

3.1 IMPLEMENT AN INTEGRATED AND COMPREHENSIVE APPROACH TO ENERGY-EFFICIENT DESIGN OF BUILDING SITE, BUILDING ENVELOPE, AND MECHANICAL SPACE CONDITIONING SYSTEMS

Intent:

To use a whole systems approach in designing and building an energy-efficient home. Key concepts are integrated and comprehensive.

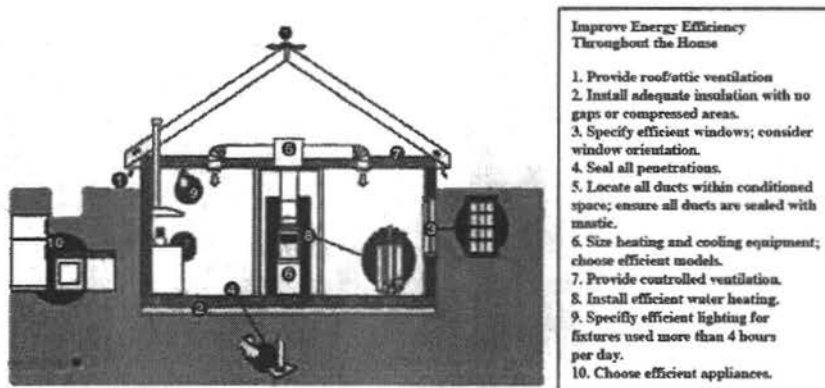
Information/How to Implement:

Pay attention to multiple facets related to energy efficiency during the design and construction process. For instance, rather than simply focusing on individual decisions related to energy efficiency, such as the R-value of attic insulation, consider the implications of each choice on the performance of the whole house. Balance the cost and performance of each component of the home system, such as a well-insulated building envelope (foundation, walls, and attic); windows recommended for the climate by experts such as the Efficient Windows Collaborative, the Department of Energy, and/or local energy professionals; a thorough and carefully implemented air sealing package; climate-appropriate heating and cooling equipment that balances efficiency with cost-effectiveness; sealed ductwork kept within the conditioned space; and efficient water heating equipment and distribution. Moisture and indoor environmental quality are closely related factors that are affected by energy-efficiency measures.

For more detailed information and explanation about the sizing and design of space heating and cooling, refer to "Understanding HVAC System Design Issues" at the end of this Energy Efficiency section.

Resources:

- *Home Energy Checklist* (EEBA) www.eeba.org/technology/publications/hec/default.htm
- *Whole Home Energy Checklist* (U.S. DOE fact sheet), www.southface.org/web/resources&services/publications/technical_bulletins/WH-Energy%20Checklist%20GO-10099-766.pdf
- *Energy Efficiency Pays* (U.S. DOE fact sheet), www.southface.org/web/resources&services/publications/technical_bulletins/EEP-Efficiency_pays%2099-746.pdf
- *Considerations for Building a More Energy Efficient Home*, NAHB Research Center fact sheet. Available at www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1809&DocumentID=4168



Courtesy of Southface Institute: developed with funding from the U.S. Department of Energy

Requirements:

- 3.1.1 Home is equivalent to the IECC 2003 or local energy code whichever, is more stringent. Conformance shall be based on plan analysis using software such as REScheck or other as approved by green building program administrator or NAHB.**
- 3.1.2 Space heating and cooling system/equipment shall be sized according to building heating and cooling loads calculated using ANSI/ACCA Manual J 8th Edition or equivalent. Computerized software recognized by ACCA as being in compliance with Manual J 8th Edition may be used.**
- 3.1.3 Conduct third-party plan review to verify design and compliance with Section 3. When multiple homes of the same model are to be built by the same builder, a representative sample of homes (15%) may be reviewed subject to a sampling protocol.**

Intent:

To establish a minimum energy threshold for all NAHB-certified green homes

Information / How to Implement:

If you are building under the jurisdiction of the 2003 International Energy Conservation Code (IECC), your home will meet this requirement. If you do not follow the IECC 2003, you can determine if your project meets this energy code by using REScheck, a free, easy-to-use software package.

Resources:

- **REScheck** is a free software tool that can be downloaded at www.energycodes.gov/rescheck/.
- **Manual J 8th Edition** is available through the Air Conditioning Contractors of America and can be purchased online at www.accaconference.com/Merchant2/merchant.mv?Screen=SFNT&Store_Code=ACCOA. Also, see www.acca.org for additional approved third-party software providers.
- **Heat Loss Calculation Guide H-22**, Hydronics Institute Division of GAMA, 2001
- **International Energy Conservation Code (IECC) 2003**. Available from the International Code Council, www.iccsafe.org
- Third-party plan review: A Certified Home Energy Rating System (HERS) rater. A directory of Home Energy Raters can be found on the ENERGY STAR® website at www.energystar.gov.

3.2 PERFORMANCE MEASURES

Optional guidelines—At least 37 points must be obtained from the line items under the Energy Efficiency section to qualify your project as a green home at the Bronze level. The Silver level requires 62 points and the Gold level 100 points.

3.2.1 Home is X % above IECC 2003:

- A. 15%
- B. 30%
- C. 40%

Intent:

To offer builders a flexible, performance-based means of achieving higher levels of energy performance than the IECC 2003. An ENERGY STAR home is approximately 15% more energy efficient than a home that meets the IECC 2003. Some builders are now achieving a 40% or 50% improvement.

Information / How to Implement:

Use REScheck to examine the effect of different levels of insulation, window U-values and SHGC factors, and space conditioning equipment efficiencies to identify a cost-effective system for your project. The appropriate level of energy performance above IECC 2003 will vary depending upon the severity of the climate, but building to the equivalent of ENERGY STAR is usually cost-effective for consumers in most regions of the country.

Resources:

- REScheck—REScheck, available for free download at: www.energycodes.gov/rescheck/
- International Energy Conservation Code (IECC) 2003. Available from the International Code Council, www.iccsafe.org

3.3 PRESCRIPTIVE PATH

Alternate method for gaining points for energy efficiency

3.3.1 BUILDING ENVELOPE

A. Increased effective R-value of building envelope using advanced framing techniques, continuous insulation, and/or integrated structural insulating system.

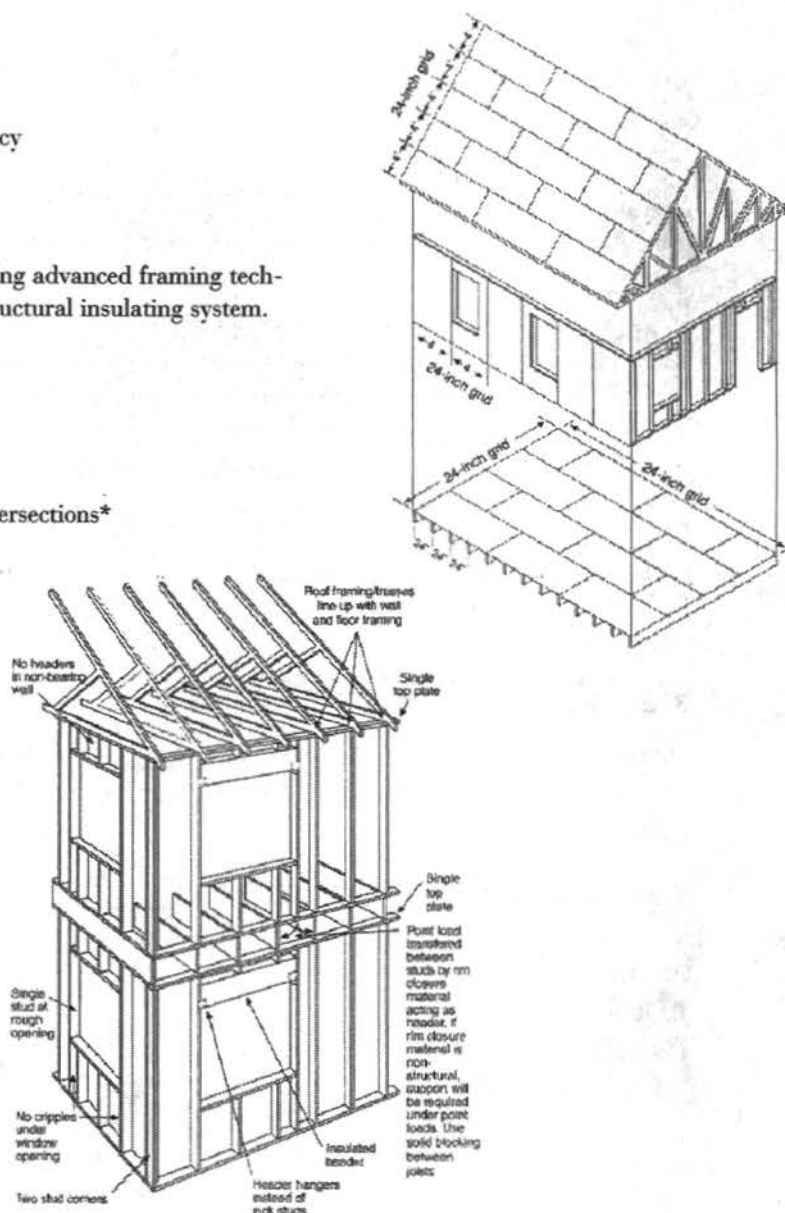
Measures may include but are not limited to:

- SIPs*
- ICFs*
- Advanced framing
- Insulated corners and interior/exterior wall intersections*
- Insulated headers on exterior walls
- Raised heel trusses
- Continuous insulation on exterior walls, cathedral ceiling, attics

* This line item also has a resource-efficiency benefit

Intent:

To enhance the insulating value of the building envelope by selecting an efficient and cost-effective framing package or alternative structural wall system. Framing details such as two-stud corner framing, ladder blocking at wall intersections, and raised heel roof trusses can eliminate thermal bridges, i.e., areas where there is no room for insulation.



