Chapter 3

Energy Efficient Features

Investments in energy efficient features in new homes are remarkable because everyone wins:

- Most homeowners win because they receive a positive cash flow within 1-3 years.
- Homeowners benefit from improved comfort, better indoor air quality and reduced moisture problems.
- Heating, ventilation and air conditioning contractors have fewer callbacks.
- Realtors receive additional fees from the additional cost of the energy features and enhance their reputations by selling higher quality homes that homebuyers appreciate.
- Participating financial institutions can receive higher mortgage payments because the homes have lower annual ownership costs due to reduced utility bills.
- National lending agencies such as the Federal Housing Authority (FHA) and the Veteran's Administration (VA) permit energy efficient home buyers to qualify for larger loans because their energy bills will be lower.
- The local community benefits as more money stays within the community; and local subcontractors and product suppliers make additional income by selling improved energy efficient features.

To compensate for heat gains in hot humid climates like Louisiana air conditioning design must take into consideration all forms of energy that will elevate the temperature in the home. These forms are often called "energy loads." "Energy loads" are imposed either by climate, life style choices, people and animals, and power required to light the spaces and cook food. Each watt of electricity used in the home, whether it is running a computer, playing music, operating a blow dryer or charging a cell phone battery, produces 3.412 Btus. The average human being at rest may put out 500 Btus. Pets may produce even more heat. Then there is power from lighting, cooking, washing, and making hot water. Add to that the amount of light passing through windows facing the sun at different times of the day. This applies to walls and ceilings as well even though they are more resistant to heat conduction. All have quantifiable load characteristics that must be taken into account when designing the air conditioning system. In winter the envelope components reverse their flow while the others contribute to heating the space.

Achieving Energy Efficiency

Overall success, resulting in a well-designed and constructed home that is also energy efficient, requires careful and cooperative collaboration between the owner, the architect (or licensed home designer), and the builder. The architect, if used, or a home energy rater should serve as the main coordinating party between the participants.

Designing and building a home that uses energy wisely does not mean sacrificing a home's aesthetic qualities or amenities. Quite the opposite; usually, the better the home is designed, the easier and more natural it is to make it energy efficient, comfortable and convenient. While an energy efficient home usually incorporates higher quality windows and doors than a standard code compliant home, the payback due to increased energy savings for the better quality materials is usually 2-3 years.

After payback, the owner continues to benefit from the energy savings as long as he occupies the home.

International Residential Code 2006 (IRC 2006)

The state of Louisiana adopted IRC 2006, effective January 2007, as its residential building code. Chapter 11 of the IRC 2006 deals with residential energy efficiency. Figure 3-1 is the climate zone map that is used by the IRC 2006. Along with Tables N1102.1 and N1102.1.2 of the IRC 2006, a builder can determine which residential building components are permitted at that location. The dotted white line separates the portion of the southeast that is considered to have high humidity affecting building design.

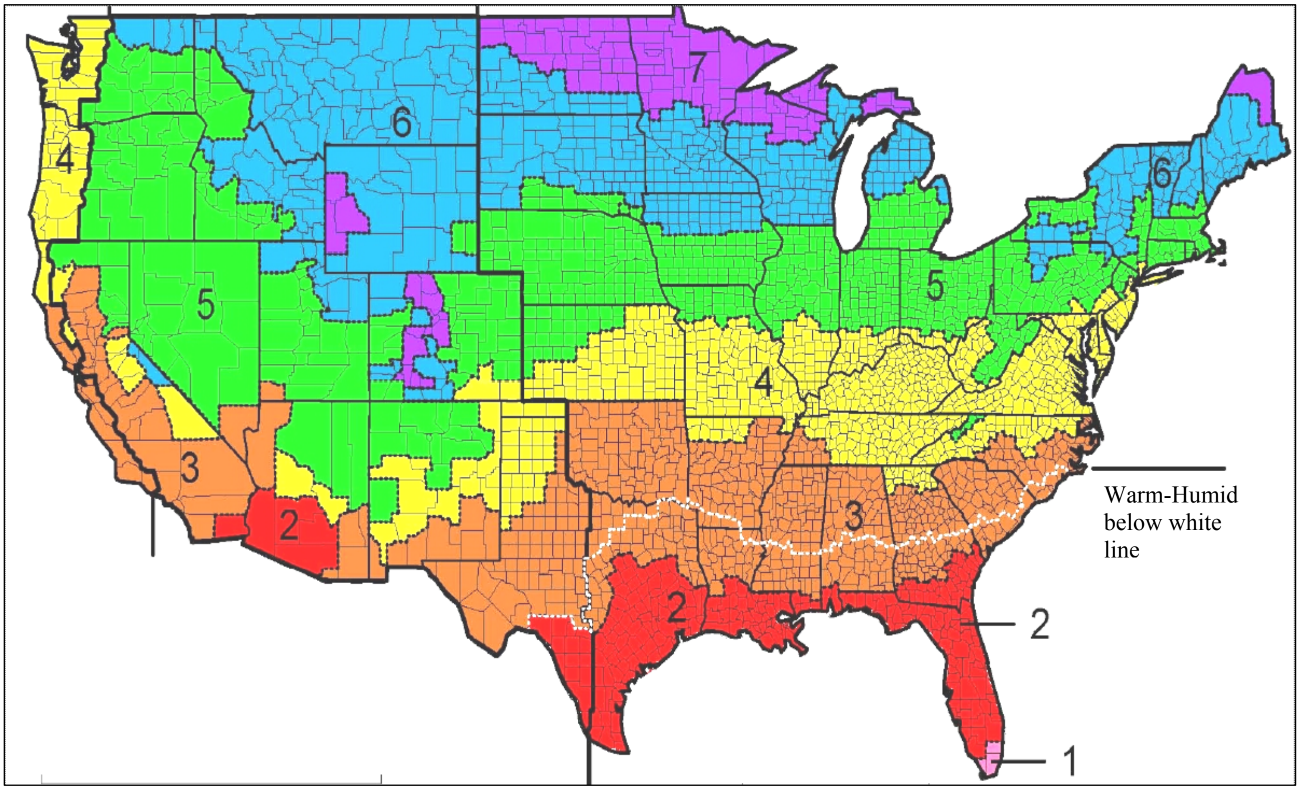
For the purpose of this guide we are only concerned with Louisiana, Zones 2 & 3, Hot and Humid, including the north east corner of the state for the following energy related items:

1. The building thermal envelope*
2. Insulation and fenestration**
3. Duct insulation for supply and return ducts
4. Duct sealing
5. Air leakage and moisture control
6. General lighting - limiting air leakage

* The building envelope consists of the building's roof, walls, windows and doors. The envelope controls the flow of energy between the interior and exterior of the building. Source: U.S. DOE EERE website (URL: http://www.eere.energy.gov, May 2, 2007).

