- ventilation of the house.

Start by selling a potential buyer on your choice of home plans that have reduced glass area, emphasizing these advantages:

- less expensive to build and operate
- lower initial cost for air conditioner
- less of the sun's heat entering the house, therefore less air conditioning needed
- less heat escaping in winter
- greater thermal comfort for anyone sitting or standing near (smaller) windows, because of less radiant heat exchange between the glass and the person in winter or summer.

You can also point out other benefits of less window area. The home buyer will not have to spend as much on window coverings. The house will generally be quieter. It will be more secure with fewer or smaller points of entry.



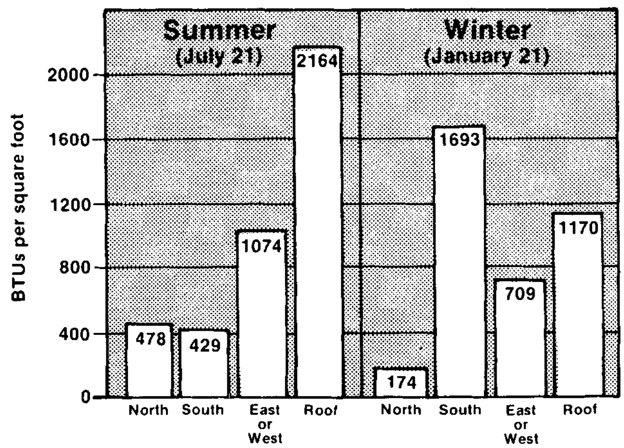
Windows allow you to look out, and let in light and breezes. But windows are the weak link in the building envelope.

Regardless of all these benefits, many home buyers will want more glass for the sake of light and appearance. As an alternative to small windows and window areas, you can provide larger window areas that are well shaded. A big advantage to their use is that glare is much less of a potential problem than with small unshaded windows.

There are many methods of shading windows. When you select trees, awnings, sunscreens, reflective glass or interior blinds, you have something tangible and visible to sell. Show clients the shading device and explain that it will cut out unwanted heat from the sun. Mention that the sun's heat entering the house can account for about 20% to 30% of their air conditioning bill.

Explain that the south side receives less sun in summer and more in winter, so seasonal shading is ideal for south-facing windows. Indicate how you have taken special care to minimize eastwardly and westwardly facing windows, which are difficult to shade, but have assured adequate shading for windows that do appear on those sides of the house. (Refer to Chapters 3 and 4 for more marketing suggestions.)

Daily Solar Heat Gain for 1/8" Single Glass



North- and south-facing glass is preferred to east, west, and roof (horizontal) facing glass.

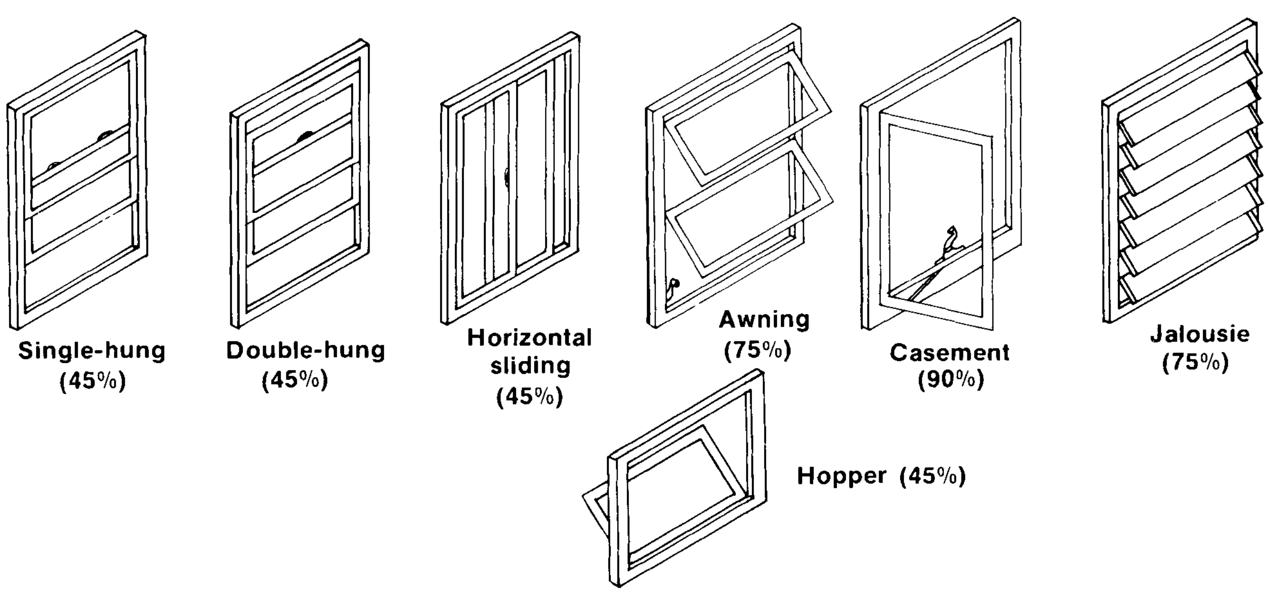
Explain to clients that cracks around windows and doors can cause a loss of up to 10% of their heated or cooled air. Show them the door weatherstripping and the caulking around the windows and glass doors. If you have chosen window products that are two, three or four times tighter than industry standards, with hardware guaranteed to be durable (10-year or lifetime guarantees), make sure to point that out. Potential home buyers who have lived in an apartment or house with poorly sealed windows will appreciate superior products.

Promote the ventilation aspects of awning and casement windows and pocketing or swinging glass doors by demonstrating how the entire windowed area opens to provide the greatest ventilation with the least amount of glass (see illustration below).

Consider selling screen doors as a ventilation-enhancing option, both for front doors and doors opening to the garage or other outside area. Many home owners add screen doors later, so why not show an appropriate one on your model?

Most home buyers recognize that insulated (double pane) glass is an energy saver, so merely pointing out that you have used it may be sufficient. Explain that in winter when it is 40°F outside and 70°F inside, a single layer of non-insulated glass isn't effective enough in deterring the escape of heat. Furthermore, anyone sitting or standing near glass will be far more comfortable if it is insulated. Also, insulated glass reduces moisture condensation and usually will reduce sound transmission as well.

If you have chosen insulated steel doors, promote them in a similar fashion.



Effective open area of various types of windows (percentages).

Selecting and Installing Energy-Efficient Windows and Doors

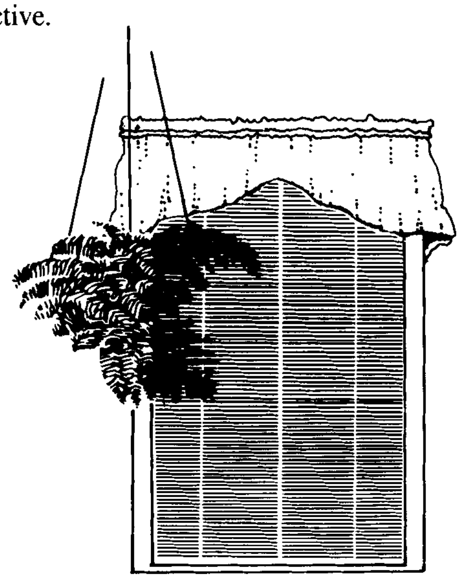
1. Reduced glass area

Your approach to reducing the amount of glass in the home is best begun at the time you select the house plan. Check the plans. Will smaller windows significantly affect the marketability of the house? Can an 8-foot-wide section of windows be replaced by a 6-foot section? Consult the architect or designer to explore the possibilities. In some situations, front doors with glass may be less desirable than solid doors. In other cases, larger glass areas can be tolerated for marketing and aesthetic reasons, without significant energy penalties, if they are oriented properly and shaded well.

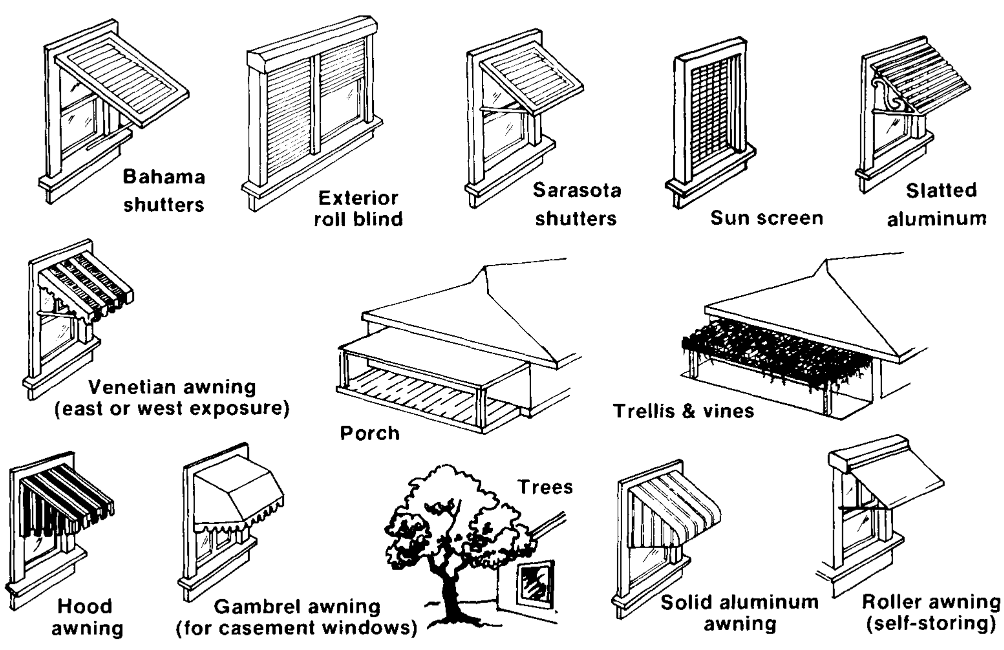
2. Shaded glass

Sun entering through windows in a home can account for 30% of the air conditioning load. Typically, residents use interior drapes or blinds to help reject the sun's heat, reducing the solar load to about 20% of the air conditioning load. You can take steps to reduce that even more. Choose Bahama shutters, awnings, trees, trellises, window films or sunscreens for exterior shading. Each of these is effective. Exterior shading is generally more effective than interior shading because the heat absorbed by the shade is dissipated outdoors rather than inside the house.

Although interior shading devices are subject to the control of the home owner and can be ineffective if not operated properly, most of them can be effective if designed and controlled correctly. Window coverings which have white (highly reflective) backs and are opaque (no light passing through) are most effective.



Vertical or horizontal blinds, white-backed draperies and shades are effective interior shading options.



Exterior shading options.

3. Reduced-transmittance glass

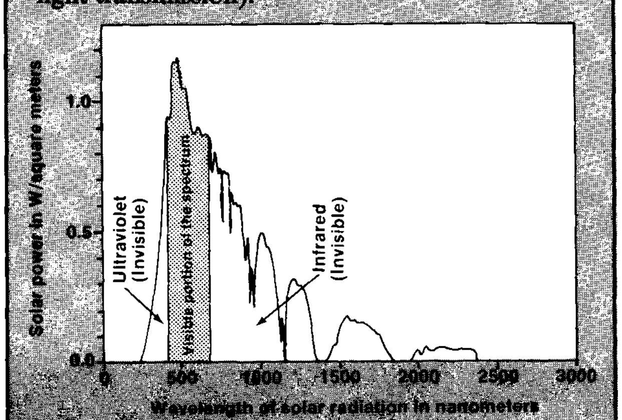
Not all alternatives to clear glass are created equal. Some glass absorbs a lot of sun, and part of that absorbed heat reradiates into the house. Other kinds of glass are highly reflective and reject most radiant heat to the outside; others are only slightly reflective. Some appear almost clear; others look tinted.

There is a way to compare the available choices. Ask the dealer or manufacturer about two key measurable qualities: the "shading coefficient" and the "visible transmittance." A low shading coefficient is desired to block solar heat. A high visible transmittance is desirable for a clear appearance and letting light in (see box). However, if the exterior scene is composed of unshaded expanses of brightly reflecting surfaces (buildings, parking lots, or paved areas, etc.), the visible transmittance should be lowered somewhat to minimize glare. Values for certain glasses appear in the adjacent table.

If you cannot find a commercially available window with the combination of visible transmittance and shading coefficient you desire, a relatively low-cost alternative is to use clear glass with an applied plastic sun-control film having the desired characteristics. Inform the window supplier of your intentions. Some films have not worked well on certain windows, especially on insulated glass units.

The Sun's Light

Not all of the sun's radiation is visible. All of it provides heat, but only the visible portion provides light. The invisible parts are called ultraviolet and infrared. Some windows and window films are available which are better at blocking invisible solar radiation than others. The two measures of interest are shading coefficient (low values mean good heat gain prevention) and visible transmittance (high values mean good light transmission).



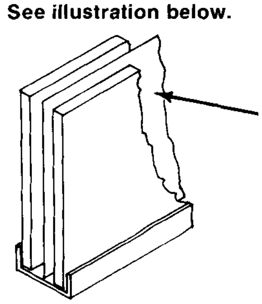
$$\text{Shading Coefficient (SC)} = \frac{\text{Total solar heat gain through window and shading device}}{\text{Total solar heat gain through a single sheet of 1/8'' glass}}$$

$$\text{\% Visible Light Transmittance} = \frac{\text{Amount of light that comes through window}}{\text{Amount of light incident on window surface}} \times 100$$

Specifications of Various Window Glasses

Glass Type	% Visible (Daylight) Transmittance	Shading Coefficient	Winter R-Value
Single clear	90	1.00	.86
Single green	84-86	.85-.87	.86
Insulated clear	81	.89	1.72
Low-e clear insulated	76	.72	2-3
Insulated green	76-78	.71-.76	.76
Single bronze	69	.85	.86
Insulated bronze	62-67	.71-.78	1.72
Single plus control film	(10-90)	(.2-.9)	.86
Anderson Sun Glass, bronze	44	.38	3.13
Reflective bronze single	27	.51	.86
Reflective bronze insulated	25	.42	1.72
Heat Mirror*			
66/clear	55	.50	4.00
66/bronze	42	.41	4.00
44/clear	38	.35	4.20
44/bronze	22	.25	4.20

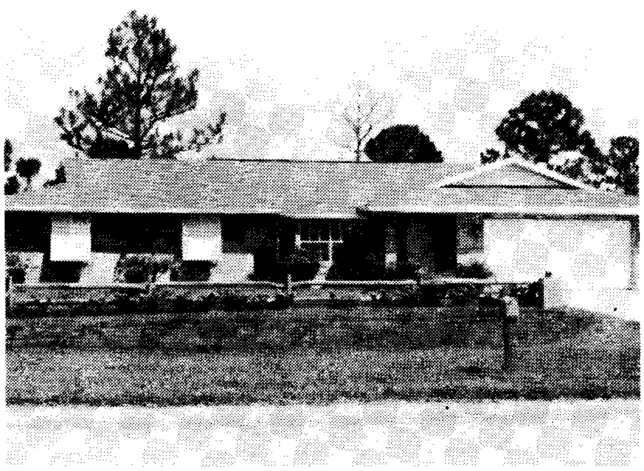
* See illustration below.



4. Orientation

House design and site planning should place most or all glass areas on the north and south sides. Avoid easterly and westerly facing windows, or provide porches or other shading. If left unshaded, make certain to choose a glass or film with a low shading coefficient.

In North and Central Florida, select clear glass for south windows and shade them using seasonal methods such as deciduous trees (Chapter 3), overhangs (Chapter 4), retractable awnings, and interior white-backed blinds or shades. These permit winter sun to enter the room. White mini-blinds can reduce solar heat and still permit ventilation while maintaining privacy, making them a good choice for an energy-conserving window treatment. See Chapters 3 and 4 for more information on orientation.



Bahama shutters can be an effective shading strategy for east- or west-facing windows.

5. Tight-fitting windows, doors

You know that windows and doors should fit tightly to save energy. But how do you know if the products you are considering purchasing will be tight-fitting?

Windows are tested for air infiltration in accordance with the American Society for Testing and Manufacturing (ASTM) Test E-283. Product literature will sometimes list the results of the test. Request the results from your dealer or the manufacturer if you don't see them. The results will be expressed in cubic feet per minute per foot (cfm/ft) of sash for windows, and in cubic feet per minute per square foot (cfm/ft^2) of overall area for glass door units. The industry standard is a maximum of 0.375 cfm/ft for windows tested at 25 miles-per-hour wind speed. The standard for glass doors is 0.50 cfm/ft^2 of total glass area. Most windows and doors easily pass this test. Some windows have ratings as low as 0.02 cfm/ft. Use test data for comparisons. Make sure the tests were done at 25 mph or 1.56 pounds per square foot (psf), not 15 mph.

Be aware, however, that the window you obtain may or may not perform exactly like the tested unit, since the manufacturer usually selects the unit to be tested. Also, infiltration tests do not measure how well the window seal will hold up over the lifetime of the product.

Window seals vary not only between manufacturers, but certain types of windows have inherently better sealing capabilities. Casement and awning windows typically have low infiltration ratings (about 0.05 cfm/ft), while single-hung, double-hung and sliding windows typically have higher infiltration ratings

Example

Suppose you are building a 1500-square-foot house with about 224 square feet (15%) of window area: two glass doors make up 80 square feet and the remaining 144 square feet is in windows. Assume there are 12 windows, each 12 square feet. You're deciding whether to buy aluminum-clad wood casement windows approximately 2.4 feet wide by 5 feet high with an infiltration rating at 25 mph of 0.03 cfm/ft; or whether to buy aluminum-clad wood double-hung units 3 feet wide by 4 feet high with an infiltration rating at 25 mph of 0.24 cfm/ft. What is the total leakage of each window type at 25 mph?

Multiply the crack length by the infiltration rating by the number of windows to get total leakage:

Casements:

2.4 + 5.0 + 2.4 + 5.0 = 14.8 ft sash
14.8 ft/window x 0.03 cfm/ft x 12 windows
= 5.3 cfm

Double hung:

(3 + 2 + 3 + 2) x 2 (halves) = 20 ft sash
20 ft/window x 0.24 cfm/ft x 12 windows
= 56.7 cfm

The air leakage with the double-hung windows is, in this example, 10 times greater than with the casements. Use this formula to show clients how tight your windows are.

(0.15 to 0.30 cfm/ft). However, most of the crank operators on aluminum awning windows are not very durable — eventually leading to leaks. Most wood-frame casement and awning windows have compression seals and a separate hook-type lock in addition to the operating crank. They seal tightly when closed. Jalousie windows have severe problems with operator reliability and air leakage. They are not recommended for heated or air-conditioned buildings.

Installation. Proper installation of windows is important in preventing air leakage. Use spray insulation (foam caulk) around frame edges and caulk inside and out with a long-lasting material. Poor installation can defeat the quality built into a window unit. Window movement after installation can open up cracks. Air gaps around windows can short-circuit the tight seals provided in good windows.

Make sure you select doors that are well weather-stripped, and install them with a snug fit. When choosing glass doors, consider tight-fitting swinging doors instead of sliding doors, which frequently leak.

French doors are an efficient way to increase ventilation in a room.

6. Maximum ventilation openings

Swinging glass doors that open onto porches can provide greater ventilation than sliding glass doors. Consider a single 3-foot-wide swinging door (with or without French-style lights) instead of 5- or 6-foot sliding glass doors. Or consider a double-opening swinging door. Alternatively, select a sliding glass door that will pocket inside or just outside of a wall. Telescoping doors are also available and do not inhibit the placement of wall insulation.

Single-hung, double-hung and sliding windows provide an openable area that is less than half of the window area as shown in the adjacent illustration. Awning and casement windows provide 60% to 90% openable area.

A summary of the relative performance of window types (with single-hung the basis of comparison) is given below.

Outstanding Good Average Below average Poor

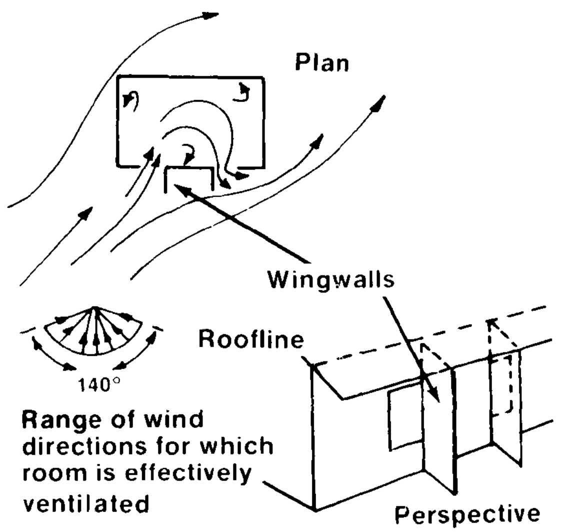
Window type	Ventilation	Infiltration	Egress 1	Rain protection when open	View	Security
Casement	Outstanding	Outstanding [2]	Outstanding [3]	Below average	Average	Average
Awning	Good	Outstanding [2]	Poor	Outstanding	Average	Average [2]
Aluminum awning	Good	Below average [4]	Poor	Outstanding	Average	Below average [4]
Single hung	Average	Average	Average	Average	Average	Average
Double hung	Average	Below average	Average	Good	Average	Average
Sliding /rolling	Average	Below average	Average	Average	Average	Average
Jalousie	Good	Poor	Poor	Outstanding	Below average	Poor
Sliding door	Average	Below average	Outstanding	Below average	Good	Poor
French door	Average	Average	Outstanding	Below average	Good	Below average
Fixed glass	Poor	Outstanding	Poor	N.A.	Outstanding	Outstanding

1 Window (not door) rating, based on minimizing glass area while providing egress in common sizes.
2 Based on weatherstripped, locking models.
3 Optional egress hardware may be required on smaller units.
4 Typical aluminum awning window hardware.

Relative performance of window types.

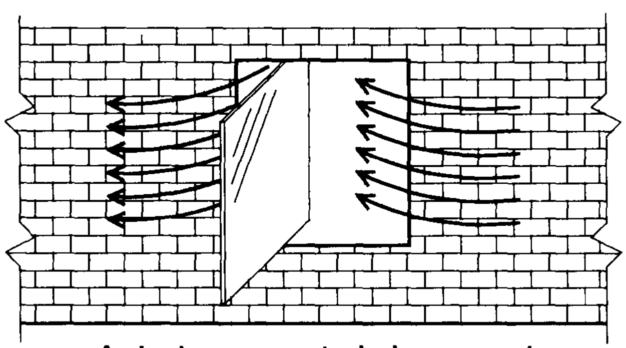
7. Casements as wingwalls

Rooms with windows on only one wall do not typically have cross-ventilation. One way to provide it is with two widely spaced windows, with short walls extending like wings from the wall adjacent to the windows. This creates positive and negative pressure zones, and breezes will be more likely to enter and leave the room. Look at the figure below and refer to Chapter 4 for more information on wingwalls.



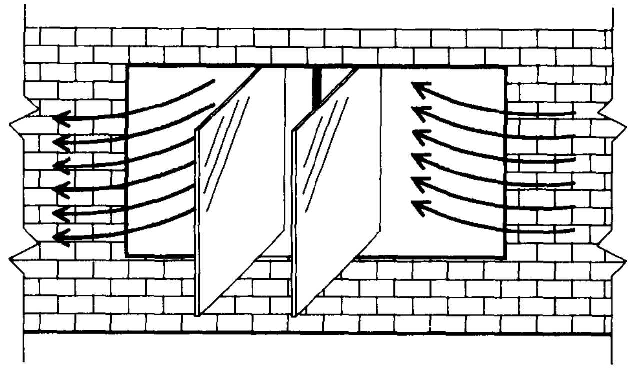
Wingwalls create inlets and outlets for ventilation of rooms with one outside wall.

A single casement window that is hinged so air can enter from each side can perform the same function as a wingwall. Note that most casement windows



A single casement window can act as a wingwall.

are hinged in this manner to permit cleaning of both sides of glass from inside the house. If two windows are used, whether together or apart, they should be hinged so they act as a wingwall. This hinging is different from most standard arrangements.



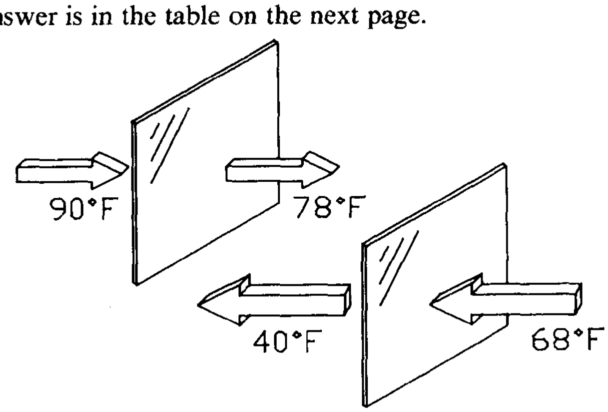
A double casement window hinged as shown can act as a wingwall.

8. Screen doors

A great method for increasing ventilation is through doorways. A solid opaque door blocks the daytime sun, but augmented with a screen door it can be opened to provide ventilation at night. For appearance's sake, wall pockets can be designed to conceal screen doors when they are not in use. If a double front door is used, use a double screen door. Use a screen door on the garage service door, too.

9. Insulated glass

Except for radiant heat from the sun, heat flows through a given type of glass at a rate directly related to the indoor-outdoor temperature difference. In hot climates like Florida, indoor and outdoor summer temperatures differ by 20°F at most. The average summer temperature difference over 24 hours is typically less than 10°F. Conduction through window glass is thus not a meaningful part of the cooling load. However, it is a concern in the heating season. The question is, how much extra can one justify paying for insulated glass? The answer is in the table on the next page.



Insulated glass is most important when temperature differences between outside and inside are high.

Annual Savings of Using Insulated Glass Instead of Single-pane Glass($/sq.ft)[1]

	South Florida	Central Florida	North Florida
Heat Pump (COP=2.0)[2]	0.15	0.15	0.20
Electric Resistance	0.15	0.20	0.25

To obtain a reasonable return on investment, how much more can a home owner justify paying for insulated glass than single pane glass ($/sq.ft)[3]

	South Florida	Central Florida	North Florida
Heat Pump(COP=2.0)	1.65	2.00	2.25
Electric Resistance	1.75	2.60	3.30

Annual Savings of Using Clear Low-e Windows Instead of Clear Insulated Windows ($/sq.ft)[4]

	South Florida	Central Florida	North Florida
Low-e surface 3	0	0.05	0.05
Low-e surface 2	0.15	0.15	0.15
Heat Mirror 88	0.20	0.20	0.20

To obtain a reasonable return on investment, how much more can a home owner justify paying for low-e window than clear insulated windows ($/sq.ft)[3]

	South Florida	Central Florida	North Florida
Low-e surface 3	0	0.55	0.75
Low-e surface 2	1.75	1.75	1.75
Heat Mirror 88	2.25	2.50	2.75

[1] Assume an air conditioner with SEER=8.0, electricity costs at 8.5 cents/kWh. All values based on 10% duct loss. All values rounded to nearest $0.05. Heating set point = 68°F, Cooling set point = 78°F.

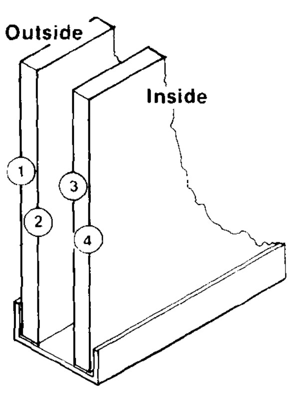
[2] Seasonally adjusted value. Equivalent of 2.5 to 3.0 COP units.

[3] Based on 10% internal rate of return on investment. Also assumes fuel prices increasing at 5% per year and a 20 year life for window products. All values rounded to nearest $0.05.

[4] Assume an air conditioner with SEER=8.0, electricity costs at 8.5 cents/kWh. Choice of heat type insignificant. All values rounded to nearest $0.05. Heating set point = 68°F, Cooling set point = 78°F.

Low-emissivity (low-e) insulated glass units have entered the market. These units have one surface with a special coating. The main effect of the coating is an increased resistance to heat flow. This product is ideal for the northern U.S., since it makes an insulated window unit that is the equivalent of a triple-pane unit. But again, how much more should you pay for such a unit in Florida?

If you are convinced that insulated glass is cost-effective, then examine the table above to see how much more you can justifiably pay for a clear, low-emissivity coating. The table lists values that depend on which surface has the low-e coating. Surface 2 is preferred for hot climates. Unfortunately, most manufacturers sell the unit with surface 3 as the low-e surface. Due to heating of the glass itself, this is less desirable than surface 2. Ask your supplier if you can order your windows with the low-e coating on surface 2.



The low-e coating in insulated units faces the airspace and absorbs heat. Having the coating on surface 2 rather than surface 3 more effectively block the sun's heat from the house.

The values given do not refer to low-transmittance glass choices, some of which use reflective glass or films in conjunction with a low-e surface. (See the section on low-transmittance glass in this chapter.)

Newcomers on the market are single-layer low-e glass and low-e window films. In general, they will perform nearly as well as insulated glass. Compare the additional cost with the justifiable costs in the insulated glass table.

Aside from energy savings, most insulated glass products offer greater noise control and improved thermal comfort to home occupants. They also reduce the number of times condensation will appear on the room side of the glass. That alone may make the difference worthwhile for some applications.

Summary

Minimizing unshaded glass is a principal requirement for an energy-efficient Florida house. The site planning and house plan selection should aim at providing windows oriented for summer shading. Shading can also be provided by awnings, shutters, sunscreens, window films and interior window coverings.

In selecting windows, you should generally choose glass with a low shading coefficient and high visible transmittance. Use insulated glass when its cost is justifiable. Use tight-fitting windows and doors with durable hardware.

Select floor plans that permit cross-ventilation, and then provide maximum open area with minimum glass. Consider swinging glass doors or pocketed sliding glass doors to porches, and casement windows for rooms with one outside wall. Use screened doors to provide excellent ventilation inlets and outlets.

For further information

"Window Treatment for Energy Conservation," W.R. McCluney, FSEC-EN-4-80, January 1985.

"Light Without Heat Gain - Glazing with a Difference," Bradley J. Davids, *Architectural Lighting*, June 1987.

"Windows for Hot Climates," R. Vieira, *Progressive Builder*, November 1986.

"A Buyer's Guide - High Performance Windows," *Practical Homeowner*, October 1987.

Solar Control and Shading Devices, Aladar Olgyay and Victor Olgyay, Princeton University Press, Princeton, NJ, 1957.

Architectural Aluminum Manufacturer's Association, 2700 River Road, Des Plaines, IL 60018, (312)699-7310.

National Wood Window & Door Association, 1400 East Touhy Ave., Suite G54, Des Plaines, IL 60018, (312)299-5200.

Vinyl Window & Door Institute, 355 Lexington Ave., New York, NY 10017, (212)370-9341.

Chapter 8

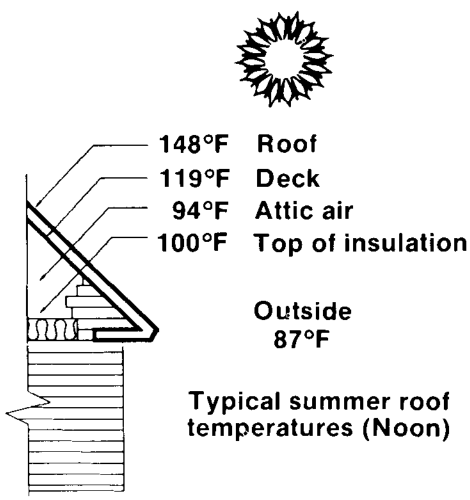
Energy-Efficient Roof, Ceilings and Attics

Recommendations	First Cost	% Potential Savings	
		Cooling	Heating
1. Seal potential air leakage sources in ceiling.	S	10	15
2. Use light-colored shingles and roofs.	N	5	—
3. Use continuous soffit vents at eaves and ridge vents at all peaks.	S	5	—
4. Insulate the attic thoroughly.	S	5-10	10
5. Use radiant barrier systems in attics.	S/M	8-12	8-12
Maximum Combined Total	M	25	25

Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft² of floor area)
M = medium (>$0.25 and <$1.00/ft² of floor area)
H = high (>$1.00/ft² of floor area)

Marketing Energy-Efficient Roofs, Ceilings and Attics

If it's hot outside, there's one very easy way to show your clients the importance of a cool roof. Ask them to go up to the attic of their current house for a couple of minutes. Just opening the door or hatch to their attic will probably do the job. The blast of hot air hitting their faces should quickly and powerfully show them how hot roofs and attics can get, and why something must be done to keep that heat from getting into their house. Your well-built, energy-efficient home will take on added value since you have done something to reduce the flow of heat from the attic downward into the house.



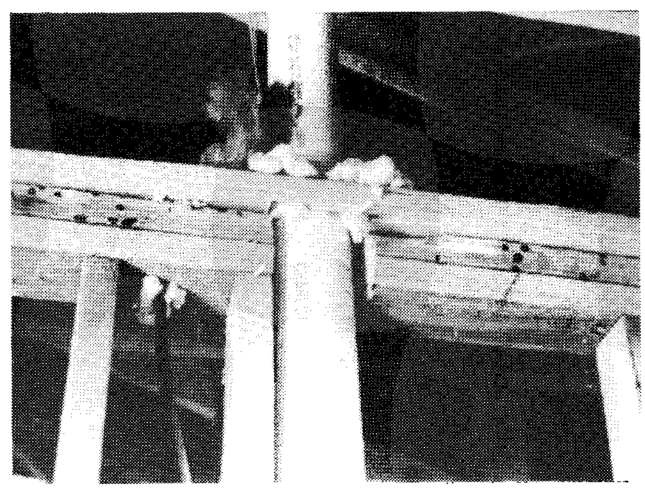
Typical summertime attic temperatures.