Information / How to Implement:

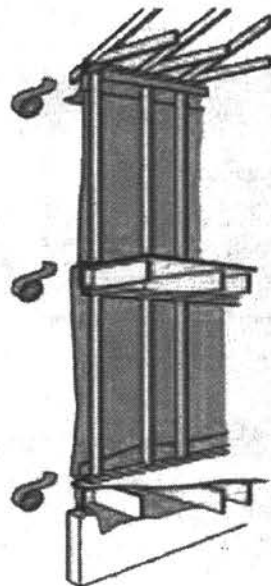
The Resources listed below will help identify methods for insulating walls to the fullest extent and avoiding thermal bridging.

Resources:

- *Reduce Framing Costs with Advanced Framing Techniques*, U.S. EPA:
www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3D.pdf
- *Advanced Framing Fact Sheet*, U.S. DOE:
www.toolbase.org/docs/MainNav/WoodFrameConstruction/3949_advancedwallframing1.pdf
- Advanced framing: www.buildingscience.com/housethatwork/advancedframing/default.htm
- *Cost Effective Homebuilding: A Design and Construction Handbook*, 1994, NAHB Research Center, available for purchase at www.nahbrc.org/tertiaryR.asp?TrackID=&DocumentID=2584&CategoryID=917

B. Incorporate air sealing package to reduce infiltration. (All measures that apply to project must be performed.)

- Use sill sealer between foundation and sill plate.
- Caulk bottom plate of exterior walls.
- Air seal band joist cavities between floors.
- Ensure air barrier continuity at all framed cavities such as air chases, soffits, coffered or dropped ceilings, and behind tub/shower units on exterior walls.
- Caulk/foam all electrical, plumbing, heating penetrations between floors (including attic, basement, crawl space, and garage) and to exterior.
- Block and seal cantilevered floors and kneewalls.
- Weatherstrip attic hatches, kneewall doors.
- Insulate, caulk, or foam between window/door jambs and framing.
- If installing recessed lights in ceilings adjacent to unconditioned space, use rated, air-tight Type IC housings.
- Caulk/foam HVAC register boots to subfloor or drywall that penetrate the building envelope.
- If a fireplace is installed, install a sealed-combustion gas fireplace that is sealed combustion or a wood-burning fireplace with gasketed doors.



Housewrap Installation

Intent:

When building an energy-efficient home, it is equally or more important to prevent air infiltration as it is to provide a high R-value wall system. Air can pass through very small cracks, resulting in energy loss and condensation, so it is necessary to be very detail-oriented when it comes to air sealing.

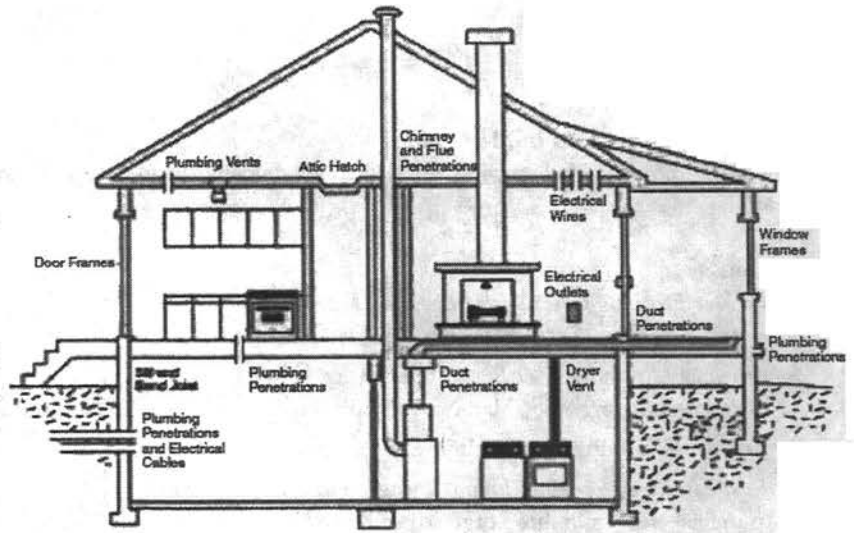
Information / How to Implement:

See also Section 5.2.2, *Indoor Environmental Quality* section for more information about mechanical ventilation options.

Air leakage can account for as much as 20%-30% of energy loss through the building envelope. Although insulation reduces energy loss, air infiltration can compromise the efficiency of a building because it brings conditioned air directly outdoors (or outdoor air inside), bypassing the insulation. In addition, it not only carries heated (or cooled) air to the outdoors, but may also create moisture problems as water vapor in the air moves from a warmer to colder location and condenses. Use the list above to make sure that you seal the nooks and crannies where air may escape.

To perform air sealing, use a variety of materials such as caulk, foam, and gasket materials. It has been proven that “chinking” with fiberglass insulation does not prevent airflow. Low-expanding foams should be used around windows and doors so that the frame doesn’t bind—a common complaint with first-generation, high-expanding foam products.

In conjunction with implementing an air sealing package, consider a means of providing fresh air to the home. This may be operable windows if the homeowner will use them, but often an automatic mechanical means of introducing fresh air may be the most reliable way to ensure adequate ventilation. Controlled ventilation that is carefully designed and installed provides a more consistent rate of air exchange compared with simply building a leaky structure. A tight building envelope with an intentional means of introducing outdoor air enhances energy efficiency, comfort, and indoor air quality. See the Indoor Environmental Quality section for additional information about mechanical ventilation.



Typical Locations of Air Leakage

Resources:

- *Advanced Air Sealing* (book available for viewing online): <http://oikos.com/library/airsealing/index.html>
- U.S. DOE’s fact sheet, *Airtight Drywall Approach* (no diagrams), www.eere.energy.gov/consumerinfo/fact_sheets/bd8.html
- Southface Energy Institute’s fact sheet, *Airtight Drywall Approach* (contains diagrams), www.southface.org/web/resources&services/publications/fact_sheets/24ada_drywal.pdf

C. Use ENERGY STAR-rated windows appropriate for local climate.

Intent:

To assure optimum building envelope performance. Window area often comprises a substantial portion of the wall area in new homes. Compared with an opaque insulated wall, windows offer only about 15% to 25% of the R-value. In addition, they are a source of direct solar gains in the summer, which can add to the cooling load.

Information / How to Implement:

Select windows featuring the ENERGY STAR label. Alternately, visit the Efficient Windows Collaborative Web site to see which type of glazing is recommended for your climate. Low-E coatings for windows are recommended for almost all regions of the United States. Generally, look for windows with as low a U-value as is affordable—they offer the best insulating value (U-value is the inverse of R-value). In cooling-dominated climates, use a window that has a low SHGC. Always choose a frame that provides a thermal break, e.g., wood, composite, vinyl, or aluminum with a thermal break. Using high-efficiency windows can not only enhance thermal performance but also reduce the risk of condensation on windows. For passive solar designs and homes that are constructed with large amounts of glazing in a specific orientation, use windows selected for each orientation (e.g., high SHGC on south face for direct solar gain). Refer to the Resources for a more detailed understanding of how window technologies perform in various climates.

Resources:

- www.efficientwindows.org
- *Improve Energy Efficiency with High Performance Windows*, ENERGY STAR fact sheet, www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3E.pdf

- Efficient Windows Collaborative, www.efficientwindows.org. Recommends U-value and solar heat gain coefficient (SHGC) by climate region.
- ENERGY STAR website www.energystar.gov for list of stores that sell ENERGY STAR-labeled windows
- The National Fenestration Rating Council (NFRC) labels windows for U-value and solar heat gain coefficient and has searchable directory of windows meeting specific criteria on its web site at www.nfrc.org.

3.3.2 HVAC DESIGN, EQUIPMENT, AND INSTALLATION

A. Size, design, and install duct system using ANSI/ACCA Manual D® or equivalent.

Intent:

Getting the proper amount of airflow to and from each room is as important to comfort and efficiency as the equipment itself. Careful sizing and layout according to recognized industry standards is essential.

Information / How to Implement:

Ask your HVAC contractor to use ACCA Manual D to size and lay out supply and return ductwork to each area of the home. Manual D recommends duct diameter to fit the load in each room, taking into account the length of the duct run and the type of duct being used. Request a copy of the Manual D printout. After the system has been installed, examine it to verify that it is in accord with the design and that there are no sharp bends or poor connections.

Resources:

- *ACCA Manual D®*, Residential Duct Systems (available for purchase at www.acca.org)
- *Air Distribution System Design* (U.S. DOE fact sheet)
www.toolbase.org/docs/MainNav/Energy/4074_doe_airstributionsystemdesign.pdf
- *A Builder's Guide to Placement of Ducts and HVAC Equipment in Conditioned Spaces*, 2000, NAHB Research Center. Available for \$5 from NAHB Research Center bookstore at <http://nahbrc.org/tertiaryR.asp?TrackID=&DocumentID=2570&CategoryID=110>
- *Design and Construction of Interior Duct System*, Florida Solar Energy Center, (2002)
www.fsec.ucf.edu/bldg/baihp/pubs/Papers/interior_ducts.pdf

B. Design radiant or hydronic space heating systems using industry-approved guidelines, e.g., *Guidelines for the Design and Installation of Radiant Panel Heating and Snow/Ice Melting Systems by the Radiant Panel Association*, *Heat Loss Guide (H-22)*, by the Hydronics Institute Division of GAMA or accredited design professionals and manufacturer's recommendations.

Intent:

To ensure proper design of hydronic and radiant space heating systems by using industry expertise. Hydronic and radiant systems require the same attention to detail as forced air systems. Components such as piping and pumps must be properly sized and matched according to the equipment being used.

Information / How to Implement:

Ask your HVAC contractor to use the Radiant Panel Association design guidelines when designing a hydronic system. There are training and certification programs through the Radiant Panel Association for HVAC contractors

Resources:

- *Quick Reference to RPA Guidelines for Hydronic Radiant Floor Heating*, Radiant Panel Association (RPA), www.radiantpanelassociation.org/files/public/GdlnQuick.htm. (Entire guidelines available to download for \$15 at www.radiantpanelassociation.org/i4a/store/category.cfm?category_id=8)

- List of RPA certified contractors, available at www.radiantpanelassociation.org

C. Use ANSI/ACCA Manual S® or equivalent to select heating and/or cooling equipment.

Intent:

Manual S is the second step in assuring proper design of a space heating and/or cooling system. After using Manual J to calculate the building's heating and cooling load, use Manual S to help select and size equipment that will satisfy the latent and sensible heating and cooling loads.