** Fenestration is defined as the arrangement, proportioning and design of windows and doors in a building.

Figure 3-1
International Residential Code (2006) Climate Zone Map



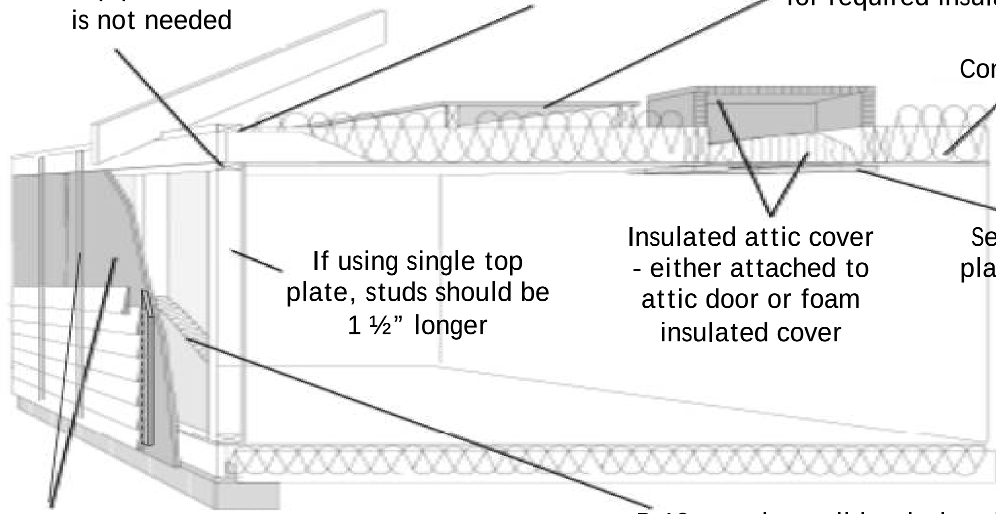
Quality of Construction Affects Energy Efficiency

Quality of the basic construction goes a long way in providing comfort to the homeowner and savings on energy costs. The following areas should be thoroughly reviewed in the design process and during construction:

1. One of the most important aspects of the planning of a home is making advantageous use of the site for the comfort of the occupants. Planning for a nice view from the site is very important. However, where windows are placed affects energy use. Solar heat gain is greatest from the East and West, so minimizing glass on those sides is the best idea. With good windows, cold North winds are not much of a winter heating concern in Louisiana, therefore orienting the home to face north and installing more glazing there is better than facing either east or west. Southerly views are also better as long as the windows are shaded with the maximum code-allowed overhang. Another good solution for providing shade to South facing windows is the use of an arbor or pergola, to reduce the amount of light hitting the glass without obstructing the view. See Chapter 1 for more detail on site planning.

2. Quality of framing and installation of insulation and windows. In order to have infiltration control of a house all the pieces must be fit together tightly. Any cracks must be sealed by a material that will last and conform to any changes that occur. Discontinuous or compacted insulation does not perform as it would if installed properly. Some critical areas are shown in Figures 3-2, 3-3, and 3-4.

Figure 3-2
Envelope Construction Ideas



3. Attention to detail in sealing air leaks.

Figure 3-3
Sealing Holes in Framing

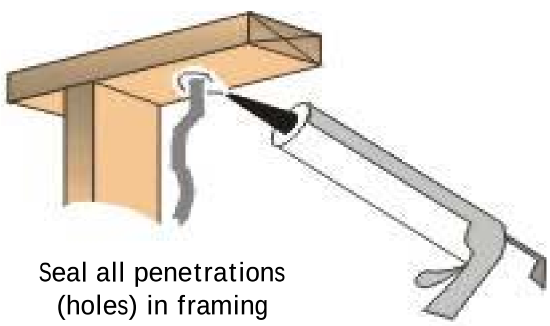
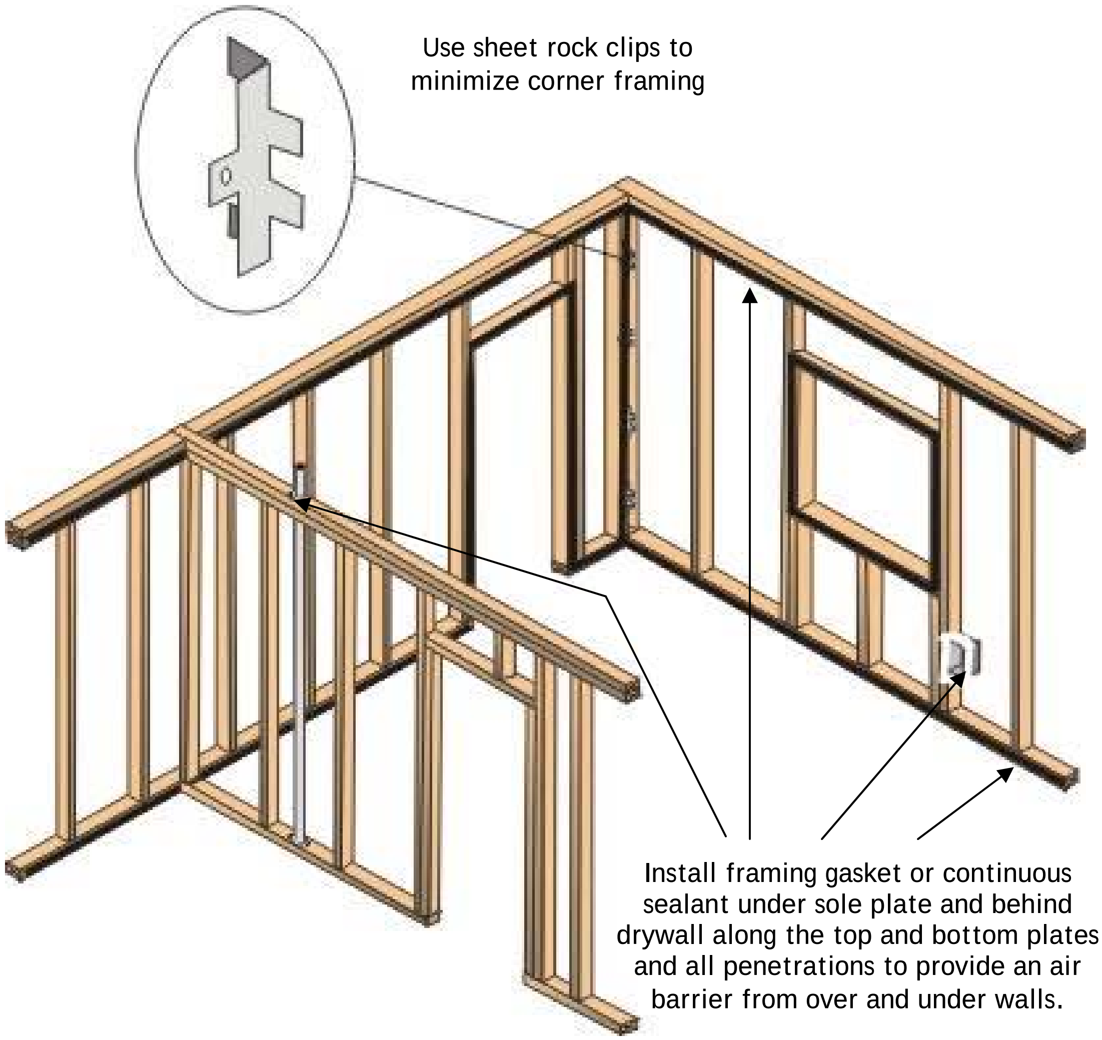
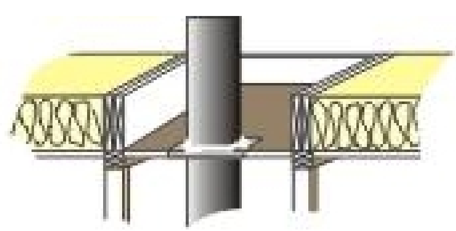


Figure 3-4
More Sealing Techniques





4. Design and installation of the heating and cooling equipment. Make sure that the HVAC contractor knows he is dealing with a well designed, energy efficient house before he sizes the equipment. Excessive air conditioning can cause moisture problems by cooling the air before it removes the moisture. This can cause moisture condensation in wall cavities, promoting the growth of mold inside walls and ducts. Many air handler cabinets come from the factory with leaks. Use mastic to seal holes and seams. Seal removable panels with approved metal duct tape.