If the weather isn't hot, you can still explain this effect to your clients by showing them the above illustration of attic temperatures. The numbers are dramatic enough to do the selling job for you.

It is important to emphasize to your clients the major role roofs and attics play in heating Florida homes. Research shows that about 10-20% of the cooling load in homes in our state comes from heat conducted into the home through the ceiling, putting a major load on the air conditioner and greatly affecting the comfort level in the house. An additional 25% of the cooling load comes from heat and moisture infiltration, some of which enters the house through ceiling penetrations. The double whammy of higher air conditioning costs and an uncomfortable house poses a major problem to home owners, so you should not minimize the steps you have taken to keep their roof and attic cool.

You have five basic energy-conserving strategies to sell in your homes which can alleviate the problems of a hot roof: well-sealed ceilings, proper roof materials, good ventilation, adequate insulation and attic radiant barriers. Your attention to these areas will help your buyers enjoy a comfortable home with affordable energy costs. They will feel and enjoy the benefits of these building strategies for many years.

Explain to prospective home buyers that the unwanted flow of air and moisture from the attic into a house — called air infiltration — is a major cooling load in Florida homes. Point out that much of the problem is caused by air leaking into the house from openings for electrical lines, plumbing penetrations, and other building components which go between the attic and living area below. Describe how well-sealed *your* homes are, and how your crew pays special attention to these sources of air leakage.



Let a photo show the attention you have paid to sealing plumbing and wiring penetrations in the top plate.

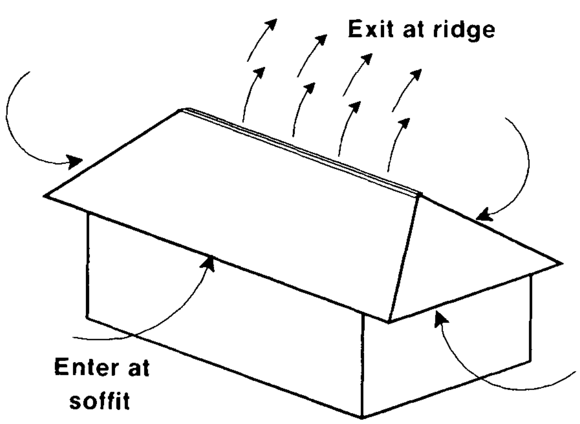
Be sure to emphasize that your crew's attention to such hard-to-reach places as ducts and dampers, pipes, and other sources of infiltration may save the home owner considerable expense later on, since many of the areas needing sealing are inaccessible once the home is built.

Some builders leave two pieces of asphalt shingle — one black and one white — outside their office window for a simple demonstration of the effects of shingle colors. Try doing this, then take prospective clients outside on a sunny afternoon to this "test area" and ask them to pick up or at least put their hands above each piece. The darker colored shingle

A white tile roof reflects most of the sun's heat.

will be very hot to hold, and will clearly be much hotter than the lighter colored piece. Your clients will see how important shingle color is to the temperature of their roof.

Emphasize to clients how effective vents are at increasing ventilation in their home's attic. If you have installed soffit and ridge vents, explain that these create better attic air flow than gable vents.



Attic air flow is best with continuous soffit and ridge vents.

Many potential buyers will ask you about the insulation in your homes. Media advertising, news articles and other promotional messages over the past few years have convinced home owners that insulation is a major factor in a home's energy use.

Adequate insulation slows the flow of heat through the attic and ceiling, allowing the occupants of the house to maintain comfortable temperatures throughout the year with minimum energy cost.

Inform the home buyer that the best time to install insulation is during construction, since many parts of the attic will be difficult to reach with insulation once the home is completed.

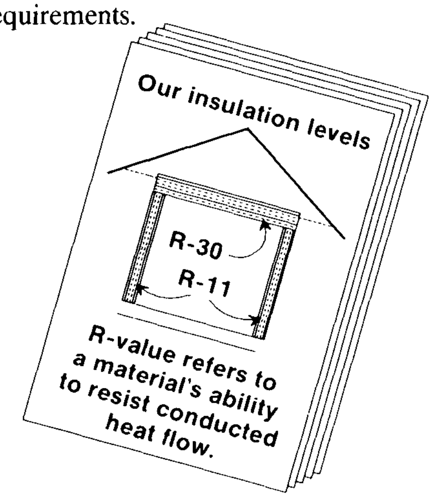
It is important that you anticipate your clients' interest in insulation, and present them with enough information to convince them that your homes are well-built with adequate levels of insulation.

The Federal Trade Commission requires that builders disclose R values to buyers. You can show them the energy code forms to disclose the information.

In Florida, ceiling insulation with an R-value between 19 and 30 is generally recommended (R-19 is the minimum under Florida's Energy Efficiency Code). R-19 is equivalent to about 6 inches of fiberglass batts, 8.5 inches of blown fiberglass, or 6 inches of blown cellulose. R-30, or R-19 plus a radiant barrier, is suggested for good energy conservation.

Explain R-value to customers this way: R-value refers to an insulation's ability to resist the flow of heat from one side of it through to the other. The higher the R-value, the more effective the insulation. Note, though, that each added amount of insulation is not as cost-effective as the previous amount.

To help your clients better understand what R-value means to them, prepare a simple hand-out sheet with a brief definition of R-value (similar to the one above), along with a drawing of your house showing the wall and attic R-values. This will be especially impressive if any of the numbers exceed the minimum requirements.



Prepare a hand-out sheet showing R-value of insulation levels in your home.

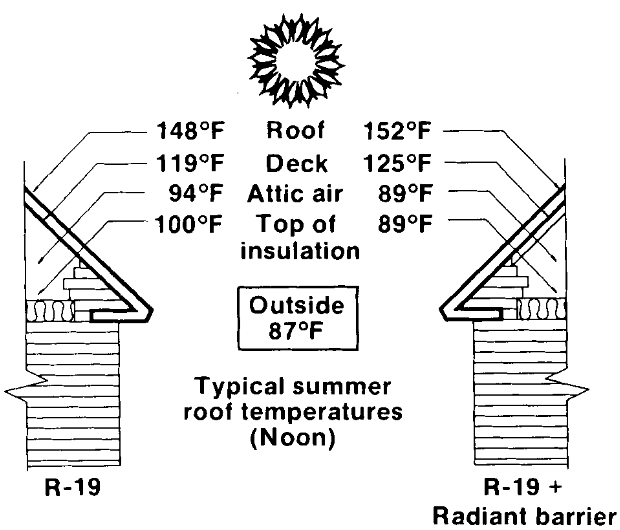
Point out the benefits of buying a house with a radiant barrier already installed. Retrofitting these systems can be very difficult since attics usually have limited space, and stapling the materials onto the trusses can be an uncomfortable and, in some cases, even impossible task.

Emphasize to your clients that heat transferring (radiating) downward from a hot roof causes the home's air conditioner to run longer and use more electricity. A radiant barrier system (aluminum foil facing the attic air space), however, will stop most of this radiant heat transfer — and, when combined with good soffit and ridge vents, can reduce the heat flow at the ceiling by about 40%. Look at the next illustration and notice how much lower the attic temperatures are with a radiant barrier system.

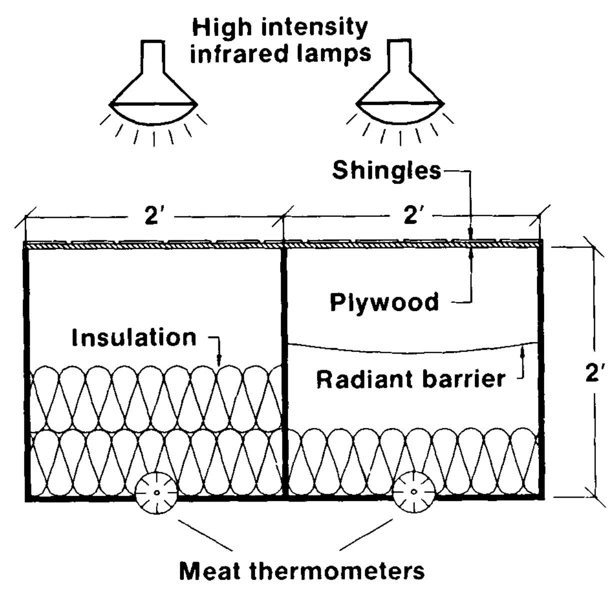
Since these systems keep attic temperatures much lower, the ductwork, plumbing and other materials in the attic may have longer life spans. Cooler ducts also make the cooling system in the home operate more efficiently. The combined effect may even result in a smaller-sized air conditioner.

It is reasonable to expect an attic radiant barrier to save the home owner 8% to 12% on annual space conditioning costs. Actual savings will depend on the amount of heat the roof and attic contribute to the home's total cooling load.

There is a dramatic and effective way to demonstrate radiant barriers to prospective home buyers. Take some plywood and a couple of 2x4s and build a large box about 4 feet wide, 2 feet deep and 2 feet high. Leave the top and front open, and divide the box into two equal compartments. Put a 6-inch layer of insulation on the floor of each compartment. Add 6 more inches of insulation in one compartment, and put a radiant barrier above the insulation in the other one. Put plywood and a shingle roof on the box. Place a sunlamp or other high-intensity bulb a good distance above each compartment. Put a piece of transparent material, such as clear acrylic, on the open side. Drill a hole in the front of each compartment, one inch from the bottom, and insert a meat thermometer into the insulation. After the lamps have been on a few minutes, your clients will see how much cooler the insulation stays under the radiant barrier.



Comparison of temperatures in attics with and without a radiant barrier.

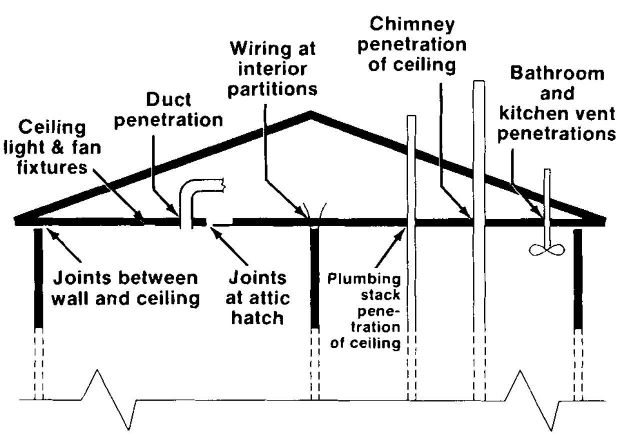


A radiant barrier demonstration box can be a dramatic sales tool.

Product Selection and Installation for Energy-Efficient Roofs, Ceilings and Attics

1. Air-tight ceilings

Prevent air infiltration from attics by paying close attention to areas around ceiling lights and fan fixtures, water lines, switches, outlets, attic access doors and whole-house fans. Seal the wall top plates around wiring and plumbing with noncombustible materials. Check carefully for leaks around bath and kitchen vent fans and chimney penetrations. During the day the attic becomes a source of very high temperatures and moisture, and much of this unwanted air can penetrate through these openings into the house.



Major locations of air leakage between conditioned area and attic.

2. Roof materials

Tests at FSEC and other research centers have shown that both the color and the type of roof material affect energy consumption and home comfort.

The solar absorptance of a surface is the extent to which that surface will convert solar radiation to heat. A surface with a rating of 1 will convert all the solar radiation; a surface rated at 0 will convert none of it. Roofs typically range from 0.35 for clean white tile (absorbing only about 35% of the solar radiation) to 0.95 for black shingles (converting about 95% of the radiation to heat). Choose light-colored surfaces whenever possible, because their lower solar absorbtance will help keep heat out of the house.

Also, materials with more exposed surface area — such as tiles, shakes and pebbles —will be cooler than asphalt shingles.

Effective Solar Absorptance of Common Roof Surfaces

Surface	Solar Absorptance
Dark asphalt shingles	.85 - .95
Medium asphalt shingles	.80 - .85
Light asphalt shingles	.70 - .75
Dark pebbles built-up roof	.80 - .90
Medium pebbles built-up roof	.60 - .80
Light pebbles built-up roof	.50 - .60
Dark roof tiles	.80 - .90
Medium roof tiles	.70 - .80
Light roof tiles	.35 - .50
Old cedar shakes	.80 - .80
New cedar shakes	.65 - .75

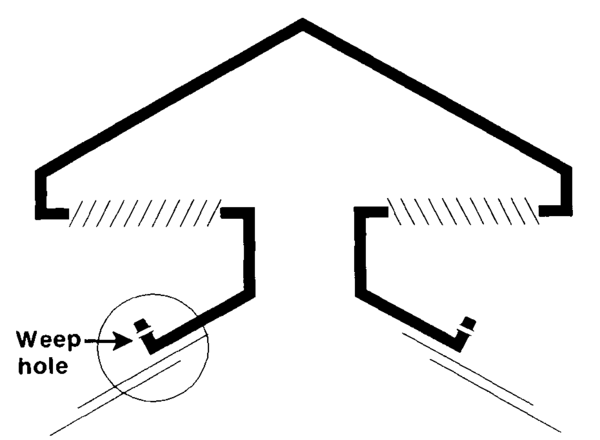
Note: Dark colors: black and dark primary color combinations

Medium colors: pastels to warm primary color combinations

Light colors: white or off white.

3. Attic ventilation

We recommend the use of continuous soffit and ridge vents whenever possible. You will need at least one square foot of free vent area for each 150 square feet of ceiling to meet building codes. Be sure that vents are sized to provide an equal open area for both inlets and exits. Cut felt paper clear of ridge vents to assure the maximum opening. Use a



A ridge vent of this type is effective in resisting wind-driven water from backing up into openings. Weep hole is present in end flange.

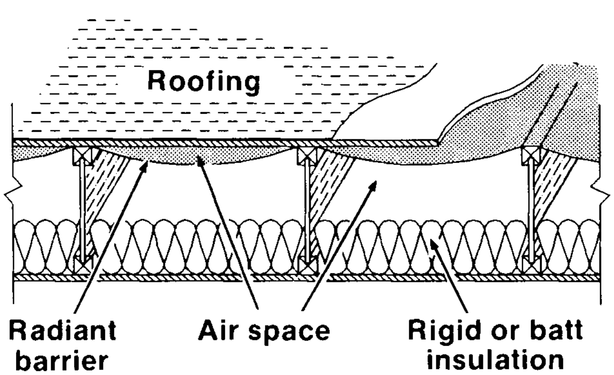
continuous baffle at eaves to prevent insulation from blocking air flow.

There are ridge vent products that can be shingled or tiled over. Such ridge vents make it possible to have a roof of uniform appearance.

If you're building homes with vaulted or cathedral ceilings, use an appropriate truss system to obtain an airspace and thereby reduce heat gain. If you are using a single-assembly roof (no attic space), you will have to find some other means to provide an airspace between the roof decking and the insulation. The use of 2x12s or plywood-webbed I-beams for framing allows room for the airspace, insulation and a radiant barrier (if used) without blocking airflow.

Avoid the use of wind turbines in new construction. Although they may have a place in retrofit applications, they are not as reliable as other new construction venting methods (gable or ridge vents with soffit vents).

Power ventilators are not necessary. Natural ventilation can achieve similar attic heat-flow reduction without the cost of running power ventilators.



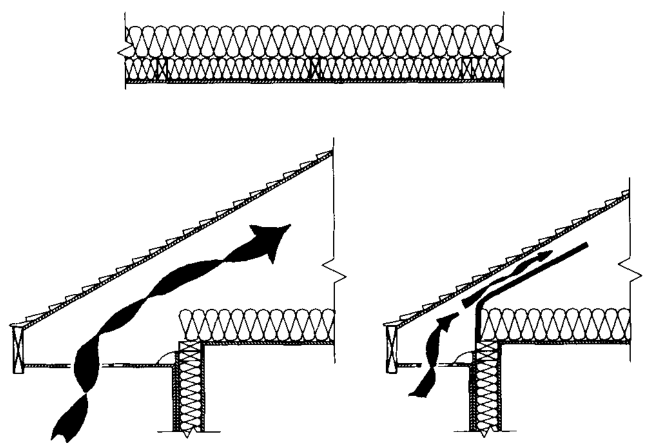
Use plywood-webbed I-beams to assure air space for ventilation and radiant barriers (if used) in cathedral roofs.

4. Insulation

Insulation comes in blankets (rolls made of glass fiber or rock wool), batts (pre-cut blankets in standard sizes), rock wool or fiberglass (loose insulation requiring blown-in installation), cellulose fiber (recycled paper particles treated with chemicals and blown-in or sprayed), foam-in-place (liquid foamed plastic), phenolics, or rigid foam (sheets or boards of foamed plastic such as polyurethane or polystyrene). When choosing the insulation for your job, consider such factors as cost, quality, special characteristics (e.g., odor, treatment for insects, etc.), and insulating capability (R-value). Chapter 6 contains a table that compares the insulating materials frequently used in new home construction.

The goal of any installation is to have a continuous layer of insulation without gaps, cracks or air bypasses. Among the points that require special attention:

- The insulation at the edge of the ceiling must not be allowed to contact the roof decking and block airflow from the soffit vents. When installing ceiling insulating materials, use baffles to prevent blocking the vents.
- Batts or blankets must butt tightly against framing or other batts and blankets. Cover the bottom chord of the truss so that heat will not easily transfer through the wood.



Insulation should extend over the top ceiling joints and ventilation should be provided at the eaves with extended trusses or baffles.

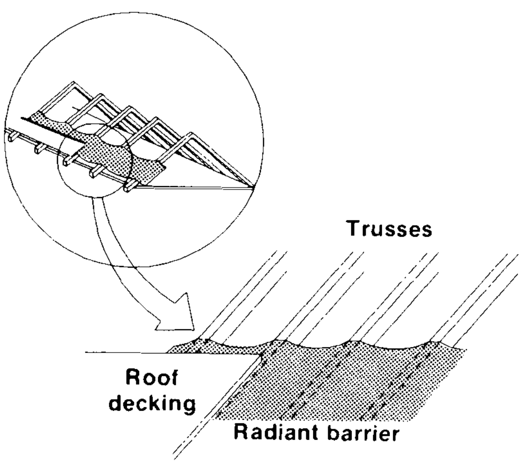
- Cut batts or blankets to fit at framing joints to avoid buckling and gaps.
- Avoid using recessed light fixtures if possible. If you must use them, choose ones with insulated covers. For fire safety, do not cover standard recessed light with insulation.
- Insulate and weatherstrip the attic access panel.

It is essential that insulation be properly installed. Follow the manufacturer's instruction to achieve the desired thermal performance. An R-11 fiberglass batt will perform at less than R-7 if compressed to half the designated thickness. Insulation that is blown or poured into an attic will not perform to its stated standards unless it is evenly applied to the proper depth and density. You can check the depth by placing markings on the truss webs. You can also check the quantity by counting the number of bags the installer used.

In addition, gaps that are often found around wiring, piping and other openings can seriously impair the overall performance of the insulation. Inspect thoroughly and fill any gaps with insulation.

5. Attic radiant barriers

FSEC tests have shown that the effects of radiant barrier systems are effective in stopping heat transfer between a hot roof and conventional attic insulation. However, it is important to have soffit and ridge vents before even considering a radiant barrier system. Radiant barriers perform far better with good ventilation from soffit and ridge vents.



A radiant barrier can be draped over the trusses with the foil facing down.

Selection. There are many types of radiant barrier material on the market. Select the type which fits best with your needs.

The identified generic types that are in use are:
- single-sided foil with another material backing, such as kraft paper or polypropylene
- double-sided foil with reinforcement between the foil layers
- foil-faced insulation with a special material to impede heat conduction (such as polyisocyanurate or polyethylene)
- multilayered foil systems which form enclosed, insulating airspaces.

When choosing the best type for your construction needs, be sure to take into account the emissivity of the material — the lower, the better. A maximum of 0.06 is permitted in the energy code. A fire rating of Class A is required by Florida building codes. Also consider ease of handling, strength of reinforcement, appropriate width, and cost. Radiant barriers should be considered a supplement to conventional insulation, not a replacement. Most builders have found fiber-reinforced, single-sided-foil radiant barrier products economical and durable in attics. When choosing foil products, remember that low emissivity is a characteristic of the foil surface. Avoid products which are not labeled as radiant barriers. Even though some building materials may include aluminum foil or appear reflective, the surface may be treated in a way that would make them ineffective.

Most foil-backed insulations are not fire rated to exposure to an airspace and cannot be used as a radiant barrier. However, one batt insulation product has a radiant barrier attached.

There is also a low-emissivity paint that can be applied directly to the under side of the roof decking. This paint does not qualify as a radiant barrier under the energy code because it has a emissivity of 0.23. However, it does reduce the heat flow across the attic into the house and is an appropriate product for many applications.

Installation. Installation of radiant barriers is fairly easy during new construction. In some localities, you can hire subcontractors specializing in such installation. It can be a sideline for a carpenter, roofer, or other skilled worker. If you decide to install the systems yourself, we recommend using a team of two workers. After some experience, they should be able to install 500 to 1000 square feet of material per hour in new construction.

However, working with radiant barriers is new to Florida builders, and it is important that they follow a few basic guidelines.

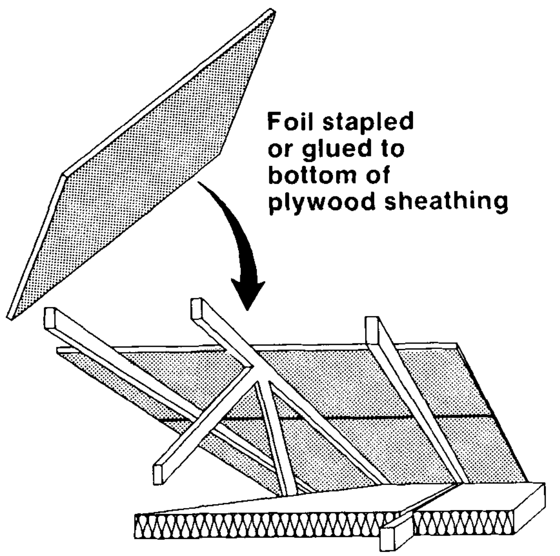
In particular, **installers must allow an airspace next to the foil side of the material.** The airspace is essential for the radiant barrier effect.

Face the foil side down to ensure that dust won't collect on the low-emissivity surface and degrade the system's performance. **Leave a 3- to 6-inch gap near the peak for hot attic air to exit the ridge vent.**

There are four locations where radiant barriers could

be installed:
- glued or stapled to the underside of the plywood roof sheathing, foil side facing down
- draped from the roof rafters underneath the plywood, foil side facing down
- stapled from the bottom of the roof rafters, foil side facing down
- placed on top of the insulation, foil side facing up.

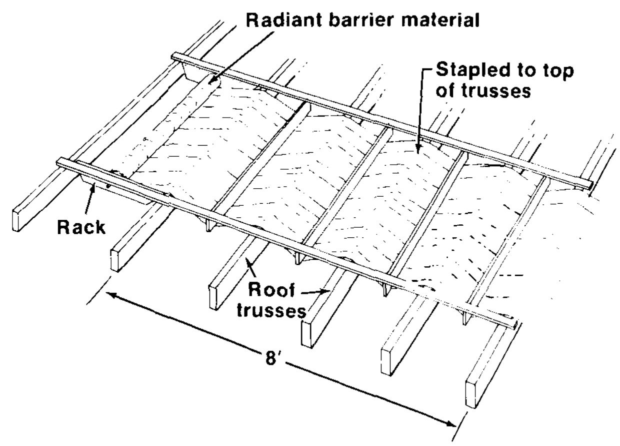
Although attaching a radiant barrier to roof sheathing is the simplest and least costly method, the location does not conform to the model energy code (because of the lack of data when the code was issued). However, recent experiments indicate this location is as good as others.



Attaching the radiant barrier directly to the sheathing can reduce installation costs.

Builders usually find that draping the radiant barrier before putting down the decking is made easier by the use of an installation rack (see drawing). With it, foil can be unrolled horizontally across the top of the trusses from one end of the roof to the other. The first length should be installed at the soffit end; each successive length should overlap the preceding one.

The rack serves three important functions:
- It holds plywood-sized lengths of foil in place, even in the wind.
- It makes it easier to unroll and fasten the material.
- It ensures an even drape of the foil between the trusses.



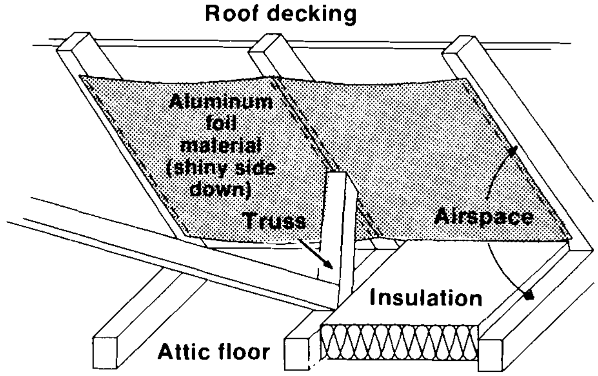
An easily-built radiant barrier installation rack.

The radiant barrier material should be tacked or stapled to the top of the trusses until the decking is applied. A hammer stapler is very handy. It's easiest to apply one section of foil and decking at a time so that the installation crew has a stable working surface on the roof.

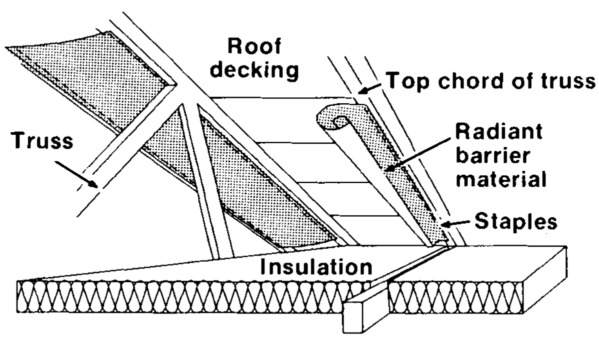
An alternative method is to install the material on the roof rafters after the roof sheathing has been installed. Some builders prefer this method since the sheathing reduces the wind force and the need for close coordination between the barrier and sheathing installers. Begin the job by measuring the distance from roof peak to the soffits along the roof rafters. This often can be done by counting the number of 4-foot plywood widths on the roof. Mark that distance, minus 4 inches for airflow, before attempting to install. Scrap wood can be used as markers. Roll out the radiant barrier material and cut it to the desired length. Install the piece. If the cut is a little too long, cut off the excess. If the size is correct, proceed to roll and cut pieces of the same size for that roof section.

One person can now get up on the ceiling joists near the peak with pre-cut rolls. A second worker stays on a ladder near the soffit. The material is first stapled at opposite ends of the same rafter and then stretched across the space and stapled to the other rafter or roof truss. **Be generous with staples.** Follow the same procedure for other roof sections.

Laying a radiant barrier on top of insulation is not recommended. Although initially it will be fully



A radiant barrier can also be installed by stapling it to the bottom of the trusses.



The foil is stapled at opposite ends of the same rafter and then stretched to the other rafter.

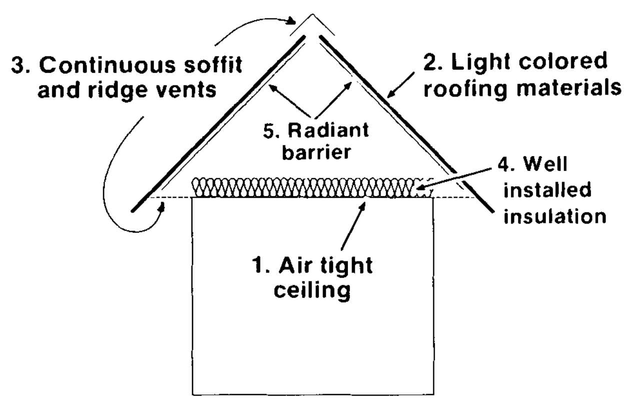
effective, dust may accumulate and degrade performance. Further, the first time a contractor or home owner walks in the attic the foil may rip.

Two more points on radiant barrier systems:

- Only one low-emissivity surface is required for the radiant barrier system to be effective. Little is gained with two radiant barriers or double-sided foil.
- If installation is difficult in places and you leave small gaps, this will not significantly reduce the effectiveness of the system. The more of the attic you can do, the better, but whatever can be done will be beneficial.

Summary

There are five effective strategies to making the roof/attic/ceiling more energy efficient, as shown in the drawing below. Use these strategies whenever you can. Together, these strategies should reduce heat flow to the house from the roof by 50-70% over minimum required practices.



There are five energy-efficient roof/attic/ceiling strategies.

For further information

"White Roofs vs. Black: Which Save Me Energy?" Dan Backenstow, *Roofing, Siding and Insulation*, August 1987.

"Attic Ventilation," Henry Spies, *Progressive Builder*, August 1987.

"Finding the Flaws in Superinsulation," Gary Nelson, *New England Builder*, August 1984.

"Radiant Barriers: A Question and Answer Primer," Ingrid Melody, FSEC-EN-15-87.

Chapter 9

Energy-Efficient Comfort Conditioning Equipment

Recommendations	First Cost	% Potential Savings	
		Cooling	Heating
1. Choose air conditioners with SEERs of 12 or higher with sensible heat fractions (SHF) less than 0.8; consider multispeed compressors.	M	20-40	—
2. Properly size the air conditioner.	R	0-10	—
3. Shade the compressor/condensing unit.	N	0-5	—
4. Choose the best heating system for your location.	S/M		0-60
5. Use a multispeed blower to maintain comfort.	S	—	—
6. Locate air handler and duct system in conditioned space.	S/M	10-15	10-15
7. Install and seal the air handler and duct system properly.	S	10-25	10-25
8. Create zoned HVAC system.	M	0-15	0-15
9. Choose an appropriate thermostat and thermostat location.	S	0-5	0-5
10. Install timers on kitchen and bath exhaust fans.	S	5	—
11. Install ceiling fans.	M	5-30	—
12. Install whole house fans.	S/M	5-15	—
13. Seal fan penetrations.	N	0-5	0-5
Maximum Combined Total	H	65	60

Cost Codes:
R = reduced
N = negligible
S = small ($<$\$0.25/ft^2 of floor area)
M = medium ($>$\$0.25 and $<$\$1.00/ft^2 of floor area)
H = high ($>$\$1.00/ft^2 of floor area)

Marketing Comfort Conditioning Equipment

"Come on in – it's 20 degrees cooler inside!"

Not too many years ago, banners worded like this were commonly used outside movie theaters to entice people to come in. Many people chose to spend summer afternoons in theaters for the air-conditioned comfort as much as for the featured movies.

Times have changed greatly, and air conditioning is now a part of just about every Floridian's lifestyle. And because energy use for home cooling ranges from 25% of the annual energy bill in North Florida to nearly 50% in the southern part of the state, an efficient system can significantly lower a home owner's utility bills. An efficient air conditioning system is a major selling point in marketing Florida homes.

To promote energy-efficient equipment selected for your homes, you need to explain to your clients how much they will save on their power bills. Prepare a sheet with a definition of SEER (see p. 9-3), and list the values for the units you have chosen.

Next, show your clients how much money an efficient unit will save them. The following chart shows dollar savings associated with installing efficient units (assuming a 3 ton air conditioner, 2100 annual cooling hours, and an energy cost of $0.09 per kwh).

	Existing SEER										
New SEER	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
15.0	227	194	165	138	113	91	70	50	32	16	0
14.5	211	179	149	122	98	75	54	35	17	0	
14.0	194	162	133	106	81	58	37	18	0		
13.5	176	144	115	88	63	40	19	0			
13.0	157	125	95	68	44	21	0				
12.5	136	104	74	47	23	0					
12.0	113	81	52	25	0						
11.5	89	56	27	0							
11.0	62	29	0								
10.5	32	0									
10.0	0										

Compare SEER values along top of chart with SEER values at left to find annual energy savings in dollars by using units with higher SEERS. For example, choosing a unit with SEER = 13 instead of 10 would save $157/year (savings are for a 3 ton A/C, 2100 annual cooling hours at $0.09 per kwh).

An important part of marketing efficient cooling and heating equipment is assuring the home buyer that the equipment has been sized properly. Too large a system will do a poor job of dehumidifying the home and will cost more to purchase and operate. Too small a system will not do an adequate cooling job. Show the home buyers the actual calculations or other guidelines you have used to determine the best system size.

Explain to your clients that because you will be properly locating and sealing the air handler and ductwork, they will save up to 25% on their cooling and heating bills over typical new construction.

The best way to market fans is to use the most effective and attractive products in your office, model homes, or other areas where you meet with clients. Give clients who may be unfamiliar with whole house, exhaust, and ceiling fans the opportunity to appreciate how effective they are by demonstrating their use.

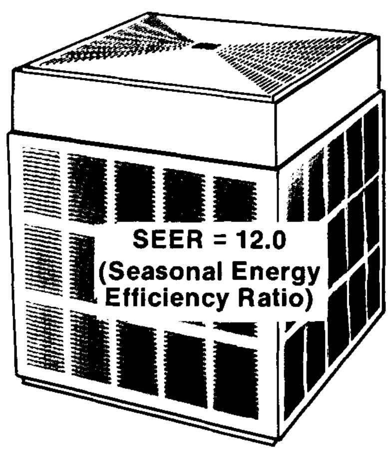
Ceiling fans increase comfort by making people feel cooler. They can be effective when ventilating or air conditioning. If you do not install ceiling fans in all the major rooms, at least consider pre-wiring rooms for them. Making it easier for home owners to add fans at a later time is a strong selling point in marketing your houses. Point out to prospective buyers that they should be able to install their own ceiling fans fairly easily, but that putting in the wiring after the house is built can be tricky and, if done by an electrician, expensive.