Information/ How to Implement:

Ask your HVAC contractor to use ACCA Manual S in selecting the heating or cooling equipment for the home. By reviewing this process, you can better understand some of the issues involved and help guide customers' decisions about their heating and cooling system. Very efficient homes that require less energy for heating and cooling are much more sensitive to proper HVAC equipment sizing.

Resources:

- ACCA Manual S®, *Equipment Selection*, available for purchase at www.acca.org
- U.S. DOE fact sheet, Right Size Heating and Cooling Equipment, www.toolbase.org/docs/MainNav/Energy/4073_doe_hvac sizing.pdf

D. Verify performance of the heating/cooling system. The HVAC contractor should perform the following:

- Start-up procedure according to manufacturer's instructions
- Refrigerant charge verified by super-heat and/or sub-cooling method
- Burner set to fire at nameplate input
- Air handler setting/fan speed
- Total airflow within 10% of design flow
- Total external system static should not exceed equipment capability at rated airflow.

Intent:

Verification of performance provides a final assurance that the system has been designed, installed, and commissioned as intended. Items can easily be overlooked during a busy construction schedule, even given the most conscientious approach.

Information/ How to Implement:

Ask your HVAC contractor to carefully follow the start-up procedure outlined in the equipment literature. Ask for a checklist of the recommended start-up procedure.

Resources:

- North American Technician Excellence. Operates a certification program for HVAC technicians. Maintains a database of certified technicians at www.natex.org/ or by calling 877-420-NATE.
- Manufacturer's Web site or printed installation instructions

E. Use HVAC installer and/or service technician who are certified under a nationally or regionally recognized program such as NATE, BPI, RPA, or manufacturers' training.

Intent:

The programs cited above are the equivalent of a "technical degree" for an HVAC contractor. With an HVAC trade contractor who has completed a certification, you and your customer can have added assurance that the HVAC system in the home is designed and installed in accordance with the industry's best recommended practices.

Information / How to Implement:

Encourage your contractor to investigate the local availability of HVAC training and certification programs. Ask for certifications when seeking proposals. Some agencies maintain a database of certified contractors; consider using HVAC contractors in your area that have been certified.

At the time of the printing of this document, the Air Conditioning Contractors of America (ACCA) is in the process of establishing a contractor accreditation program that will ensure contractors perform quality installations.

Resources:

- NATEX Business Locator, available at www.natex.org or by calling 877-420-NATE. A searchable database of contractors certified by the National Association for Technician Excellence (NATE).
- The Building Performance Institute. Certifies whole-house performance contractors and provides a searchable database of certified contractors at www.bpi.org.
- List of Radiant Panel Association members that are certified by RPA (for hydronic heating) www.radiantpanelassociation.org
- Manufacturers' website for directory of contractors trained for proprietary equipment
- The Air Conditioning Contractors of America Web site at www.acca.org

F. Fuel-fired space heating equipment efficiency (AFUE):

		% Improvement above Federal minimum
Gas Furnace	≥81%	3%
	≥88% (ENERGY STAR)	10%
	≥94%	6%
Oil Furnace	≥83%	5%
Gas or Oil Boiler	≥85%	5%
	> 90%	10%



Note: Add three points associated with increasing AFUE if Manuals S and D and start-up procedure are followed when one of the space heating units noted above is installed.

Intent:

As with cooling equipment, higher-efficiency equipment will satisfy space heating requirements using less fuel.

Information / How to Implement:

Select equipment bearing the ENERGY STAR label, or check manufacturer's literature for efficiency information. The American Council for an Energy-Efficient Economy (ACEEE) lists the highest-efficiency equipment available (see Resources). The measure of furnace efficiency, annual fuel utilization efficiency (AFUE), is the ratio of heat produced per unit of fuel consumed over the course of a heating season. Depending upon the fuel used, ask your HVAC contractor about pricing higher-efficiency furnaces or boilers. Typically, 81%-83% of AFUE furnaces carry little cost increase over those meeting federal minimum efficiency standards (currently 78%). Higher-efficiency gas furnaces or boilers (greater than 90% AFUE) are usually direct vent, sealed combustion units and, because the flue gases are cooler, PVC pipe can often be used for venting, eliminating the need for a chimney. Through-the-wall venting may offset the higher cost of the equipment.

Keep in mind that sealed combustion equipment not only offers an energy-efficiency benefit but may also be advantageous with respect to indoor environmental quality as well. The sealed combustion chamber eliminates any possibility of backdrafting or spillage of combustion gases into the home.

It is usually a good idea to invest in high-AFUE heating equipment in climates that have a significant heating load or high fuel costs. Energy-efficiency investment dollars may be better spent elsewhere in cooling-dominated climates.

Resources:

- American Council for an Energy-Efficient Economy's list of most energy efficient appliances
www.aceee.org/consumerguide/mostenef.htm
- www.energystar.gov for a list of equipment meeting ENERGY STAR standards
- *Gas Appliance Manufacturer's Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment.* www.gamanet.org
- Manufacturers' Web sites.

G. Heat pump efficiency (cooling mode)

1. SEER 11-12*—(9%-17% improvement above SEER 10 air conditioner)
2. SEER 13-14—(23%-29% improvement above SEER 10 air conditioner)
3. SEER 15-18—(33%-44% improvement above SEER 10 air conditioner)
4. SEER 19+—(47%+ improvement above SEER 10 air conditioner)
5. Staged air conditioning equipment

Split systems must be ARI-tested as a matched set.

*SEER 13 is the federal minimum as of January 2006.



NOTE: Additional three points given if Manuals S and D have been used and start-up procedures are followed when one of the AC units noted above is installed.

Intent:

High-efficiency equipment uses less energy to accomplish the same task. The intent of this guideline is to reduce the electrical energy necessary to cool the home.

Information/ How to Implement:

Select equipment that carries the ENERGY STAR label, or check manufacturer's literature for information on SEER. The ACEEE lists the highest-efficiency equipment available (see Resources). Several issues to consider:

As of January 2006, the federal minimum efficiency for air conditioning units is SEER 13.

It is often more beneficial to concentrate on improving design, installation, and commissioning procedures before simply installing equipment with a higher SEER rating. For instance, proper sizing, insulating, and sealing of ductwork can reduce the amount of energy loss and increase occupant comfort as well. Even the most efficient equipment cannot make up for deficiencies in a distribution system or inadequate sizing and commissioning. Before investing in more efficient cooling equipment, invest in proper sizing, design, installation, and commissioning of the entire system.

To encourage such practices, the guidelines award double points for increasing SEER if Manuals S and D and start-up procedures are followed.

For cooling-dominated climates, it often makes sense to invest energy-efficiency dollars in high-SEER equipment. For climates with little cooling load, investments in efficiency may be better spent elsewhere.

Resources:

- List of most energy efficient appliances
- www.aceee.org/consumerguide/mostenef.htm
- www.energystar.gov for a list of equipment meeting ENERGY STAR standards

H. Heat pump efficiency (heating mode)

1. 7.2-7.9 HSPF (6%-16% increase in efficiency)
2. 8.0-8.9 HSPF (18%-31% increase in efficiency)
3. 9.0-10.5 HSPF (32%-54% increase in efficiency)
4. >10.5 HSPF (>54% increase in efficiency)

Intent:

To reduce the amount of nonrenewable energy used to meet the space heating requirements of a home.

Information / How to Implement:

Select equipment that carries the ENERGY STAR label, or check manufacturer's literature for HSPF data. The ACEEE lists the highest-efficiency equipment available (see Resources). The current federal minimum heating season performance factor (HSPF), the standard measure of heat pump efficiency in the heating mode, is 6.8. Heat pumps are often the cost-effective solution for space conditioning equipment in climates where outdoor temperatures are moderate and there is a need for both heating and cooling. Air-to-air heat pumps are not recommended if winter temperatures often drop below 35° F. If heating is the predominant load, consider a heat pump with an HSPF of 8.0 or higher.

Resources:

- American Council for an Energy-Efficient Economy's list of most energy efficient appliances
www.aceee.org/consumerguide/mostenef.htm
 - www.energystar.gov for a list of equipment meeting ENERGY STAR standards
- I. Ground source heat pump installed by a Certified Geothermal Service Contractor. (cooling mode)
1. EER = 13-14
 2. EER = 15-18
 3. EER = 19-24
 4. EER = > 25

Note: An additional three points are given if Manuals S and D and start-up procedures are followed when one of the ground source heat pumps noted above has been installed. Do not duplicate points if these additional points have been taken in Guidelines 3.3.2.f and 3.3.2.h above.

Intent:

To reduce consumption of non-renewable energy for space heating and cooling requirements and ensure that design and installation are conducted according to industry standards.

Information / How to Implement:

Select ENERGY STAR-labeled equipment, or check manufacturer's literature for EER information. Use a contractor that has been certified in design and installation of geothermal systems by the International Ground Source Heat Pump Association (see Resources)—proper sizing of geothermal systems is crucial for efficiency and to reduce first cost. Ground source heat pumps are often more efficient than air-to-air heat pumps because they take advantage of the constant and more moderate temperature of the ground which is an advantage for space heating in the winter and cooling in the summer. Ground source heat pumps are more expensive to install than air-to-air heat pumps due to the added

cost of drilling wells or trenching for the ground loop. However, they may be cost competitive when compared with very high efficiency furnaces and central air conditioning systems. Geothermal systems may also include a desuperheater, a device that uses some of the waste energy from the heat pump to pre-heat water for domestic use.

Because the selection of equipment, design of ductwork, and commissioning are integral to efficient performance of the system, additional points will be given if these measures have also been completed.