5. Effectiveness in sealing duct leaks. Well sealed ducts keep your conditioned air inside your dwelling rather than trying to cool the whole world. Cloth duct tape will fail too quickly to be used on ducts or air handlers. See Chapters 7 and 8 for more detail.

Economics of Energy Efficient Improvements

Unlike nice granite counter tops, energy efficiency features pay for themselves. World economics change and to set a price for any one feature and its value/savings is not possible. Prices shown below were representative when this book was written and illustrate how they can pay back their initial cost many times over. You will have to determine the cost at the time you build. If utility rates do not go up as expected, the payback will be longer.

All energy efficient features will produce a return on your investment, but sometimes you are better off investing the dollars in those features that will save you more or provide a higher return. Ways to determine this are shown later in this chapter.

The Energy Star Home

The criteria for an Energy Star Home is that it be at least 15% more efficient than a house built to the International Residential Code of 2003 and its supplement of 2004. The economic benefits for an Energy Star Home are seen in Tables 3-1 and 3-2. The minimum design requirements to meet the 2006 IRC, the Louisiana state building code, are shown in Table 3-3.

Table 3-1
Estimated Extra Costs of a 2,000 sq ft Energy Star Home in Baton Rouge

Energy Efficiency Improvement:	Unit Cost $ (incremental)	Quantity	Total Estimated Cost
Attic- Increase insulation from R30 to R38 insulation of roof rather than ceiling with sealed attic	$0.30/sq.ft.	2,000 sq.ft.	$660
Seal air leakage to unconditioned space	$0.20/sq.ft.	2,000 sq.ft.	$400
Install fluorescent fixtures throughout home	$31 each	12 lamps	$372
Install Energy Star Appliances	$200 each	4	$800
Perform RESNET Energy Rating	$200 each	1	$200
Insulation wrap on water heater & hot pipes	$100 each	1 unit	$100
Perform ACCA Manual J, D and S to properly design the complete HVAC system	$300 each	1	$300
Upgrade HVAC system from SEER 13 to 14	$600 each	1 unit	$600
Install Heat Recovery Ventilation System	$600 each	1 unit	$600
Install humidistat controlled exhaust fans	$200 each	2 units	$400
Cost Subtotal			$4,332
Savings from Properly designed HVAC*			($1,500)
Net Total Cost			$2,932

*A properly designed HVAC system for a well insulated and sealed house including the above modifications can have a lower rated output with shorter duct runs, providing for a major cost reduction.

Table 3-2
Energy Savings for an Energy Star Home

Louisiana Code Home		**Energy Star Home**				
Year	Annual Energy* Cost	Annual Energy* Cost	Annual Energy Savings	Extra Mortgage Cost	Total Cost	Cumulative savings
1	1613	1371	242	581	-339	-339
2	1645	1398	247	81	166	-173
3	1678	1426	252	81	171	-2
4	1712	1455	257	81	176	173
5	1746	1484	262	81	181	354
6	1781	1514	267	81	186	541
7	1816	1544	273	81	192	732
8	1853	1575	278	81	197	929
9	1890	1606	284	81	203	1132
10	1928	1638	289	81	208	1340
15	2128	1809	319	81	238	2470
20	2350	1997	353	81	272	3760
25	2594	2205	389	81	308	5226
30	2864	2435	430	81	349	6887

*Energy prices are assumed to escalate 2% per year. Savings determined by RemRate modeling software based on Baton Rouge and prevailing utility rates. Your savings for the same design and equipment will vary. A home energy rater can provide more accurate results for your house design and location as well as advise you on other options.

Table 3-3
Design Requirements to Meet the 2006 International Residential Code

FEATURE:	Climate Zone 2	Climate Zone 3
Fenestration U-Factor	0.75	0.65
Skylight U-Factor	0.75	0.65
Glazed Fenestration SHGC	0.4	0.4
Ceiling R-Value	30	30
Wood Frame Wall R-Value	13	13
Mass Wall R-Value	4	5
Elevated Floor R-Value	13	19
Basement Wall R-Value	0	0
Slab R-Value and Depth	0	0
Crawl Space Wall R-Value	0	5

Evaluating Energy Efficient Products

The energy efficient builder seeks to minimize the lifetime costs of a home rather than the first cost. Making such calculations is often time-consuming and confusing. One of the best ways to determine whether an investment is sound is to compare the annual energy savings with the additional annual mortgage costs to find the Net Annual Savings.

Simple Payback

An example: suppose you want to know whether it is worthwhile to install efficient, low-e windows which use special coatings to reduce heat loss and gain. You receive the following information comparing low-e windows to plain double-glazed windows from a window dealer:

- Additional Cost for 20 Windows = $500
- Annual Energy Savings = $75

You can easily calculate that the simple payback period on the above investment is slightly less than 7 years (500/75). However, you are unsure whether the payback is acceptable.

Net Annual Savings

To find the Net Annual Savings, find the extra mortgage costs for the windows:

- Mortgage Interest Rate = 8.5%
- Term of Mortgage = 30 years
- Monthly Payment per $1,000 (from Table 3-5 below) = $7.69
- Annual Payment per $1,000 (Monthly payment x 12 months/year) = $7.69 * 12 = $92.28 per year for $1,000 of principal
- Extra Annual Payment (multiply the additional cost of the windows by the above factor/l ,000) = $500/$1,000 * $92.28 = ~$46 per year mortgage payment
- Net Annual Energy Savings (subtract the annual payment from annual energy savings) = $75 – $46 = $29 annual savings

Since the Net Annual Energy Savings is positive, the investment is sound, especially when considering that energy costs will increase over time, while mortgage costs will remain constant.

Internal Rate of Return

It is often useful to calculate the Internal Rate of Return (IRR) for an energy investment. The IRR represents the interest rate you would have to receive on the amount to equal the savings generated by the energy efficiency you have invested in. Homeowners can compare the annual return from an energy measure to that earned by a typical financial investment at a bank. To find the IRR for the above example:

Find the payback period (divide the total cost by the annual savings) = 500/75 = about 7 years.
Determine the life of the energy measure in this case over 20 years.
To find the IRR, locate the row in Table 3-4 for the 7 year payback; then slide across to the 20-year column and find the IRR, which is 15% in this example (and it is tax free).

Note: A zero indicates the rate of return is either negligible or negative.
Energy prices are assumed to escalate 2% per year.