Selecting and Installing Comfort Conditioning Equipment

1. Select efficient air conditioners

While all the energy-conserving strategies discussed in this book affect both comfort and electricity consumption, selection of an efficient air conditioner with the right characteristics is the number one factor in reducing cooling bills.

Air conditioners are rated by their Seasonal Energy Efficiency Ratio (SEER). The higher the SEER rating of the unit, the greater the efficiency. A minimum SEER of 10.0 for central air conditioners is required by the National Appliance Efficiency Standard which went into effect in January of 1992. A unit rated at SEER 12, for example (the minimum we recommend for today's Florida homes), will be 20% more efficient than one rated at SEER 10.



Choose efficient air conditioners that have SEERs of 12 or greater.

You can obtain a copy of the latest ratings of energy-efficient cooling and heating equipment from the Air-Conditioning Refrigeration Institute (see "For further information" at the end of this chapter).

Keep in mind that the SEER rating tells you nothing about the unit's dehumidification ability. This is expressed by its sensible heat fraction (SHF); **the lower the SHF, the better the dehumidification ability**. The suggested maximum SHF is 0.80. Units with a higher rating may not adequately dehumidify some Florida homes, allowing mildew to grow and causing physical discomfort. Some air conditioners with high SEERs have high SHFs, so there is a trade-off between cooling efficiency and dehumidification. Compare manufacturers' engineering data to determine the SHF. Make sure to check the data for the combination of compressor *and evaporator* unit you will be using. The air flow rate is also important. Faster flow rates reduce air conditioner run times but also increase the SHF. Multispeed blowers are a good solution (see Section 5 of this chapter). **In general, search for units with an SEER of 12 or greater and SHF less than 0.80.**

Key Concepts for Heating/Cooling Systems

SEER - Seasonal Energy Efficiency Ratio - The seasonal weighted performance of an air conditioner based on the cooling accomplished (in Btu's of energy) divided by the electricity consumed (in kW).

$$SEER = \frac{\text{Btu cooling provided}}{\text{kW consumed}}$$

SHF - Sensible Heat Fraction is the fraction of a given cooling system's total capacity that is being used to remove sensible heat. One minus the SHF is the fraction that is used to remove moisture (latent heat).

CFM - Cubic Feet per Minute - This abbreviation is used to describe the rate of air flow for a given system.

COP - The Coefficient of Performance gives the energy output/energy input ratio for a given system at a given operating point.

HSPF - Heating Season Performance Factor - Rating used to describe the seasonal performance of heat pump heating systems.

AFUE - Annual Fuel Utilization Efficiency - Rating used to describe the efficiencies of gas units.

There are computer programs and calculations that can help you decide on the best combination of SEER and SHF for the home you are building. Check with your local utility company or air-conditioning suppliers for assistance in selecting programs and sizing guidelines.

Multispeed compressors. Some manufacturers have released air-conditioning units with two-speed or multispeed compressors. Depending on the operating conditions, a two-speed unit will run in either an efficient low-speed mode or a more powerful high-speed mode. A multispeed or variable-speed unit will change to any one of a number of speeds based on the operating conditions. These units can be sized to meet a peak party load without sacrificing energy savings and moisture removal during most of the cooling season. The overall efficiency of these units can be compared by their SEER rating. Using multispeed blowers with multispeed compressors will provide significant flexibility.

Sensible Heat Fraction (SHF) — To determine an air conditioner's dehumidification ability you have to find the sensible heat fraction for the compressor, evaporator and air flow rate you expect to use. Ask your dealer for the *manufacturer's engineering data.* Some manufacturers give the SHF value (which is always between 0 and 1) as shown below (0.71). Others give the sensible capacity as shown at right. Divide the sensible capacity at standard conditions (95 outdoor dry bulb, 67 indoor wet bulb, 80 indoor dry bulb) by the total capacity. For the example at right the SHF is 17.3/22.8 = 0.76. The lower the SHF, the more moisture the air conditioner will remove.

Compressor unit, evaporator unit, CFM rating

O.D. D.B.	I.D. W.B.	TOTAL CAP.	SENS. CAP. AT ENTERING D.B. TEMP. 72	76	80
85	59	20.9	18.1	21.1	22.1
	63	22.5	14.9	18.1	21.3
	67	24.1	11.4	14.6	17.8
	71	25.8	7.8	11.1	14.3
95	59	19.7	17.6	20.1	21.1
	63	21.2	14.4	17.6	20.8
	67	22.8	10.9	14.1	17.3
	71	24.4	7.4	10.6	13.8
105	59	18.4	17.0	19.0	19.9
	63	19.8	13.8	17.0	19.9
	67	21.3	10.3	13.6	16.8
	71	22.8	6.8	10.0	13.2

Compressor unit, evaporator unit

Enter. Wet Bulb (°F)	Total Air Vol. (cfm)	Outdoor Air Temperature Entering Condenser Coil (°F): 85 — Total Cool Cap. (Btuh)	Comp. Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb (°F) 76	80	84	95 — Total Cool Cap. (Btuh)	Comp. Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb (°F) 76	80	84	105 — Total Cool Cap. (Btuh)	Comp. Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb (°F) 76	80	84
63	1000	36,300	2850	.70	.80	.90	34,000	3000	.72	.83	.93	31,800	3160	.74	.85	.96
	1250	37,900	2890	.75	.86	.97	35,400	3050	.77	.89	1.00	33,200	3210	.80	.93	1.00
	1500	39,100	2920	.79	.92	1.00	36,400	3080	.82	.95	1.00	34,400	3260	.85	.99	1.00
67	1000	39,300	2930	.55	.65	.74	36,800	3090	.56	.66	.76	34,400	3260	.58	.68	.79
	1250	40,600	2970	.58	.69	.80	38,000	3140	.60	.71	.83	35,500	3300	.61	.74	.86
	1500	41,600	3000	.61	.73	.85	38,900	3160	.63	.76	.89	36,300	3330	.64	.79	.92
71	1000	42,200	3010	.42	.51	.60	39,700	3190	.43	.52	.61	37,200	3360	.43	.53	.63
	1250	43,700	3050	.43	.54	.64	40,900	3230	.44	.55	.66	30,300	3400	.45	.56	.68
	1500	44,600	3080	.45	.56	.68	41,800	3250	.45	.58	.70	39,000	3430	.46	.60	.73

Basic Air Conditioning System Components and Terms

ADS - Air Distribution System- All indoor components of a heating/cooling system including the air handler, plenums, and supply and return ducts.

AIR HANDLER - Indoor component of a heating/cooling system comprised of a rectangular metal enclosure which houses the blower, evaporator, and in many cases a heater.

BLOWER - Fan mounted within the air handler used to drive air across the evaporator and through the air distribution system.

COMPRESSOR - Central outdoor component of a cooling system used to compress and drive refrigerant through the system.

CONDENSER - Heat exchanger which condenses hot, gaseous refrigerant, typically transferring the heat to the surrounding air.

DUCT - A passageway through which air moves, typically made of metal, fiberglass board with sheathing, or flexible tubing.

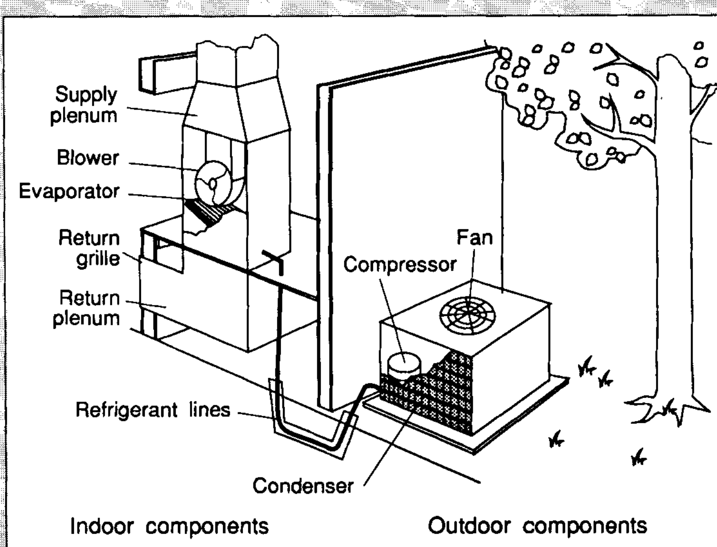
EVAPORATOR - Heat exchanger which vaporizes cold liquid refrigerant, typically absorbing heat from the surrounding air.

PLENUM - Enclosure on either side of the air handler through which air moves. Supply plenums are areas in which air is deposited before entering the supply ducts; return plenums are areas in which air is collected before entering the air handler.

RETURN AIR - House air drawn back to the air handler to be conditioned. The air is drawn either through open areas of the house (i.e. hallways) or through separate return ducts.

SUPPLY AIR - Conditioned air distributed throughout the house through supply ducts.

TONNAGE - Measure of the amount of cooling an air conditioner or heat pump is capable of; 1 ton = 12,000 Btu per hour.

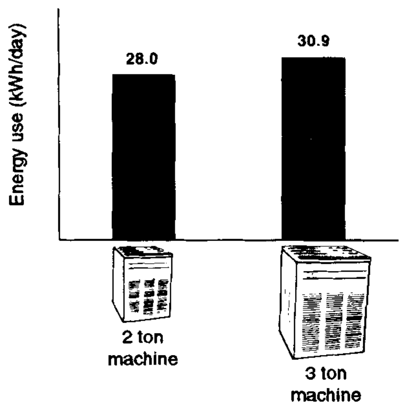


Air conditioning system components (heat pump in cooling mode).

2. Properly size the air conditioner

Accurate sizing is an important part of obtaining the most energy-efficient air conditioner. Systems should be sized to meet peak heating and cooling requirements. Peak heating generally is needed during early morning hours in winter; peak cooling is needed during the afternoon in summer.

Air conditioners are sized by the "ton." One ton is equal to 12,000 Btu of cooling per hour. When choosing the systems for your houses, keep in mind that bigger is not necessarily better. In fact, oversizing a residential air conditioner by 50% has been estimated to cause a 10% increase in energy use.



Source: FSEC analysis, unpublished, 1990

50% oversizing of a residential air conditioning system causes 10% increase in energy consumption

In the past, many builders have relied on general rules-of-thumb in sizing systems. Some builders have roughly estimated the needed size, then installed a slightly larger unit to make sure it was adequate. But as houses become more energy-efficient, with less air infiltration and more energy-conserving features, these old guidelines grow obsolete.

Air conditioning sizing should never be based merely on an estimate. Sizing methods are available from professional organizations such as ASHRAE and the Air Conditioning Contractors of American (ACCA). The most popular method is the ACCA's "Manual J" load calculation (required by FHA and VA). All these methods find home cooling and heating loads based on the area, orientation, and insulation of walls, windows, and doors and the area and type of ceiling and floor. They also account for load due to infiltration, people, and appliances. Many utilities will assist you in making the calculations.

System Charging

Air conditioner efficiencies are greatly affected by the state of refrigerant charge. A system that is undercharged by 10% may have a drop in efficiency of 20%. Over-charging can lead to refrigerant and oil flooding – causing over-heating of bearings and motor, and slugging or a reduced system life.

Unfortunately, system charging is not always done correctly, mainly because it can be time-consuming, taking a trained technician close to an hour. A device has recently been introduced that should lead to more accurate charging. The device, called an accumulator charger, is installed in the suction line external to the condensing unit and provides a visual means of charging systems. Results from field tests in Texas indicated the device does keep the system properly charged, and reduces maintenance calls.

The few minutes spent calculating the numbers and sizing the air conditioner to match may result in:

- Saving hundreds of dollars on initial cost of the system and ducting.
- Better air conditioner run time resulting in better humidity control, making it unnecessary for home owners to set thermostats lower to remove moisture.

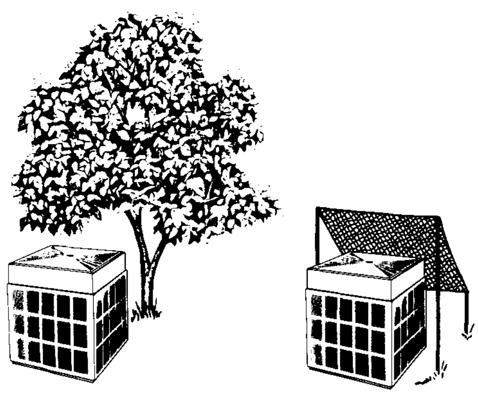
The disadvantages of not over-sizing are:

- The house will not cool down as fast when the system is first turned on.
- The unit may have trouble meeting the load for a large party held during a summer afternoon, requiring home owners to precool before the party begins.

The best compromise would be to use a multispeed blower, a multispeed compressor, or preferably both (see sections 1 and 5).

3. Shade the compressor/ condensing unit

Shading the compressor unit helps keep the condensing coil inside cooler and running more efficiently. One way to shade the unit is to install it on the north side of the house, in an area where it will receive little direct solar radiation in the summer. Avoid unshaded locations on the west side of the house because the sun will strike the unit when it needs to work the most in the late afternoon and evening. The condensor can also be effectively shaded with a shade tree, but be sure not to block airflow to and from the unit. Another shading method is to use a screen similar to the sun screens used for windows. Support the screen as shown below.



A tree or screen can be used to shade the compressor.

4. Choose the best heating system

Even though cooling is a greater concern of Florida home owners, annual heating costs still account for 18% of the total energy used to condition homes. The most common heating systems in Florida are electric strip, natural gas, oil and heat pumps.

Electric resistance or strip heat. First used in the state because of its low initial cost, electric resistance heating is more expensive to operate than alternative systems. It has a Coefficient of Performance (COP) of 1.0. The more efficient heat pumps, by comparison, typically have a COP of 2.0 to 3.5. Although most new homes with this type of heating use an air handler equipped with an electric resistance heater, baseboard heaters located in each room of the house are preferred. They offer the benefits of zoning and no duct losses.

Natural gas furnaces. Generally costing only one-third as much to operate as electric resistance heating, these systems offer benefits to home owners throughout the state. Gas units will cost about as much to operate as heat pumps, but offer two distinct advantages over heat pumps:

- Their efficiency does not decrease with colder weather.
- They have reduced maintenance costs (heat pumps require proper charging).

Look for sealed combustion systems which draw combustion air directly from and exhaust flue gases directly to the outdoors. These units are generally more efficient than non-sealed units and greatly reduce the possibility of dangerous combustion gases getting into the house through back-drafting or leaks.

Recent technological developments have resulted in substantial increases in furnace efficiency. The AFUE (Annual Fuel Utilization Efficiency) rating can be used to compare the efficiency of different models. Typical AFUE ratings for presently available furnaces and boilers are 0.78 to 0.85, meaning that 78 to 85% of the combustion heat is used effectively. The most efficient units achieve ratings of 0.90 or higher. Condensing furnaces that have an AFUE rating of 0.90 or greater need no chimney. Plastic pipe is adequate, thereby reducing the net cost of a high-efficiency unit. Typical annual heating bills for gas furnaces are shown below.

Annual Cost of Gas Heating*

AREA	AFUE	
	0.80	0.93
North Florida	$117	$102
Central Florida	83	72
South Florida	25	22

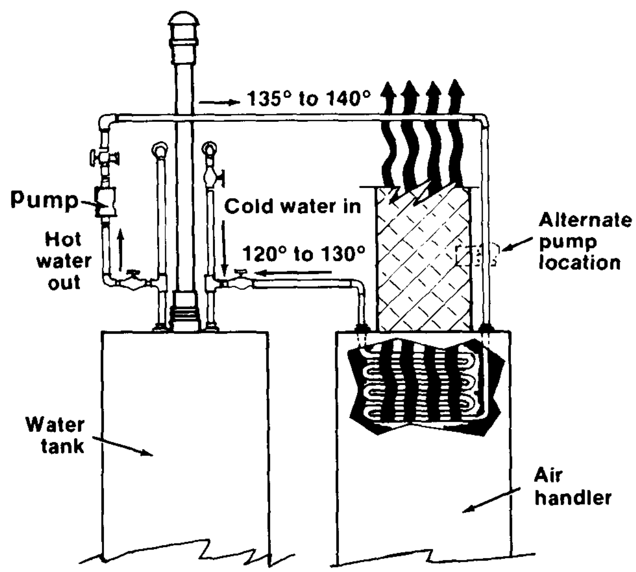
* Gas priced at $0.60/therm.
Table source: City of Tallahassee Energy Services.

Highly efficient units cost only a few hundred dollars more than standard systems, and can repay the investment where heating requirements are significant. **Choose a system with electronic ignition to eliminate the need for a pilot light and its continuous use of gas.**

If you decide on natural gas, also consider using it for heating water, cooking, drying clothes, and fueling a barbecue grill.

Hydronic gas systems. An excellent method of providing gas space heating is the use of a hydronic forced-air gas system. The system takes water heated by a gas water heater and circulates it through a coil in the air handler. It offers the following advantages over a conventional gas furnace:

- There is only one source of combustion.
- The air handler can be located in the conditioned space.
- There is less heat loss.



Forced-air hydronic systems use hot water to supply heat.

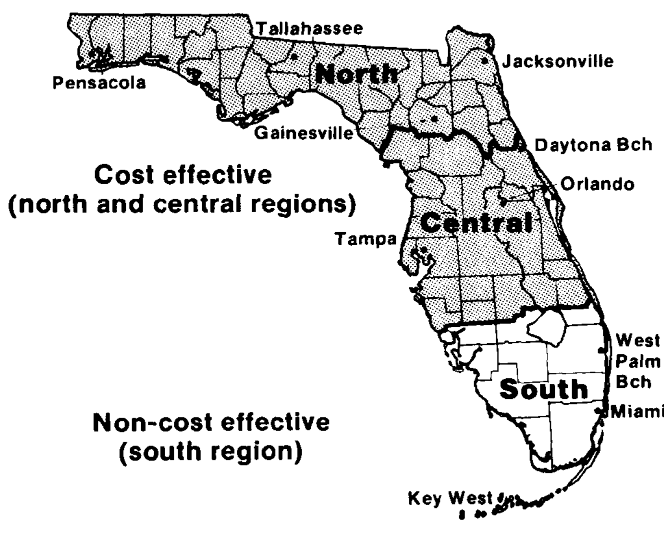
A number of manufacturers of these systems offer matched components (air handler and water heater). Consult with a gas utility representative or a dealer for sizing guidelines.

LP or propane. With propane systems you get the benefits of gas heating where natural gas is not available. Propane gas is readily available and is recommended over electric resistance heating, but may cost more to operate than a heat pump.

Oil heat. Oil furnaces were installed in many Florida homes 15 to 30 years ago. They are rarely used these days. Fuel oil prices fluctuate more than other heat sources. During times of oil surplus (the 1980s), oil heating can be the least expensive form of heating. If you do install an oil heater, you need an above-ground location for the 100- to 200-gallon oil tank. Burying tanks underground is no longer recommended due to the difficulty in detecting leaks and the environmental contamination associated with leaking underground tanks.

Heat pumps. Another option growing in popularity is to combine air conditioning and heating with an electric heat pump. A heat pump is basically an air conditioner that can be run in reverse in the winter to heat by switching the use of the evaporator and condenser coils. Naturally, a heat pump will cost more than an air conditioner alone so its cost effectiveness is dependent on the amount of heating required in the winter. A heat pump is generally an energy efficient choice in central and northern Florida, especially if it is to be used in the place of electric resistance heating.

The efficiency of a heat pump is measured by a units Heating Season Performance Factor (HSPF). Heat pump HSPFs generally average 7.0 to 9.0. An HSPF of 9.4 or higher is possible.



In North and Central Florida heat pumps are a cost-effective choice for electric space heating.

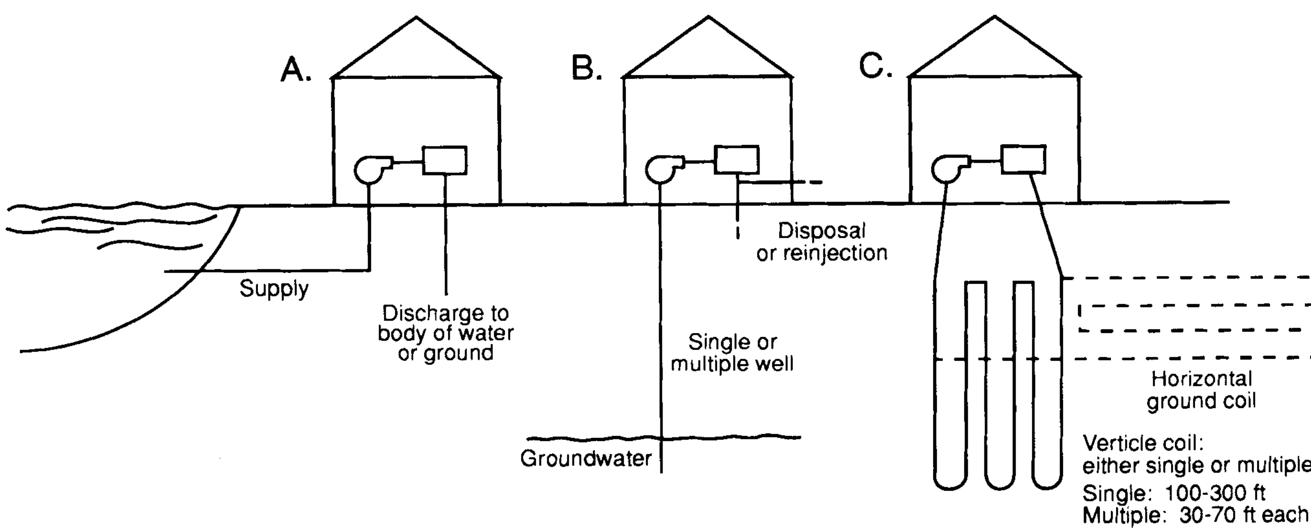
There are two main types of heat pumps, air-to-air and ground-source. Both operate on the same principle but use different cooling and heating sources.

By far the most widely used, the air-to-air heat pump uses outside air flowing across the outdoor coil as its heating and cooling source. As a result, the capacity of the system is dependent on the outdoor air temperature. In the winter, as the outdoor temperatures decrease, the system capacity and energy efficiency decrease as well. At some point the system is not able to deliver enough heat to maintain home comfort and an auxiliary heat source such as an electric strip must be used in conjunction with the heat pump.

A ground-source heat pump is either directly or indirectly connected to the ground and/or water table which the system uses to exchange heat. These systems benefit from the fact that Florida's ground water temperatures stay fairly constant throughout the year, mostly eliminating the problem of decreased performance during outdoor air temperature extremes. Cost effectiveness of the ground-source systems is dependent on many factors including location, soil type, water table height, and type of system chosen.

The figure below shows the types of ground-source heat pumps available today. The open-loop system circulates water from either a body of water or the water table, discharging it back to its source or other point. Water disposal is strictly regulated however, so the appropriate authorities must be contacted before installing this type of system. A closed-loop heat pump circulates a working fluid through long buried pipe using the earth as a heat source and heat sink. The pipe can be buried either horizontally or vertically. Using a closed loop eliminates the need for supply water and water discharge.

One problem sometimes encountered by heat pump owners is discomfort from semi-warm air (80^{o}-90^{o}F) blowing out of the ducts (oil or gas furnaces generate much hotter air). This inadequacy can be partly remedied by having well-insulated, well-sealed ductwork so that the air does not cool down en route from the air handler to the room. The cooling effect can also be reduced by using a multispeed blower set at a low speed (see next section) and installing diffusers at the grilles to control the direction of the air flow.



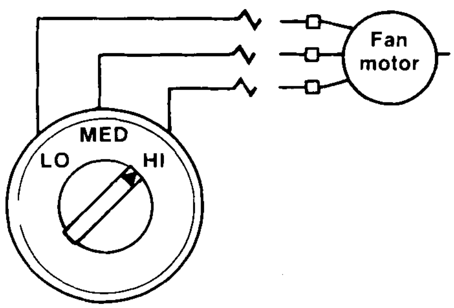
Three types of available ground-source heat pumps:

A. Surface water B. Ground water — Open-loop

C. Ground coupled — Closed-loop

5. Use a multispeed blower

Select an air handler unit with a multispeed blower and connect it in a manner that permits the home owner to change its speed. The unit will perform most efficiently if the blower is on high speed, but will remove more moisture from the air on a lower speed. This mode can be used during humid nights or to remove moisture from typically wet areas such as a room with a jacuzzi or a large number of plants. Any qualified HVAC installer or electrician should be able to install a simple switch the home owner can control. At least one manufacturer offers a blower hooked up to a humidistat to perform this function automatically.



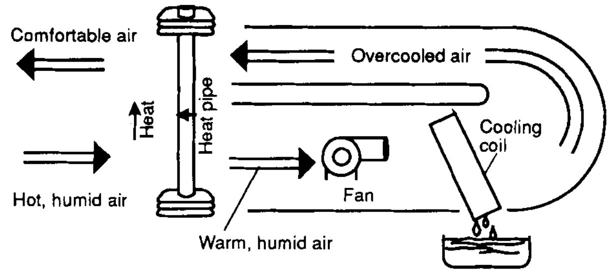
Use multispeed blowers that home owners can control with a switch.

One alternative to a multispeed blower for removing moisture is a heat pipe (offered by at least one air conditioning manufacturer). The heat pipe performs the function of a heat exchanger, precooling return air with cool supply air. The compressor thus uses more of its cooling capability to dehumidify. Remember though, a heat pipe should only be considered where higher than usual moisture loads are anticipated. Even though heat pipes are very efficient, their use will increase energy consumption.

Discourage the home buyer's use of a separate dehumidifier for humidity control. Unless custom built to expel the compressor heat outdoors, dehumidifiers introduce heat into the house which must be removed by the air conditioner, causing extra power usage.

6. Locate air handler and duct system in conditioned space

Florida home designs usually show space for the air handler and ducts in unconditioned space. But because duct systems tend to leak air, they can be a major source of infiltration and energy loss and should be installed in conditioned areas instead. Especially try to avoid attic and crawl space locations for the air handler because service and maintenance is difficult in these areas and any condensate problems in an attic could damage the ceiling. A **properly** installed air handler and ductwork system in conditioned areas can reduce total heating and cooling energy use by up to 25% in new homes. The main task you face is finding the needed area.

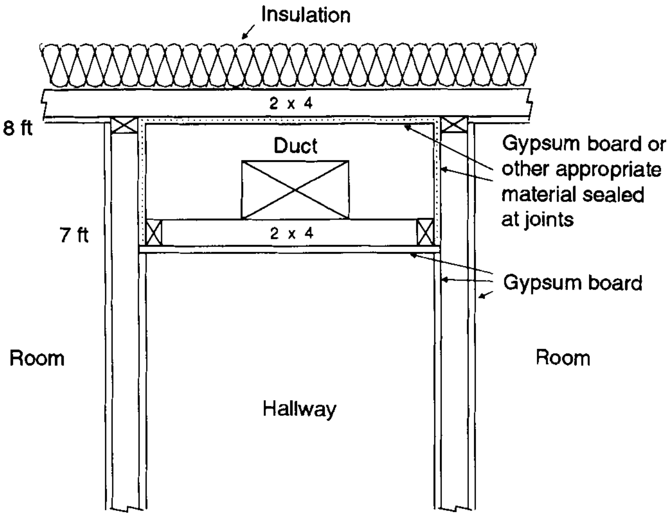


A heat pipe precools return air with overcooled supply air to provide more moisture removal.

Locating the air handler. You should design your home to locate the air handler in conditioned space. If your design has not provided this space consider using a corner of a bedroom closet adjacent to a hallway. See the house plan examples in Chapter 4 for ideas.

Locating the ducts. While aesthetics must be considered, it is still possible to locate ducts in the conditioned space. Exposed, insulated ductwork has become popular in many restaurants and some residences, but most home owners will probably prefer to conceal ductwork by covering it with drywall. Keep in mind that you will gain a significant energy code credit by locating ductwork within conditioned areas. You will still want to insulate all ducts. In some home designs, you can install ductwork above 7-foot hallways. The space above the kitchen cabinets can also be used to conceal ductwork. Ducts can be run along the perimeter of a room, or across the center of a great room with a high ceiling to suggest separate living and dining functions.

Multistory houses make it easy to place all ductwork in conditioned spaces by using well-sealed ductwork between floors. You can eliminate the duct in the attic and use grilles in the floor or wall spaces to supply air to the

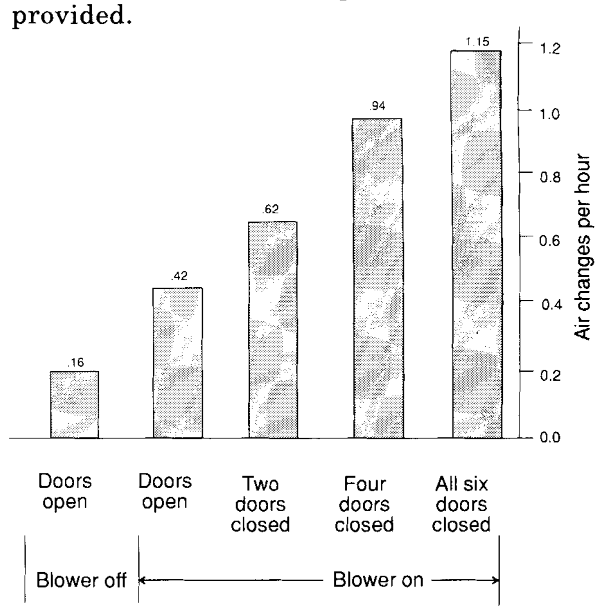


Isolate ductwork from unconditioned space with a continuous air and heat barrier.

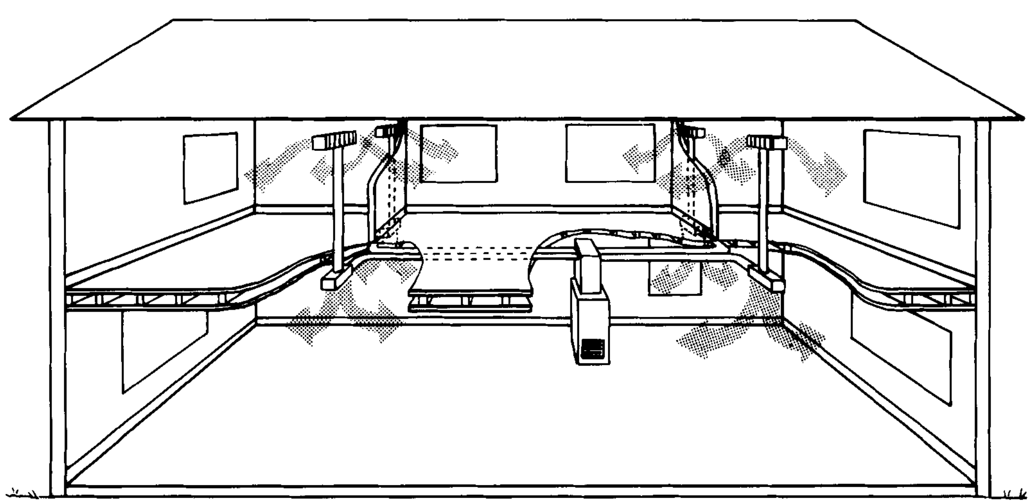
second floor. Typically, about half of the total duct length will be eliminated, saving on installation costs.

Still, the best solution from an energy standpoint is to use "exposed" ducts in conditioned space, which guarantees that any losses go to conditioned areas. Ducts installed in conditioned spaces behind drywall need to be properly isolated from unconditioned areas or significant losses may result, defeating the purpose of the installation. This is especially true because once the drywall is sealed and painted, leaks may go unnoticed and be difficult and expensive to repair (see Section 7 on sealing the duct system).

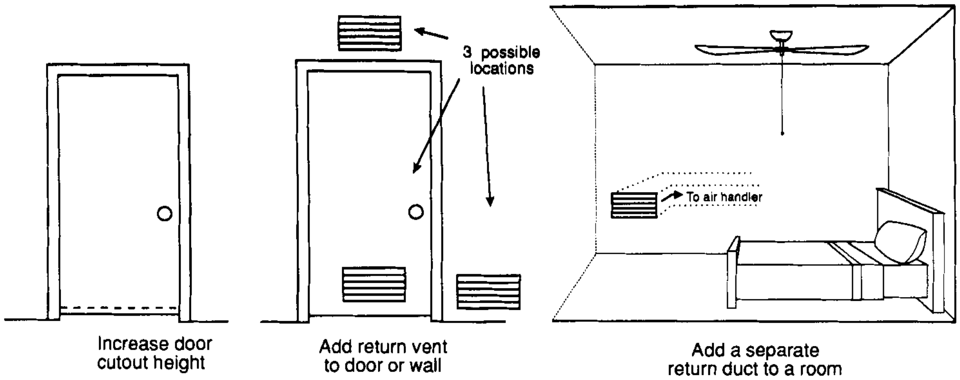
Providing a return system. A properly designed duct system will also include provisions to assure ample return air. Many builders use a "free air return system" in which the rooms and hallways of the house serve as the return duct. Not having to use a separate return duct gives an immediate savings during construction and is preferred to extra returns in which ducts run through attic space. Oftentimes, however, adequate provisions for the return air are not made. The following graph shows the significant increase in infiltration (the unintentional movement of outdoor air into the house) that closing interior doors can cause if an ample return is not provided.