Resources:

- American Council for an Energy-Efficient Economy's list of most energy efficient appliances
www.aceee.org/consumerguide/mostenef.htm
- www.energystar.gov for a list of equipment meeting ENERGY STAR standards
- International Ground Source Heat Pump Association (IGSHPA), database of accredited installers and designers of geothermal heat pump systems: www.igshpa.okstate.edu/business_directory/home.html
- J. Ground Source Heat Pump installed by a Certified Geothermal Service Contractor (heating mode)
 1. COP = 2.4-2.6
 2. COP = 2.7-2.9
 3. COP > 3.0

(See Section 3.3.2.I above for more information.)

K. Seal ducts, plenums, and equipment to reduce leakage. Use UL 181 foil tapes and/or mastic.

Intent:

To assure optimum performance of the forced-air space conditioning system by reducing duct leakage.

Information / How to Implement:

Leaking Ducts can reduce the heating and cooling efficiency of a forced-air system by as much as 30%. While duct leakage to the conditioned space does not compromise energy performance as does leakage into unconditioned spaces, it may result in a less comfortable space due to insufficient air delivery. Best industry practice is to seal all ductwork with a foil tape meeting UL 181 requirements or with mastic. It is also important to seal plenum connections at the equipment as well as holes in the fan cabinet. Gasketed cabinet doors allow for a tight seal without compromising ease of maintenance. An achievable goal is to strive for less than 5% leakage (as a share of the air handler capacity) to unconditioned space.

Resources:

- Air Distribution System Installation and Sealing, (U.S. DOE fact sheet),
www.toolbase.org/docs/MainNav/Energy/4071_doe_airstributionsysteminstallation.pdf
- Source of supply for duct mastic: Oikos.com has a list of manufacturers of Duct Mastic (category 15816)
- Advanced Air Sealing (book available for viewing online): <http://oikos.com/library/airsealing/index.html>
- Overview of sealing ductwork: <http://energyoutlet.com/res/ducts/index.html>

L. When installing ductwork:

1. No building cavities used as ductwork, e.g., panning joist or stud cavities.
2. Installation of all heating and cooling ducts and mechanical equipment within the conditioned building envelope.
3. No ductwork installed in exterior walls.

Intent:

The possibility of duct leakage to unconditioned space is significantly reduced by avoiding placement of ducts in areas listed.

Information / How to Implement:

Panned joists or stud cavities should be avoided because they can rarely be effectively sealed. When cavities are used as returns, air may be pulled from unintended locations in the home and create unwanted pressure imbalances that may compound energy loss. When cavities are used as supplies, the volume of delivered air may be inadequate, and, because these areas may be dusty and dirty, indoor environmental quality issues may result.

Methods for keeping ductwork in the conditioned envelope include extending the thermal boundary by insulating the foundation walls, insulating the attic at the roof, or installing ductwork beneath an insulated ceiling and enclosing it with bulkheads.

With improved window technology and air sealing practices, there is less need to supply warm air along exterior walls—a common practice in older homes that needed airflow near windows to prevent condensation on poorly insulating windows and to keep occupants warm near drafty windows. In tightly sealed and well-insulated homes, heating or cooling registers can be located near the interior, thereby minimizing duct length and eliminating any need to run ductwork in outside walls. This not only reduces leaking to the exterior but also eliminates the need to reduce insulation in those wall cavities.

Resources:

- *A Builder's Guide to Placement of Ducts and HVAC Equipment in Conditioned Space*, 2000, NAHB Research Center. Available for purchase at www.toolbase.org/tertiaryT.asp?TrackID=&DocumentID=2570&CategoryID=110

M. Install return ducts or transfer grilles in every room having a door except baths, kitchens, closets, pantries, and laundry rooms.

Intent:

To prevent pressure imbalances that may occur when there are central return(s) and interior doors are closed. Pressure imbalances can lead to inadequate airflow to a room, which can create uncomfortable conditions.

Information / How to Implement:

Supply and return registers located in every room and sized according to industry standards provide the best assurance that airflow to each room is balanced. However, having supply and return vents in each room increases the installation cost of a forced-air heating or cooling system. Common practice is to locate a single central return on each floor of the home. This method pulls return air from all areas of the home in most cases, but return airflow is restricted when doors are closed. Doors cannot be undercut sufficiently to provide an adequate path for airflow. When return air flow is restricted from a particular room, that area becomes pressurized and air leakage to the outdoors increases. Other areas of the home may become depressurized causing the opposite effect, i.e., outdoor air is drawn through cracks and crevices. Transfer grilles in interior walls are a cost-effective compromise to ensuring that all rooms have adequate supply and return airflow.

Resources:

- ACCA Manual D® Residential Duct Systems

N. Install ENERGY STAR ceiling fans. (Points per fan)

Intent:

To reduce energy use for space cooling while maintaining comfort.

Information / How to Implement:

A ceiling fan helps occupants feel cooler without lowering a thermostat because it provides convective cooling from the breeze created. Under many conditions, ceiling fans, which use less energy than most light bulbs, will be all that is

required to keep occupants cool, thereby reducing the need for compressor cooling. ENERGY STAR fans produce more airflow per watt than standard ceiling fans due to improved blade design and more efficient motors.

Resources:

- List of ENERGY STAR-labeled ceiling fans (fan only)
www.energystar.gov/ia/products/prod_lists/ceiling_fans_only_prod_list.pdf
- List of ENERGY STAR-labeled ceiling fans (fan and light)
www.energystar.gov/ia/products/prod_lists/ceiling_fans_with_lighting_prod_list.pdf
- List of ENERGY STAR-labeled ceiling fan (light kits only)
www.energystar.gov/ia/products/prod_lists/ceiling_fans_lightkit_prod_list.pdf

O. Install whole-house fan with insulated louvers.

Intent:

To reduce energy use for space cooling while maintaining comfort.

Information / How to Implement:

A whole-house fan can draw outdoor air inside quickly, providing cooling at night and at other times when the outdoor air is cooler than indoors. A whole-house fan can reduce the energy needed for cooling by taking advantage of the “free” cooling from outside air. Usually placed in the ceiling of the top floor of a home, whole-house fans use less energy than a compressor and air handler. One disadvantage of whole-house fans is that they can be difficult to seal off when not in use. Care must be taken in selecting equipment that has an effective insulating enclosure and in designing and installing a custom insulating and weather stripping system for the enclosure.

Resources:

- Home Energy Magazine article <http://hem.dis.anl.gov/eehem/99/990511.html>
- Whole-House Fan: How to install and use a whole-house fan,
www.southface.org/web/resources&services/publications/technical_bulletins/WHF-Wholehousefan%2099-745.pdf

P. Install ENERGY STAR-labeled mechanical exhaust from every bathroom ducted to the outside.

Intent:

To achieve spot exhaust ventilation using highly efficient ventilation equipment.

Information / How to Implement:

ENERGY STAR-labeled fans provide more ventilation capacity at a lower wattage than a standard bath fan. They are also quieter than most standard fans and therefore are more likely to be used. Because of their more efficient blade design and motors, they are more durable and carry longer warranties than standard fans. Most major manufacturers offer an ENERGY STAR model, but in some areas, it may be a special order item.

This guideline also has an indoor environmental quality benefit in that local removal of moisture and humidity is achieved in a more effective and efficient manner.

Resources:

- List of products meeting ENERGY STAR criteria: www.energystar.gov/ia/products/prod_lists/vent_fans_prod_list.pdf
- Spot Ventilation: Source control to improve indoor air quality (U.S. DOE fact sheet),
www.toolbase.org/docs/MainNav/Energy/3947_spotventilation1.pdf

3.3.3 WATER HEATING DESIGN, EQUIPMENT, AND INSTALLATION

A. Water heater energy factor equal to or greater than those listed in the following table.

GAS	
Size (gallons)	Energy Factor
30	0.64
40	0.62
50	0.60
65	0.58
75	0.56
ELECTRIC	
Size (gallons)	Energy Factor
30	0.95
40	0.94
50	0.92
65	0.90
80	0.88
100	0.86
OIL	
Size (gallons)	Energy Factor
30	0.59
50	0.55

Intent:

To increase the efficiency of water heating by installing equipment that provides the same amount of hot water for less energy than standard water heating equipment.

Information / How to Implement:

The hot water heater energy rating that is used to compare different water heaters is the energy factor (EF). EF represents the percentage of purchased fuel (electricity, gas, propane or oil) that is used for heating water; it includes losses through the tank as well as flue losses. Electric tanks have a higher EF than fuel-fired heaters since they do not have flue losses. However, electric tanks can be more expensive to operate than fuel-fired tanks.

To select high-efficiency water heating equipment, compare the yellow Energy Guide labels of similar equipment. Review manufacturer's literature for energy factor information—the EF is not usually prominently displayed on the unit. Alternately, the ACEEE maintains a list of the highest-efficiency water heating equipment (see Resources).

Resources:

- *The Most Energy Efficient Appliances*, (list from Consumer's Guide to Home Energy Savings), American Council for an Energy Efficient Economy, www.aceee.org/consumerguide/mostenef.htm
- *Gas Appliance Manufacturer's Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment*. www.gamanet.org
- *Water Heating: Energy-Efficient Strategies for Supplying Hot Water in the Home* (U.S. DOE fact sheet), www.toolbase.org/docs/SubsystemNav/Plumbing/3946_waterheating.pdf



B. Install whole-house instantaneous (tankless) water heater. (Water heater complies with DOE Standard 10CFR430)

Intent:

To reduce energy use associated with water heating by eliminating standby losses that occur with tank heaters.

Information/ How to Implement:

Even though newer tank water heaters are better insulated than their predecessors, heat lost from the tank can account for a large portion of hot water energy consumption, especially in homes that use relatively little hot water. By having no reservoir of hot water, tankless water heaters eliminate these standby losses. For gas tankless water heaters, there are similar flue losses to gas tanks. Both electric and gas tankless water heaters have higher energy factors (EF = 0.62 minimum) than most tank water heaters.

Gas, propane, and electric instantaneous water heaters are available. Typically, gas water heaters can heat a larger volume of water each minute than electric heaters and can provide a greater temperature rise for a given flow rate. This can be an important consideration when coincident hot water uses are expected or when high flow rates at hot temperatures are desired. Electric tankless units can achieve about a 77°F temperature rise at 2.5 gallons per minute—which is plenty for a hot shower but it does not leave a lot of extra capacity for simultaneous hot water usage. Gas units will provide greater capacity to allow for simultaneous multiple uses.