Table 3-4
Rate of Return for Energy Investments (%)

Simple Payback	Lifetime of Energy Investments (Years)			
Years	5	10	15	20
1.5	62%	68%	69%	69%
2	43%	51%	52%	52%
3	21%	33%	35%	35%
4	9%	23%	26%	27%
5	1%	17%	20%	21%
6	0%	12%	16%	18%
7	0%	9%	13%	15%
8	0%	6%	11%	13%
9	0%	4%	9%	11%
10	0%	2%	7%	10%
11	0%	0%	6%	8%
12	0%	0%	5%	7%
13	0%	0%	4%	6%
14	0%	0%	3%	6%
15	0%	0%	2%	5%
16	0%	0%	1%	4%
17	0%	0%	0%	3%
18	0%	0%	0%	3%
19	0%	0%	0%	2%
20	0%	0%	0%	2%

Mortgage Rate Tables

The following Table 3-5 shows the monthly payment for principal and interest for a $1,000 loan at various interest rates and amortization periods. According to the chart, a mortgage of 20 years at 10% annual interest would have monthly payments of $9.65 per $1,000 of principal or 12 x 9.65= $115.80 per year of payments per $1,000 of principal.

If the extra energy features of a home cost an additional $2,500, the extra annual mortgage would be:

$2,500 x $115.80/ $1,000 = $289.50.

This approach is useful in comparing different methods of financing construction loans and permanent mortgages and their effect on the economics of energy efficient construction techniques.

Table 3-5
Mortgage Rate Table by Interest Rate by Term- $/$1000

Annual Percentage Rate (APR) / Years of Amortization

%	5	7	10	15	20	25	30
5.00	18.87	14.13	10.61	7.91	6.60	5.85	5.37
5.25	18.99	14.25	10.73	8.04	6.74	5.99	5.52
5.50	19.10	14.37	10.85	8.17	6.88	6.14	5.68
5.75	19.22	14.49	10.98	8.30	7.02	6.29	5.84
6.00	19.33	14.61	11.10	8.44	7.16	6.44	6.00
6.25	19.45	14.73	11.23	8.57	7.31	6.60	6.16
6.50	19.57	14.85	11.35	8.71	7.46	6.75	6.32
6.75	19.68	14.97	11.48	8.85	7.60	6.91	6.49
7.00	19.80	15.09	11.61	8.99	7.75	7.07	6.65
7.25	19.92	15.22	11.74	9.13	7.90	7.23	6.82
7.50	20.04	15.34	11.87	9.27	8.06	7.39	6.99
7.75	20.16	15.46	12.00	9.41	8.21	7.55	7.16
8.00	20.28	15.59	12.13	9.56	8.36	7.72	7.34
8.25	20.40	15.71	12.27	9.70	8.52	7.88	7.51
8.50	20.52	15.84	12.40	9.85	8.68	8.05	7.69
8.75	20.64	15.96	12.53	9.99	8.84	8.22	7.87
9.00	20.76	16.09	12.67	10.14	9.00	8.39	8.05
9.25	20.88	16.22	12.80	10.29	9.16	8.56	8.23
9.50	21.00	16.34	12.94	10.44	9.32	8.74	8.41
9.75	21.12	16.47	13.08	10.59	9.49	8.91	8.59
10.00	21.25	16.60	13.22	10.75	9.65	9.09	8.78
10.25	21.37	16.73	13.35	10.90	9.82	9.26	8.96
10.50	21.49	16.86	13.49	11.05	9.98	9.44	9.15
10.75	21.62	16.99	13.63	11.21	10.15	9.62	9.33
11.00	21.74	17.12	13.78	11.37	10.32	9.80	9.52
11.25	21.87	17.25	13.92	11.52	10.49	9.98	9.71
11.50	21.99	17.39	14.06	11.68	10.66	10.16	9.90
11.75	22.12	17.52	14.20	11.84	10.84	10.35	10.09
12.00	22.24	17.65	14.35	12.00	11.01	10.53	10.29
12.25	22.37	17.79	14.49	12.16	11.19	10.72	10.48
12.50	22.50	17.92	14.64	12.33	11.36	10.90	10.67
12.75	22.63	18.06	14.78	12.49	11.54	11.09	10.87
13.00	22.75	18.19	14.93	12.65	11.72	11.28	11.06
13.25	22.88	18.33	15.08	12.82	11.89	11.47	11.26
13.50	23.01	18.46	15.23	12.98	12.07	11.66	11.45
13.75	23.14	18.60	15.38	13.15	12.25	11.85	11.65
14.00	23.27	18.74	15.53	13.32	12.44	12.04	11.85
14.25	23.40	18.88	15.68	13.49	12.62	12.23	12.05
14.50	23.53	19.02	15.83	13.66	12.80	12.42	12.25
14.75	23.66	19.16	15.98	13.83	12.98	12.61	12.44
15.00	23.79	19.30	16.13	14.00	13.17	12.81	12.64
15.50	24.05	19.58	16.44	14.34	13.54	13.20	13.05
16.00	24.32	19.86	16.75	14.69	13.91	13.59	13.45
16.50	24.58	20.15	17.06	15.04	14.29	13.98	13.85
17.00	24.85	20.44	17.38	15.39	14.67	14.38	14.26
17.50	25.12	20.73	17.70	15.75	15.05	14.78	14.66
18.00	25.39	21.02	18.02	16.10	15.43	15.17	15.07
18.50	25.67	21.31	18.34	16.47	15.82	15.57	15.48
19.00	25.94	21.61	18.67	16.83	16.21	15.98	15.89
19.50	26.22	21.91	19.00	17.19	16.60	16.38	16.30
20.00	26.49	22.21	19.33	17.56	16.99	16.78	16.71
20.50	26.77	22.51	19.66	17.93	17.38	17.19	17.12
21.00	27.05	22.81	19.99	18.31	17.78	17.60	17.53

Home Energy Features

A well-designed, energy efficient home requires close attention to detail on the parts of the builder and the designer. Insulation and high quality windows are not enough. To eliminate energy waste the homebuilder must have a well planned approach with careful management of details. The designer and builder should compare the initial cost of features to long term energy savings. Successful builders realize that efficiency not only saves money, but also improves the quality, comfort, and durability of the home. Quality construction reduces the builder's risk and liability; comfort provides a satisfied customer; and durability means fewer callbacks and higher profits.

Home Energy Features are a planning and marketing tool that can prove valuable to those involved in home construction and sales. Two typical levels of efficiency features are:

- Code – The construction of the home must meet the requirements of the 2006 version of the International Residential Code, which includes energy efficiency requirements based on the International Energy Conservation Code of 2006. It specifies insulation R factors for the attic, walls and the floor. It also affects the maximum allowable solar heat gain coefficient of the glass in fenestration and the allowable U factor of the building shell. It mandates the R value of the duct insulation (Louisiana amended this portion to a minimum of R-6). Such a home, if given an energy rating, could score 100 or better on the Residential Energy Services Network (RESNET) scale.

- Energy Star – A modest effort beyond the standard IRC 2006 Code requirements that includes a Home Energy Rating System (HERS) test of the home to determine the air infiltration and duct leakage of the home. To earn the ENERGY STAR, a home must meet guidelines for energy efficiency set by the U.S. Environmental Protection Agency. These homes are at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC). (http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_IRC)

There are two ways to achieve Energy Star compliance. The first is a prescriptive list of components that may be picked from to complete the house. It is called the Builder Option Package (BOP). The second way, the National Performance Path, is performance based. If the complete house meets the 15% energy reduction goal, it qualifies, even if some of the components are not energy efficient. There are prescriptive parts, but it offers more flexibility in some areas. The National Performance Path requirements include a minimum number of Energy Star labeled light fixtures, appliances, etc., as well as a maximum allowable amount of duct leakage per square foot of conditioned space. These homes must have an Energy Star label on the breaker box showing that it has been energy rated by a certified RESNET Energy Rater. It must score no higher than an 85 index in Climate Zones 2 & 3.