Closing interior doors can significantly increase air infiltration.



Place ducts between floors in two-story homes.



Provide adequate air return capacity for when doors are closed.

Infiltration is increased because air supplied to rooms cannot easily return so it exits though cracks in windows, walls, floors and ceilings. At the same time, the room containing the return is not receiving air from the other rooms so it pulls air in from the attic or outdoors. There can be a significant energy penalty because of this infiltration. Adequate return air can be provided in a number of ways:

- Door cutaway heights can be increased.
- Grilles can be put in the door or a wall of the room.
- A separate return can be installed in rooms in which the door is often kept closed (i.e., a master suite) if grilles to a common area or hallway are not desired.

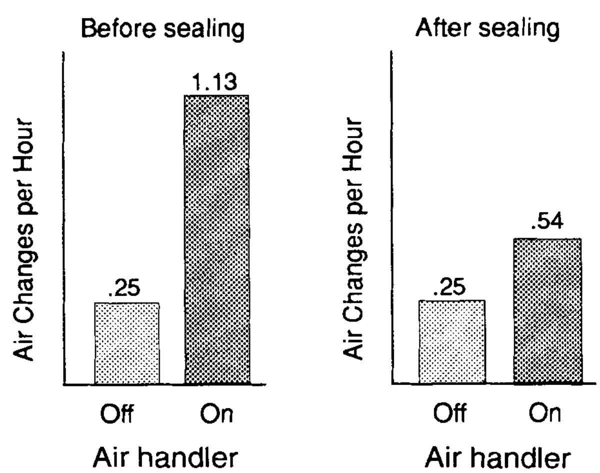
No matter which solution is chosen, it is important that the work is properly sealed (see next section).

If a door cutaway, door grille or wall grille is used, the area of the air passageway should be at least two times the total supply duct area. If a separate return duct is used, its area should be at least the same as that of the supply duct terminating in the room.

Finally, note that return plenum pressures are also influenced by the size of the grille and filter used in them. If the grille/filter area is too small, higher plenum pressures will result causing increased losses through any leaks, so the grille and filter should be oversized whenever possible.

7. Install and seal the air handler and duct system properly

Proper duct system installation and sealing can greatly reduce energy use. As mentioned earlier, duct system losses account for about 25% of heating and cooling loads in Florida homes. This is because although air handler and duct system leak area is usually a small part of the total leak area of a house (estimated to be 10-15%), pressures are much greater in these systems. As a result, the leaks greatly increase house infiltration, commonly by as much as 100 to over 400%. The graph below shows the results of a study done on 25 homes to find the effects of duct system leaks on house infiltration.



Sealing the duct system can dramatically decrease house infiltration.

Types of ducts. Three basic types of ducts are used in Florida homes: rigid fiberglass ductboard, round metal duct, and flexible plastic duct. Each offers different benefits.

Fiberglass ductboard produces a relatively quiet system than can have very low air leakage if correctly sealed. However, it costs more than the other types of ducting, and a high degree of skill is needed to properly install it, especially in making the L-shaped turns to decrease pressure losses. Labor costs can be reduced by using machine-fabricated segments.

The smoothness of round metal ductwork minimizes air pressure loss and allows the use of smaller diameter duct. Because the surface is galvanized and zinc-coated, mildew or fungus cannot grow inside. It is important that the joints be tightly sealed during installation to prevent leaks. This type of system is more expensive to install than flexible plastic duct.

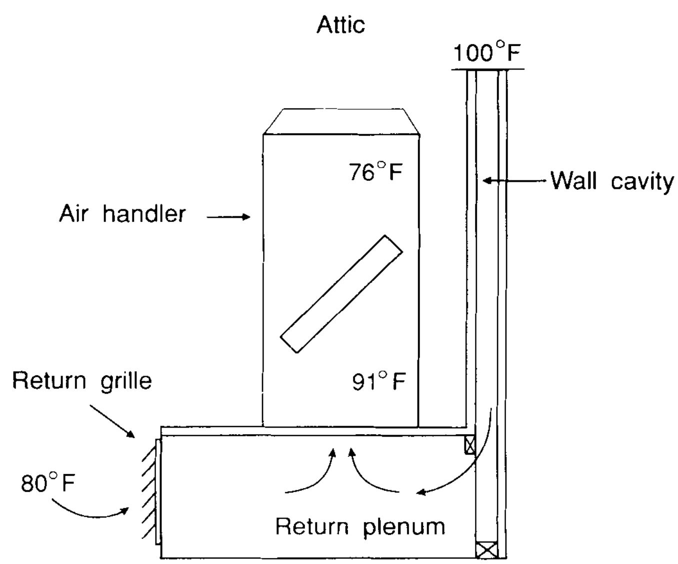
Commonly called flex-duct, flexible plastic duct is pre-constructed with two thin plastic sleeves separated by fiberglass insulation. It can be made fairly airtight if care is taken to overcome its tendency to leak at joints. The material is susceptible to damage from inadequate support, abrasion, and ozone generated by the air-handler fan motor. However, its low cost and ease of installation have made it popular with many builders.

Because ducts carry all of the air-conditioned and heated air through the house but have fairly low R-values, you may wish to add more insulation to whichever system you choose. Insulation wraps are available for metal ducts, higher-insulation ductboard can be used if the fiberglass type is selected, and a mound of blown insulation can cover any type of rigid duct which is supported near the attic floor.

It shows that sealing the ducts caused a 52% reduction in house infiltration when the air handler was on. This reduction corresponded to an 18% cooling energy savings.

In order for duct systems to work efficiently, it is necessary to achieve a continuous air barrier – an uninterrupted partition between air in the duct and the air surrounding it. Almost all commonly used duct materials are themselves effective air barriers. The problem is that because of seams, connections and terminations, the whole system is not usually continuous. Making a system continuous requires a good understanding of how and where duct systems leak and proper sealing methods.

Sealing the air handler/plenums. Fifty percent of all duct leakage is through the return plenum. Although having the air handler in conditioned space can help reduce plenum leaks, it does not guarantee a leak-free return system. In actual test cases of indoor mounted air handlers, return air leaks were found to be causing reductions in air conditioner capacity of up to 75%. In many cases, the leaks caused much of the return air to be pulled in from the attic or outdoors.

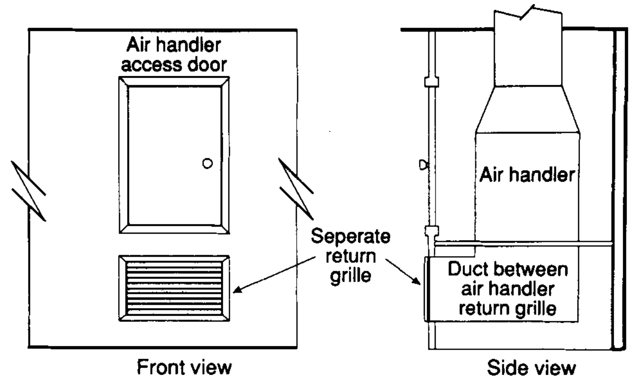


A common problem: The air conditioner must cool 91°F air instead of 80°F air because of leaks from the attic.

In one house, leaks from the attic were so severe that the air conditioner was not able to cool the house during daytime hours.

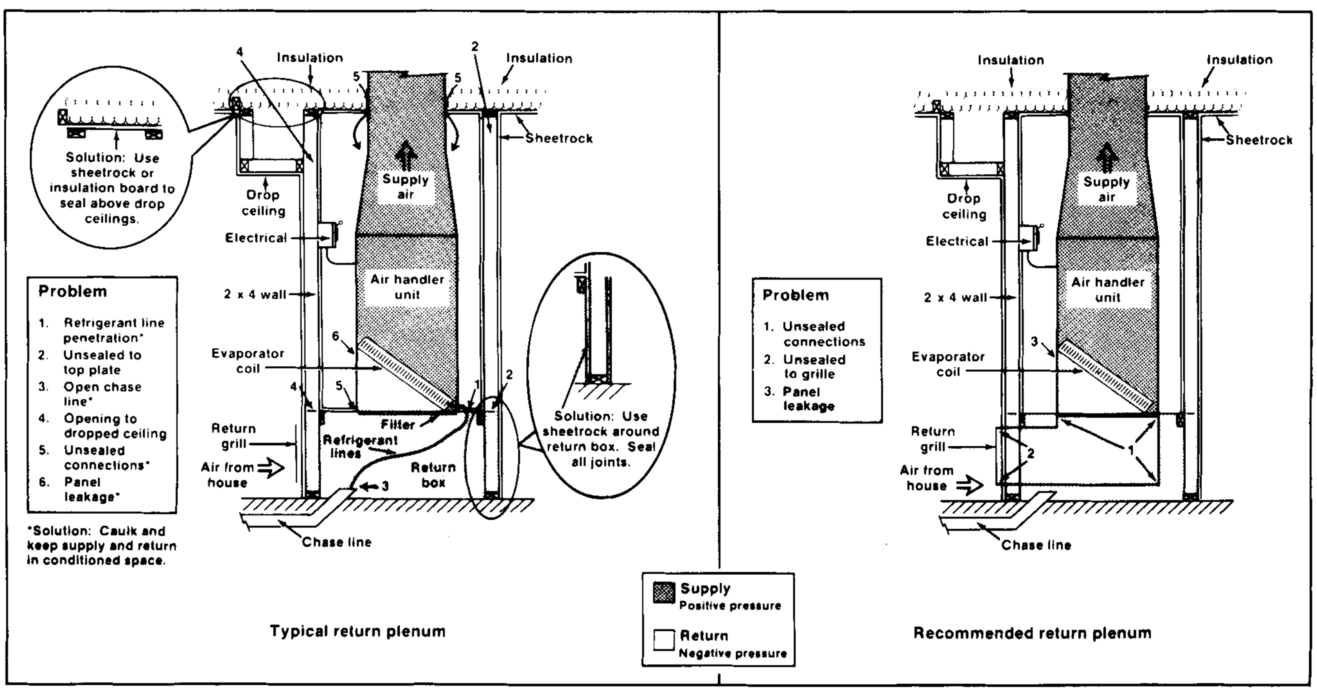
The figure below shows common air handler system leak sites. It is important to consider all these potential sites and prevent any leaks through them. Return boxes or platforms especially tend to be a major source of leaks because appearance is not important in them and so in many cases they are not fully finished and sealed. To eliminate these leaks, use sealed ducts between the grille and air handler instead. The location of the air filter can also affect return leaks. If, for example, a dirty filter is located at the grille, air flow through the return grill will be restricted and pressure inside the duct to the air handler will increase, causing increased air flow through any leaks.

A louvered door return system in which the whole air handler closet is used as the return is not recommended. Because of the large closet area involved with this type of return, there is also a large potential for leakage. Use a cut solid door for air handler access with a separate sealed return duct to the air handler.



Use a solid door for air handler access and a separate sealed return duct from the air handler to a grille below.

Sealing the duct system. No matter if the ducts are located in conditioned or unconditioned space, it is important to properly seal them. Duct leaks are most common at connections with plenums, junction boxes, boots, and registers.



Typical leakage points in air handler systems.
(Based on illustration by Natural Florida Retrofit, Inc.)

Combustion Safety and Air Quality

In order to properly install an air handler and ductwork, it is important to first of all understand all the possible impacts the equipment and its installation may have. The use of an air handler and duct system will affect house pressures, infiltration, and air quality. Duct systems work at high pressure (10 to 100 pascals) compared with pressures a house normally experiences (averaging less than 1 pascal) from wind or thermal stack. If these systems are not designed and sealed properly they can pressurize or depressurize rooms and leak, possibly causing:

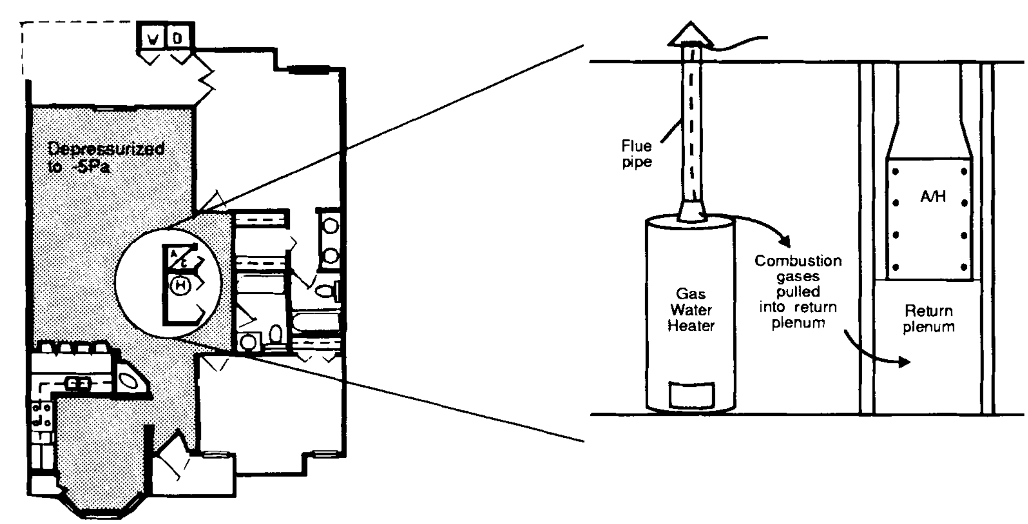
1) Backdrafting and flame-roll-out in combustion appliances if depressurization goes below -3 pascals and -12.5 pascals respectively. Backdrafting can lead to lethal levels of carbon monoxide and flame roll out can cause house fires.
2) Reduced air quality because of pollutants such as insulation from the attic or harmful vapors from chemicals stored in the garage being pulled into the air distribution system.

For example, closing interior doors in a house with insufficient return capacity may depressurize a room in which a gas water heater is located, causing the heater to backdraft and leak carbon monoxide into the house. Also note that use of an exhaust fan (clothes dryer, kitchen or bath fan, etc.) when the air handler is on can further depressurize rooms in which they are used, possibly increasing the effects listed above.

Understanding house systems interaction is the key to preventing the potential problems listed above. Achieving this understanding requires training and the proper use of diagnostic equipment, which is highly recommended but beyond the scope of this manual. In general, try to follow these guidelines:

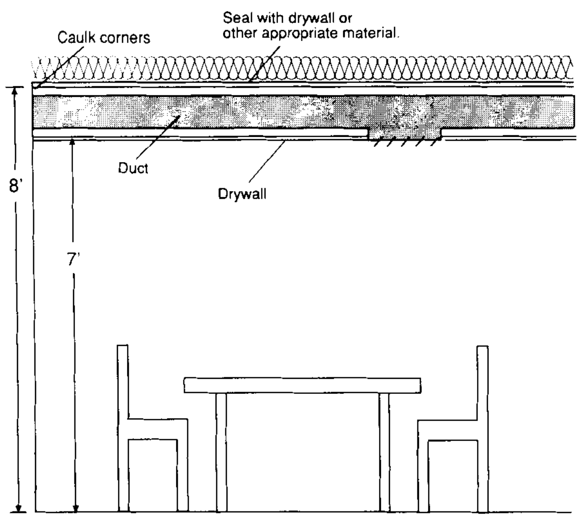
- Assure a continuous air barrier on return and supply ducts using non-toxic sealing materials.
- Allow for adequate return air flow in the house - even when interior doors are closed.
- Provide a storage area for toxic household products away from the air handler, preferably outside of the house.
- When selecting combustion appliances, choose units with sealed air intake and exhaust and install vents properly.

Research findings and instruction on duct system diagnostics are available through a Florida Solar Energy Center training program entitled "Duct Doctoring" (see "For Further Information" at the end of this chapter).



Closing bedroom and bathroom doors with the air handler on may depressurize the main body of the house, and subsequently cause backdrafting of the gas water heater.

Be sure to seal each joint and any other area you are not certain is airtight. Also, if ducts are located in conditioned space behind drywall, it is important that this space is completely sealed. Especially be sure to seal above 7-ft drop ceilings at the 8-ft level to preclude losses to the attic or outdoors through leaks between wall cavities or joists. For the same reason, seal along the edges and in the corners of any wall or floor cavities that ducts are run through. Seal all duct joints before the insulation materials are applied.



Seal and insulate well at the 8 ft. level above ducts in conditioned space.

Proper sealing materials. Fabric imbedded mastic, not duct tape, is recommended for all sealing. Mastic is preferred because of its mechanical strength and ability to fill gaps and retain its adhesion to surfaces. Although high quality tape can be an effective sealant if applied properly, its long term durability is questionable; experience has shown that tape seals fail much more frequently than fabric and mastic seals.

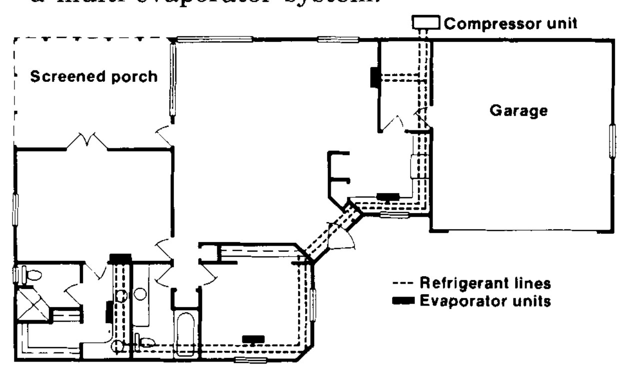
Note that the fiberglass in ductboard is not an air barrier and should not be used in making seals. Always seal to the foil liner when using this material.

8. Create separate zones

Home owners can save on air-conditioning and heating costs by only cooling or heating part of the house at any given time. To accomplish this, part of the home must be separated from the rest with a door or doors that close tightly. In some designs, you may want to consider providing one area that is naturally ventilated, instead of air conditioned, and heated only by a local space heater. The rest of the home can be conventionally cooled and heated and used as a retreat during the times of year when temperatures reach extremes.

Usually, however, home owners will want the option of air conditioning the entire house. To achieve the energy saving advantages of zoning, one of the following is then required:

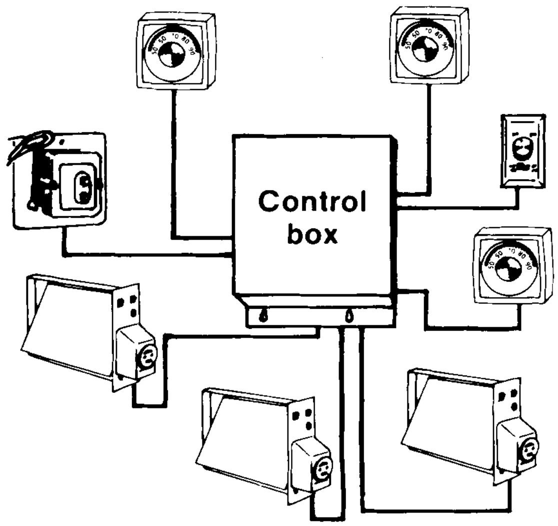
- more than one heating/cooling system
- a multizone control system
- a manually controlled damper
- a multi-evaporator system.



A multi-evaporator system sends refrigerant to individual room conditioning units, eliminating ductwork.

When using separate systems, one is usually chosen for the living, dining, kitchen and den areas and another for the bedrooms. In split floor plans, the master bedroom suite may be combined with the living areas and the other bedrooms can be conditioned by a separate system. With separate systems it should be easier to keep duct runs short and to place the ducts in conditioned space. Accurately size the units for each zone. Typically, a rather small (1 1/4- to 1 1/2-ton) air conditioner or heat pump can be used for the bedroom zone. For some zones, available central systems may not be small enough, so room units may be more appropriate.

Another alternative is to use one system but control the airflow to different parts of the house at different times, either manually or through a thermostat in each zone. A typical system consists of a unit with one compressor and dampers (a multizone control system) or refrigerant valves with no duct work (a multi-evaporator system) to control conditioning in specific zones.



An automatic multizone control system has a controller, plus thermostats and dampers for each zone.

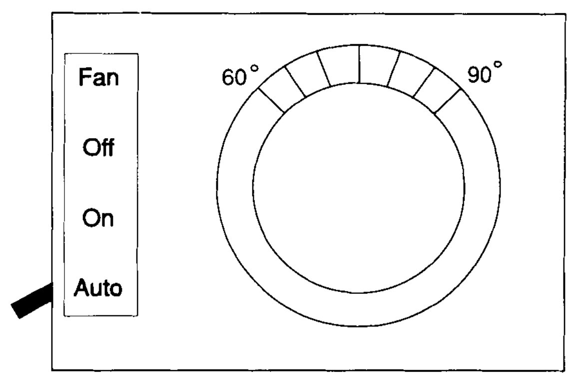
In two-story homes with ductwork placed between floors, a single system can be easy to control and less expensive than two separate heating/cooling systems. It can also be a solution to the distribution problem of rising hot air keeping the upstairs too hot and the downstairs too cold. Through the use of either a motorized or manual damper, the air flow can be directed upstairs in summer and downstairs in winter, or changed everyday, directed upstairs at night when people go to bed and downstairs in the morning.

A simplified method of creating some of the benefits of a multizone system is to use a hi-lo return. It makes use of the fact that hot air rises by providing two returns: one high (on a second story) and one low (first story). In summer, you seal off the high return and open the low return. The coolest air from the house will be conditioned and then redistributed. In winter, seal the low return and take warm air from the second-story through the high return. With this system, it is very important that the return ducts be in conditioned spaces.

9. Choose an appropriate thermostat and thermostat location

Install the thermostat on an interior partition wall away from direct sunlight to ensure the most accurate reading. It is also important to locate the thermostat away from fireplaces, ovens, or other home features which could affect the unit's temperature-sensing ability. Do not place it where it will receive air directly from a duct outlet, causing the unit to cycle too frequently. Install it where the home owner can easily read the numbers and make adjustments when needed.

Make sure the differential has been set according to manufacturer's recommendations, and instruct the residents to set the thermostat to "auto," not "fan on". Leaving the fan on typically increases energy use by 10% and relative humidity levels by 5-10%, decreasing comfort. With a heat pump, a two-stage thermostat is required by the Florida energy code to control the use of the electric strip element. Otherwise, the electric strip may run too often, reducing the overall efficiency of the system.



Setting thermostats to "auto" instead of "fan on" will save energy and increase comfort.

The two main types of thermostats used to control home cooling and heating today are the conventional, bimetallic thermostat and the electronic or programmable thermostat.

The conventional thermostat utilizes a bimetallic element which rotates as the air temperature changes, opening and closing a mercury switch. An anticipator is commonly used with conventional thermostats. It consists of a resistive heating element which artificially causes the air conditioner to start sooner than it otherwise would. As a result, temperature swings are decreased and comfort is improved, but at the price of decreased overall air conditioner efficiency due to an increased cycling rate.

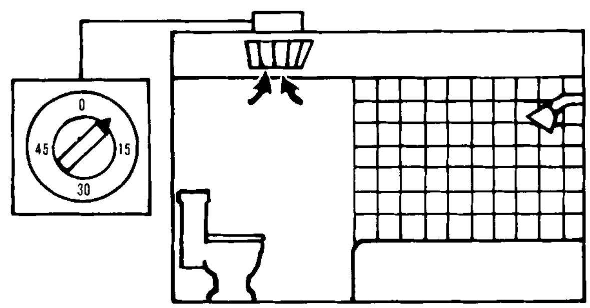
A programmable or electronic thermostat uses electronic logic to activate a relay when temperatures go above or below given setpoints. One of the main benefits of a programmable thermostat is that it can be programmed to cool or heat the house to given temperatures at selected times. For example, during the summer the home owner may wish to set the temperature to be 76°F at 6:30 a.m. when the occupants awaken, and then increase to 83°F at 8:00 a.m. when they leave for the day, etc. While a standard thermostat can be adjusted manually to the desired settings, its shortcomings are obvious when the residents forget to make the changes. However, many home buyers may not want to learn how to program thermostats so this device is best left as an option.

Most programmable thermostats do not have anticipators, but control system cycling using a deadband (the temperature difference between turn-on and turn-off), which should be user adjustable. Those programmable thermostats that have small deadbands (plus or minus 1°F) or contain anticipaters will provide greater comfort for occupants.

10. Use kitchen and bath exhaust fans

Fans should be installed in kitchens and bathrooms to exhaust moisture to the outdoors. For ease of use, and energy efficiency, observe the following guidelines:

- Use a timer control switch on the bathroom vent fan. After a bath or shower, the fan should continue running long enough to remove excess moisture from the bathroom and should shut off by itself. Fans left on for long periods of time will cause unwanted air infiltration and use unnecessary electricity.
- Use fans which have vent dampers so air will not infiltrate when not in use.
- Choose quiet fans that have ratings (given in most suppliers' catalogs) of 3 sones or less, so occupants are not deterred from using them.
- Install exhaust fans properly:
  - Exhaust air to the outdoors.
  - If possible, do not have bends in the exhaust duct; take it straight out of a wall or up into the attic and out the roof. Do not run flexible duct over and around trusses as a trap may form and collect condensation.
  - Do not exhaust bath or kitchen fans to the attic; moisture may accumulate, causing mold growth or damage to insulation or the ceiling.
  - Seal tightly around the exhaust duct penetration through the ceiling.



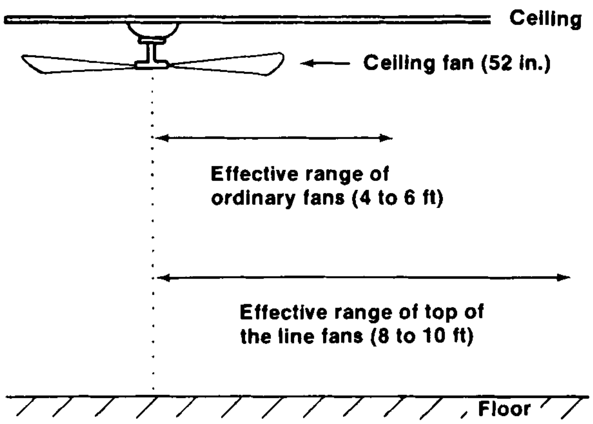
Use time controls on bath exhaust fans.

11. Install ceiling fans

In general, a ceiling fan should produce enough air movement so the occupants will be comfortable at a temperature of 82°F and 80% relative humidity. The average ceiling or portable oscillating fan will allow the home owner to raise the thermostat by about 4°F without any decrease in human comfort. This could result in significant savings, since each degree the thermostat is raised above 78°F will save about 7 to 8% on electric cooling costs.

Fans do not cool rooms; they cool people by creating air movement across the skin, so ceiling fans are most beneficial if installed in rooms where people spend the most time. Since the fans take up no floor space, they can be installed in just about any room (providing there is at least 7 feet between the fan blades and the floor for safety). As a rule, the larger the fan, the greater the air movement and also the quieter it is for a given flow rate.

Fan quality and blade size will make a difference in the comfort people feel at varying distances from the fan. Unfortunately, there are no objective tests presently used to establish standards of quality. Generally, the more expensive fans tend to be most effective. The illustration below shows the difference quality can make in the effective range of the fan.



Quality can make a difference in the effective range of ceiling fans.

As for blade size, you can figure that a top-of-the-line 52-inch fan will be effective 8 to 10 feet from the fan's center, while a smaller fan will cool people within 4 to 6 feet. In a bedroom, with the fan directly over the bed, a 36-inch fan may be adequate. In the family and living areas, consider installing a 48- to 56-inch fan, and use two if the room is longer than 18 feet.

Fan Guidelines

Largest room dimension	Minimum fan diameter
12 feet or less	36 inches
12 - 16 feet	48 inches
16 - 17.5 feet	52 inches
17.5 - 18.5 feet	56 inches
18.5 feet or more	Two fans

Research shows that using a downrod to lower the fan 8 to 10 inches from the ceiling will give much better air movement for cooling people in the room. **Fans too close to the ceiling, such as most "ceiling huggers," will not provide adequate breeze.**

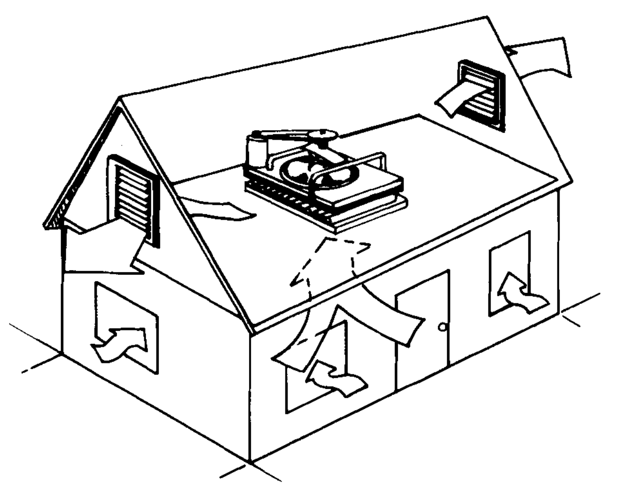
When wiring and installing ceiling fans, be especially careful to tightly seal the attic penetrations. These openings can otherwise be a major source of air infiltration.

Fans allow the home owner to save about one-fourth to one-third on cooling costs and still stay comfortable when the outside temperature rises. Fans also help to extend the "swing" seasons, those nice months in spring and fall when it's not hot enough for air conditioning but it's warm enough that the air movement feels good. Although a ceiling fan may help limit air stratification, its use in the winter may not be beneficial because of the cooling effect caused by the increase in air movement.

Ceiling fans should be controlled just as lights are. When leaving a room, shut off the fan. The fan motor consumes electricity and adds heat to the room.

12. Whole-house fans

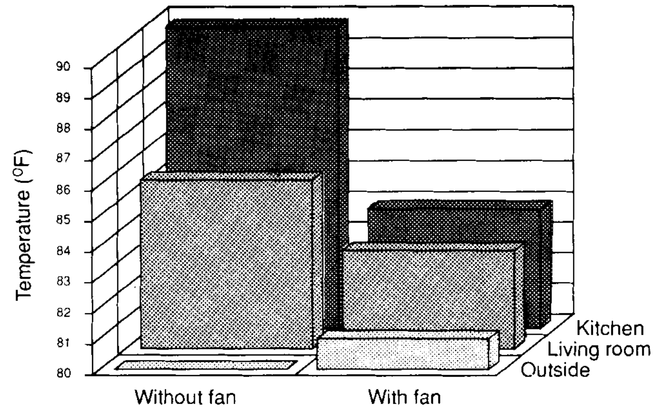
In most cases, natural ventilation alone will not take full advantage of the cooling potential of outdoor air. Whole-house fans increase natural ventilation by drawing outdoor air through the house and expelling it back outside through the attic.



Whole-house fans effectively increase natural ventilation.

They can be effective in decreasing air conditioner use by both venting heat built-up in the house structure and furnishings and causing evaporative cooling by increasing air movement (as does a ceiling fan). In addition, because the air is expelled through the attic, attic temperatures are lowered. If the outside air temperature and humidity remain low enough, a whole-house fan can be used without the air conditioner to keep the house comfortable throughout the day. Research comparing natural and whole-house fan ventilation showed use of a fan to lower room temperatures by up to 5°F.

In many cases, however, the fans are mainly used in the evening hours when outdoor temperatures are lower than indoor temperatures to augment air conditioner use during the day. Research done in Gainesville showed a whole-house fan reduced air-conditioning energy use by 22 to 44%. Note that the fans are used in the place of air-conditioning; a whole house fan and air conditioner should never be on at the same time.



Whole-house fans can keep homes cooler.

Whole-house fans can provide 20 or more air changes of the home's air per hour, or 0.33 air changes per minute. To accurately size the fan,

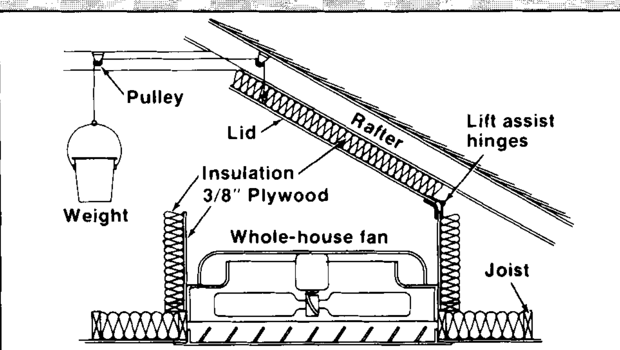
An Automatic Fan Cover

(from *Rodale's New Shelter*, June, 1984.)

In summer, a whole-house fan can cut your air-conditioning bills by as much as 20%. You can use the fan to ventilate your home with large volumes of cool night air or create a breeze on a hot, still day.

But at other times, the fan actually can cost you, because its large, ceiling mounting hole is usually covered with sievelike louvers. Whenever the fan isn't running, your expensively heated or air-conditioned air bleeds away into the attic.

One solution is to make or buy an insulated cover for the fan, but most require manual opening and closing every time you want to use the fan. Florida resident Kurt Voss devised a solution to that problem – a self-opening and closing, insulated cover for the fan.



A design for an automatic whole house fan cover.

The cover – actually a lid to an insulated box – is attached to counter-weights that work in much the same way as those in double-hung windows. Because the weights are just a few ounces lighter than the lid, the lightest air pressure from the whole-house fan can open the lid.

Voss designed the insulated box to fit around his whole-house fan and under the attic rafters. He insulated the plywood box in sections so he could get it up into the attic. Once the box was assembled in the attic, he attached two pulleys to the rafters with screw eyes, then added to a weight bag until the force of the whole-house fan lifted the insulated box lid easily.