All tankless water heaters use large amounts of energy at higher flow rates. These large draws often require a larger-than-normal service entrance for electric units or larger pipe diameter for gas units. Evaluate these differences when comparing installed costs. Although peak demand for space heating and water heating usually do not occur at similar times, your local utility may offer helpful advice regarding peak demand and selection of whole-house water heating appliances.

Resources:

- *The Most Energy Efficient Appliances*, (list from Consumer's Guide to Home Energy Savings), American Council for an Energy Efficient Economy, www.aceee.org/consumerguide/mostenef.htm

C. Insulate all hot water lines with a minimum of one-inch insulation.

Intent:

To reduce energy losses from hot water piping.

Information/ How to Implement:

Insulating hot water piping can be beneficial in two ways: 1) losses are reduced as hot water moves through the lines to the point of use, and 2) losses are slowed and may be reduced when hot water sits in the lines between draws. Foam pipe insulation is relatively inexpensive and easy to install. In addition to offering some energy savings, insulating the hot water lines is also likely to add convenience, comfort, and water savings. Hot water will get to the tap more quickly—meaning there is less potential for water to run down the drain while the user waits for it to get hot.

Resources:

- *Water Heating: Energy-Efficient Strategies for Supplying Hot Water in the Home* (U.S. DOE fact sheet), www.toolbase.org/docs/SubsystemNav/Plumbing/3946_waterheating.pdf

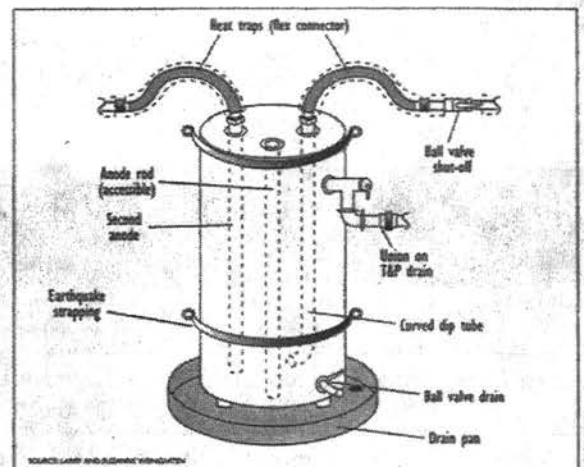
D. Install heat trap on cold and hot water lines to and from the water heater (if not integral to the water heater).

Intent:

To minimize energy loss associated with thermo siphoning action from a water heater.

Information / How to Implement:

In the same way that warm air moves toward cooler air and warm air rises, hot water will rise and displace cooler water in the lines leading to and from the heater tank. This thermo siphoning action contributes to heat loss from the tank, and, once the water temperature in the tank has cooled below the thermostat set point, the elements or burner will need to activate to bring the water back up to temperature, even when there is no demand for hot water. Heat traps prevent thermo siphoning. Many new water heaters have integral heat traps; ask your plumber or plumbing materials supplier or check manufacturers' literature. If heat traps are not integral to the water heater, install them on the inlet and outlet to the water heater.

**Resources:**

- *Water Heating: Energy-Efficient Strategies for Supplying Hot Water in the Home* (U.S. DOE fact sheet)

E. Install manifold plumbing system with parallel piping configuration (aka “home run”) using smallest diameter piping allowed by code.

Intent:

Reduce energy use associated with waiting for hot water at taps and with hot water left standing in pipes after a hot water draw.

Information / How to Implement:

A manifold plumbing system in which dedicated “home run” hot and cold water piping services each fixture allows the most direct (and therefore shortest) pipe run and smaller diameter piping than a “tree” type piping configuration. Reduced pipe diameter means hot water is delivered faster to a faucet and there is less water left in a pipe after a hot water draw—and therefore less energy waste from hot water left to cool in pipes. Most manifold piping is cross-linked polyethylene (PEX) pipe rather than copper or CPVC. Because PEX allows for gentle bends, fittings are reduced, which saves installation time and minimizes the possibility of leaks. Often, three-eighths-inch diameter pipe can be used. PEX also has better insulating value than copper piping. In order to maximize the benefits of a manifold system, baths and kitchens should be located in close proximity to one another and to the water heater.

Resources:

Information will be added in Version 2.

3.3.4 LIGHTING AND APPLIANCES

A. Use an ENERGY STAR Advanced Lighting Package (ALP).

Intent:

To use high-quality, aesthetically pleasing electric light using less energy than conventional incandescent lighting.

Information / How to Implement:

ENERGY STAR fixtures use about two-thirds less electricity than standard fixtures to provide equal light. Although on average, an ENERGY STAR fixture may cost about \$30 more than a comparable standard fixture, the fluorescent bulbs will last longer (about seven years) and cost less to operate over their lifetime than incandescent bulbs. Placing 20

ENERGY STAR fixtures in a home in which electricity costs are 10.5 cents per kWh will reap almost \$100 in annual savings to the homeowner in energy and bulb replacement costs, after accounting for the increase in the mortgage due to higher initial cost. Today's fluorescent bulbs are dramatically improved over the old technology: Not only are a wide variety of styles available, but the light quality is high and there is no flicker, hum, or delayed start. ENERGY STAR fixtures also carry a two-year warranty.

Room Category	Specific Rooms within Category	Minimum Required ENERGY STAR Qualified Fixtures per Room Category
High-Use Rooms	Kitchen, Dining Room, Living Room, Family Room, Bathroom(s), Halls/Stairway(s)	50% of Total Number of Fixtures
Med/Low-Use Rooms	Bedroom, Den, Office, Basement, Laundry Room, Garage, Closet(s), and All Other Rooms	25% of Total Number of Fixtures
Outdoors	Outdoor Lighting Affixed to Home or Free-Standing Pole(s) Except for Landscape and Solar Lighting	50% of Total Number of Fixtures Including All Flood Lighting

Resources:

- Tool to estimate lighting energy savings of advanced lighting package: www.energystar.gov/ia/partners/manuf_res/Savings_Look-up_ChartsLR.pdf
- ENERGY STAR program information for builders: www.energystar.gov/index.cfm?c=bldrs_lenders_raters.ALP_Builder



B. Install all recessed lighting fixtures within the conditioned envelope of the building, e.g., fixture housing does not penetrate insulated ceiling.

Intent:

To eliminate energy losses associated with inadequate insulation above, and air infiltration through, light fixtures in insulated ceilings.

Information / How to Implement:

Although there are recessed light fixtures rated for insulation contact, they still carry an energy penalty because of reduced insulation thickness in the ceiling above the fixture and/or air leakage around the housing. To completely avoid this energy penalty, do not install recessed lights in an insulated ceiling. Bulkheads or dropped soffits can permit the installation of recessed lights in insulated ceilings. Be sure that there is a continuous air barrier at the top of the bulkhead or the original ceiling. The preferred method is to install drywall (or other finish material) on the ceiling prior to constructing the bulkhead.

Resources:

Information will be added in Version 2.

C. Install motion sensors on outdoor lighting (if not credited under 3.3.4.a).

Intent:

To minimize outdoor lighting energy use by activating outdoor lighting when needed, rather than operating it continuously.

Information / How to Implement:

Motion sensors activate outdoor lighting only when it is needed: to light an entry as one returns home after dark or to maintain security by illuminating outdoor areas when motion is detected. Many fixtures come with motion sensors, but they can also be installed separately. Not all outdoor ENERGY STAR fixtures have built-in motion sensors.

Resources:

Information will be added in Version 2.



D. Install tubular skylights in rooms without windows.

Intent:

To reduce the need for artificial lighting by providing natural light when available.

Information / How to Implement:

Tubular skylights provide natural lighting to interior spaces while minimizing the inherent energy losses of standard skylights. Tubular skylights have a smaller diameter roof penetration than most skylights and have an additional layer of insulating glazing at the ceiling level.

Resources:

- Tubular Skylights (NAHB Research Center technology fact sheet)
www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1282&DocumentID=2024

E. Install ENERGY STAR labeled appliance: Refrigerator, dishwasher, washing machine. (Points per appliance)

Intent:

To reduce energy use in the home for appliances.

Information / How to Implement:

On average, ENERGY STAR-labeled appliances use at least 20% less energy than standard appliances to perform the same duties. ENERGY STAR-labeled dishwashers and washing machines also use less water, which contributes to added resource efficiency. Look for the ENERGY STAR label when selecting major appliances or use the yellow Energy Guide label to compare efficiency of similar appliances.

If you are not directly responsible for the purchase and installation of appliances, you can help customers learn about ENERGY STAR options. It is recommended that points be awarded only if ENERGY STAR appliances are actually installed in the home at the time a project is certified.

Resources:

- www.energystar.gov for list of appliances meeting ENERGY STAR criteria and list of local stores that sell ENERGY STAR appliances. The Web site also includes a calculator to show prospective homeowners how much they will save and how fast the upgraded appliance will pay for itself over time.

3.3.5 RENEWABLE ENERGY/SOLAR HEATING AND COOLING

3.3.5.1 Solar Space Heating and Cooling

More detailed design guidance for climate-specific passive solar design is available from the Sustainable Building Industry Council, 1331 H Street NW, Suite 1000, Washington, DC 20005; Phone: (202) 628-7400; www.sbicouncil.org.

A. Use sun-tempered design: Building orientation, sizing of glazing, design of overhangs to provide shading are in accordance with guidelines below:

- Long side of the home faces within 30° of south;
- Glazing area < 7% of finished floor area (FFA) on south face (Low-E);
- Glazing area < 2% of FFA on west face (Low-E, Low SHGC);
- Glazing area < 4% of FFA on east face (Low-E, Low SHGC);

- Glazing area < 4% of FFA on north face (Low-E);
- Skylights less than 2% of finished ceiling area, with shades and insulated wells;
- Overhangs designed to provide shading on south-facing glass (at a minimum), or adjustable canopies or awnings. (See *UserGuide* for charts that indicate length of overhang, amount and period of shading according to latitude.)