Energy Star features go beyond simple conservation measures. The features, costs and energy savings of different systems are compared in Tables 3-6 and 3-7.

Special Note: Energy Star ratings are based on meeting basic performance required of the 2003 IRC and 2004 supplements, not the IRC 2006. However, Louisiana law requires the 2006 IRC version, so the builder and the energy rater will have to take this into consideration when planning the home to meet either the Energy Star or the High Performance Homes.

Table 3-6
IRC 2006 Code and Energy Star Homes for Climate Zones 2 & 3

	IRC 2006 Code Minimum Compliant Home	Energy Star Home
RESNET Home Energy Rating Score	100+/- index	85 index
Insulation		
Ceiling or Roof Insulation -Zone 2 & 3	R-30	R-30
Raised Floor R Value -Zone 2 / Zone 3	R-19	R-13 / R-19
2x4 Wood Frame Wall R Value	R-13	R-13
Crawl Space Wall - Zone 3 Only	R-5 or 13	R-5 or 13
Infiltration Control Construction Systems		
2x4 Wood Frame	Standard Details w/ Batt or Cellulose	Energy Efficient Details w/ quality installation
Structural Insulated Panels (Option)	Exceeds Code	Continuous Air Barrier
Insulated Concrete Forms (Option)	Exceeds Code	Continuous Air Barrier
Windows and Doors (Fenestration)		
U Factor -Zone 2 / Zone 3	0.75 / .65	0.55
Solar Heat Gain Coefficient - both	0.4	0.35
Heating Ventilation and Air Conditioning		
Furnace (AFUE)	= 80	= 80
Heat Pump (HSPF)	= 7.7	= 8.2; EER = 11.5
Air Conditioner (SEER)	= 13	= 14; EER = 11.5
Ventilation	0.35 Natural Air Changes per Hour	Same
Thermostat	Standard	ENERGY STAR qualified
Sizing	not specified in La.	Manual J required
Duct Work Leakage		
In a Vented Attic of Crawl Space	= 13 cfm/sf conditioned space	≤ 4 cfm to outdoors/100 sq. ft.
Non-vented Attic or Crawl Space	= 13 cfm/sf conditioned space	(waived if inside envelope)
Duct insulation	R-6 insulation	R-6 insulation
Design	not specified in La.	Manual D required
Water Heating	Standard Storage Tank	Tankless (Option)
Lighting & Appliances		
Interior	Not defined	5 Energy Star fixtures or appliances minimum
Exterior	Not defined	>40 lumens per watt
Energy Rating Confirmed	None	Energy Star label

Table 3-7
Economic Analysis of Energy Efficient Features

Annual Energy Costs*		
	IRC 2006 Compliant Home	Energy Star Home
Heating	269	233
Cooling	339	301
Water Heating	303	251
Lighting	213	115
Other (Appliances; Service Charges)	593	590
Total	1717	1490
Annual Energy Savings		227
Total Additional Construction Costs		1710**
Extra Mortgage ($/yr)		127**
Payback Period (years)		8.1**
Estimated Rate of Return (IRR)		14.9%**

*For a home with a 2,000 square-foot floor located in Baton Rouge. Analysis assumes 2% annual fuel price escalation; mortgage is 30-year, 7% loan; the energy savings were estimated using REMrate v.12.0 software.
**Compared to IRC baseline compliant home.

The energy efficiency features provide an excellent investment to the homeowner; the energy savings exceed the added annual mortgage costs incurred from the first year on.

One thing that builders must understand about high performance home design is that mechanical system designs must take into account the performance of the components of the building shell with regard to heat transfer, condensation, and vapor transmission.

For example, an old, poorly-insulated home with single pane, metal frame windows, leaky envelope, and a dark roof is considered. Combined with these deficiencies, a poorly planned return path to the air handler and poorly sealed and insulated ductwork in a vented attic or crawl space will require much more air conditioning tonnage to keep the home cool. If the ducts are in the attic, which can be over 140 degrees Fahrenheit in the summer, the conditioned air temperature from the air handler will rise. Also, the air that is leaked is lost to the surrounding environment, causing the air handler to draw outside ‘make-up’ air from unfiltered locations. This air is often filled with humidity, pollen, and pollution. Windows may form condensation on the outside because of the low thermal resistance through metal and glass.

Conversely, a high performance home with an air tight shell, well-insulated walls, roof or attic, and floor (if on piers), and high performance windows will not be losing its ‘cool’. Its duct work will be better sealed and have more insulation. If in a sealed, roof insulated attic or crawl space, the duct work can leak a small amount since the attic or crawl space is part of the conditioned envelope. A sealed, roof insulated attic will be only a few degrees different than the living space.

Building a much tighter and better insulated envelope means excess water vapor (latent load) must be removed for the comfort of the occupants. The builder/mechanical contractor can no longer base his sizing of the HVAC system or the duct runs on a 'rule of thumb.' He should employ Air Conditioning Contractors of America (ACCA) Manuals D-"Residential Duct Systems," J-"Residential Load Calculation," and S-"Residential Equipment selection," to properly size the system for the latent load and the sensible load and plan the duct layout to move the correct amount of air into and out of each space. The equipment load will often be smaller and the ductwork shorter. The reduction in overall cost of the home and air conditioning system makes the owners' time to recover his investment short. See Chapters 7 and 8 for more detail on this.

High Performance Homes – There are other construction systems that can reduce energy costs more than 30% compared to the standard 2006 IRC home. Such a home will have much tighter envelope, ductwork inside of the conditioned envelope, and a higher efficiency HVAC system than either the Energy Star or the 2006 IRC house. It may be built using sprayed foam as the sealing and insulation system, including between the roof rafters, in the walls, and under the floor if built off the ground. It may be built with foam core panel systems called Structural Insulated Panels (SIPS) or Insulated Concrete Forms (ICF). Both SIPS and ICF homes, when tested during a standard HERS rating for air infiltration, are several times tighter than a standard, wood frame home.

Due to the reduction in load combined with solar or wind power generation systems such a house may produce all the power needed to operate making it a "Net Zero" structure. "Net Zero" means that the energy used from the utility is replaced by the generation system(s) when they exceed the needs of the house. If not connected to the distribution system, it will have to have a battery bank or other storage device for those times when the sun isn't shinning or wind blowing adequately.