"The insulated box saves energy in summer and winter," Voss says. "It works by itself."

use a cubic-feet-per-minute (CFM) rating that is equal to or greater than the house volume (square footage of floor area x ceiling height in feet) multiplied by 0.33. For example, a home with 1500-square feet of floor area and an 8-foot ceiling has a volume of 12,000-cubic feet. The required rating is thus 12,000 x 0.33, or 3960 CFM. Compare this value to the manufacturer's CFM rating. Most manufacturers would typically rate a 24-inch fan running at high speed to equal or exceed the 3960 CFM given in this example. However, you should **consider installing a larger diameter unit so that the fan will run at a quiet low speed to deliver the required volume of air.**

When you read the manufacturer's CFM rating, be aware that it may be one of two different types. The preferred rating gives the CFM under a static pressure (SP) drop of 0.1 inch of water column. If the CFM rating with the fan does not specify the pressure drop, assume that the manufacturer has used the free-air CFM rating, which gives the maximum possible CFM. Subtract 15% to 20% from the free-air CFM to get the 0.1 inch SP rating. A wall-mounted timer switch (12 hour) should be used to control the fan. Home owners can then elect to have it turn off automatically during the night.

Be sure to include adequate vent openings in the attic to allow hot air to escape. The free-exhaust vent area in the attic should be approximately twice that of the fan area. A total vent cutout area (add all cutout areas for gables, turbine vents, ridge vents, etc.) equal to four times the fan open area should be sufficient. Though soffit and gable vents should do the job, a continuous ridge vent with soffits is preferable (see Chapter 8).

Some owners of whole-house fans have complained about fan noise and the fact that they consume between 300 and 500 watts of electricity. However, they offer an excellent ventilation alternative especially in areas where low wind speeds are prevalent. Since a whole-house fan is more difficult to install once the house has been built, you should emphasize to the prospective buyer the value of having it installed during construction.

13. Seal fan penetrations

As discussed in Chapter 8, it is very important to seal penetrations between the house and attic spaces. The energy and comfort benefits of exhaust fans, ceiling fans and whole-house fans will be negated if penetrations are not sealed.

Caulk around exhaust fan casing and seal ceiling fan wire or pole connections with an expandable sealant.

Summary

Properly sized, efficient air conditioners will keep home owners comfortable and utility costs low. Choosing units with low sensible heat fractions and multi-speed blowers can help remove excess moisture. Heating equipment should also be carefully selected, keeping in mind the heating requirements of the part of the state the equipment is to be used in. Locating and properly installing the air handler and duct work in conditioned space can save 25% of the cooling and heating energy used in the home. Fans are also important in reducing energy use. Kitchen and bath fans with timers should be used to remove moisture at its source. Ceiling fans can increase comfort in lieu of lower thermostat settings, and whole-house fans can be used to reduce the need for air conditioning during several months of the year.

For further information

Air Conditioning Contractors of America, *Manual J Load Calculation for Residential Winter and Summer Air Conditioning*, 1986.

Air Conditioning Refrigeration Institute, 1815 North Myer Dr., Arlington, VA 22209.

American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329.

Florida Natural Gas Association, P.O. Box 2562, Tampa, FL 33601.

Florida Propane Gas Association, 526 East Park Ave., Tallahassee, FL 32301.

"Central Air Conditioner Impact Upon Infiltration Rates in Florida Homes," James B. Cummings, FSEC-PF-194-90, Passive Proceedings, American Solar Energy Society, 1988.

"Dealing with heat and humidity in Florida homes," Robin Vieira, FSEC-EN-14-86, 1986.

"Duct Doctoring: Diagnosis and Repair of Duct System Leaks," James B. Cummings, et al., Florida Solar Energy Center, 1992.

"Duct Leakage Impacts on Airtightness, Infiltration, and Peak Electrical Demand in Florida Homes," James B. Cummings, et al., FSEC-PF-212-90, 1990.

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"Florida Cooling, the Natural Way," Danny Parker, *Home Energy*, November/December 1991.

"Measuring Thermostat and Air Conditioner Performance in Florida Homes," Hugh I. Henderson, Jr., et al., FSEC-RR-24-91, 1991.

"A Report on a New Device and Method to Extend the Life, Efficiency and Maintainability of Unitary Air Conditioning Compressors and Systems," Richard J. Avery, Jr., Proceedings of the 42nd Meeting of the Mechanical Failures Prevention Group, Gaitherburg, MD, 1987.

"Bathroom Fans by Capacity-to-Noise Ratio," *Energy Design Update*, November 1987.

Certified Home Ventilating Products Directory, Home Ventilating Institute (30 West University Dr., Arlington Heights, IL 60004; 708/394-0150) 1984.

Consumer Guide to Home Energy Savings, Alex Wilson, American Council for an Energy Efficient Economy, Washington D.C., 1990.

Low Energy Cooling, Donald W. Abrams, Van Nostrand Reinhold Company, New York.

"New Products Home Energy – Heat your house with a water heater?," V. Elaine Gilmore, *Popular Science*, October, 1986.

Chapter 10

Energy-Efficient Appliances

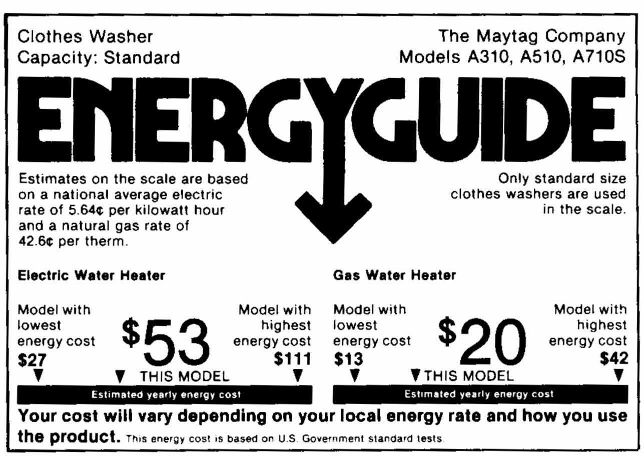
Recommendations	First Cost	% Estimated Savings on Utility Bill
1. Choose an efficient water heater and insulate hot water pipes.	S/M	5-20
2. Choose highly efficient kitchen and laundry appliances.	S/M	2-10
3. Locate clothes washer, dryer and water heater in an unconditioned space.	R	0-5
4. Use efficient lighting.	S	0-5
5. Install water-saving shower heads and toilets	S	0-5 (Energy bill) 20-30 (Water bill)
Maximum Combined Total	M	30

Cost Codes:
R = reduced
N = negligible
S = small ($<\$0.25/ft^2$ of floor area)
M = medium ($>\$0.25$ and $<\$1.00/ft^2$ of floor area)
H = high ($>\$1.00/ft^2$ of floor area)

Many home builders adopt a "lowest-cost" attitude, selecting appliances which are least expensive at the time of purchase. If you were buying a refrigerator, stove, washing machine or other major appliance for your own use, you'd want to consider what it will cost to operate over its lifetime. Extend that same concern to your home buyers. By installing more efficient and better-made appliances that will last longer and save substantial money during their lifetime, you make your homes more marketable and distinctive.

Quite often, the initial extra cost of energy-efficient appliances is moderate and should not greatly raise the home's price. You can usually justify whatever increase is necessary by showing a prospective purchaser the life-cycle cost estimates you have prepared for the home's major appliances. This information will reveal how much the appliance will cost to operate over its lifetime, including expenses for maintenance and energy. The savings will be readily apparent.

Energy information is presented on the labels affixed to refrigerators, refrigerator/freezers, freezers, water heaters, clothes washers, dishwashers, and room air conditioners. Federal law requires that "EnergyGuide" labels give the average yearly operating cost and comparison information relative to other comparable models. A yearly cost table allows you to estimate the annual operating costs based on varying utility rates.



Use EnergyGuide labels to promote your appliances.

The life-cycle costs of two different appliances can be calculated by using the following formula:

Life-cycle cost = purchase price + (annual energy cost x estimated lifetime x discount factor).

The discount factor is a number that adjusts for inflation and takes into account the fact that today's dollar is more valuable than a future dollar (since today's money could be invested and earn interest over time). Discount factors are given in the table below.

Appliance Information for Life-Cycle Cost Comparisons

Appliance	Average Lifetime (years)	Discount Factor
Refrigerator/freezer	20	0.76
Freezer	20	0.76
Central air conditioner	12	0.84
Clothes washer	13	0.83
Clothes dryer	18	0.78
Dishwasher	12	0.84
Electric water heater	13	0.83
Gas water heater	13	0.83
Range/oven	18	0.78

Note: The discount factors here are based on a discount rate of 5% and an energy price escalation rate of 2% per year above inflation.

Chart is courtesy of Massachusetts Audubon Society and the American Council for an Energy-Efficient Economy. Gas water heater information supplied by City of Tallahassee Energy Services.

Example

Consider two refrigerators with different efficiencies. By comparing the EnergyGuide labels, you may find that Model A, which sells for $800, has an estimated annual operating cost of $100. Model B sells for only $700, but will cost $130 a year for electricity. The discount factor for this appliance can be figured at 0.76. (See the table above for numbers for other appliances, along with an explanation of the discount rate.)

By using the formula given above, you find the Model A refrigerator will have a lifetime operating cost of $1520 (a total life-cycle cost of $2320), while Model B, which cost only $100 less initially, has a lifetime operating cost of $1976 (a life-cycle cost of $2676). Most consumers would gladly pay $100 more for Model A to save $456, or almost 25% in energy costs, over its lifetime.

If you are reluctant to purchase high-efficiency models of all the appliances for your homes, at least buy highly efficient water heaters, refrigerators and freezers. These appliances consume a great amount of energy, so they offer greater potential savings and in most cases are very cost-effective.

You can further promote highly efficient appliances by comparing their efficiencies to national standards established by Congress. Ask your reference librarian or local congressman for a copy of Public Law 100-12-March 17, 1987, which contains these standards. If your efficiencies exceed the legislated standards, point out how you are ahead of the builders who merely *meet* them.

When you purchase efficient appliances, be sure to feature this in your promotional material. If electrical equipment has been tested by Underwriter's Laboratories, Inc., or gas equipment certified by the American Gas Association, you have seals and certificates which can be prominently displayed in your model homes to show that your appliances comply with national safety and efficiency standards.

Low-cost publications available from major national associations contain detailed energy information you can use in choosing and marketing appliances. Contact the organizations listed in the "For further information" section at the end of the chapter.

Also promote toilets and showerheads that demand very little water. In many communities, these features can be an easy sell because water and sewer rates have skyrocketed in recent years. Consumers will appreciate the effect of reduced water use on household expenses, and at the same time feel good about helping to conserve our natural resources.

1. Water heating options

Water heating is the second largest user of energy in Florida homes, making up 23 percent of the utility bill. This percentage translates to an average electrical cost of $150 to $380 per year, depending upon hot water usage, fuel costs and unit efficiency. Choice of a water heater is one of the most important a consumer can make, since the selected option will have such a direct effect on the buyer's monthly energy cost.

Before discussing water heating options, water conservation must be mentioned. The best way to save on water heating is to use less hot water. In Florida residences, a family of two will typically use 40 gallons of hot water per day; a family of four will consume about 70 gallons. Homebuyers and their builders can take steps to minimize hot water consumption. Clothes should be washed in cold or warm water instead of hot water. The hot water tank thermostat should be set at the lowest satisfactory temperature. If the family needs hot water only for a few hours a day, an automatic timer may be installed, setting the timer to allow the heating element to come on just prior to the needed hours. Timers may also be of added benefit if peak-load pricing of electricity is available. Builders should insulate hot water pipes and install low-flow showerheads. These simple measures cost very little but can save from 15% to 25% of the energy otherwise used for heating water.

Five types of water heating systems are available for Florida homes — electric resistance, waste heat recovery, heat pump water heater, solar and gas. The following sections explain each of the five water heating options. To make the best decision on a water heating option, the advantages and disadvantages of each, as well as its cost, performance and maintenance requirements, must be carefully considered.

Electric Resistance Water Heaters. The most commonly installed type of water heater is the electric resistance unit because of its low purchase price and ease of installation. However, electric ater heaters cost more in energy charges than any of the other options. Uncertainty in the future price of electricity makes the option even less desirable. The cost of installing a new electric resistance heater will vary from $150 for a very energy-inefficient model (not recommended) with an energy factor (EF) of 0.75, to $350 for an efficient model with an EF of approximately 0.88. For electric resistance water heaters, the EFs range from 0.74 to 0.97, with the higher the EF, the more efficient the unit. For an electric resistance unit, you can calculate its yearly cost to operate based on the following formula:

Cost = 0.89 (gal/day)(water temperature rise - F°) (Electricity cost -$/kWh)/EF

For a sample computation, assume a hot water temperature of 122°F and incoming water temperature of 72°F, a daily water consumption of 70 gallons, a heater with an EF of 0.88, and electricity costing $0.08 per kWh. The annual electricity cost is then:

Cost = 0.89(70)(122-72)(0.08)/0.88 =$283/year

Heat Recovery Water Heating. An alternative for water heating is a heat recovery unit (HRU). An HRU operates only in conjunction with a central air conditioner or heat pump and uses heat discharged by these systems to heat water. The system works like this: super-heated refrigerant from the air-conditioning system enters the heat recovery system's heat exchanger. Cool water from the water storage tank circulates through the heat exchanger, where a large amount of the air conditioner's exhausted heat is captured and then transferred to the water. The heated water is then pumped back into the water storage tank and is ready for use.

An HRU will cost from $600 to $1,000. If the home is air conditioned five to seven months per year, a heat recovery unit could save from 20 to 50 percent on annual water heating energy costs. Savings will depend upon hot water usage and maintenance costs. One drawback of these units is that they work best with less efficient air conditioners, but a benefit is that they increase the operating efficiency of the air conditioner itself.

Installation is an important consideration for an HRU. Contract only with experienced installers of these systems, since improper installation can minimize the effectiveness. Also be sure that the central air conditioner or heat pump warranty will not be voided by adding HRU equipment. In order to receive Energy Code points, the HRU must be tested according to ARI Standard 470-80, with Florida regulatory modifications.

Heat Pump Water Heating. Two factors have kept heat pump water heaters from gaining more popularity — their relatively high initial cost ($900 to $1100) and their newness in the market. Installed and operating correctly, these systems use about half the energy of conventional electric resistance models.

A heat pump water heater takes heat from the air and pumps it into a tank filled with water. There are two types: integral and remote. The integral heat pump has its own water tank, while the remote unit is connected to an existing electric unit. Both systems use a resistance element for backup needs. Maintenance requirements for the best units should be similar to those required by heat pumps used for space conditioning. Because of the way the technology developed, most heat pump units are sold through air conditioning distributors rather than conventional plumbing supply companies.

For extra savings, select a unit that in summer permits air to be drawn from the house and returned (much cooler) to the house. In winter the air should be drawn from and returned to the outdoors.

Solar Water Heating. A solar water heater uses the sun's energy rather than electricity or gas to heat water. In Florida, the most widely used type of solar water heater — a pumped system — circulates potable water from the water-storage tank through one or more solar collectors and back into the tank. A controller regulates the circulating pump, turning it on when there is enough solar energy to heat the water. A backup electric element heats the water during periods of insufficient sunshine or high hot water demand. See pages 10-7 and 10-8 for a detailed discussion of the different types of solar water heating systems. For Florida residences, a rough rule of thumb for the size of the solar system is 10 to 15 square feet of solar collector area per person and 20 gallons of water storage per person. Thus, for a family of four, 40 to 60 square feet of collector and an 80-gallon storage tank are typical. Monthly savings will depend on hot water consumption, solar energy system size, and type and price of fuel used for backup. A solar water heater can save between 50% and 85% of the hot water portion of the monthly electric utility bill, or $12-$24 per month for a family of four if the backup element is kept at 122°F. A solar water heater can save even more if the backup is turned off and the homeowner relies solely on the sun for hot water. During the summer months, when hot water demands are lower and the sun shines longer, most solar owners turn off the backup and still get plenty of hot water.

Gas Water Heaters. Gas water heaters cost a little more to purchase than do electric resistance units, but they offer an excellent operating cost advantage at the present cost of natural gas. Rebates from gas utilities also can make the initial cost lower. To compute the annual cost of natural gas heating, use the following formula:

Cost=(0.03)(gal/day)(Water temperature rise-F°)
(gas price - $/therm)/EF

For gas heaters, the range of EFs is larger than electric resistance and can vary from 0.40 to 0.63. As an example, consider 70 gallons per day, a hot water temperature of 122°F and incoming water temperature of 72°F, with natural gas costing $0.60 per therm and EF equal to 0.55. The fuel cost will be:

Cost = (0.03)(70)(122-72)(0.60)/(.55) = $115/year

For propane gas at $1.10/gal, it will cost $229/year.

Comparing Options. Any comparison of options is difficult because of the many variables involved — hot water usage, unit efficiency, fuel costs, water temperatures, initial purchase price, and operation and maintenance costs. In addition, if life cycle costs are considered, then estimates must be made of fuel escalation and inflation and discount rates.

To provide a simple comparison of the different options, the table on page 10-6 was constructed to compare the water heating options with electric resistance heating. The first column shows the range of initial purchase prices, and the last three columns show savings for each option (vs. electric resistance). The range of values are for different unit efficiencies.

There are many advantages to the home buyer when a nonelectric resistance water heating system is installed during construction. One of the most significant is the economic benefit over the life of the system. For example, the bulk of the cost of a solar water heating system occurs at the front end, as opposed to its electric counterpart, which has fuel costs that escalate during the life of the system. The home builder who offers a solar water heating package could give clients a positive cash flow on water heating costs from day one of occupancy. Including the cost of the solar system in the mortgage (as with other appliances) will allow the home owner to pay for the system through monthly energy savings. For

Annual Energy Savings Comparison: Alternative Water Heating Options and Electric Resistance

Type of Water Heating	Retail System Price	40 Gal per Day Use	70 Gal per Day Use	Percent Savings
Electric Resistance	$150-$350	—*	—*	—
Heat Recovery Unit	$600-$1000	$32-$95	$57-$166	20-50%
Heat pump	$900-$1100	$65-$95	$113-$166	40-50%
Solar	$1500-$2500	$81-$162	$142-$282	50-85%
Natural Gas	$350-$450	$97-$125	$168-$217	59-65%

*Electrical resistance heating values are calculated using the formula on page 10-4 and EF values of 0.75 and 0.88. These calculations assume annual electrical costs of $162 to $190 for 40 gpd and $283 to $332 for 70 gpd usage.

example, if the system costs $2,000, is 80% financed and is amortized over 30 years at 10.5 percent interest, the monthly payment will be $14.64. In addition, the interest is tax deductible. At present, the typical monthly energy savings from the solar system will vary from $12 to $24 per month for a family of four and will increase as energy costs rise.

Instantaneous Water Heating. Instantaneous water heaters are powered by gas or electricity. The heating source turns on when the faucet, shower, or dishwasher demands hot water. These types of water heaters are typically used in residences where hot water usage points are separated by long distances or in homes which would normally require two separate hot water storage tanks. Its advantage is that no storage tank is required.

An electric unit heats water where hot water is needed; typically one unit is placed in the kitchen and another in each bathroom. The advantages of the electric unit are that the hot water pipes are eliminated throughout the house, and hot water arrives very rapidly when demanded. A disadvantage of the electric instant water heater is that it requires a large amount of power (5 kW to 9 kW) for each unit. If residential electric rates have peak demand charges these type of units could cause heavy cost penalities and home owners may have to adjust their water-use habits.

Instantaneous gas heaters typically provide hot water to the whole house. Thus, the input rating is much higher than the normal gas water heater storage unit. These units should be located in nonconditioned space.

2. Choose efficient kitchen and laundry appliances

Except for mortgage payments and possibly food bills, the energy used to run the home's space conditioning equipment and appliances is the costliest single household expense. Consider the electricity costs to operate these major home appliances for one month:

- $6 for a clothes dryer
- $16 for a large frost-free refrigerator/freezer
- $25 or more for an electric resistance water heater for a family of four.

Since the electricity to run a refrigerator for 15 to 20 years can cost three times as much as the unit's original purchase price, you can see the impact of appliance efficiency on your clients' pocketbooks.

The growth of consumerism has pushed manufacturers to upgrade their products, resulting in appliances that are far more efficient than those produced just a decade ago. Since builders usually can obtain good discounts from manufacturers and distributors, you should be able to install highly efficient appliances in your homes at little extra cost—but with more profit in your pocket.

According tothe Association of Home Appliance Manufacturers, electricity use has decreased for today's appliances as compared to similiar appliances in the early 1970s. For example:

- Clothes washers use 32% less energy.
- Dishwashers use 34% less energy.
- Freezers use 46% less energy.

The American Council for an Energy-Efficient Economy provides annual energy usage and costs for the most efficient products on the market.

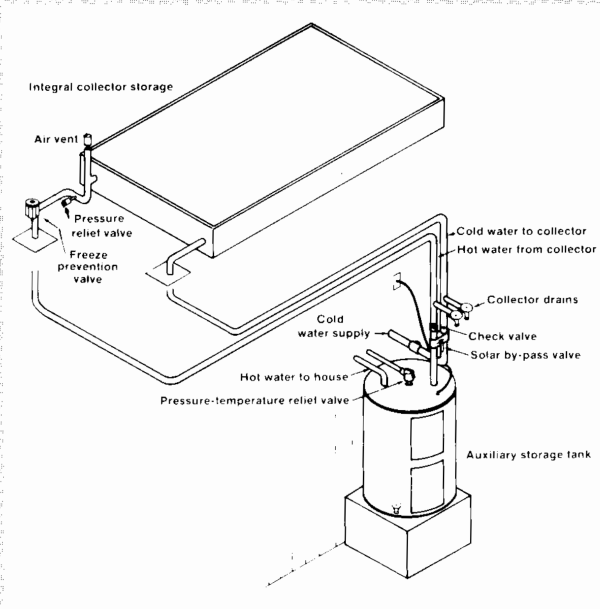
What is the difference in solar systems?

Available solar water heating systems differ in their methods of controlling the pump (if there is one), freeze protection, ease of installation, efficiency and cost. The order in which they are discussed here is from the simplest to the most complex.

Integral Collector Storage (ICS) System. An ICS system (also called breadbox or batch system) can provide reasonably hot water or serve as a cost-effective preheater for a conventional heater.

The hot water storage system is part of the collector. Cold water flows progressively through one or more tanks where it is heated by the sun. Hot water is drawn from the hottest tank at the top, and is replaced by city supply water entering the lower tanks. Pumps and controllers are not required. On demand, hot water from the collector flows to a standard hot water auxiliary tank within the structure.

This type of unit will perform best in warmer weather and with mostly afternoon or evening water use. Its simple design should allow any plumber to install it. However, due to the weight of 30 or 40 gallons of water on the roof, plan to strengthen the roof support under the collector.



Integral collector storage system.

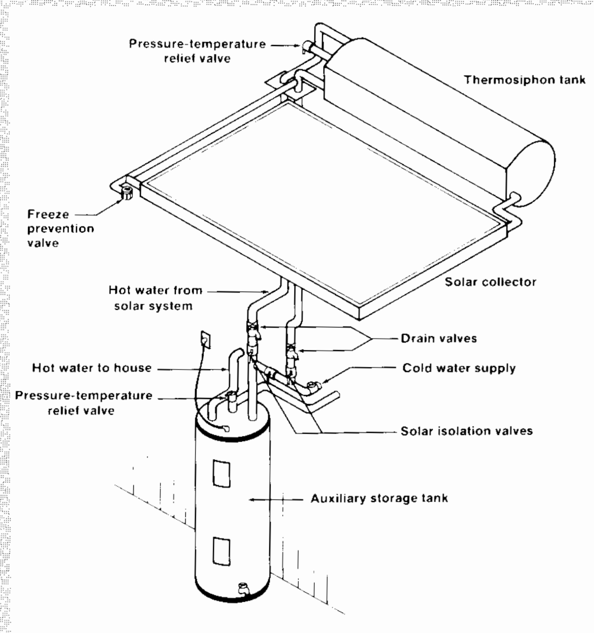
The average cost to a builder of an ICS system, including installation, is about $1500 to $2000.

Thermosiphon System. This system was widely used in the early days of solar water heating in Florida. It is automatic, simple and reliable.

As the sun shines on the collector, the water inside is heated. Gravity then pulls denser cold water down from the tank and into the collector inlet. The cold water pushes the less dense heated water through the collector outlet and into the top of the tank. This continuous action provides a tank full of hot water at the end of the day.

Neither a pump nor controller is needed. Cold city water flows directly to the tank on the roof. Solar-heated water flows from the rooftop tank to the ground-level auxiliary tank whenever water is drawn.

A thermally operated valve is sometimes provided to protect the collector from freezing. Manual draining is suggested as a backup.



Thermosiphon system.

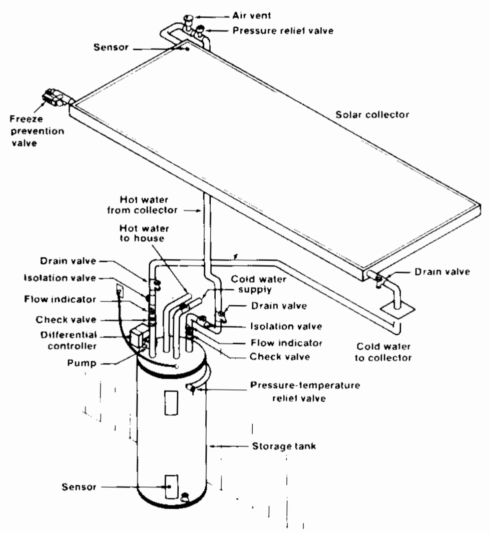
The average cost to the builder, with installation, is about $1800 to $2500.

Direct Pumped System. This is the type of system most common in Florida. The sun's heat is transferred directly to the potable water circulating through the collector tubing and storage tank; no antifreeze solution or heat exchanger is involved.

Different solar water heating systems (continued)

Typically, a controller turns on the pump when the collector is 20°F warmer than the tank water. It turns off the pump when the difference is less than 5°F. In some systems, the controller is replaced by a photovoltaic panel which varies the pump speed in proportion to the solar intensity. Appliance timers may also be used to control system operation.

Freeze protection is achieved by automatic recirculation of tank water when the collector falls below 42°F or so, or by dribble valves which open when the collector approaches freezing.



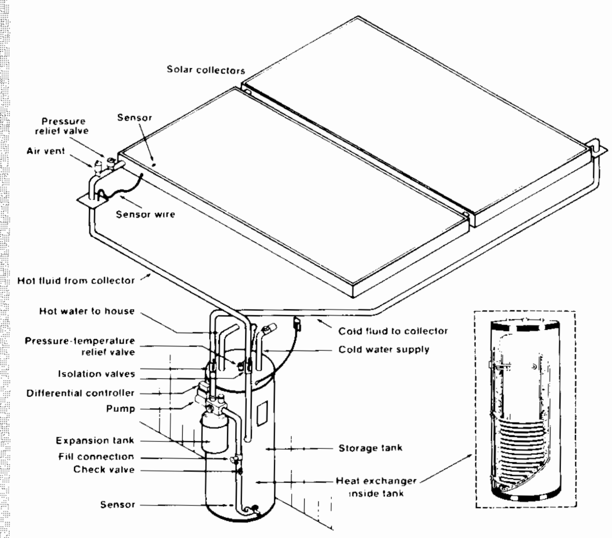
Direct pumped system.

The average installed price to builders is about $1700 to $2500. However, the builder will save the $200 to $300 cost of a conventional water tank.

Indirect Pumped System. This closed-loop system is common in northern Florida, where freezing weather is more frequent. An antifreeze solution circulates through the collector, and a heat exchanger transfers the heat to the tank water.

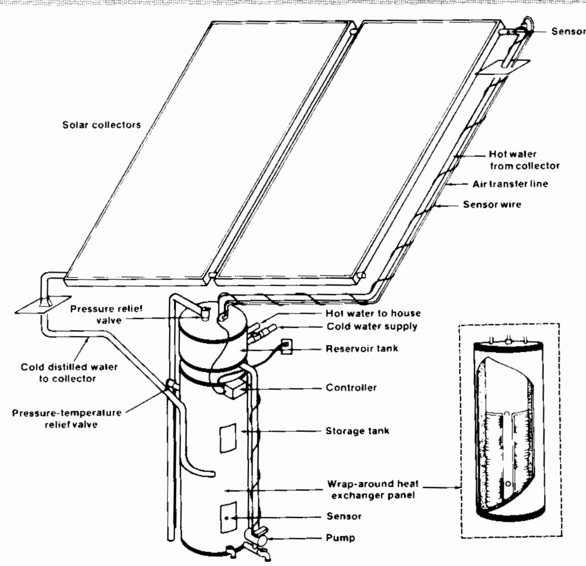
In conjunction with collector and tank temperature sensors, a differential controller determines when the pump should be activated to pump the heat transfer fluid through the collector.

The average cost, including installation, is about $2000 to $2500. However, the builder will avoid the $200 to $300 cost of a conventional water tank.



Indirect pumped system.

Drain-Back System. A major design feature of the drain-back system is fail-safe freeze protection. When the system is not collecting heat, water in the collectors and exposed piping drains into an insulated reservoir tank. The slight tilt of the collectors allows complete drainage. The fluid used in this system is either distilled water or a mixture of distilled water and antifreeze.



Drain-back system.

Average installed cost: about $2000 to $2500, minus cost of a conventional water tank.

Refrigerators. The typical refrigerator with top-mounted freezer and automatic defrost now uses about half of the energy a comparable model used just 15 years ago. Models with side-by-side freezers use more energy than those with top-mounted freezers, and energy use increases with refrigerator size.

Comparison of Refrigerators

Type of Refrigerator	Energy Use & Energy Cost kWh/yr (@8.0 cents/kWh) Lowest	Highest
Single-door, manual defrost		
12.5-14.4 cu. ft	504 ($40)	693 ($55)
Top freezer, partial automatic defrost		
12.5-14.4 cu. ft	730 ($58)	819 ($66)
Top freezer, automatic defrost		
12.5-14.4 cu. ft	819 ($66)	1360 ($109)
14.5-16.4 cu. ft	770 ($62)	1452 ($116)
16.5-18.4 cu. ft	768 ($61)	1272 ($102)
18.5-20.4 cu. ft	844 ($68)	1348 ($108)
20.5-22.4 cu. ft	948 ($76)	1481 ($119)
22.5-24.4 cu. ft	978 ($78)	1524 ($122)
Side-by-side freezer, automatic defrost		
18.5-20.4 cu. ft	1159 ($93)	1713 ($137)
20.5-22.4 cu. ft	1156 ($92)	1807 ($145)
22.5-24.4 cu. ft	1222 ($98)	1914 ($153)
24.5 cu.ft & larger	1319 ($105)	2933 ($235)

Freezers. Chest freezers are generally more efficient than upright models, and manual defrost models use less electricity than those with automatic defrost.

Comparison of Freezers

Type of Freezer	Energy Use & Energy Cost kWh/yr (@8.0 cents/kWh) Lowest	Highest
Upright, manual defrost		
11.5-13.4 cu. ft	578 ($46)	1022 ($82)
13.5-15.4 cu. ft	652 ($52)	1096 ($88)
15.5-17.4 cu. ft	617 ($49)	932 ($75)
17.5-19.4 cu. ft	730 ($58)	1071 ($86)
19.5-21.4 cu. ft	785 ($63)	1067 ($85)
Upright, automatic defrost		
13.5-15.4 cu. ft	652 ($52)	1141 ($91)
15.5-17.4 cu. ft	882 ($71)	1474 ($118)
17.5-19.4 cu. ft	1108 ($89)	1285 ($103)
Chest, manual defrost		
13.5-15.4 cu. ft	428 ($34)	743 ($59)
15.5-17.4 cu. ft	430 ($34)	578 ($46)
17.5-19.4 cu. ft	607 ($49)	993 ($79)
19.5-21.4 cu. ft	529 ($42)	882 ($71)

Dish and Clothes Washers. The information below on dishwashers and clothes washers is based on average usage when connected to an electric resistance water heater. Since most of the energy used by these appliances is for heating water, installing an efficient water heater along with an efficient dishwasher and clothes washer can save the home owner considerable money. Dishwashers with built-in heaters permit lower settings for the hot water tank thermostat and offer even more savings.

The top-rated dishwasher uses 574 kWh per year, for an annual energy cost of $46.

The most energy-efficient compact clothes washer (less than 16 gallons capacity) uses 623 kWh for an annual energy cost of $50. A front-loading standard-size model uses 451 kWh ($36 energy cost) and a top-loading model uses 651 kWh ($52 energy cost).

Clothes Dryers. A gas unit may save 50% of the cost of drying clothes with an electric unit. Regardless of your choice, make sure the dryer is vented to the outdoors.

3. Locating appliances

Appliances which give off considerable heat should be placed in nonconditioned spaces. The best locations for a clothes washer, clothes dryer and water heater are in a garage, in a nonconditioned utility room, or, for a multifamily dwelling, in a closet off the porch. As noted above, vent the dryer to the outdoors. Use of a pressure-activated damper is recommended.

If laundry areas are to be located in an enclosed area other than a garage, install a vent fan (like a bathroom fan) to the outdoors. The fan will prevent moisture buildup. See fan recommendations in Chapter 9.