Intent:

To reduce the amount of non-renewable energy required to heat and cool a home through design features that permit solar heat gains and minimize the potential for overheating.

Information/ How to Implement:

The Sustainable Buildings Industry Council provides the most concise and clear-cut guidance on sun-tempered design. The design rules of thumb cited above will provide some solar benefit and prevent overheating in most climates.

Resources:

- *Green Building Guidelines—Meeting the Demand for Low-Energy, Resource-Efficient Homes*, Chapter 2A: Renewable Energy: Solar and Other Renewables, Sustainable Buildings Industry Council
- *Passive Solar Design Strategies, Guidelines for Home Building*, Sustainable Building Industries Council, www.psic.org
- *Passive Solar Design* (NAHB Research Center fact sheet) www.toolbase.org/docs/MainNav/Energy/3944_passivesolardesign.pdf

B. Use passive solar design: Sun-tempered design as above plus additional south-facing glazing, appropriately designed thermal mass to prevent overheating, and provision for airflow to adjoining rooms.

- Sun-tempered design as outlined in Section 3.3.5.1a except additional glazing permitted on south wall PLUS
- For any room with south-facing glazing > 7% of FFA, properly sized thermal mass, and
- Provision for forced air flow to adjoining areas as needed.
- SBIC Passive Solar Design Guidelines for your climate should be referenced to size thermal mass.

Intent:

To reduce the amount of non-renewable energy required to heat and cool a home by taking advantage of the sun's energy through passive design features that collect desirable solar heat gain and mitigate unwanted solar heat gain.

Information/ How to Implement:

Note: 3.3.5.1A must also be implemented to receive points for 3.3.5.1.B.

In most regions of the country having a winter heating load, homes can be designed so a portion of this load is satisfied by solar gains. As south-facing glass is increased to obtain greater solar benefit, thermal mass must be provided to store excess heat gain, prevent overheating, and moderate heat delivery to the home. Properly sized thermal mass (typically in the form of masonry materials such as tile floors and brick walls, or water) absorbs heat while the sun strikes it and releases that heat slowly once the sun has gone down. Designing a truly passive solar home requires careful calculation of solar gain, thermal storage capacity, and hourly outdoor winter conditions. Obtain the passive solar design guidelines (see Resource) for your climate as well as the other references cited below. It is also advisable to consult a design professional with background and experience in passive solar design.

Resources:

- *Green Building Guidelines—Meeting the Demand for Low-Energy, Resource-Efficient Homes*, Chapter 2A: Renewable Energy: Solar and Other Renewables, Sustainable Buildings Industry Council
- Sustainable Building Industry Council Passive Solar Design Guidelines, available at www.sbicouncil.org

C. Use passive cooling.

- Exterior shading on east and west windows, e.g., shade trees, moveable awnings or louvers, covered porches
- Overhangs designed to provide shading on south-facing glazing. (Use supplied charts that indicate length of overhang and amount and period of shading according to latitude. Not to be double-counted if credited in 3.4.1.a above)
- Windows located to facilitate cross ventilation.
- Solar reflective roof or radiant barrier in hot climate.

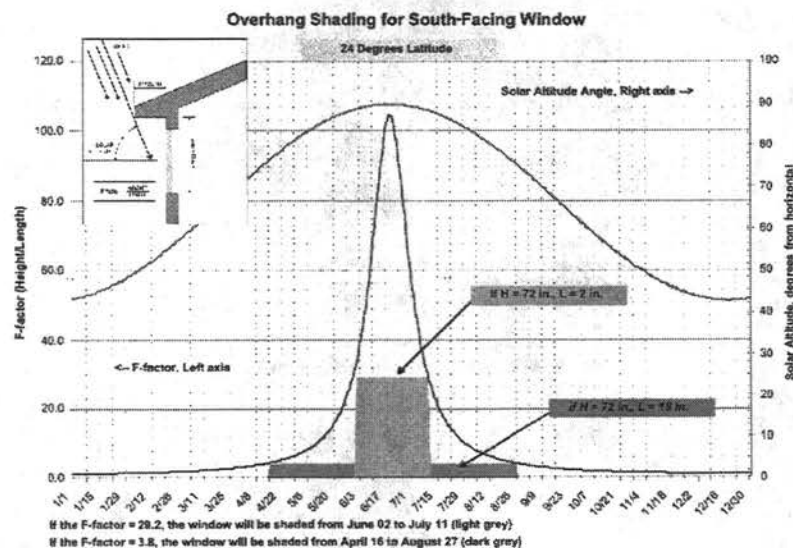
Intent:

To reduce non-renewable energy required for space cooling in the home by mitigating solar heat gain and using design features that promote natural ventilation.

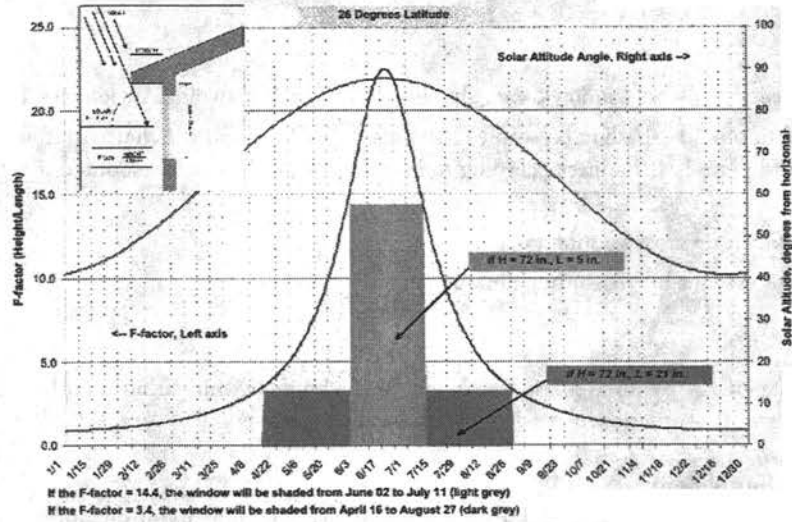
Information / How to Implement:

Natural features, landscaping, and architectural features can help cool a home naturally and/or reduce unwanted solar gains that increase cooling load. The charts below provide guidance on the length of overhangs to achieve desired shading of south-facing glass for different latitudes in the country.

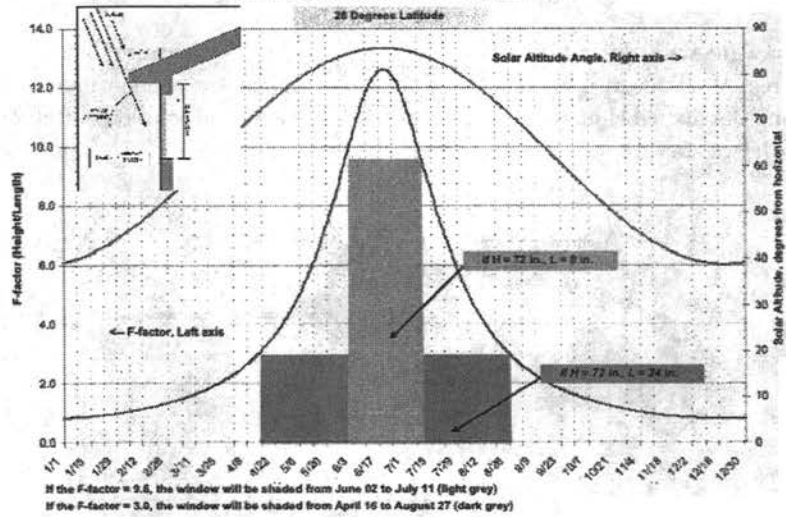
Shading of east and west windows is difficult to achieve with a fixed overhang because the sun is low in the sky when shading is typically desired. Moveable awnings or louvers allow the flexibility to shade windows during certain times of the day or year. In cooling-dominated climates, a covered porch may be a good solution on the west side of the home to mitigate unwanted solar heat gain.



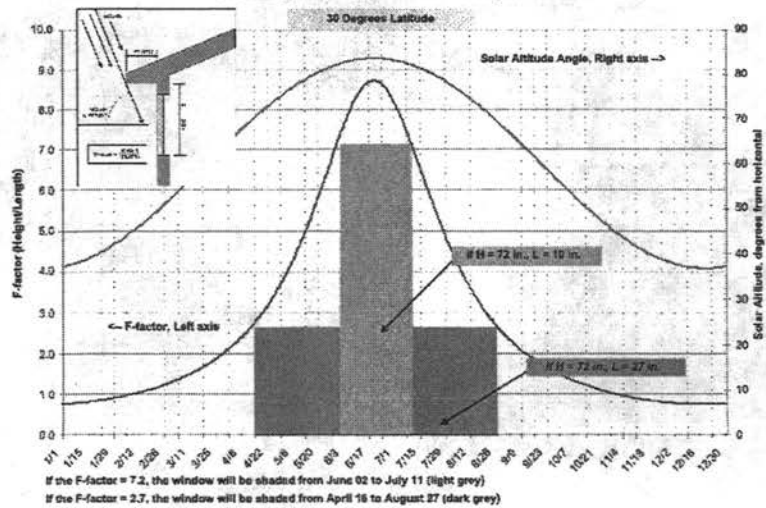
Overhang Shading for South-Facing Window



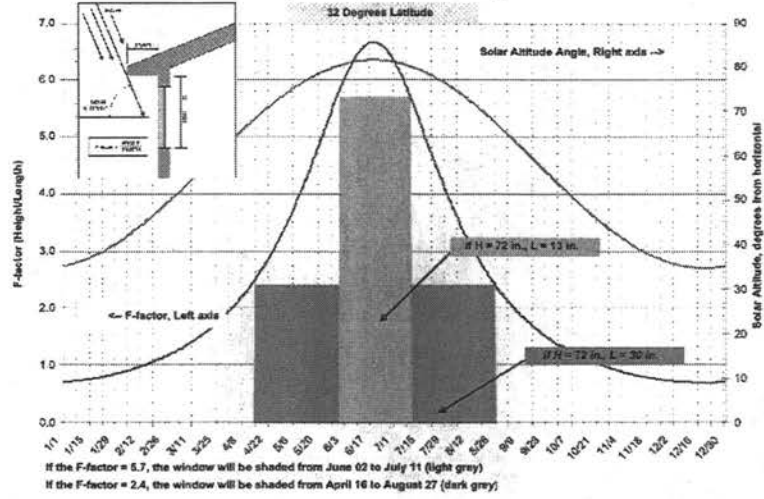
Overhang Shading for South-Facing Window