Figure 3-5
Typical Insulated Concrete Forms (ICF)

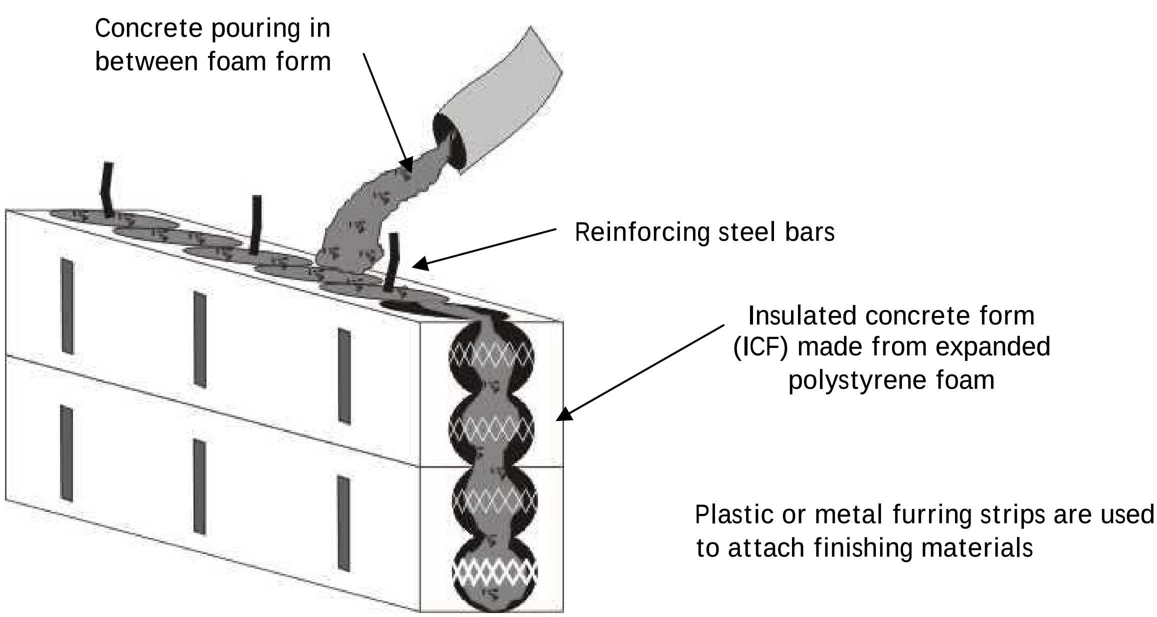
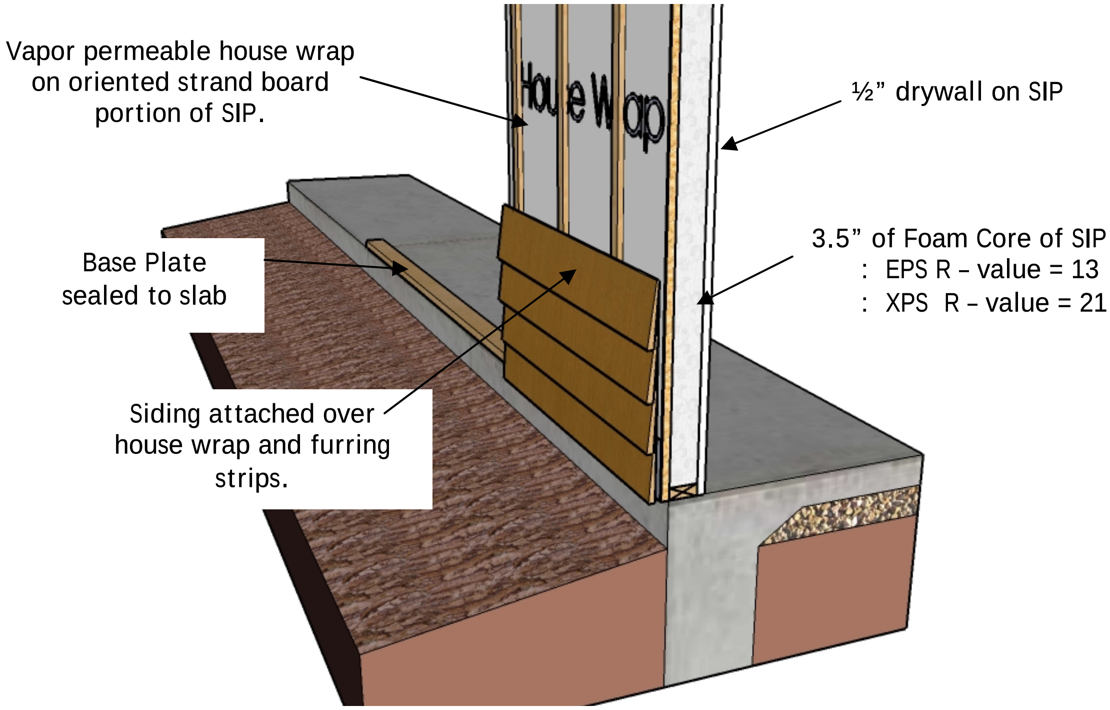


Figure 3-6
Typical Structural Insulated Panel



One side benefit of homes built with these two systems is that they are often much more wind resistant and secure from natural disasters. Wood or steel frame homes that have sprayed high density foam in the cavities of the walls, roofs, and floor joists, are significantly stronger than standard frame construction. The insulated concrete form homes are built with steel reinforced concrete that does not burn easily, will resist impact loads, and may be able to withstand tornadic winds. A home built with a structural insulated panel system is a much tighter and stronger home, as well. All of these with the foam insulation will more easily recover from flooding than fiberglass or cellulose insulated homes, since both of those insulation materials can hold large amounts of water.

Should you wish to build houses to a higher standard than the Energy Star criteria, please visit the following websites for more information:

Energy Efficiency and Renewable Energy at DOE
http://www1.eere.energy.gov/buildings/residential/

Hot and humid climates present several challenges for home building.
http://www1.eere.energy.gov/buildings/residential/hot_humid.html

The U.S. Department of Energy (DOE) has posed a challenge to the homebuilding industry - to build 220,000 high performance homes by 2012. The initiative is called the Builders Challenge, and homes that qualify must meet a 70 or better on the EnergySmart Home Scale (E-Scale). The E-Scale is a scale that allows homebuyers to understand - at a glance - how the performance of a particular home compares to that of others.

EnergySmart Home http://www1.eere.energy.gov/buildings/challenge/

U.S. Green Building Association
The U.S. Green Building Council (USGBC) is a non-profit organization committed to expanding sustainable building practices. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ encourages and accelerates global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222
Publications: http://www.usgbc.org/Store/PublicationsList.aspx?CMSPageID=1518

For those that are interested in building energy efficient homes that produce their own power and make little use of non-renewable resources, sometimes called "Green" Homes or "Sustainable" Homes, please visit the following websites:

PATH - The Partnership for Advancing Technology in Housing (PATH) is dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing. PATH is a voluntary partnership between leaders of the homebuilding, product manufacturing, insurance, and financial industries and representatives of Federal agencies concerned with housing. http://www.pathnet.org/ .

ToolBase Services is the housing industry's resource for technical information on building products, materials, new technologies, business management, and housing systems. The NAHB Research Center provides the services, with funding from the Department of Housing and Urban Development (HUD) through The Partnership for Advancing Technology in Housing (PATH) program, and other industry sponsors. The Zero Energy Homes Project :
http://www.toolbase.org/Home-Building-Topics/zero-energy-homes/seven-steps-zeh

Appendix - Energy Star Homes Technical Resources

Guidelines for ENERGY STAR Qualified New Homes:

There are two ways to qualify a house for Energy Star's guidelines for energy efficiency. Both paths require that the home must meet minimum requirements set forth by the Energy Star Thermal Bypass Checklist and that the finished house be tested by an independent, qualified Home Energy Rater. See http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.homes_guidelns for the most current required.