A refrigerator puts out a fair amount of heat, so do not place it where the heat will remain trapped. The refrigerator will have to work harder to overcome the heat, driving up the energy usage. Leave a 6-inch space between the wall and the unit. An added suggestion: Locating an extra air-conditioner vent near the refrigerator may reduce its running time, thereby reducing the load on the air conditioner. Inform clients that the grille must be shut in winter when the heater is used so that the refrigerator will not have to work harder then.

4. Lighting options

The effective use of home lighting is important for both economic and task-related reasons. Lighting can account for about 5% of a home's energy use.

The quality and quantity of light affects the home's security and atmosphere and the performance of such basic activities as reading, study and conversation.

The efficiency, in lumens (a measurement of light quantity) per watt of electricity, of different types of lighting is given in the table below.

The most common artificial light source is the incandescent light bulb. It is relatively inexpensive and gives a natural appearance to the objects it illuminates. However, almost 90% of its power is wasted as heat (creating an additional load on the air conditioner in the summer). Standard light fixtures decrease a bulb's light output even further. Use light fixtures which allow light to flow unhindered into the living space, and install soft (reduced glare) bulbs or clear bulbs with diffusers in the fixtures.

Because incandescent bulbs usually burn out after about 750 hours of use, the average family spends around $10 a year to replace them — in addition to about $100 a year for the electricity they consume.

Do not use four- or five-bulb incandescent fixtures. The bulbs may create an unwanted 200- or 300-watt space heater whose output can be very annoying, especially in a small space like a bathroom.

Fluorescent. Fluorescent lamps offer an alternative for builders interested in lowering the home owner's lighting costs. These lamps, used commercially for many years, require only one-fourth the electricity needed to power an incandescent bulb. The standard fluorescent lamp has been kept out of most home uses because of its shape, the unattractiveness of its fixture, its tendency to flicker, and the unflattering color of its light.

Lighting manufacturers have now introduced a compact screw-in fluorescent bulb which offers the energy economy of the older fluorescent type and lasts 10 to 12 times longer than an incandescent bulb. It can give up to 10,000 hours of use. Also, it produces equivalent light with far less heat. Placed in a kitchen or bathroom, these bulbs can pay for themselves in about three years.

Most new fluorescent bulbs have no noticeable flicker or hum, and provide light that is neither harsh nor abnormal in color. However, they typically take from several seconds to a couple of minutes to come to full brightness, making them unsuitable for applications where immediate light is needed (such as for stairway illumination).

Halogens. Another alternative growing in popularity is the halogen lamp, which is less efficient than the compact fluorescent but is still about 20% more efficient than incandescent bulbs. Hologens bulbs give a sharp, controlled light beam, and builders are using them in track fixtures to allow the exact focusing of light.

Light Source Characteristics

Light Source	Lamp Efficacy (lm/watt)	Mean Lifetime (1000 hrs)	Initial Cost	Life-Cycle Cost	Lamp Color	Start Time	CRI	Restart Time	Available Wattage
Incandescent and halogen	4-30	0.5-3	low	high	reddish	inst.	93	inst.	60-1500
Fluorescent	28-120	8-28	med	med	bluish white	rapid	82	rapid	40-125
Mercury vapor	23-46	16-24	high	med	bluish	5 min	NA	NA	50-100
Metal halide	50-90	10-20	high	med	white	5 min	NA	NA	175-1500
High-pressure sodium	46-120	10-24	high	low	yellow	NA	NA	NA	35-1000
Low-pressure sodium	60-160	10-18	high	lowest	yellow-orange	NA	NA	NA	18-180

Color. When choosing bulbs of any type, check the *color rendering index* (CRI) on the box. The CRI is a measure of how well the bulb defines colors and how closely an illuminated object's color will resemble its color in daylight. Most compact fluorescents have a CRI of around 82, a little less than incandescents, which have a CRI of about 93. The closer to 100, the more natural objects will appear. Select tubes coated with rare-earth phosphors for the most accurate colors.

Bulb color temperature also can help you make your purchase decision, since it gives an idea of how the light will look. Lights with lower temperatures tend to have a reddish-yellow appearance, while those with higher temperatures look bluish. Where the bulbs will be used, how often they are turned on, and other general lifestyle factors help determine the appropriate type.

Compact fluorescents can be used for many lighting applications.

Daylight. Keep in mind that the need for electric lighting is strongly affected by the use of daylighting in the home. Your choice of such passive building strategies as clerestory windows and shaded, glare-free window areas can minimize the need for electric lights. Also, you can install dimmers (choose solid-state ones) and other controls which permit the occupants to use only the amount of electric light they need.

Outdoor Lighting. When choosing outdoor lights for the home, consider using the new photovoltaic-powered (PV) lights. A number of manufacturers offer low-cost systems well-suited for such low power uses as home walkways and landscaping. The lights add a high-tech, modern look to the home, and will capture the attention of your prospective buyers. Most available units have storage batteries that can power the lights from three hours to all night long, and provide that power for two or three days if the weather is cloudy. The lights are simply pushed into the ground and need no electrical line installation. It is important to use efficient (not incandescent) bulbs in these fixtures to achieve the desired quantity of light at a reasonable cost. Contact the Florida Solar Energy Center for a listing of PV dealers and manufacturers.

For brightly lit outdoor spaces like patios, consider efficient low-pressure sodium, mercury vapor or fluorescent lamps. These units will provide the needed light more efficiently than incandescent lamps.

Aid to Selection. With so many new types of bulbs available, making the right choice isn't always easy. An informative booklet called "Lighting Your Life" offers helpful suggestions for comparing various types of light sources. For a copy, send $1 to the American Home Lighting Institute, 435 N. Michigan Ave., Suite 1717, Chicago, IL 60611.

5. Bathroom Fixtures

The fixtures you install in the bathroom especially affect the home owner's water bill. Some water rates in Florida have increased as much as 400% in the last 15 years! Toilets can account for 40% of the water used in a home.

Toilets in most older homes use 5 or 6 gallons per flush. While the state plumbing code requires 3½ gallon toilets, new toilets are available that use from one quart to 1½ gallons per flush and perform as well or better. Many of the ultra-low-water toilets on the market are stylish European models. Installation is easy, although slightly different than for conventional toilets.

Shower faucets are another potential water saver. Conventional ones permit a water flow of 5 to 10 gallons a minute, accounting for up to 30% of the water used in the home. Some showerheads on the market will reduce that to 1½ to 3 gallons per minute (gpm). State law requires that all showerheads in new construction be 3 gpm or less. A good showerhead not only saves water but reduces hot water demand and its associated energy use. The home owner will want a comfortable shower with adequate temperature and water force. Some water-saving units produce a mist that reduces the water temperature, while others do not feel forceful enough. Consult articles in consumer magazines for information on which showerheads to buy. If you've narrowed your choice to several models, test them yourself. Additional benefits from using water-conserving fixtures may include down-sizing a septic tank or paying reduced impact fees to hook up to a sewer system.

Summary

Growing consumer interest in efficient appliances can make a small extra investment on your part an important marketing aid. Even when the extra costs of efficient appliances are built into the home's price, consumers can easily see how monthly savings outweigh higher mortgage payments. A profitable marketing strategy is to offer these appliances as part of an energy option package.

Selecting energy-efficient water heaters and refrigerators can mean significantly lower utility bills. Water heaters and washers and dryers should be located in the garage or other nonconditioned space. New choices in lighting, toilets and showerheads can also reduce utility bills.

For further information

"Water-Saving Toilets." Carl Lowe, *New Shelter* (now *Practical Homeowner*) August 1986.

Air-Conditioning and Refrigeration Institute (1501 Wilson Blvd., 6th Floor, Arlington, VA 22209-2403) publishes directories of certified products and general interest material.

The American Council for an Energy-Efficient Economy (1001 Connecticut Ave., N.W., Suite 535, Washington, D.C. 20036) publishes a guide to the top-rated appliances twice each year.

The Association of Home Appliance Manufacturers (20 North Wacker Drive, Chicago, IL 60606) publishes energy information on refrigerators, freezers and room air conditioners, along with general fact sheets on saving energy.

The Gas Appliance Manufacturers Association, Inc. (P.O. Box 9245, Arlington, VA 22209) publishes informative materials and product directories.

"Amendment to the Energy Policy and Conservation Act with respect to energy conservation standards for appliances," 100th Congress, Public Law 100-12-March 17, 1987.

Florida Solar Energy Industries Association, 1732 N. County Road 427, Longwood, FL 32750, (407) 260-0770.

Association of Refrigerant Desuperheater Manufacturers, 2469 Aloma Ave., Suite 220, Winter Park, FL 32792.

"Residential Conservation Demonstration, Domestic Hot Water," Final Report, FSEC-CR-90-83, Tim Merrigan, 1983.

Chapter 11

Amenities

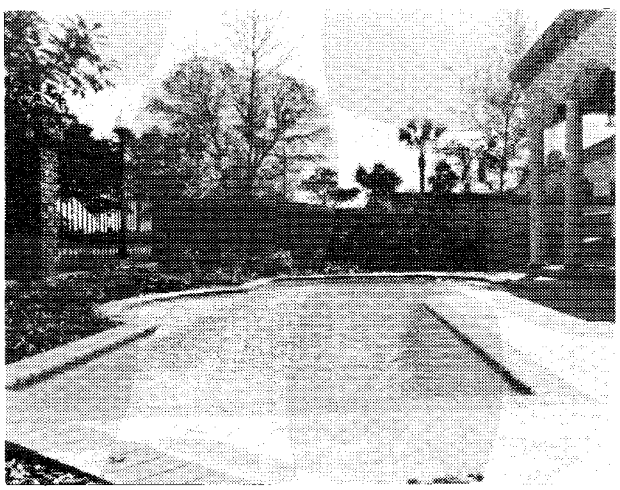
Recommendations	First Cost	Energy Use **Reduction** by Following Recommendations	Energy Use **Savings** by Following Recommendations
1. Reduce impact of energy-**intensive** amenities – pools, spas or Jacuzzis, fire-places, skylights, freezers.	R/N/S	20-75%	—
2. Use energy-**saving** amenities — porches, microwave ovens, outdoor cooking areas.	M/H	—	5%

Cost Codes:
R = reduced
N = negligible
S = small (<$0.25/ft² of floor area)
M = medium (>$0.25 and <$1.00/ft² of floor area)
H = high (>$1.00/ft² of floor area)

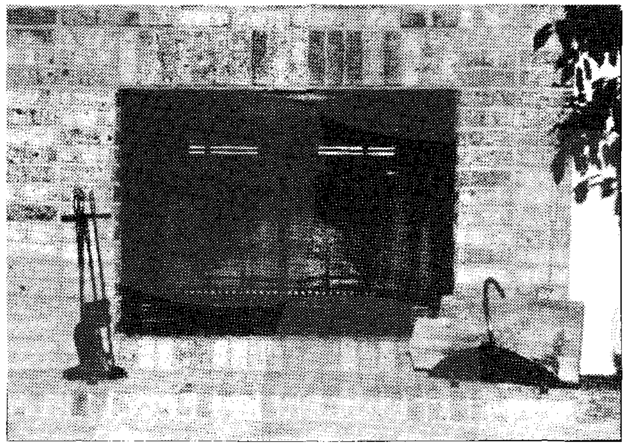
Amenities are those little (or big) extras you put into your homes even though they are not essential. They can be sold by describing them to clients, but they usually will be easier to sell when they can be seen, as in a model home. A home buyer typically will view an amenity either as something that looks nice but is useless — or as a delicious ice-cream topping. In the latter case, it may be the feature that makes a good house irresistible. Because amenities can be desirable to some but not all home buyers, it generally is best to market them as options.

Although energy savings rarely is the prime reason a home buyer chooses an amenity, both you and the buyer should be aware of its energy impact and most effective use. This chapter provides you with the energy information on amenities and ideas for marketing them.

Amenities that can significantly affect a home owner's energy bills are termed energy-intensive. If you have built and marketed an energy-efficient house, and the home buyer chooses to have skylights, swimming pool, Jacuzzi, freezer and/or fireplace, the utility bills are likely to be quite high. Without discouraging home buyers' desires, you should inform them of the energy costs of the amenities so they will not accuse you of building a home that consumes too much energy. This chapter contains important tips on how to minimize the impact of energy-intensive amenities, including advice to pass on to your clients.



Correct pump choice and run times will reduce the energy consumption of swimming pools.



Fireplaces are attractive, but conditioned air escapes year round unless preventive measures are taken.

The table below points out the typical energy impact of some of the more common amenities:

Amenity	Energy Use	Monthly Cost
2x4 ft clear skylight	240 kWh/year *	$ 4ˢ
16 cu ft vertical freezer	900 kWh/year	$ 6
20,000 gallon swimming pool		
— pump	3000 kWh/year	$20
— heat	Fuel dependent	$100-200ʷ
500 gallon spa (pump & heat)	3000 kWh/year	$20
Fireplace	450 kWh/year**	$ 3

* due to increased air conditioning load

** due to increased infiltration of air, whether in use or not

ˢ summer months only

ʷ when heat is required: typically late fall, early spring, and winter months

Fortunately, if strategies described later in this chapter are followed, the energy costs of these amenities can be reduced by 30-40% on average. It should not be difficult to promote sealing the chimney penetrations or using tight-fitting glass doors on fireplaces. Promote an efficient freezer the same way you promote any other efficient appliance (see Chapter 10).

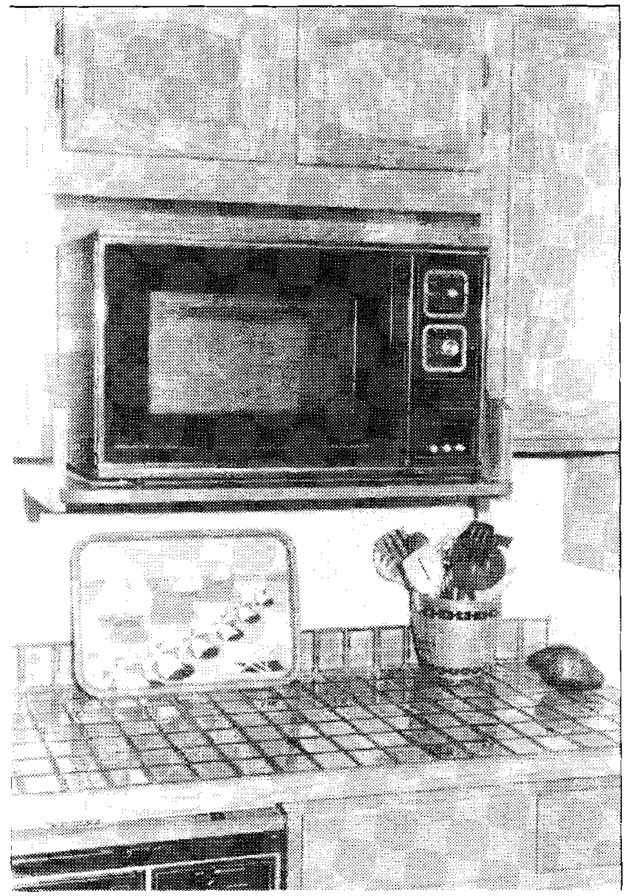
Promote the advantages of shaded skylights, as opposed to clear unshaded ones, because they provide better-quality light and greater comfort for occupants, as well as lower air conditioning bills. Recommend proper running times, efficient pumps and efficient heaters for pools and spas or Jacuzzis. The cost savings can be outstanding, as shown in the table below:

Savings in pool pumping costs by:		Savings from base ($240/year)
Running pump only for the required time	60%	$140
Efficient pump choice	40%	$100
Combination of pump choice and running time	75%	$180

Some amenities can be promoted as energy-saving. Covered porches, microwave ovens, ceiling fans and outdoor cooking areas can reduce air conditioning costs.

Promote covered porches as an excellent energy-saving amenity that provides both shade for the house and an outdoor living area. The shade helps reduce cooling bills. And, if occupants spend time on the porch rather than inside the house, the load on the air conditioner is reduced even more.

Having the microwave unit built in can assure a convenient location and reduce counter clutter. Inform potential home buyers that microwave cooking is five times more efficient than with a conventional oven. With less wasted heat, the air conditioner will not have to work as hard. The kitchen will be more comfortable, a benefit every food preparer will appreciate. Add a ceiling fan in the kitchen to further that comfort. As you know, a kitchen, like a bath, often is the room that makes people buy the house.



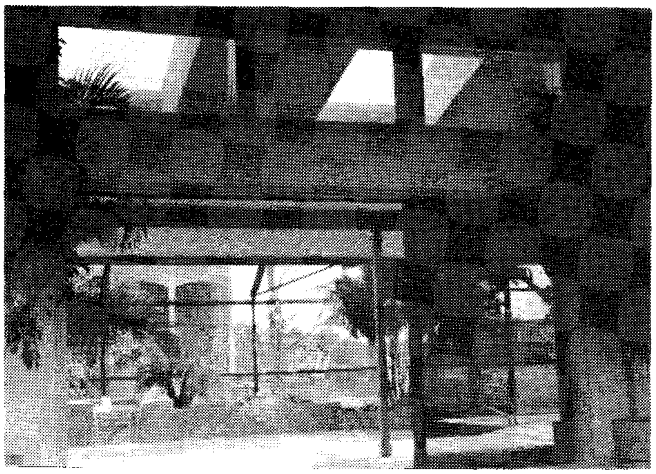
Provide a shelf for a microwave oven.

An alternative for hot-food preparation in summer is the outdoor barbecue, a popular amenity. Point out the greater convenience of a built-in outdoor grill. For upscale home buyers, suggest an entire outdoor food preparation area — sink, grill and storage space for dishes and utensils — that invites cooking out more often. The obvious energy saving is in not having to cool the heat created by cooking indoors. If you provide a shady location and an exhaust fan, the barbecuer may discover a new world of cooking comfort!

1. Energy-intensive amenities

As noted earlier, energy-intensive amenities are those which can significantly affect the home owner's utility bills. Here is how to reduce their impact through proper selection and application.

Skylights. The amount of heat entering through six skylights (8 square feet each) at noon in July is enough to cause a one-ton air conditioner to run the entire hour. Due to the high angle of the summer sun, skylights let in two to four times as much heat as do vertical windows. Stopping this heat is important. First, consider if the skylight can be replaced by vertical glass or eliminated. Next, consider reducing the size of the skylight, particularly if its benefit is limited because of location. A bathroom, for example, is most frequently used in early morning and before bedtime when the daylight may not even be available. Finally, provide skylight shade in the form of:



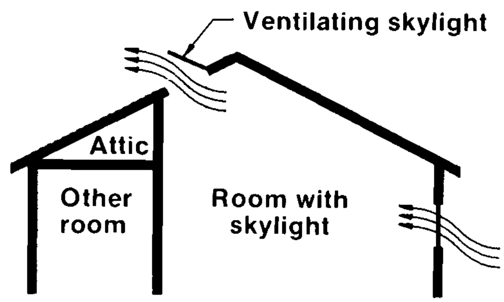
Skylights should be located on a porch rather than in the conditioned space.

- interior shades, blinds or panels (available from skylight manufacturers and dealers) that can be controlled manually or by mechanical remote control, or
- skylight glazing with a low shading coefficient (see Chapter 7 for selection criteria).

A shaded skylight, in comparison to an unshaded one, can provide a more uniform source of light and reduce discomfort from the sun's rays and heat intrusion.

Consider including a skylight on a porch adjacent to a window (see photo) instead of in the house. The skylight will be attractive and will help light the home, but far less heat will enter the house. Furthermore, if a leak ever develops the porch will get wet, not the inside of the house.

If you are going to locate a skylight in a high ceiling or in a bathroom without a window, choose a ventilating skylight (one that can open) to take away the hot air that rises to ceiling level. Although rods are frequently used to open skylights, some manufacturers offer remote control devices which make it easier for the home owner. There is one instance where a ventilating skylight may create cross-ventilation in a room otherwise without it: that is, when the skylight is on a roof section facing a different direction than the room window.



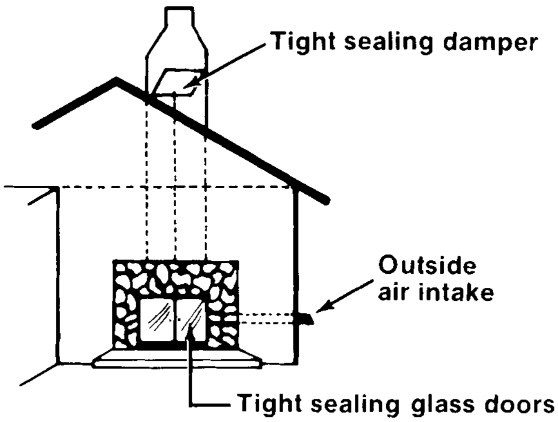
Skylight openings can aid cross-ventilation.

If you use plastic glazed skylights, make sure they have been treated to withstand ultraviolet light.

Follow manufacturer's installation instructions and seal the unit thoroughly to prevent water or air leakage. The skylight should be as air-tight as possible: Industry standards are 0.5 cfm/ft of skylight perimeter, but be sure to choose skylights that *far exceed* this industry standard. High-quality roof work around the skylight is important.

Fireplaces. Most fireplaces are poor heat providers, wasting more heat than they give to a house. Air is drawn from other rooms and used for combustion of the fire. The rising combustion gases serve as an air pump, drawing additional conditioned air into the fireplace and up the chimney. It then escapes out the chimney, causing unconditioned outside air to be sucked into the home. Due to the extra ceiling penetrations and the chimney or flue itself (most dampers do not seal tightly and double-walled flues have an open vent space), fireplaces are a major, year-round source of air infiltration.

If wood heating is desired, an air-tight wood stove is a far better heater than a conventional fireplace. Also better than a conventional fireplace is a heat-recirculating fireplace which draws room air in through a heat exchanger and returns it to the room.



An energy-efficient fireplace has tight-sealing components.

Many new factory-built fireplaces have borrowed technology from the woodstove industry and are more efficient than masonry units. The fire will last longer and less wood will be needed. Most factory-built units also cost less than custom masonry units.

If a conventional masonry or factory-built fireplace is used, provide tight-fitting, high-temperature glass doors for the fireplace and a combustion air inlet from the outdoors. That way, warm inside air won't be lost, and the glass will re-radiate the fire's heat and provide warmth to the room occupants. Use non-flammable spray foam and caulk to seal around the chimney penetration at the ceiling and around air intake areas. To minimize flue cavity air leakage: (a) use a triple-walled flue and a firestop insulated with unfaced mineral insulation, or (b), if a double-walled flue is used for a fireplace cavity in contact with an exposed inside wall, separate the fireplace and flue from the conditioned space by an insulated partition wall which is sealed against air infiltration. Choose dampers doors that seal tightly. Seal joints between the masonry and other house materials when the fireplace is on an outside wall.

Freezers. If you are offering a freezer as an option, select an energy-efficient one as listed in the AHAM directory (see Chapter 10). It has to keep food frozen all day, and therefore consumes a lot of electricity. The extra cost of an efficient unit usually can be regained in just one year's time. It is best to place freezers where they will stay cool, away from windows, ovens, refrigerators and other sources of heat. If installed in an air-conditioned space, the freezer should have a duct from the air conditioner located near it to improve efficiency — but tell the home owner the duct grill should be closed in winter.

Swimming Pool Pumping. Pool pumps frequently are oversized, not as efficient as possible, and set to run for too long a period of time. You, your pool contractor, and the home buyer can take a few simple, inexpensive steps to reduce pumping costs by as much as 75% (around $180 per year for the average pool owner).

Monthly Circulating Pump Operating Costs*

	Daily Running Time			
Pump Size	2 Hrs.	4 Hrs.	8 Hrs.	24 Hrs.
1/2 hp	$3.50	$7.00	$14.05	$42.15
3/4 hp	$4.80	$9.60	$19.20	$57.60
1 hp	$5.50	$11.00	$22.05	$66.15
1 1/2 hp	$8.10	$16.15	$32.35	$97.05
2 hp	$9.50	$19.00	$38.05	$114.15

* Based on electrical rates of $.08 per kWh.

For the quietest and most efficient operation, have your pool contractor install a small pump, large pipes and large filter, following guidelines below.

Recommended Pump, Filter and Pipe Sizes for Pools

Pool Size in Gallons	Pump Size	Flow Rates (Gal. per Min.)		Filter Area			Pipe Size
		Medium Head	High Head	Sand	DE	Cartridge	
Less than 12,000	1/3 hp	35	30	2.6	26	67	1½-inch
12,000-20,000	1/2 hp	60	50	2.6-4.3	26-43	67-111	2-inch
20,000-30,000	3/4 hp	80	65	43.-6.4	43-64	111-167	2½-inch
30,000-50,000	1 hp	95	80	6.4-10.6	64-106	167-278	3-inch

The piping sizes refer to lines that contain total pump flow, such as the lines from the main drain and skimmer to the pump and from the pump to the point where three or four smaller lines distribute water back to the pool. The sizing of small pipe lines should be based on flow as shown below.

Recommended Maximum Design Flow Rates for Various Pipe Sizes

Pipe Size	Maximum Flow
1-inch	9 gpm
1 1/4-inch	18 gpm
1 1/2-inch	28 gpm
2-inch	55 gpm
2 1/2-inch	85 gpm
3-inch	140 gpm

To further reduce resistance to efficient flow, your contractor should use 45-degree elbows and sweep 90-degree elbows or flexible pipe instead of sharp 90-degree elbows.

The total cost for the energy-efficient improvements at the time of pool construction is less than $100, and the monthly savings can far exceed the additional monthly payment.

Circulation of pool water is important for mixing of water and chemicals and keeping the pool free of debris (by drawing water out through the skimmer, floor vacuum and the filter). Pool pumps typically have been set to circulate the water for 6 to 12 hours a day. However, a Florida Atlantic University study indicates that most people are happy with the cleanliness of their pool when the pump run time is reduced to 3 or 4 hours a day or less.

Reduced circulation time really does not increase the chances of having a dirty pool. Consider the facts:

- As long as the water is circulating when chemicals are added, the water and chemicals will be mixed.
- Algae growth is not reduced by high circulation rates. The right balance of chemicals in the water and brushing the walls of the pool are the only solutions.
- Debris that enters a pool either sinks to the bottom and has to be removed by a vacuum, or floats and is readily removed by the skimmer.
- After less than an hour, pumping power is usually wasted in recirculating clean, debris-free water.

It is best to inform your pool contractor (who may not be as knowledgeable as you now are) and home buyer of the above facts. Have the pump time-clock set to run two times a day for an hour and a half, or three times a day for an hour. The frequent running will keep the surface free of floating debris. Additionally, it is recommended that pool owners run the pump when the utility is not trying to meet peak power demand; electricity costs will stay lower if utilities do not have to build more power plants to meet increased demand. Suggested pool pump running times are noted below. Pass these on to your home buyer.

Suggested Pool Timeclock Set Points

Circulation	Interval	On	Off
One cycle per day	Cycle 1	11 am	2 pm
Two cycles per day	Cycle 1	9 am	10:30 am
	Cycle 2	9 pm	10:30 pm
Three cycles per day	Cycle 1	9 am	10 am
	Cycle 2	1 pm	2 pm
	Cycle 3	9 pm	10 pm

Pool Heating. Pool heating can be costly to the home buyer, both in the initial investment and in future energy costs.

The first step in heating a pool economically is to use a transparent pool cover. The cover blocks the loss of heat by evaporation but still permits the sun to heat the water. Heating a pool without a cover has been compared to heating a house without a roof. A pool cover alone can add two months to the swimming season.

Pool water is an ideal application for solar heating. When solar collectors are used to heat water to high temperatures (150°-200°F), their efficiency is reduced because of the heat loss to the outdoor air. However, swimming pools need to be heated only to 75°F to 90°F. The main disadvantages of solar collectors are an initial cost of around $2500 and the large roof area they require. The following table lists approximate area requirements for most solar collectors, based on the ratio of collector area to pool surface area for south-facing collectors. North-facing collectors will not receive direct sun in winter and are not recommended.

Ratio Values (Collector Area/Pool Surface Area) for Florida Pools

Covered, unscreened pool

Region	Months of swimming 9	10	11	12
N. Florida	.47	.68	.80	.94
C. Florida	.37	.55	.65	.75
S. Florida	.25	.40	.50	.60

Covered, screened pool*

Region	Months of swimming 9	10	11	12
N. Florida	.80	1.0	1.10	1.25
C. Florida	.70	.85	.95	1.05
S. Florida	.55	.68	.75	.83

* Screens block some of the sun's direct rays.

The heat output of a solar pool collector can be calculated as follows:

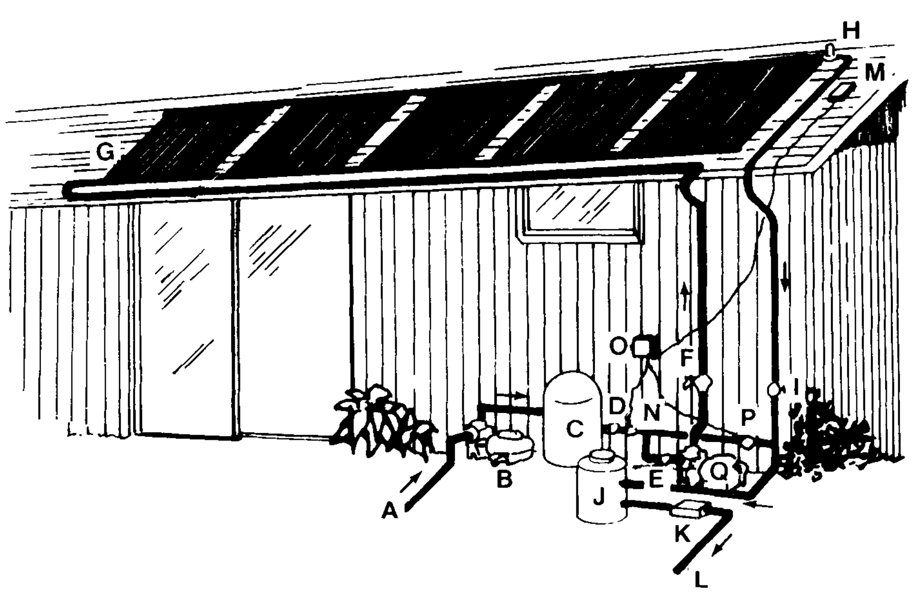
Energy (in Btu) = Collector rating (Btu/ft^2) x collector area (ft^2) x number of days system is utilized per year (see table in the next column).

As an example, a 30- by 15-foot screened, covered pool in Orlando that is to be swimmable 12 months of the year has an area ratio of 1.05. The required collector area is 1.05 x 30 ft x 15 ft = 472.5 sq. ft. The number of days of heater operation is 210. The annual energy output of a collector that delivers 850 Btu/sq. ft is 850 x 472.5 x 210 = 84 million Btu (84 MMBtu).

Approximate Days of Heater Operation

Region	Months of swimming 9	10	11	12
N. Florida	150	180	210	240
C. Florida	120	150	180	210
S. Florida	90	120	150	180

The energy cost of other pool heating options are listed on the next page. An efficiency of 60% is assumed for gas and oil furnaces. Actual fuel purchase price may be different in your area. The yearly cost of operating these heaters will be the cost in \$/MMBtu times the number of Btu required. For the Orlando pool described above, the energy required is 84 MMBtu. The current yearly cost for propane is \$22.81/MMBtu x 84 MMBtu = \$1916. Depending on the pool and heat choice, the initial cost of the solar pool heater can be made up in savings in one to six years.



A. Pool water in
B. Pump
C. Filter
D. Check valve
E. Gate valve 1
F. Drain valve
G. Solar collectors
H. Vacuum breaker & auto relief
I. Gate valve 2
J. Fossil fuel heater (if existing)
K. Chlorinator (if existing)
L. Warm water returns to pool
M. Sensor 1
N. Sensor 2
O. Automatic control box
P. Electric or vacuum valve (collector bypass)
Q. Booster pump (if needed)

Solar swimming pool heating system components.

Costs of Different Fuels

Fuel	Purchase price	Cost* in $/MMBtu	Cost* in $/therm+
Natural gas	$0.60/ therm	$ 9.96	$0.99
Propane & LPG	$1.25/gal	$22.81	$2.28
Electric heat pump (COP=3)	$0.08/kWh	$ 7.81	$0.78
Fuel oil	$1.15/gal	$13.69	$1.37

* These costs reflect the efficiencies of gas and oil heaters.

+1 therm = 100,000 Btu.

Spas and Jacuzzis. Spa (hot-tub) temperatures are 95°-110°F. Most spas have covers which help retain the heat. However, using the electric heater supplied with most spas may cost $10-$30 a month, depending on heater size and temperature set point. There are two methods of reducing this operating cost:

- Use a less costly form of heat.
- Reduce the spa water temperature when not in use.

If a spa or Jacuzzi will be used regularly, the sun is the least expensive source for heating it. If it will be used no more often than twice a month, a conventional heating source (propane, electric) will be more cost effective because of the higher first cost of solar systems. For a home buyer who wants hot spa water available regardless of weather, it is best to have a backup to the solar system (this is not necessary with large swimming pools).

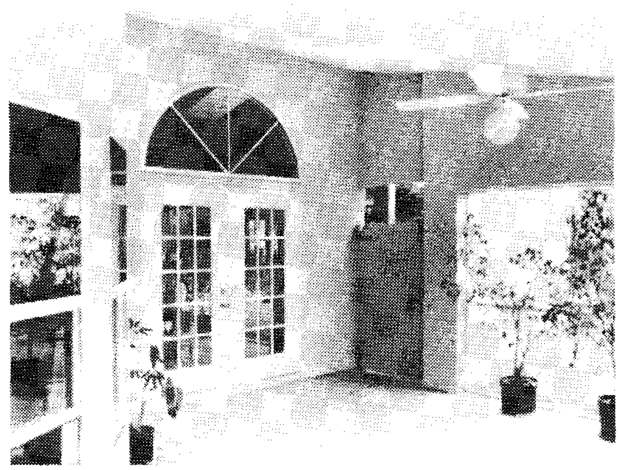
The performances of solar pool collectors are rated in a free Florida Solar Energy Center publication, "Thermal Performance Rating (Pools) GP-16."