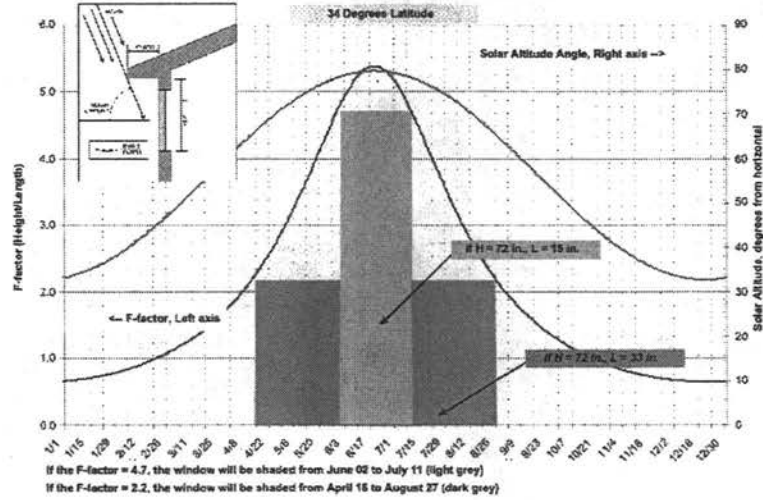
Overhang Shading for South-Facing Window



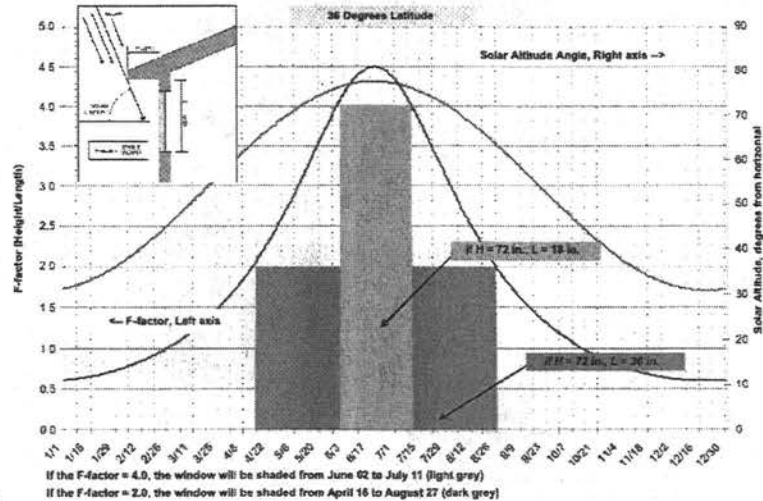
Overhang Shading for South-Facing Window

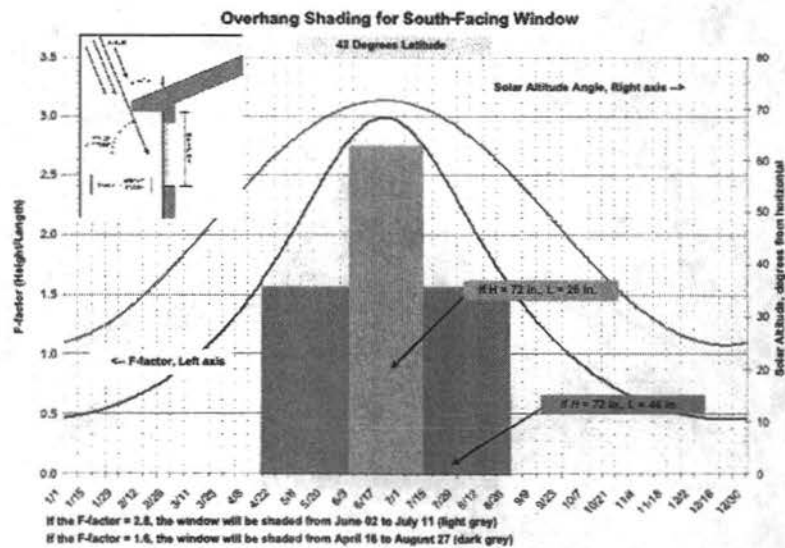
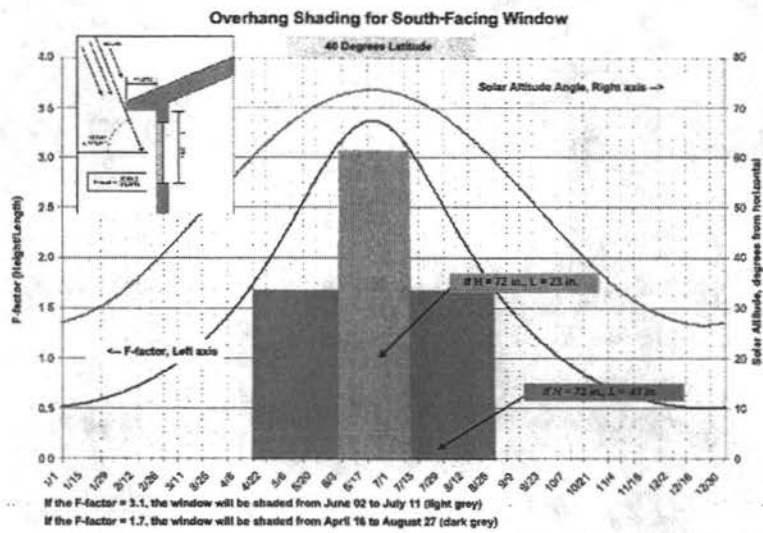
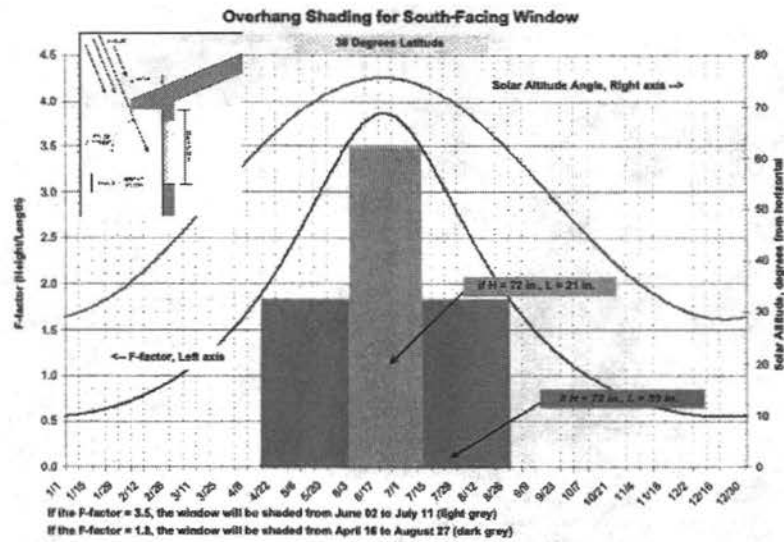


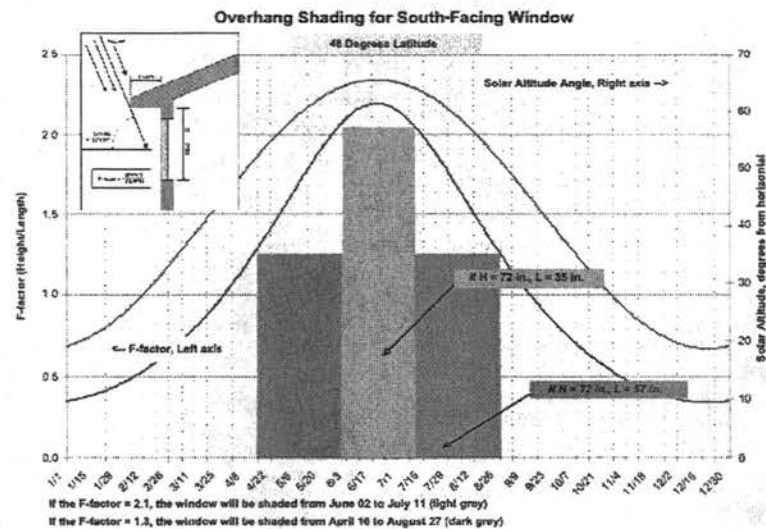
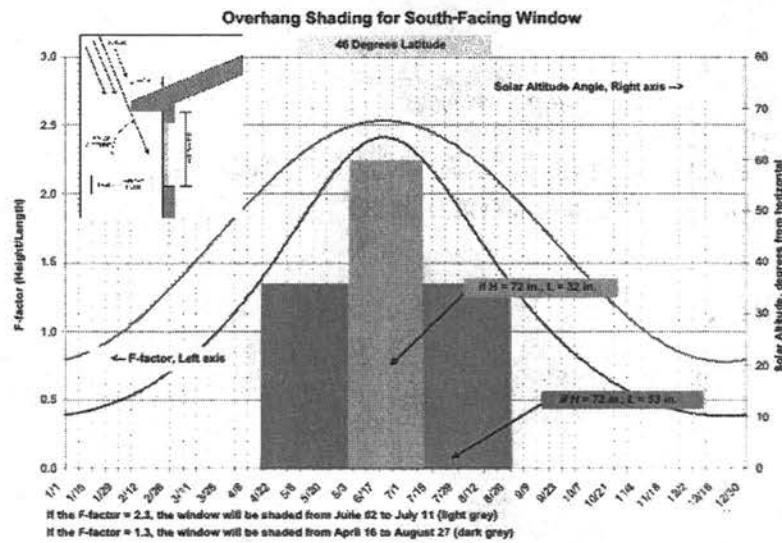
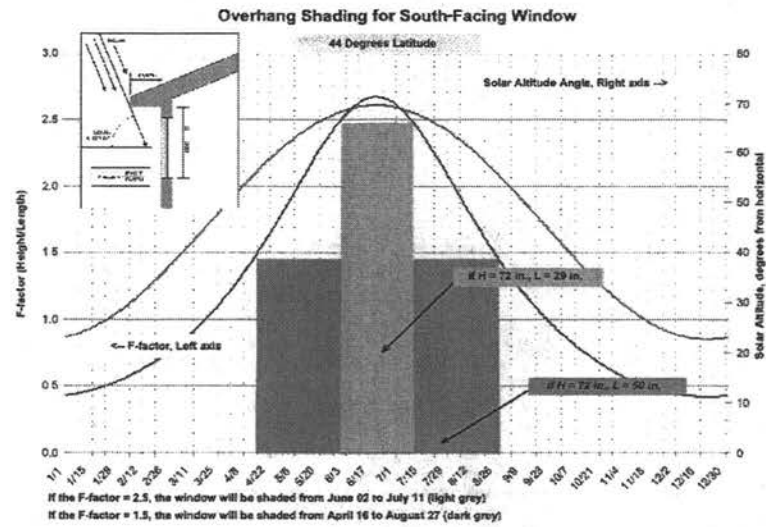
Overhang Shading for South-Facing Window