The Energy Star Thermal Bypass Checklist can be found at:
http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.thermal_bypass_checklist

The National Prescriptive Path: A Builder Option Package (BOP), where a builder constructs the home using a prescribed set of construction specifications that meet program requirements.
http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Nat_BOP_Final_062807.pdf

The National Performance Path: A means to qualify a house based on its total efficiency verified by a home energy rating which uses software to model the home's energy use showing that it meets a target energy efficiency score.
(http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS)
http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/PerfPathTRK_060206.pdf

ENERGY STAR Qualified Homes National Builder Option Package

ENERGY STAR Builder Option Package (BOP) requirements are specified in the table below.
To qualify as ENERGY STAR using this BOP, a home must meet the requirements specified, be verified and field-tested in accordance with the HERS Standards by a RESNET-accredited Provider, and meet all applicable codes.

Feature	Hot Climates 1 (2004 IRC Climate Zones 1, 2, 3)
Cooling Equipment (Where Provided)	Right-Sized2: • ENERGY STAR qualified A/C (14 SEER / 11.5 EER); OR • ENERGY STAR qualified heat pump 3 (14 SEER / 11.5 EER / 8.2 HSPF)
Heating Equipment	• 80 AFUE gas furnace; OR • ENERGY STAR qualified heat pump 2, 3 (14 SEER / 11.5 EER / 8.2 HSPF); OR • 80 AFUE boiler; OR • 80 AFUE oil furnace
Thermostat 3	ENERGY STAR qualified thermostat (except for zones with radiant heat)
Ductwork	Leakage 4: ≤ 4 cfm to outdoors/100 sq. ft.; AND R-6 min. insulation on ducts in unconditioned spaces 5
Envelope	• Infiltration 6,7 (ACH50): 7 in CZ 2 │ 6 in CZ 3; AND • Insulation levels that meet or exceed the 2004 IRC 8; AND • Completed Thermal Bypass Inspection Checklist 9
Windows	ENERGY STAR qualified windows or better (additional requirements for CZ 2)10, 11, 12
Water Heater 13	Gas (EF): 40 Gal = 0.61 │ 60 Gal = 0.57 │ 80 Gal = 0.53 Electric (EF): 40 Gal = 0.93 │ 50 Gal = 0.92 │ 80 Gal = 0.89 Oil or Gas 14: Integrated with space heating boiler
Lighting and Appliances 15,16	Five or more ENERGY STAR qualified appliances, light fixtures, ceiling fans equipped with lighting fixtures, and/or ventilation fans

1. The appropriate climate zone shall be determined by the 2004 International Residential Code (IRC), Figure N1101.2.

2. Cooling equipment shall be sized according to the latest editions of ACCA Manuals J and S, ASHRAE 2001 Handbook of Fundamentals, or an equivalent procedure. Maximum oversizing limit for air conditioners and heat pumps is 15%. The following operating conditions shall be used in the sizing calculations and verified where reviewed by the rater:

    i. Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the home's location or most representative city for which design temperature data are available.
    ii. Indoor temperatures shall be 75 F for cooling and 70 F for heating. Infiltration rate shall be selected as "tight", or the equivalent term. In specifying equipment, the next available size may be used. In addition, indoor and outdoor coils shall be matched in accordance with ARI standards.

3. Homes with heat pumps in Climate Zones 4 and 5 (Not applicable to Climate Zones 2 & 3)

4. Ducts must be sealed and tested to be ≤ 4 cfm to outdoors/100 sq. ft. of conditioned floor area, as determined and documented by a RESNET-certified rater using a RESNET-approved or equivalent ASTM-approved testing protocol. Duct leakage testing can be waived if all ducts and air handling equipment are located in conditioned space (i.e., within the home's air and thermal barriers) AND the envelope leakage has been tested to be ≤ 3 ACH50 OR ≤ 0.25 CFM 50 per sq. ft. of the building envelope.

5. EPA recommends, but does not require, locating ducts within the home's conditioned space (i.e., inside the air and thermal barriers), and using a minimum of R-4 insulation for ducts inside the conditioned space to prevent condensation.

6. Envelope leakage must be determined by a RESNET-certified rater using a RESNET-approved testing protocol.

7. To ensure consistent exchange of indoor air, whole-house mechanical ventilation is recommended, but not required.

8. Insulation levels of a home must meet or exceed Sections N1102.1 and N1102.2 of the 2004 IRC. These sections allow for compliance to be determined by meeting prescriptive insulation requirements, by using U-factor alternatives, or by using a total UA alternative. These sections also provide guidance and exceptions that may be used. However, note that the U-factor for steel-frame envelope assemblies addressed in Section N1102.2.4 shall be calculated using the ASHRAE zone method or a method providing equivalent results, and not a series-parallel path calculation method as is stated in the code. Additionally, Section N1102.2.2, which allows for the reduction of ceiling insulation in space constrained roof/ceiling assemblies, shall be limited to 500 sq. ft. or 20% of ceiling area, whichever is

less. In all cases, insulation shall be inspected to Grade I installation as defined in the RESNET Standards by a RESNET-certified rater, with the following exceptions:

i. Rim/Band Joists - the interior sheathing/enclosure material is optional in all climate zones, provided insulation is adequately supported and meets all other requirements.

ii. Wall Insulation - the interior sheathing/enclosure material is optional in climate zones 1-3, provided insulation is adequately supported and meets all other requirements.

iii. Sealed, Unvented Attic/Roof Assemblies - the interior sheathing/enclosure material is optional in climate zones 1-3, provided insulation is adequately supported and meets all other requirements, including full contact with the exterior (roof) sheathing.

iv. Floor insulation over unconditioned basements or enclosed crawlspaces, either vented or unvented, need not be enclosed (though floor insulation over ambient conditions does).

9. The Thermal Bypass Inspection Checklist must be completed for homes to earn the ENERGY STAR label. The Checklist requires visual inspection of framing areas where air barriers are commonly missed and inspection of insulation to ensure proper alignment with air barriers, thus serving as an extra check that the air and thermal barriers are continuous and complete.

10. All windows and skylights must be ENERGY STAR qualified or meet all specifications for ENERGY STAR qualified windows. Windows in Climate Zones 2 must exceed ENERGY STAR specifications (CZ 2: U-value ≤ 0.55 and SHGC ≤ 0.35). Visit www.energystar.gov/windows for more information on ENERGY STAR qualified windows.

    i. Note that the fenestration requirements of the 2004 IRC do not apply to the fenestration requirements of the National Builder Option Package. Therefore, if UA calculations are performed, they must use the IRC requirements (with the exception of fenestration) plus the fenestration requirements contained in the national BOP. For more information, refer to the "Codes and Standards Information" document.

11. All decorative glass and skylight window area counts toward the total window area to above-grade conditioned floor area (WFA) ratio. For homes with a WFA ratio >18%, the following additional requirements apply:

    i. In IRC Climate Zones 1, 2, and 3, an improved window SHGC is required, and is determined by:

        a. Required SHGC = [0.18 / WFA] x [ENERGY STAR SHGC]

    ii. Where the ENERGY STAR SHGC is the minimum required SHGC of the climate-appropriate window specified in this BOP.

12. Up to 0.75% WFA may be used for decorative glass that does not meet ENERGY STAR requirements. For example, a home with total above-grade conditioned floor area of 2,000 sq. ft. may have up to 15 sq. ft. (0.75% of 2,000) of decorative glass.