2. Energy-saving amenities

Porches. Covered screened porches are an option that many home buyers desire. For their maximum enjoyment, consider incorporating these features:

- a vented radiant barrier roof above the porch
- a ceiling fan
- cross-ventilation of the porch
- access from more than one room
- easy access from the kitchen.

Also, depending on site and floor plan, a porch can be an attractive sales feature when it is on the side of a house. A screened back porch and open-air front porch can provide shade on those two facades. A second-floor porch or balcony offers a different view; this can help sell the two-story home. A porch on the east side provides not only shade to the house but an enjoyable shady haven from west sun on hot afternoons and early evenings.



A screened porch with hinged doors to the house and ceiling fans can be a comfortable, energy-saving amenity for home buyers.

Built-in Microwave Ovens. As noted in the marketing section, typical cooking appliances are inefficient. Conventional ovens (gas or electric) are only 10% efficient, which means that 10% of the energy goes for heating the food and 90% is wasted. Even worse, that wasted heat must be removed by the air conditioner. Microwave ovens are 50% efficient. Stoves are less efficient than microwaves. Cooking one potato in a pressure cooker on a gas stove will cost 1.5 times as much as cooking it in a microwave. However, cooking large quantities — eight potatoes for example — may be less expensive in an oven or pressure cooker. The stove's wasted heat must be removed either by an exhaust fan or the air conditioner.

Although a microwave unit is more energy-efficient than stoves and conventional ovens, its heat must still be vented. Follow the manufacturer's instructions in regard to air space required for ventilation of the unit. If you are providing a built-in microwave oven, select one designed for that purpose: It will have the exhaust on the front of the unit. Locate an oven where people can conveniently move food in and out of it. Choose a height between waist and shoulder level; no one wants to lift heavy, hot food out of an oven higher than that. An alternative some home buyers may prefer is an above-counter shelf that can accept a microwave unit they already own or may purchase.

Built-in Outdoor Cook Areas. Providing an outdoor grill, generally on a porch, has become a popular offering of custom home builders. A vent should be used to exhaust the smoke if charcoal or gas is burned. Consider expanding the cooking area to include a sink and cabinet space for washing and storing of the cooking utensils.

An outdoor food preparation center can reduce kitchen heat.

Other Energy-Saving Features. As mentioned in Chapter 9, ceiling fans and whole house fans can be energy savers. Consider installing a ceiling fan in every room. Include the kitchen, since it is frequently the hottest room of the house and needs air circulation the most. Also, use timer switches for a whole-house fan and for bath exhaust fans with automatic vent dampers.

Other concepts described in this book can be offered as energy-saving upgrades. A landscaping upgrade (see Chapter 3) could include three to ten shade trees. A window treatment option (see Chapter 7) could provide vertical blinds on all windows, and canvas awnings on east and west windows. Show these features in a model home or have photographic displays in your sales office.

Summary

The amenities you add to a home can help you sell it quickly. Most of these extra features should be offered as options. Many can either use or save energy, and deserve your special attention. Steps should be taken to minimize the energy consumption or penalty of such amenities as skylights, swimming pools, spas, freezers and fireplaces. Encouragement should be given to the use of porches, fans, microwave ovens and outdoor cooking areas — all of which help reduce the energy demand of the home.

For further information

1. "Residential Skylight Primer," Ross McCluney, *Sunspeak*, May 1984.

2. "Movable Insulation for Skylights," Larry Medinger, *Fine Home Building*, Aug./Sept. 1985.

3. "Solar Control Strategies for Skylights," Magie Riechers, *The Construction Specifier*, July 1984.

4. "Skylight Problem Solvers," Judy Tretheway, *WES*, April 1984.

5. "Easy-to-Install Fireplaces," *Practical Homeowner*, September 1987.

6. "Efficient Design," Roger Messenger and Shirley Hayes, *Pool & Spa News*, January 26, 1987.

7. "Swimming Pool Circulation System Energy Efficiency Study," R.A. Messenger and S.J. Hayes, Final Report, Florida Atlantic University, Department of Electrical and Computer Engineering, Center for Energy Conservation, 1984.

8. "Solar Heating of Swimming Pools: A question and answer primer," Charles J. Cromer, Florida Solar Energy Center, FSEC-EN-6.

9. "Yet Another Way to Cook a Potato," *Energy Auditor & Retrofitter*, Sept./Oct. 1985.

Appendix A

The Economics of Energy-Saving Features in Home Construction

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This appendix provides an economic analysis of various energy-saving options for new residential construction in Florida. The analysis is presented for a 1500-square-foot frame home described more fully in footnote A on page A-16. Three economic tools are used for evaluating the various energy choices.

The first tool is the determination of net cash flow through a comparison of increased mortgage payment with fuel savings. In this approach, the increased cost of the energy-saving item (for example, insulation, high-efficiency appliance, etc.) is converted to an increased mortgage payment (for a 10%-interest, 30-year loan) less the tax savings for a person in the 15% tax bracket. For applications which have an expected life of less than 30 years, the energy savings in the first year are reduced by a pro-rated system replacement cost. This can be thought of as an annual payment into an escrow account for the purchase of a new unit at the end of its life. Thus, the selected energy-saving option pays for the cost to perpetuate itself over the full 30-year mortgage period. The energy savings are also reduced by maintenance costs for those items expected to need repairs.

The net cash flow is the dollar value of the first year energy savings less the net added annual mortgage payment. If the net cash flow is positive, it is definitely a good deal for the customer. Even if it is negative, the cash flow may become positive after a number of years because of escalating fuel prices. Also keep in mind that since the energy savings are tax-free income, net first year cash flow is, in effect, larger than shown.

A second economic tool presented here is the simple payback period. This is calculated by dividing the cost of the energy feature by the first year fuel savings (less extra maintenance and repair costs). For example, if a heat pump costs $300 more than an air conditioner and saves $100 per year in heating costs compared to electric resistance heating, then the simple payback is 3.0 years. For items with a life expectancy of 15 years or more, a simple payback of less than 10 years is a reasonable option, and less than 7 years is very good. For items which have shorter life expectancy, a shorter payback period is necessary for the option to be considered a good choice. A general rule of thumb is that a simple payback period of less than half the item's life expectancy is a good choice.

The third economic analysis tool is internal rate of return on investment (IRRI). This more accurately reflects an item's economic merit because it takes into account the estimated year-to-year escalation in energy costs. For this analysis we assume the nominal fuel inflation rate is 5% per year. The IRRI can be thought of as the interest rate which an energy investment yields over its life (years of analysis is listed in parentheses next to the IRRI value).

If there are added maintenance and repair costs associated with the energy option, then the fuel savings is reduced by that amount in the calculation of IRRI. Also, if the owner sells the house before the end of the option's expected life, the actual rate of return on investment will be smaller. However, it is likely that at the time of sale the energy option will have market value that increases the selling price of the property. In fact, options having a very long life expectancy may appreciate in value as much as the house itself.

The IRRI should be compared to the return expected from a savings account or other investment. An energy option that has a return on investment of 10% or greater should be a reasonable choice for most home buyers. The fact that the energy savings (though not the interest from reinvesting the energy savings) is tax-free income makes the yield even more favorable than comparable taxable investments. Following this text are tables of these ecomomic performance indicators for a large number of energy-saving features. Caution is advised in using these tables.

First, it should be noted that cost data for the various energy features is subject to considerable variation. This is because product and material costs vary widely, as do labor and contractor costs. If your costs are very different from the values in the tables, you can make calculations to correct for these differences. The net added annual mortgage cost (NAAMC) can be adjusted by a straight proportion method. For example, if your cost for a 2.5-ton, 11.0 SEER air conditioner (compared to a SEER of 8.0) is $700 while the table uses $500, then the NAAMC will be $700/$500 x $45.18 = $63.25. The net first year cash flow (NFYCF) will be reduced by the amount $63.25 - 45.18 = $18.07. The NFYCF of installing an 11.0 SEER rather than an 8.0 SEER air conditioner in central Florida would be reduced by $18.07, from $75.34 to $57.27.

The simple payback (SPB) period would be calculated by dividing the new added system cost by the first year savings (less maintenance costs) found in footnote 82 on page A-22. The simple payback period would increase from 5.4 years to 7.6 years ($700/92.00 = 7.6 years). The rate of return on investment can be calculated for 15- and 30-year life items by means of the following formulas (note that ln is natural log):

$$IRRI = 97.72 - 72.57 * \ln(SPB) + 20.52 \times (\ln(SPB))^2 - 2.35 \times (\ln(SPB))^3 \quad \text{(15 years)}$$

$$IRRI = 91.82 - 63.41 * \ln(SPB) + 16.67 \times (\ln(SPB))^2 - 1.617 \times (\ln(SPB))^3 \quad \text{(30 years)}$$

For life expectancies other than 15 and 30 years we provide no easy means for calculating the IRRI.

A second caution is that in Florida's climate, home space conditioning energy use is strongly dependent upon occupant behavior. Especially important are variations in thermostat setpoints in the cooling and heating seasons, the fraction of the year the house is ventilated, and how much internal heat is generated from appliances and people.

If in the cooling season you raise your thermostat from 78° to 82°F, your cooling energy use will typically drop by about 37%. In the winter, if you lower your thermostat from 72°F to 68°F your heating energy use drops by about 55%. How much you ventilate your house during the summer greatly affects energy use. If you keep your house closed all year and do not ventilate, your cooling energy use in central Florida will be 16% higher than if you cool only May through October, and 49% higher than if you cool only June through September. The generation of heat inside your home affects your space conditioning energy use. In our analysis we have assumed 50,807 Btu/day of sensible internal heat generation. If electricity use within your home (for lights, cooking, television, refrigeration, freezer, dishwasher, heated waterbed, etc.) or the number of people generating heat within your home is greater than our assumption, then your cooling energy will be higher and your space heating requirements will be lower.

The importance of these occupant behavior effects upon space conditioning energy use depends on the extent to which you use your home differently than our stated simulation assumptions (footnote A). If you keep your thermostat at 82°F in the summer, the return on investment for high-efficiency cooling equipment will be lower. If you keep your house at 68°F in the winter in central Florida, then a heat pump may have an 8.1 year simple payback compared to 2.9 years at 72°F setpoint. Therefore, while a 4°F reduction in thermostat setpoint in heating-dominated climates like Minnesota may cause less than a 15% reduction in the heating utility bill, in Florida it can cause a 50% difference.

A third caution is that heating season energy savings are based here upon the use of heat pump. If you use electric resistance heating, those options which reduce heating load (insulation, double-pane windows, etc.) will actually save considerably more than what is shown.

Window shading options are presented on pages A-5 through A-10, for south, central, and north Florida. These options are applied to an unshaded window and to a partially shaded window. The unshaded window is assumed to have no window blinds or curtains and no shading by adjacent vegetation and buildings. Having only an exterior insect screen over half the window area reduces solar radiation striking the window by about 20%. Relatively few windows have no external shading and no blinds or curtains in use. However, if you have such windows, you will find several options listed which yield good rates of return on investment.

When the same analysis is done for a more typical window which has 20% external shading from vegetation or structures, 20% shading from an outside insect screen, and about 30% shading from the blinds or curtains, the energy savings will be only about 60% as great for the given shading options. However, double-pane windows achieve much of their energy savings by stemming heat losses during the winter and therefore are not very greatly affected by partial shading.

Some caution should be observed in the use of shading options. Keep in mind that shading options may affect your view of the outdoors, the appearance of your house, and the amount of daylight coming into your home. These may be unwanted side-effects of your attempts to cut cooling costs. They may also cause you to use more electric lighting when daylight is not adequate, which can reduce or eliminate the savings achieved by the windows.

Note that sunlight enters your house in two forms: diffuse and beam solar radiation. Diffuse light enters the window all day long while beam sunlight enters usually for only a few hours. Even though the beam radiation is much more intense, over a whole day the diffuse solar is nearly two-thirds of the total for a west window during the cooling season. The diffuse light is generally considered desirable because it provides light throughout the house. The beam radiation is often undesirable because it creates glare, overheats the room, and heats anyone in its path. For example, the impact of the sun upon a dining area with a west exposure can produce considerable discomfort during the evening meal.

Therefore, obstruction of beam radiation is the most important window shading requirement. Fixed shading options such as window tinting, reflective coatings, awnings, shade screen, and Bahama shutters block heat gain from beam radiation and also diffuse radiation. Flexible shading options such as window blinds can be used to block the beam solar during a few hours of the day and yet provide unobstructed view and maximum daylight during other hours of the day. White vertical blinds can produce a shading coefficient as low as 0.25. (However, keep in mind that dark blinds have a shading coefficient of only 0.59.) Properly located vegetation also can be used to obstruct direct sunlight but still admit diffuse daylight throughout the day and provide a good view.

The tables that follow provide an assessment of the economic benefit of energy options in new construction that have identifiable added cost and energy savings. These are by no means the only energy-saving measures that can be employed. Excluded from this analysis are items that do not have added costs, such as white-colored exterior walls. Also excluded are options that do not have readily identifiable costs and/or energy savings, such as planting vegetation for shading or insuring that the air handler and duct system are tightly sealed.

These tables are not designed for assessing energy changes to existing homes. The energy savings associated with retrofit options will be the same, but the costs of installing the options will generally be greater. In some cases the energy choice may be all but impossible in an existing home.

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
BUILDING ENVELOPE [A]							
Attic insulation & radiant barriers [H] **SOUTH FLORIDA**							
R-19 (fiberglass batts) -> R-30 (fiberglass batts)	$ 324 [I]	$ 24.64	$ 29.27	$ -4.63	13.2	11.7	(30)
R-19 (blown fiberglass) -> R-30 (blown fiberglass)	180 [J]	24.64	16.27	8.37	7.3	19.0	(30)
R-19 (batts) -> R-30 (blown fiberglass)	- 36	24.64	-3.41	28.05	<0	100^{+}	(30)
R-19 (batts) -> R-30 (blown cellulose)	- 54 [K]	24.64	-4.88	29.52	<0	100^{+}	(30)
R-19 -> R-19 + radiant barrier	325 [L]	46.88	29.36	17.52	6.9	19.9	(30)
R-30 -> R-30 + radiant barrier	325	30.83	29.36	1.47	10.5	14.2	(30)
Wall insulation (block construction)							
R-3 (fiberglass batt) -> R-8 (foil-faced foam board)	$ 277 [M]	$ 15.71	$ 25.03	$ -9.32	17.6	9.0	(30)
Wall insulation (frame construction)							
R-11 -> R-19 (foil-faced foam board exterior)	$ 324 [N]	$ 9.74	$ 29.27	$-19.53	33.3	4.3	(30)
Ceiling fans (6 fans) (savings from setting thermostat from 78 to 82° during cooling season)	$ 600	$137.62 [1]	$ 54.22	$ 73.40	4.4	29.0	(30)
Attic insulation & radiant barriers [H] **CENTRAL FLORIDA**							
R-19 (fiberglass batts) -> R-30 (fiberglass batts)	$ 324 [I]	$ 27.06	$ 29.27	$ -2.21	12.0	12.7	(30)
R-19 (blown fiberglass) -> R-30 (blown fiberglass)	180 [J]	27.06	16.27	10.79	6.7	20.5	(30)
R-19 (batts) -> R-30 (blown fiberglass)	- 36	27.06	-3.41	30.47	<0	100^{+}	(30)
R-19 (batts) -> R-30 (blown cellulose)	- 54 [K]	27.06	-4.88	31.94	<0	100^{+}	(30)
R-19 -> R-19 + radiant barrier	325 [L]	49.28	29.36	19.92	6.6	20.7	(30)
R-30 -> R-30 + radiant barrier	325	31.34	29.36	1.98	10.4	14.3	(30)
Wall insulation (block construction)							
R-3 (fiberglass batt) -> R-8 (foil-faced foam board)	$ 277 [M]	$ 22.26	$ 25.03	$ -2.77	12.4	12.3	(30)
Wall insulation (frame construction)							
R-11 -> R-19 (foil-faced foam board exterior)	$ 324 [N]	$ 13.95	$ 29.27	$-15.32	23.2	6.8	(30)
Ceiling fans (6 fans) (savings from setting thermostat from 78 to 82° during cooling season)	$ 600	$ 95.90 [2]	$ 54.22	$ 31.68	6.3	21.6	(30)
Attic insulation & radiant barriers [H] **NORTH FLORIDA**							
R-19 (fiberglass batts) -> R-30 (fiberglass batts)	$ 324 [I]	$ 27.57	$ 29.27	$ -1.70	11.8	12.9	(30)
R-19 (blown fiberglass) -> R-30 (blown fiberglass)	180 [J]	27.57	16.27	11.30	6.5	20.9	(30)
R-19 (batts) -> R-30 (blown fiberglass)	- 36	27.57	-3.41	30.98	<0	100^{+}	(30)
R-19 (batts) -> R-30 (blown cellulose)	- 54 [K]	27.57	-4.88	32.45	<0	100^{+}	(30)
R-19 -> R-19 + radiant barrier	325 [L]	48.00	29.36	18.64	6.8	20.2	(30)
R-30 -> R-30 + radiant barrier	325	30.61	29.36	1.25	10.6	14.2	(30)
Wall insulation (block construction)							
R-3 (fiberglass batt) -> R-8 (foil-faced foam board)	$ 277 [M]	$ 29.08	$ 29.08	$ 4.05	9.5	15.4	(30)
Wall insulation (frame construction)							
R-11 -> R-19 (foil-faced foam board exterior)	$ 324 [N]	$ 16.46	$ 29.27	$-12.81	19.7	8.1	(30)
Ceiling fans (6 fans) (savings from setting thermostat from 78 to 82° during cooling season)	$ 600	$ 85.86 [3]	$ 54.22	$ 21.64	7.0	19.7	(30)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
WINDOW OPTIONS (savings compared to unshaded clear windows with with insect screen on 50% of window, SC=0.80, 100 ft^2 area) [O,P]							
South Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 9.92	$ 17.17	$ -7.25	19.2	8.3	(30)
North		8.16	17.17	-9.01	23.3	6.4	(30)
East/West		11.28	17.17	-5.89	16.8	9.2	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 32.16	$ 17.17	$ 14.99	5.9	22.5	(30)
North		26.64	17.17	9.47	7.1	19.5	(30)
East/West		36.56	17.17	19.39	5.2	24.9	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 4.88	$ 22.59	$ -17.71	51.2	1.6	(30)
North		3.92	22.59	-18.67	63.8	0.7	(30)
East/West		5.68	22.59	-16.91	44.0	2.4	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 18.08	$ 33.88	$ -15.80	20.7	7.3	(30)
North		14.80	33.88	-19.08	25.3	5.7	(30)
East/West		20.64	33.88	-13.24	18.2	8.5	(30)
Double pane (reflective)(SC = .42)	$ 500						
South		$ 37.04	$ 45.18	$ -8.14	13.5	11.5	(30)
North		30.48	45.18	-14 70	16.4	9.5	(30)
East/West		42.24	45.18	-2.94	11.8	12.9	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 31.24 [4]	$ 27.11	$ 4.13	8.3	16.0	(20)
North		25.00 [5]	27.11	-2.11	10.0	13.1	(20)
East/West		36.20 [6]	27.11	9.09	7.3	18.0	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ 27.92 [7]	$ 54.22	$ -26.30	21.5	7.4	(30)
North		21.44 [8]	54.22	-32.78	28.0	5.5	(30)
East/West		33.12 [9]	54.22	-21.10	18.1	8.8	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 45.36 [10]	$ 67.77	$-22.41	16.5	9.6	(30)
North		37.52 [11]	67.77	-30.25	20.0	8.0	(30)
East/West		51.52 [12]	67.77	-16.25	14.6	10.8	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-20.12 [13]	$ 81.32	$-101.44	32.3	<0	(12)
North		-27.48 [14]	81.32	-108.80	43.9	<0	(12)
East/West		-14.28 [15]	81.32	-95.60	26.7	<0	(12)

WINDOW OPTIONS (savings compared to unshaded clear windows with insect screen on 50% of window, SC=0.80, 100 ft^2 area) [O,P]

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
Central Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 6.08	$ 17.17	$ -11.09	31.3	4.3	(30)
North		6.16	17.17	-11.01	30.8	4.4	(30)
East/West		8.00	17.17	-9.17	23.8	6.2	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 19.76	$ 17.17	$ 2.59	9.6	15.4	(30)
North		20.00	17.17	2.83	9.5	15.6	(30)
East/West		26.08	17.17	8.91	7.3	19.2	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 18.72	$ 22.59	$ -3.87	13.4	11.6	(30)
North		18.80	22.59	-3.79	13.3	11.6	(30)
East/West		19.92	22.59	-2.67	12.6	12.3	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 26.88	$ 33.88	$ -7.00	14.0	11.2	(30)
North		27.04	33.88	-6.84	13.9	11.2	(30)
East/West		30.56	33.88	-3.32	12.3	12.5	(30)
Double pane (reflective) (SC = .42)	$ 500						
South		$ 38.48	$ 45.18	$ -6.70	13.0	11.9	(30)
North		38.80	45.18	-6 38	12.9	11.9	(30)
East/West		46.00	45.18	.82	10.9	13.9	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 17.24 [16]	$ 27.11	$ -9.87	13.5	9.3	(20)
North		17.56 [17]	27.11	-9.55	13.3	9.5	(20)
East/West		24.44 [18]	27.11	-2.67	10.2	12.9	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ 13.28 [19]	$ 54.22	$ -40.94	45.2	2.4	(30)
North		13.60 [20]	54.22	-40.62	44.1	2.6	(30)
East/West		20.72 [21]	54.22	-33.50	29.0	5.2	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 27.84 [22]	$ 67.77	$-39.93	26.9	5.7	(30)
North		28.24 [23]	67.77	-39.53	26.6	5.8	(30)
East/West		36.80 [24]	67.77	-30.97	20.4	7.8	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-36.68 [25]	$ 81.32	$-118.00	79.5	<0	(12)
North		-36.28 [26]	81.32	-117.60	76.8	<0	(12)
East/West		-28.20 [27]	81.32	-109.52	45.5	<0	(12)

WINDOW OPTIONS (savings compared to unshaded clear windows with insect screen on 50% of window, SC=0.80, 100 ft^2 area) [O,P]

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
North Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 3.84	$ 17.17	$ -13.33	49.5	1.8	(30)
North		4.64	17.17	-12.53	40.9	2.7	(30)
East/West		5.68	17.17	-11.49	33.5	3.9	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 12.40	$ 17.17	$ -4.77	15.3	10.1	(30)
North		15.20	17.17	-1.97	12.5	12.3	(30)
East/West		18.48	17.17	1.31	10.3	14.6	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 29.52	$ 22.59	$ 6.93	8.5	17.1	(30)
North		31.68	22.59	9.09	7.9	18.1	(30)
East/West		30.96	22.59	8.37	8.1	17.7	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 33.92	$ 33.88	$ .04	11.1	13.7	(30)
North		37.92	33.88	4.04	9.9	15.1	(30)
East/West		38.48	33.88	4.60	9.7	15.3	(30)
Double pane (reflective) (SC = .42)	$ 500						
South		$ 40.16	$ 45.18	$ -5.02	12.5	12.3	(30)
North		46.88	45.18	1 70	10.7	14.2	(30)
East/West		49.44	45.18	4.26	10.1	14.8	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 9.00 [28]	$ 27.11	$ -18.11	21.4	4.3	(20)
North		12.04 [29]	27.11	-15.07	17.6	6.3	(20)
East/West		15.96 [30]	27.11	-11.15	14.3	8.6	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ 4.64 [31]	$ 54.22	$ -49.58	100^+	<0	(30)
North		7.84 [32]	54.22	-46.38	76.5	<0	(30)
East/West		11.92 [33]	54.22	-42.30	50.3	1.8	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 17.44 [34]	$ 67.77	$-50.33	43.0	2.7	(30)
North		21.44 [35]	67.77	-46.33	35.0	4.0	(30)
East/West		26.08 [36]	67.77	-41.69	28.8	5.3	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-46.44 [37]	$ 81.32	$-127.76	100^+	<0	(12)
North		-42.76 [38]	81.32	-124.08	100^+	<0	(12)
East/West		-38.44 [39]	81.32	-119.76	94.1	<0	(12)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
WINDOW OPTIONS (savings compared to clear windows with screen which has 20% exterior shading and some use of blinds or curtains; SC=0.50, 100 ft^2 area) [O,Q]							
South Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 5.76	$ 17.17	$ -11.41	33.0	3.9	(30)
North		4.80	17.17	-12.37	39.6	2.9	(30)
East/West		6.56	17.17	-10.61	29.0	4.8	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 18.96	$ 17.17	$ 1.79	10.0	14.9	(30)
North		15.68	17.17	-1.49	12.1	12.7	(30)
East/West		21.52	17.17	4.35	8.8	16.5	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 1.60	$ 22.59	$ -20.99	156.3	<0	(30)
North		1.12	22.59	-21.47	223.2	<0	(30)
East/West		1.92	22.59	-20.67	130.2	<0	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 9.04	$ 33.88	$ -24.84	41.5	2.6	(30)
North		7.36	33.88	-26.52	51.0	1.5	(30)
East/West		10.40	33.88	-23.48	36.1	3.5	(30)
Double pane (reflective) (SC = .42)	$ 500						
South		$ 23.84	$ 45.18	$ -21.34	21.0	7.3	(30)
North		16.88	45.18	-28 30	29.6	4.7	(30)
East/West		27.20	45.18	-17.98	18.4	8.4	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 18.04 [40]	$ 27.11	$ -9.07	13.0	9.7	(20)
North		14.12 [41]	27.11	-12.99	15.7	7.6	(20)
East/West		21.24 [42]	27.11	-5.87	11.4	11.3	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ 14.72 [43]	$ 54.22	$ -39.50	40.8	3.0	(30)
North		10.48 [44]	54.22	-43.74	57.3	1.1	(30)
East/West		18.08 [45]	54.22	-36.14	33.2	4.3	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 28.88 [46]	$ 67.77	$-38.89	26.0	6.0	(30)
North		23.92 [47]	67.77	-43.85	31.4	4.7	(30)
East/West		32.90 [48]	67.77	-34.87	22.9	6.9	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-35.80 [49]	$ 81.32	$-117.12	73.8	<0	(12)
North		-40.44 [50]	81.32	-121.76	100^+	<0	(12)
East/West		-32.04 [51]	81.32	-113.36	56.4	1.1	(12)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
WINDOW OPTIONS (savings compared to clear windows with screen which has 20% exterior shading and some use of blinds or curtains; SC=0.50, 100 ft^2 area) [O,Q]							
Central Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 3.52	$ 17.17	$ -13.65	54.0	1.4	(30)
North		3.60	17.17	-13.57	52.8	1.5	(30)
East/West		4.72	17.17	-12.45	40.3	2.8	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 11.68	$ 17.17	$ -5.49	16.3	9.6	(30)
North		11.84	17.17	-5.33	16.0	9.7	(30)
East/West		15.36	17.17	-1.81	12.4	12.4	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 16.72	$ 22.59	$ -5.87	15.0	10.4	(30)
North		16.72	22.59	-5.87	15.0	10.4	(30)
East/West		17.20	22.59	-5.39	14.5	10.7	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 21.28	$ 33.88	$ -12.60	17.6	8.8	(30)
North		21.36	33.88	-12.52	17.6	8.8	(30)
East/West		23.20	33.88	-10.68	16.2	9.6	(30)
Double pane (reflective) (SC = .42)	$ 500						
South		$ 31.92	$ 45.18	$ -13.26	15.7	9.9	(30)
North		28.56	45.18	-16 62	17.5	8.8	(30)
East/West		32.56	45.18	-12.62	15.4	10.1	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 9.16 [52]	$ 27.11	$ -17.95	21.2	4.4	(20)
North		9.40 [53]	27.11	-17.71	20.8	4.6	(20)
East/West		13.72 [54]	27.11	-13.39	16.0	7.3	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ 5.20 [55]	$ 54.22	$ -49.02	39.5	3.2	(30)
North		5.44 [56]	54.22	-48.78	38.9	3.3	(30)
East/West		10.08 [57]	54.22	-44.14	29.9	5.0	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 17.76 [58]	$ 67.77	$-50.01	42.2	2.8	(30)
North		18.00 [59]	67.77	-49.77	41.7	2.9	(30)
East/West		23.44 [60]	67.77	-44.33	32.0	4.6	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-46.28 [61]	$ 81.32	$-127.60	100$^+$	<0	(12)
North		-46.04 [62]	81.32	-127.36	100$^+$	<0	(12)
East/West		-40.92 [63]	81.32	-122.24	100$^+$	<0	(12)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
WINDOW OPTIONS (savings compared to clear windows with screen which has 20% exterior shading and some use of blinds or curtains; SC=0.50, 100 ft^2 area) [O,Q]							
North Florida							
Tinted glass (SC = .85)	$ 190						
South		$ 2.24	$ 17.17	$ -14.93	84.8	<0	(30)
North		2.64	17.17	-14.53	72.0	0.4	(30)
East/West		3.20	17.17	-13.97	59.4	1.1	(30)
Reflective glass (SC = .51)	$ 190						
South		$ 7.36	$ 17.17	$ -9.81	25.8	5.6	(30)
North		8.96	17.17	-8.21	21.2	7.3	(30)
East/West		10.88	17.17	-6.29	17.5	8.9	(30)
Double pane (clear) (SC = .91)	$ 250						
South		$ 24.80	$ 22.59	$ 5.81	8.8	16.6	(30)
North		30.16	22.59	7.57	8.3	17.4	(30)
East/West		29.04	22.59	6.45	8.6	16.9	(30)
Double pane (tinted) (SC = .71)	$ 375						
South		$ 30.88	$ 33.88	$ -3.00	12.1	12.6	(30)
North		33.60	33.88	-.28	11.2	13.6	(30)
East/West		33.28	33.88	-.60	11.3	13.5	(30)
Double pane (reflective) (SC = .42)	$ 500						
South		$ 34.72	$ 45.18	$ -10.46	14.4	10.8	(30)
North		39.12	45.18	-6.06	12.8	12.1	(30)
East/West		39.92	45.18	-5.26	12.5	12.3	(30)
Solar screen (SC = .36) [I]	$ 300						
South		$ 3.96 [64]	$ 27.11	$ -23.15	33.5	0.3	(20)
North		5.96 [65]	27.11	-21.15	27.4	2.0	(20)
East/West		8.36 [66]	27.11	-18.75	22.5	3.9	(20)
Bahama shutters (SC = .42)	$ 600						
South		$ -.40 [67]	$ 54.22	$ -54.62	100^{+}	<0	(30)
North		1.76 [68]	54.22	-52.46	100^{+}	<0	(30)
East/West		4.32 [69]	54.22	-49.90	100^{+}	<0	(30)
Metal awnings (SC = .31)	$ 750						
South		$ 11.20 [70]	$ 67.77	$ -56.57	67.0	0.2	(30)
North		13.60 [71]	67.77	-54.17	55.2	1.3	(30)
East/West		16.56 [72]	67.77	-51.21	45.3	2.4	(30)
Fabric awnings (SC = .35)	$ 900						
South		$-52.44 [73]	$ 81.32	$ -133.76	100^{+}	<0	(12)
North		-50.20 [74]	81.32	-131.52	100^{+}	<0	(12)
East/West		-47.40 [75]	81.32	-128.72	100^{+}	<0	(12)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
SPACE CONDITIONING EQUIPMENT [R]							
Air conditioner (South Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 45.17 [76]	$ 15.81	$ 29.36	3.4	35.0	(15)
8.0 -> 10.0	350	80.34 [77]	31.63	48.71	3.8	31.8	(15)
8.0 -> 11.0	500	109.34 [78]	45.18	64.16	4.0	30.3	(15)
8.0 -> 12.0	600	134.00 [79]	54.22	79.78	3.9	31.1	(15)
Air conditioner (Central Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 31.17 [80]	$ 15.81	$ 15.36	4.7	25.6	(15)
8.0 -> 10.0	350	55.34 [81]	31.63	23.71	5.2	23.4	(15)
8.0 -> 11.0	500	75.39 [82]	45.18	30.15	5.4	22.5	(15)
8.0 -> 12.0	600	92.00 [83]	54.22	37.78	5.4	22.6	(15)
Air conditioner (North Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 27.17 [84]	$ 15.81	$ 11.36	5.3	22.9	(15)
8.0 -> 10.0	350	47.34 [85]	31.63	15.71	5.9	20.5	(15)
8.0 -> 11.0	500	63.33 [86]	45.18	18.18	6.3	19.2	(15)
8.0 -> 12.0	600	78.00 [87]	54.22	23.78	6.1	19.6	(15)
Incremental Comparisons							
Air conditioner (South Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 45.17 [88]	$ 15.81	$ 29.36	3.4	35.0	(15)
9.0 -> 10.0	175	35.17 [89]	15.81	19.36	4.3	28.4	(15)
10.0 -> 11.0	150	29.00 [90]	13.56	15.44	4.4	27.5	(15)
11.0 -> 12.0	100	24.67 [91]	9.03	15.64	3.6	33.8	(15)
Air conditioner (Central Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 31.17 [92]	$ 15.81	$ 15.36	4.7	25.6	(15)
9.0 -> 10.0	175	24.16 [93]	15.81	8.35	5.8	20.6	(15)
10.0 -> 11.0	150	20.00 [94]	13.56	6.44	6.0	20.1	(15)
11.0 -> 12.0	100	16.67 [95]	9.03	7.64	5.0	24.3	(15)
Air conditioner (North Florida)							
SEER							
8.0 -> 9.0	$ 175	$ 27.16 [96]	$ 15.81	$ 11.35	5.3	22.9	(15)
9.0 -> 10.0	175	20.16 [97]	15.81	4.35	6.7	17.7	(15)
10.0 -> 11.0	150	16.00 [98]	13.56	2.44	7.1	16.5	(15)
11.0 -> 12.0	100	14.67 [99]	9.03	5.64	5.6	21.8	(15)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
Heat pump (South Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 46.17 [100]	$ 15.81	$ 30.36	3.4	35.8	(15)
8/0/2.7 -> 10.0/3.0	400	79.66 [101]	36.14	43.52	4.3	28.3	(15)
8.0/2.7 -> 11.0.3.2	600	108.00 [102]	54.22	53.78	4.7	26.0	(15)
8.0/2.7 -> 12.0/3.3	750	131.00 [103]	67.76	63.24	4.8	25.3	(15)
Heat pump (Central Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 35.16 [104]	$ 15.81	$ 19.35	4.3	28.3	(15)
8/0/2.7 -> 10.0/3.0	400	59.33 [105]	36.14	23.19	5.5	22.0	(15)
8.0/2.7 -> 11.0.3.2	600	81.00 [106]	54.22	26.78	5.9	20.5	(15)
8.0/2.7 -> 12.0/3.3	750	98.00 [107]	67.76	30.24	6.1	19.7	(15)
Heat pump (North Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 34.16 [108]	$ 15.81	$ 18.35	4.4	27.6	(15)
8/0/2.7 -> 10.0/3.0	400	55.66 [109]	36.14	19.52	5.8	20.8	(15)
8.0/2.7 -> 11.0.3.2	600	75.00 [110]	54.22	20.78	6.3	19.1	(15)
8.0/2.7 -> 12.0/3.3	750	91.00 [111]	67.76	23.24	6.5	18.4	(15)
Incremental Comparisons							
Heat pump (South Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 46.17 [112]	$ 15.81	$ 30.36	3.4	35.4	(15)
9.0/2.9 -> 10.0/3.0	225	33.50 [113]	20.33	13.17	5.5	22.0	(15)
10.0/3.0 -> 11.0.3.2	200	28.33 [114]	18.07	10.26	5.7	21.2	(15)
11.0/3.2 -> 12.0/3.3	150	23.00 [115]	13.56	9.44	5.4	22.5	(15)
Heat pump (Central Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 35.16 [116]	$ 15.81	$ 19.35	4.3	28.3	(15)
9/0/2.9 -> 10.0/3.0	225	24.50 [117]	20.33	4.17	7.0	16.9	(15)
10.0/3.0 -> 11.0.3.2	200	21.33 [118]	18.07	3.26	7.1	16.7	(15)
11.0/3.2 -> 12.0/3.3	150	17.00 [119]	13.56	3.44	6.8	17.5	(15)
Heat pump (North Florida)							
SEER/COP							
8.0/2.7 -> 9.0/2.9	$ 175	$ 34.16 [120]	$ 15.81	$ 18.35	4.4	27.6	(15)
9/0/2.9 -> 10.0/3.0	225	21.50 [121]	20.33	1.17	7.8	14.9	(15)
10.0/3.0 -> 11.0.3.2	200	19.33 [122]	18.07	1.26	7.7	15.1	(15)
11.0/3.2 -> 12.0/3.3	150	16.00 [123]	13.56	2.44	7.1	16.7	(15)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
Heat pump vs. AC with elec. resis. heat (South Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$ 11.00 [124]	$ 27.10	$-16.10	14.3	5.7	(15)
8.0 ---> 9.0/2.9	525	55.50 [125]	47.44	8.06	7.2	16.4	(15)
8.0 ---> 10.0/3.0	750	89.00 [126]	67.76	21.24	6.6	18.1	(15)
8.0 ---> 11.0/3.2	1000	115.67 [127]	90.36	25.31	6.7	17.8	(15)
8.0 ---> 12.0/3.3	1200	137.00 [128]	108.43	28.57	6.8	17.5	(15)
Heat pump vs. AC with elec. resis. heat (Central Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$ 94.00 [129]	$ 27.10	$ 66.90	2.9	40.9	(15)
8.0 ---> 9.0/2.9	525	127.50 [130]	47.44	80.06	3.6	33.5	(15)
8.0 ---> 10.0/3.0	750	152.00 [131]	67.76	84.24	4.2	28.9	(15)
8.0 ---> 11.0/3.2	1000	171.67 [132]	90.36	81.31	4.9	24.8	(15)
8.0 ---> 12.0/3.3	1200	187.00 [133]	108.43	78.57	5.3	22.9	(15)
Heat pump vs. AC with elec. resis. heat (North Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$163.00 [134]	$ 27.10	$135.90	1.7	65.6	(15)
8.0 ---> 9.0/2.9	525	195.50 [135]	47.44	148.06	2.5	47.2	(15)
8.0 ---> 10.0/3.0	750	217.00 [136]	67.76	149.24	3.1	38.5	(15)
8.0 ---> 11.0/3.2	1000	234.67 [137]	90.36	144.31	3.7	32.7	(15)
8.0 ---> 12.0/3.3	1200	249.00 [138]	108.43	140.57	4.2	28.9	(15)
Incremental Comparisons							
Heat pump vs. AC with elec. resis. heat (South Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$ 11.00 [139]	$ 27.10	$-16.10	14.3	5.7	(15)
9.0 ---> 9.0/2.9	350	10.33 [140]	31.63	-21.30	15.9	4.3	(15)
10.0 ---> 10.0/3.0	400	8.67 [141]	36.14	-27.47	18.2	2.6	(15)
11.0 ---> 11.0/3.2	500	6.33 [142]	45.18	-38.85	21.7	0.4	(15)
12.0 ---> 12.0/3.3	600	3.00 [143]	54.22	-51.22	26.1	< 0	(15)
Heat pump vs. AC with elec. resis. heat (Central Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$ 94.00 [144]	$ 27.10	$ 66.90	2.9	40.9	(15)
9.0 ---> 9.0/2.9	350	96.33 [145]	31.63	64.70	3.2	37.4	(15)
10.0 ---> 10.0/3.0	400	96.67 [146]	36.14	60.53	3.6	33.5	(15)
11.0 ---> 11.0/3.2	500	96.33 [147]	45.18	51.15	4.4	27.6	(15)
12.0 ---> 12.0/3.3	600	95.00 [148]	54.22	40.78	5.2	23.4	(15)
Heat pump vs. AC with elec. resis. heat (North Florida)							
AC SEER HP SEER/COP							
8.0 ---> 8.0/2.7	$ 300	$163.00 [149]	$ 27.10	$135.90	1.7	65.6	(15)
9.0 ---> 9.0/2.9	350	168.33 [150]	31.63	136.70	1.9	59.0	(15)
10.0 ---> 10.0/3.0	400	169.67 [151]	36.14	133.53	2.2	52.1	(15)
11.0 ---> 11.0/3.2	500	171.33 [152]	45.18	126.15	2.7	43.6	(15)
12.0 ---> 12.0/3.3	600	171.00 [153]	54.22	116.78	3.1	38.5	(15)
Gas heat vs. elec. resis. heat [J,K,L]							
South Florida	$ 300	$ 16.00 [154]	$ 27.10	$-11.10	14.3	8.6	(20)
Central Florida	300	100.00 [155]	27.10	72.90	2.9	41.7	(20)
North Florida	300	169.00 [156]	27.10	141.90	1.7	65.9	(20)

	Gal/day	Added Costs [B]	Net First Year Savings [C]		Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
HOT WATER HEATING [S,T,U] (added cost & savings vs. standard elec. water heat)									
Superinsulated tanks (40 gal)		$ 70	$ 17.94	[157]	$ 6.32	$ 11.62	3.3	36.0	(12)
AC waste heat recovery	40	$ 450	$ 13.93	[158]	$ 40.66	$-26.73	14.3	2.2	(12)
	55		31.45	[159]	40.66	-9.21	9.2	9.6	(12)
	70		48.68	[160]	40.66	8.02	6.8	15.5	(12)
Heat pump water heater	40	$ 800	$ -3.24	[161]	$ 72.28	$-75.52	100+	<0	(12)
	55		27.42	[162]	72.28	-44.86	12.8	4.0	(12)
	70		57.79	[163]	72.28	-14.49	8.6	10.7	(12)
Heat pump water heater (cool exhaust from unit ducted to house during cooling season)	40	$1100	$ 32.76	[164]	$ 99.39	$-66.63	16.2	0.4	(12)
	55		77.42	[165]	99.39	-21.97	9.8	8.5	(12)
	70		121.79	[166]	99.39	22.40	7.0	14.9	(12)
Natural gas	40	$ 200	$ 70.50	[167]	$ 18.07	$ 52.43	2.2	52.0	(12)
	55		108.92	[168]	18.07	90.85	1.6	69.9	(12)
	70		142.34	[169]	18.07	124.27	1.3	87.5	(12)
Solar water heating		$2000							
pumped system (40 ft^2, 80 gal)	40		$ 53.67	[170]	$180.69	$-127.02	23.0	3.6	(20)
	55		80.67	[171]	180.69	-100.02	17.5	6.4	(20)
	70		99.67	[172]	180.69	-81.02	15.0	8.0	(20)
batch type (32 ft^2)	55	$1800	$120.00	[173]	162.62	-42.62	15.0	10.5	(30)
Insulate 70' of hot water pipes in slab and walls		$ 70	$ 27.00		$ 6.32	$ 20.68	2.6	45.5	(30)
Reduce hot water runs from 30' to 10' by adding second water heater and insulating pipes		$ 200	$ 26.00	[174]	$ 18.07	$ 7.93	5.6	20.1	(12)
APPLIANCES									
High-efficiency refrigerators [V]									
size range: 16.5 - 18.4 ft^3		$ 50	$ 17.50	[175]	$ 4.52	$ 12.98	2.5	46.2	(12)
18.5 - 20.4 ft^3		60	17.00	[176]	5.42	11.58	3.0	38.7	(12)
20.5 - 24.0 ft^3		70	21.50	[177]	6.32	15.18	2.8	41.4	(12)
High-efficiency freezer (18 ft^3)		$ 50	$ 17.50	[178]	$ 4.52	$ 12.98	2.5	46.2	(12)
Microwave oven (savings from doing 50% of cooking in microwave)		$ 250	$ 12.50	[179]	$ 22.59	$-10.09	10.0	8.1	(12)

	Added Costs [B]	Net First Year Savings [C]	Net Added Annual Mortgage Cost [D]	Net First Year Cash Flow [E]	Simple Payback Period Years [F]	Rate of Return on Investment Percent [G]	(System Life)
High efficiency indoor lighting (savings from converting 33% of lighting to fluorescent or other high efficiency lights)	$ 100	$ 20.00 [180]	$ 9.03	$ 10.97	5.0	25.9	(30)
High efficiency outdoor lighting (150 W lighting, 12 hrs/day)							
- use mercury vapor lighting	$ 30	$ 29.00 [181]	$ 2.71	$ 26.29	1.0	113.4	(10)
- use high pressure sodium	30	40.00 [182]	2.71	37.29	0.7	152.0	(10)
Low-flow shower heads (2 units) Reduce 3.0 gpm to 1.5 gpm flow	$ 30	$ 42.00 [183]	$ 2.71	$ 39.29	0.6	169.4	(5)
Low-water use toilets 2 toilets, save 2 gal/flush (12 flushes/day)	$ 200	$ 25.00 [184]	$ 18.07	$ 6.93	8.0	17.7	(30)
Gas range/oven	$ 200	$ 36.67 [185]	$ 18.07	$ 18.60	5.0	24.4	(15)
Gas dryer	$ 100	$ 59.00 [186]	$ 9.03	$ 49.97	1.6	66.0	(15)

Footnotes

[A] Description of house used for energy analysis

1. 1-story slab-on-grade construction
2. 1500 ft^2 floor area - 50' east/west axis, 30' north/south axis
3. 214 ft^2 window area

	SC (shading coefficient)
south - 70 ft^2	.60
north - 60 ft^2	.42
east - 42 ft^2	.42
west - 42 ft^2	.42

   single-pane windows
4. roof overhangs - 2' (all sides)
5. roof slope 5/12
6. roof absorptivity a=0.80
7. walls R11, frame construction, absorptivity a=0.50
8. attic insulation =R19
9. air infiltration =0.43 air changes per hour (annual average)
10. internal load 50,807 Btu/day (sensible)
11. computer simulations done by TARP (Thermal Analysis Research Program)
12. the three Florida climate zones are represented by:
    South - Miami
    Central - Orlando
    North - Jacksonville

Additional assumptions

1. electricity cost is $0.08/kWh
2. cooling SEER is 8.0
3. heating is done by heat pump, COP=2.7, which operates at COP = 2.43 as a result of duct conduction and infiltration losses.
4. summer thermostat setpoint is 78°F - assumed for all day
5. winter thermostat setpoint is 72°F - assumed for all day
6. annual cooling costs: south - $462; central - 337; north - 295
7. annual heating costs: -

	elec. resistance	heat pump
south	- $ 33	$ 12
central	- 165	61
north	- 274	101

[B] This is the estimated added cost the home buyer will pay. Cost information for energy-saving options were obtained from surveys of contractors and product supply companies. Effort was made to determine costs that are representative of the actual prices builders would charge their customers. Because of variability in material and labor costs from one contractor to another, and from one portion of the state to another, the amount the home buyer will actually pay may be diferent from this.

[C] For most energy saving options being evaluated, the annual energy savings are reduced by system replacement costs. These are the funds necessary to perpetuate the equipment through the end of the 30-year mortgage period. With the exception of very long-lasting items (e.g. insulation, windows, etc.), all options are so adjusted. For example, if a heat pump costs $500 more than an air conditioner and has a 15-year life expectancy, then the unit will have to be replaced once in 30 years and the annual fuel savings would have to be reduced by $500/30. The assumption is being made that interest accumulation of the replacement funds approximately equals the inflation in cost of the energy option.

[D] This is the annual mortgage payment (sum of 12 monthly payments) for a 30-year mortgage with an interest rate of 10% less the tax savings from deducting mortgage interest payments from income (assuming 15% tax bracket).

[E] Net cash flow is the net first year savings less the after-tax added mortgage payment. If the net cash flow is positive, the energy option is more than paying for the added cost of the option in the first year. Actual cash flow in the second and subsequent years will be greater if fuel prices escalate. Net cash flow does not give credit for the fact that energy savings are tax-free. Real net cash flow will in effect be greater than is shown.

[F] The simple payback period is the number of years required for the accumulated energy savings (less maintenance and repair costs) to equal the initial cost of the option.

[G] Internal Rate of Return on Investment. This is (in effect) the interest rate yield the consumer receives in energy savings (less maintenance and repair costs) from the initial principal invested. This analysis assumes a nominal 5% annual fuel price escalation. In parentheses are the number of years used for IRRI analysis, which is generally the system life expectancy. This analysis provides a more favorable economic assessment than net cash flow because it takes into account escalating fuel costs. A shortcoming of any IRRI analysis is that extremely high rates of return are not the true investment return, since it assumes savings can be reinvested at the same rate of return. An IRRI greater than 10.0% can generally be considered a good option and an IRRI greater than 15% is an excellent investment. This IRRI yield is actually superior to taxable investment options of comparable risk because the energy savings are a tax-free return on investment. The interest earnings on the energy savings, however, is taxable income.

[H] Energy savings for radiant barriers and attic and wall insulation assume a heat pump for space heating. If electric resistance heat is used, savings will be significantly higher for central and north Florida.

[I] R19 batt is \$.36/ft^2 to homeowner in this calculation.
R30 batt is \$.58/ft^2 to homeowner in this calculation.

[J] R19 blown fiberglass is \$0.22/ft^2 to homeowner.
R30 blown fiberglass is \$0.34/ft^2 to homeowner.

[K] R30 cellulose fiberglass is \$0.33/ft^2 to homeowner.

[L] Radiant barrier cost is \$.20/ft^2 (roof area) to customer. As with all costs, they will vary from one contractor to another, and from one portion of the state to another. However, because of the relatively new status of radiant barriers, more variation can be anticipated than with more established technologies. In addition, there appears to be considerable opportunity for price reductions to occur as volume increases and the most cost-effective means for installation are discovered.

[M] 3/4" polyisocyanurate or closed-cell phenolic foam (foil faced) board against block with firring strips securing to the wall. \$9/32 ft^2 sheet.

[N] 3/4" polyiso board or closed-cell phenolic foam as exterior sheathing. Added cost includes material cost difference between board insulation and 1/8" sheathing board plus the added cost ($100) for corner let-in bracing. This option may significantly reduce infiltration, and by taping the seams with acrylic adhesive tape it can serve in lieu of a vapor barrier. The energy savings do not reflect the reduced infiltration.

[O] Window shading savings were done using the TARP simulation program. The savings assume a heat pump for space heating. If electric resistance heating is used, the savings for the shading options will be reduced in central and north Florida, and the savings from double-pane windows will be much higher.

[P] Shading coefficient (SC) of 0.80 represents totally unshaded windows which have an external insect screen over 50% of the window area. The savings associated with each shading option are compared against these SC=0.80 windows. A 2-foot overhang provides shade on all sides of the house.

[Q] Shading coefficient (SC) of 0.50 represents windows which have an external insect screen over 50% of the window, 20% shading of the window by vegetation or nearby structures, and some use of internal shading (blinds, curtains, etc.). Curtain impact upon and interaction with the shading options is assessed by use of Table 39 in Chapter 27 of the 1985 ASHRAE Fundamentals. The savings associated with each shading option are compared against the base case SC=0.50 windows. A 2-foot overhang provides shade on all sides of the house.

[R] Total cooling and heating energy use was determined from TARP and Typical Meterological Year Solmet data developed by Trinity University. Cost data is for 2.5 ton cooling equipment. The COP of electric resistance heating using a forced-air system is assumed to be 0.90. The heat pump COP is rated at 2.7, but we actually use a 2.23 COP. Savings in cooling and heating energy are determined by proportion to the base case energy efficiency rating. For example, if an 8.0 SEER air conditioner uses $337/year for cooling, a 10.0 SEER unit will use 8.0/10.0 x $337=$269.60/year.

[S] Following are annual maintenance costs for some hot water heating options, as assumed for the rate of return on investment analysis only.

AC waste heat recovery	$15
Heat pump water heater	$50
Gas water heater	$10
Active solar system	$50
Batch solar system	$10

[T] Water heating energy use is based on 75°F cold water coming into the water heater and 122°F tank setpoint. Standard electric water heater is assumed to have an EF (energy factor) of .88. Gas water heater has an EF of .55 and RE (recovery efficiency) of .77. Values for EF and RE can be obtained from the GAMA (Gas Appliance Manufacturer's Association) "Consumer's Directory of Certified Water Heater Efficiency Ratings."

Calculation of annual energy cost (AEC) can be made using the following formulas.

Gas units:

$$\text{AEC \$} = \left[\frac{\text{Temp rise } (^{o}\text{F}) \times \frac{\text{Gal}}{\text{day}} \times 8.3 \frac{\text{Btu}}{\text{gal } ^{o}\text{F}}}{\text{RE}} + \left[\frac{1.0}{\text{EF}} - \frac{1.0}{\text{RE}}\right] \times 47{,}743 \right]$$

$$\times \left[\frac{365 \text{ days} \times \frac{\$}{\text{therm}}}{100{,}000 \frac{\text{Btu}}{\text{therm}}} \right]$$

Electric units:

$$\text{AEC \$} = \left[\text{Temp rise } (^{o}\text{F}) \times \frac{\text{Gal}}{\text{day}} \times 8.3 \frac{\text{Btu}}{\text{gal}} \, ^{o}\text{F} + \left[\frac{1.0}{\text{EF}} - 1.0 \right] \times 47{,}743 \right]$$

$$\times \left[\frac{365 \text{ days} \times \frac{\$}{\text{kWh}}}{3413 \frac{\text{Btu}}{\text{kWh}}} \right]$$

[U] Energy savings for AC waste heat recovery, heat pump water heater, gas water heating, and solar water heating are based on field data from Tim Merrigan, "Residential Conservation Demonstration - Domestic Hot Water," FSEC-CR-90-83, Florida Solar Energy Center, September 1983.

[V] The refrigerator energy savings are for the most efficient units compared to typical units.

	Net 1st year savings		1st year savings		30-year replacement cost		maintenance costs	
[1]	$137.62	=	$143.62*	-	$ 180/30			(replace 3 fans)
[2]	95.90	=	101.90*	-	180/30			
[3]	85.86	=	91.86*	-	180/30			

* This first year savings takes into account fan electricity use and increased air-conditioning costs.

Window shading options (base SC=0.80)

South Florida

[4]	$ 31.24	=	$ 36.24	-	$ 150/30			(replace 0.5 times)
[5]	25.00	=	30.00	-	150/30			(replace 0.5 times)
[6]	36.20	=	41.20	-	150/30			(replace 0.5 times)
[7]	27.92	=	37.92	-	0	-	300/30	(repaint once)
[8]	21.44	=	31.44	-	0	-	300/30	(repaint once)
[9]	33.12	=	43.12	-	0	-	300/30	(repaint once)

	Net 1st year savings		1st year savings		30-year replacement cost		maintenance costs	
[10]	45.36	=	45.36	-	0			
[11]	37.52	=	37.52	-	0			
[12]	51.52	=	51.52	-	0			
[13]	-20.12	=	42.88	-	1350/30	-	540/30	(replace 1.5 times
[14]	-27.48	=	35.52	-	1350/30	-	540/30	resew three times)
[15]	-14.28	=	48.72	-	1350/30	-	540/30	
Central Florida								
[16]	$ 17.24	=	$ 22.24	-	$ 150/30			(replace 0.5 times)
[17]	17.56	=	22.56	-	150/30			(replace 0.5 times)
[18]	24.44	=	29.44	-	150/30			(replace 0.5 times)
[19]	13.28	=	23.28	-	0	-	300/30	(repaint once)
[20]	13.60	=	23.60	-	0	-	300/30	(repaint once)
[21]	20.72	=	30.72	-	0	-	300/30	(repaint once)
[22]	27.84	=	27.84	-	0			
[23]	28.24	=	28.24	-	0			
[24]	36.80	=	36.80	-	0			
[25]	-36.68	=	26.32	-	1350/30	-	540/30	(replace 1.5 times,
[26]	-36.28	=	26.72	-	1350/30	-	540/30	resew three times)
[27]	-28.20	=	34.80	-	1350/30	-	540/30	
North Florida								
[28]	$ 9.00	=	$ 14.00	-	$ 150/30			(replace 0.5 times)
[29]	12.04	=	17.04	-	150/30			(replace 0.5 times)
[30]	15.96	=	20.96	-	150/30			(replace 0.5 times)
[31]	4.64	=	14.64	-	0	-	300/30	(repaint once)
[32]	7.84	=	17.84	-	0	-	300/30	(repaint once)
[33]	11.92	=	21.92	-	0	-	300/30	(repaint once)
[34]	17.44	=	17.44	-	0			
[35]	21.44	=	21.44	-	0			
[36]	26.08	=	26.08	-	0			
[37]	-46.44	=	16.56	-	1350/30	-	540/30	(replace 1.5 times,
[38]	-42.76	=	20.24	-	1350/30	-	540/30	resew three times)
[39]	-38.44	=	24.56	-	1350/30	-	540/30	

Window shading options (base SC=0.50)

	Net 1st year savings		1st year savings		30-year replacement cost		maintenance costs	
South Florida								
[40]	$ 18.04	=	$ 23.04	-	$ 150/30			(replace 0.5 times)
[41]	14.12	=	19.12	-	150/30			(replace 0.5 times)
[42]	21.24	=	26.24	-	150/30			(replace 0.5 times)
[43]	14.72	=	24.72	-	0	-	300/30	(repaint once)
[44]	10.48	=	20.48	-	0	-	300/30	(repaint once)
[45]	18.08	=	28.08	-	0	-	300/30	(repaint once)
[46]	28.88	=	28.88	-	0			
[47]	23.92	=	23.92	-	0			
[48]	32.90	=	32.80	-	0			
[49]	-35.80	=	27.20	-	1350/30	-	540/30	(replace 1.5 times,
[50]	-40.44	=	22.56	-	1350/30	-	540/30	resew three times)
[51]	-32.04	=	30.96	-	1350/30	-	540/30	
Central Florida								
[52]	$ 9.16	=	$ 14.16	-	$ 150/30			(replace 0.5 times)
[53]	9.40	=	14.40	-	150/30			(replace 0.5 times)
[54]	13.72	=	18.72	-	150/30			(replace 0.5 times)
[55]	5.20	=	15.20	-	0	-	300/30	(repaint once)
[56]	5.44	=	15.44	-	0	-	300/30	(repaint once)
[57]	10.08	=	20.08	-	0	-	300/30	(repaint once)
[58]	17.76	=	17.76	-	0			
[59]	18.00	=	18.00	-	0			
[60]	23.44	=	23.44	-	0			
[61]	-46.24	=	16.72	-	1350/30	-	540/30	(replace 1.5 times,
[62]	-46.04	=	16.96	-	1350/30	-	540/30	resew three times)
[63]	-40.92	=	22.08	-	1350/30	-	540/30	
North Florida								
[64]	$ 3.96	=	$ 8.96	-	$ 150/30			(replace 0.5 times)
[65]	5.96	=	10.96	-	150/30			(replace 0.5 times)
[66]	8.36	=	13.36	-	150/30			(replace 0.5 times)
[67]	-.40	=	9.60	-	0	-	300/30	(repaint once)
[68]	1.76	=	11.76	-	0	-	300/30	(repaint once)
[69]	4.32	=	14.32	-	0	-	300/30	(repaint once)
[70]	11.20	=	11.20	-	0			
[71]	13.60	=	13.60	-	0			
[72]	16.56	=	16.56	-	0			

	Net 1st year savings		1st year savings		30-year replacement cost		maintenance costs	
[73]	-52.44	=	10.56	-	1350/30	-	540/30	(replace 1.5 times,
[74]	-50.20	=	12.80	-	1350/30	-	540/30	resew three times)
[75]	-47.40	=	15.60	-	1350/30	-	540/30	

Air conditioners

South Florida

[76]	$ 45.17	$ 51.00	$ 175/30
[77]	80.34	92.00	350/30
[78]	109.34	126.00	500/30
[79]	134.00	154.00	600/30

Central Florida

[80]	31.17	37.00	175/30
[81]	55.34	67.00	350/30
[82]	75.33	92.00	500/30
[83]	92.00	112.00	600/30

North Florida

[84]	27.17	33.00	175/30
[85]	47.34	59.00	350/30
[86]	63.33	80.00	500/30
[87]	78.00	98.00	600/30

South Florida

[88]	$ 45.17	$ 51.00	$ 175/30
[89]	35.17	41.00	175/30
[90]	29.00	34.00	150/30
[91]	24.67	28.00	100/30

Central Florida

[92]	31.17	37.00	175/30
[93]	24.16	30.00	175/30
[94]	20.00	25.00	150/30
[95]	16.67	20.00	100/30

North Florida

[96]	27.16	33.00	175/30
[97]	20.16	26.00	175/30
[98]	16.00	21.00	150/30
[99]	14.67	18.00	100/30

	Net 1st year savings		1st year savings		30-year replacement cost	maintenance costs
			Heat pumps			
South Florida						
[100]	$ 46.17	=	$ 52.00	-	$ 175/30	
[101]	79.66	=	93.00	-	400/30	
[102]	108.00	=	128.00	-	600/30	
[103]	131.00	=	156.00	-	750/30	
Central Florida						
[104]	35.16	=	41.00	-	175/30	
[105]	59.33	=	73.00	-	400/30	
[106]	81.00	=	101.00	-	600/30	
[107]	98.00	=	123.00	-	750/30	
North Florida						
[108]	34.16	=	40.00	-	175/30	
[109]	55.66	=	69.00	-	400/30	
[110]	75.00	=	95.00	-	600/30	
[111]	91.00	=	116.00	-	750/30	
South Florida						
[112]	$ 46.17	=	$ 52.00	-	$ 175/30	
[113]	33.50	=	41.00	-	225/30	
[114]	28.33	=	35.00	-	200/30	
[115]	23.00	=	28.00	-	150/30	
Central Florida						
[116]	35.16	=	41.00	-	175/30	
[117]	24.50	=	32.00	-	225/30	
[118]	21.33	=	28.00	-	200/30	
[119]	17.00	=	22.00	-	150/30	
North Florida						
[120]	34.16	=	40.00	-	175/30	
[121]	21.50	=	29.00	-	225/30	
[122]	19.33	=	26.00	-	200/30	
[123]	16.00	=	21.00	-	150/30	

	Net 1st year savings		1st year savings		30-year replacement cost	maintenance costs
	HP vs. AC with electric resistance heat					
South Florida						
[124]	$ 11.00	=	$ 21.00	-	$ 300/30	
[125]	55.50	=	73.00	-	525/30	
[126]	89.00	=	114.00	-	750/30	
[127]	115.67	=	149.00	-	1000/30	
[128]	137.00	=	177.00	-	1200/30	
Central Florida						
[129]	94.00	=	104.00	-	300/30	
[130]	127.50	=	145.00	-	525/30	
[131]	152.00	=	177.00	-	750/30	
[132]	171.67	=	205.00	-	1000/30	
[133]	187.00	=	227.00	-	1200/30	
North Florida						
[134]	163.00	=	173.00	-	300/30	
[135]	195.50	=	213.00	-	525/30	
[136]	217.00	=	242.00	-	750/30	
[137]	234.67	=	268.00	-	1000/30	
[138]	249.00	=	289.00	-	1200/30	
South Florida						
[139]	$ 11.00	=	$ 21.00	-	$ 300/30	
[140]	10.33	=	22.00	-	350/30	
[141]	8.67	=	22.00	-	400/30	
[142]	6.33	=	23.00	-	500/30	
[143]	3.00	=	23.00	-	600/30	
Central Florida						
[144]	94.00	=	104.00	-	300/30	
[145]	96.33	=	108.00	-	350/30	
[146]	96.67	=	110.00	-	400/30	
[147]	96.33	=	113.00	-	500/30	
[148]	95.00	=	115.00	-	600/30	

	Net 1st year savings		1st year savings		30-year replacement cost	maintenance costs	
North Florida							
[149]	163.00	=	173.00	-	300/30		
[150]	168.33	=	180.00	-	350/30		
[151]	169.67	=	183.00	-	400/30		
[152]	171.33	=	188.00	-	500/30		
[153]	171.00	=	191.00	-	600/30		
			Gas heating				
[154]	$ 16.00	=	$ 21.00	-	$ 150/30		(replace 0.5 times)
[155]	100.00	=	105.00	-	150/30		
[156]	169.00	=	174.00	-	150/30		
			Water heating				
[157]	$ 17.94	=	$ 21.44	-	$ 105/30		(replace 1.5 times)
[158]	13.93	=	46.43	-	525/30	15	(replace 1.5 times)
[159]	31.45	=	63.95	-	525/30	15	(replace 1.5 times)
[160]	48.68	=	81.18	-	525/30	15	(replace 1.5 times)
[161]	-3.24	=	81.76	-	1050/30	50	(replace 1.5 times)
[162]	27.42	=	112.42	-	1050/30	50	(replace 1.5 times)
[163]	57.79	=	142.79	-	1050/30	50	(replace 1.5 times)
[164]	32.76	=	117.76	-	1050/30	50	(replace 1.5 times)
[165]	77.42	=	162.42	-	1050/30	50	(replace 1.5 times)
[166]	121.79	=	206.79	-	1050/30	50	(replace 1.5 times)
[167]	70.50	=	90.50	-	150/30	10	(replace 1.5 times)
[168]	108.92	=	123.92	-	150/30	10	(replace 1.5 times)
[169]	142.34	=	157.34	-	150/30	10	(replace 1.5 times)
[170]	53.67	=	137.00	-	1000/30	50	(replace 0.5 times)
[171]	80.67	=	164.00	-	1000/30	50	(replace 0.5 times)
[172]	99.67	=	183.00	-	1000/30	50	(replace 0.5 times)
[173]	120.00	=	130.00	-	0	10	
[174]	26.00	=	71.00	-	300/30	35	(second tank heat loss and added AC load)
			Appliances				
[175]	$ 17.50	=	$ 20	-	$ 75/30		(replace 1.5 times)
[176]	17.00	=	20	-	90/30		(replace 1.5 times)
[177]	21.50	=	25	-	105/30		(replace 1.5 times)
[178]	17.50	=	20	-	75/30		(replace 1.5 times)
[179]	12.50	=	25	-	375/30		(replace 1.5 times)
[180]	20.00	=	20	-	0		
[181]	29.00	=	31	-	60/30		(replace 2 times)
[182]	40.00	=	42	-	60/30		(replace 2 times)
[183]	42.00	=	47	-	150/30		(replace 5 times)
[184]	25.00	=	25	-	0		
[185]	36.67	=	40	-	100/30		(replace 1 times)
[186]	59.00	=	61	-	60/30		(replace 1 times)

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