13. To determine domestic hot water (DHW) EF requirements for additional tank sizes, use the following equations: Gas DHW EF $\geq$ 0.69 - (0.002 x Tank Gallon Capacity); Electric DHW EF $\geq$ 0.97 - (0.001 x Tank Gallon Capacity).

14. In homes with gas or oil hydronic space heating, water heating systems must have an efficiency $\geq$ 0.78 EF. This may be met through the use of an instantaneous water heating system or an indirect storage system with a boiler that has a system efficiency $\geq$ 85 AFUE. Homes with tankless coil hot water heating systems cannot be qualified using this BOP, but can earn the label using the ENERGY STAR Performance Path requirements.

15. Any combination of ENERGY STAR qualified products listed may be installed to meet this requirement. ENERGY STAR qualified ventilation fans include range hood, bathroom, and inline fans. ENERGY STAR qualified lighting fixtures installed in the following locations shall not be counted: storage rooms (e.g., closets, pantries, sheds), or garages. Eligible appliances include ENERGY STAR qualified refrigerators, dish washers, and washing machines. Further efficiency and savings can be achieved by installing ENERGY STAR qualified products, in addition to those required (e.g., additional lighting, appliances, etc.).

16. Efficient lighting fixtures represent a significant opportunity for persistent energy savings and a meaningful way to differentiate ENERGY STAR qualified homes from those meeting minimum code requirements. In 2008, EPA intends to propose and solicit industry comments on adding the ENERGY STAR Advanced Lighting Package (ALP) as an additional requirement for ENERGY STAR qualified homes in 2009. To learn more about the ALP, refer to www.energystar.gov/homes.

ENERGY STAR Qualified Homes National Performance Path Requirements:

To qualify as ENERGY STAR, a home must meet the minimum requirements specified below, be verified and field-tested in accordance with the RESNET Standards by a RESNET-accredited Provider, and meet all applicable codes.
Maximum HERS Index Required to Earn the ENERGY STAR in Climate Zone 2 and 3 is 85.

Table 3-8
ENERGY STAR Mandatory Requirements

Envelope [2,3,4]	Completed Thermal Bypass Inspection Checklist
Ductwork [5,6]	Leakage ≤ 6 cfm to outdoors / 100 sq. ft.
ENERGY STAR Products [13,14]	Include at least one ENERGY STAR qualified product category: Heating or cooling equipment [7]; OR Windows [8]; OR Five or more ENERGY STAR qualified light fixtures [9,10], appliances[11], ceiling fans equipped with lighting fixtures, and/or ventilation fans[12]
ENERGY STAR Scoring Exceptions	On-site power generation may not be used to decrease the HERS Index to qualify for ENERGY STAR. A maximum of 20% of all screw-in light bulb sockets in the home may use compact fluorescent lamps (CFLs) to decrease the HERS Index for ENERGY STAR compliance. CFLs used for this purpose must be ENERGY STAR qualified.
Note: Due to the unique nature of some state codes and/or climates, EPA has agreed to allow regionally-developed definitions of ENERGY STAR in California, Hawaii, and the Pacific Northwest to continue to define program requirements. The States of Montana and Idaho may use either the requirements of the national program or the regionally-developed program in the Pacific Northwest.	

1. The appropriate climate zone for each building site shall be determined by the 2004 International Residential Code (IRC), Table N1101.2. The HERS Index must be calculated in accordance with the RESNET Mortgage Industry National Home Energy Rating Standards.

2. The Thermal Bypass Inspection Checklist must be completed for homes to earn the ENERGY STAR label. The Checklist requires visual inspection of framing areas where air barriers are commonly missed and inspection of insulation to ensure proper alignment with air barriers, thus serving as an extra check that the air and thermal barriers are continuous and complete.

3. Envelope leakage must be determined by a RESNET-certified rater using a RESNET-approved testing protocol.

4. To ensure consistent exchange of indoor air, whole-house mechanical ventilation is recommended, but not required.

5. Ducts must be sealed and tested to be ≤ 6 cfm to outdoors / 100 sq. ft. of conditioned floor area, as determined and documented by a RESNET-certified rater using a RESNET-approved testing protocol. If total duct leakage is < 6 cfm to outdoors / 100 sq. ft. of conditioned floor area, then leakage to outdoors does not need to be tested. Duct leakage testing can be waived if all ducts and air handling equipment are located in conditioned space (i.e., within the home's air and thermal barriers) AND the envelope leakage has been tested to be ≤ 3 ACH50 OR ≤ 0.25 CFM 50 per sq. ft. of the building envelope. Note that mechanical ventilation will be required in this situation.

6. EPA recommends, but does not require, locating ducts within conditioned space (i.e., inside the air and thermal barriers), and using a minimum of R-4 insulation for ducts inside conditioned space to prevent condensation.

7. All cooling equipment, regardless of whether it is used to satisfy the ENERGY STAR products requirement, must be sized according to the latest editions of ACCA Manuals J and S, ASHRAE 2001 Handbook of Fundamentals, or an equivalent computation procedure. Maximum oversizing limit for air conditioners and heat pumps is 15% (with the exception of heat pumps in Climate Zones 5 - 8, where the maximum oversizing limit is 25%). This can be accomplished either by the rater performing the calculations or reviewing documentation provided by the professional contractor or engineer who

calculated the sizing (e.g., HVAC contractor). The following operating conditions shall be used in the sizing calculations and verified where reviewed by the rater:

i. Outdoor temperatures shall be the 99.0% and 1.0% design temperatures as published in the ASHRAE Handbook of Fundamentals for the home's location or most representative city for which design temperature data are available.

ii. Note that a higher outdoor air design temperature may be used if it represents prevailing local practice by the HVAC industry and reflects extreme climate conditions that can be documented with recorded weather data; Indoor temperatures shall be 75° F for cooling; Infiltration rate shall be selected as "tight", or the equivalent term.

iii. In specifying equipment, the next available size may be used. In addition, indoor and outdoor coils shall be matched in accordance with ARI standards.

8. Where windows are used to meet the ENERGY STAR qualified product requirement, they shall be ENERGY STAR qualified or meet all specifications for ENERGY STAR qualified windows. Additional information can be found at www.energystar.gov/windows.

9. For the purposes of meeting the ENERGY STAR requirement, qualified lighting fixtures in the following locations cannot be counted: storage rooms (e.g., closets, pantries, sheds), or garages.

10. Efficient lighting fixtures represent a significant opportunity for persistent energy savings and a meaningful way to differentiate ENERGY STAR qualified homes from those meeting minimum code requirements. In 2008, EPA intends to propose and solicit industry comments on adding the ENERGY STAR Advanced Lighting Package (ALP) as an additional requirement for ENERGY STAR qualified homes in 2009. To learn more about the ALP, refer to www.energystar.gov/homes.

11. Eligible appliances include ENERGY STAR qualified refrigerators, dish washers, and washing machines.

12. ENERGY STAR qualified ventilation fans include range hood, bathroom, and inline fans.

13. Further efficiency and savings can be achieved by installing ENERGY STAR qualified products, in addition to those required (e.g., additional lighting, appliances, etc.). For more information, visit www.energystar.gov.

14. In homes with heat pumps that have programmable thermostats, the thermostat must have "Adaptive Recovery" technology to prevent the excessive use of electric back-up heating.