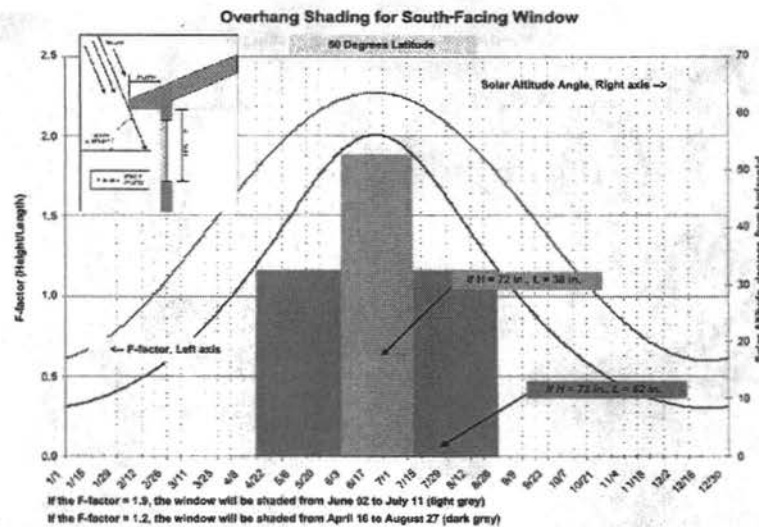


Overhang Shading for South-Facing Window









Resources:

- *Passive Solar Heating and Cooling: Natural Cooling*, Arizona Solar Center fact sheet, www.azsolarcenter.com/technology/pas-3.html
- *Cooling Your Home Naturally*, (U.S. DOE fact sheet) www.eere.energy.gov/consumerinfo/pdfs/coolhome.pdf
- *Passive Solar Design Strategies*, Guidelines for Home Building, Sustainable Building Industries Council, www.psicc.org

3.3.5.2 Solar Water Heating

A. Install solar water heating system. Must use Solar Rating and Certification Corporation (SRCC)-rated system. Solar fraction:

1. 0.3
2. >0.5

Intent:

To reduce non-renewable energy use for domestic water heating.

Information/ How to Implement:

Solar collectors that preheat water for domestic use are often cost-effective. However, solar water heaters must be designed and installed properly to operate to their maximum potential for many years. Solar water heater designs are generally climate specific, primarily with regard to freeze protection. Consult a knowledgeable local installer to design the system, select equipment, and carefully install the system. Use the references below for a basic understanding of the types of systems available and the estimated performance in your climate. Use the ratings published by the SRCC (see Resources) to determine the solar fraction provided by the system you select.

Resources:

- For a list of Solar Rating and Certification Corporation's certified solar water heating systems, see www.solar-rating.org
- *Solar Water Heaters* (NAHB Research Center technology fact sheet), www.toolbase.org/tertiary.asp?TrackID=&DocumentID=2136&CategoryID=68
- Database of State Incentives for Renewable Energy, www.dsireusa.org

3.3.5.3 Additional Renewable Energy Options

A. Supply electricity needs via onsite renewable energy source such as photovoltaic, wind, or hydro whereby the system is estimated to produce the following kWh per year:

1. 2,000 to 3,999
2. 4,000 to 5,999
3. 6,000 +



(Equipment should carry all applicable IEEE and UL certifications. Installation shall be in accordance with local utility and electrical code requirements.)

Intent:

To supply a portion of a household's electricity needs with renewable energy sources, reducing peak electricity demand of the home. Peak electricity demand can necessitate power companies to operate peak generation equipment, which, because it is operated for a short time, generally is less efficient.

Information / How to Implement:

As demand for electricity increases and costs to build additional generating capacity continue to escalate, renewable energy sources such as photovoltaics and wind power become more attractive and more cost effective to consumers and utilities. Local generation of electricity by the sun and wind is a viable option in most regions of the country. Costs of smaller (2 kW to 8 kW) photovoltaic systems are about \$8-\$9 per watt, and in some states like New York, California, and New Jersey, incentives are available that bring the cost even lower. Net metering—in which excess electricity produced at a residence causes the electric meter to spin backwards—may also be available in your area. Net metering effectively credits the customer full retail value for electricity sent back to the utility and greatly improves the economics of residential solar electric power production.

Resources:

- www.dsireusa.org—provides information about areas offering incentives that promote renewable energy and information about net metering rules.

B. Provide clear and unshaded roof area (+/-30° of south or flat) for future solar collector or photovoltaics. Minimum area of 200 sf. Provide a rough-in of piping from the roof to the utility area for:



1. Conduit
2. Insulated piping

Intent:

To encourage and facilitate installation of renewable energy systems for space and water heating needs.

Information / How to Implement:

By providing the infrastructure for the installation of a solar thermal collector or photovoltaic system, you can increase the likelihood that the homeowner will install a renewable energy system in the future. Given the uncertainties of the cost of electricity as well as the possibility of eventual incentives, it makes sense to build this flexibility into the home. It is relatively simple and inexpensive to run electrical conduit or water piping to the attic or roof area while the home is under construction but can be disruptive and costly when retrofitted at a later date. This measure contributes to the cost-effectiveness of the installation of a future renewable energy system.

Resources:

Information will be added in Version 2.

C. Provide homeowner with information and enrollment materials about options to purchase green power from the local electric utility. *(Not to duplicate points for Homeowner Manual in IEQ section below.)*

Intent:

To increase the possibility that the homeowner will select green power when available from the local utility.

Information / How to Implement:

Many utilities across the country purchase or produce at least some power from renewable sources such as wind or hydro. Some utilities offer this power to their customers through green pricing programs, in which a customer can choose to purchase a certain amount of electricity generated by renewable sources. While this electricity is usually more expensive than the utility's standard rates, green pricing programs enable customers to indicate their support for renewable energy sources.

Resources:

- www.eere.energy.gov/greenpower/markets/pricing.shtml?page=0
- Database of State Incentives for Renewable Energy, www.dsireusa.org
- State Energy Office—directory of state energy offices at www.naseo.org/members/states.htm
- Photovoltaics, U.S. DOE fact sheet, www.eere.energy.gov/RE/solar_photovoltaics.html

3.3.6 VERIFICATION**3.3.6.1 Conduct onsite third-party inspection to verify installation of energy related features such as:**

- Duct installation and sealing
- Building envelope air sealing details
- Proper installation of insulation including: no gaps, voids, or compression
- Batt insulation cut accurately to fit cavity
- Windows and doors flashed, caulked, and sealed properly.

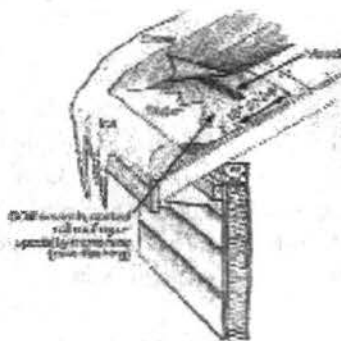
(When at least 100 homes of the same model are to be built by the same builder, a representative sample [15%] of homes may be inspected.)

Intent:

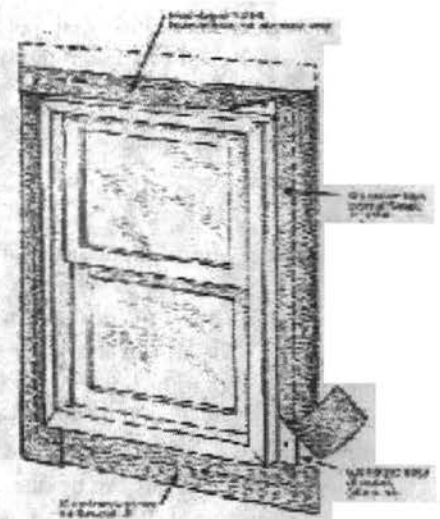
The third-party verification of materials and features that enhance energy efficiency offers customers an added level of assurance that the home will perform as designed. Most builders that have used third-party inspections say it is worth the extra cost because it provides proof to potential clients that the home has higher-quality energy features than competitors' homes.

Information / How to Implement:

A third-party inspection can be performed by any objective, experienced, outside party such as a green building program coordinator, a code enforcement official, an architect or engineer, an energy consultant or specialist, a Home Energy Rating System professional (HERS rater), or an energy program coordinator. Photographs taken by the builder during construction have often been used to defray costs associated with onsite inspections.



Ice Flashing Detail



Window Flashing Detail

Resources:

- Third-party plan review using a Certified HERS rater. A directory of home energy raters can be found on the ENERGY STAR website at www.energystar.gov.
- Local utility, if it offers a new-home energy-efficiency program.

3.3.6.2 Conduct third-party testing to verify performance, e.g., blower door, duct leakage, and flow hood testing (points given per test).

A. Building envelope leakage: blower door test results < 0.35 ACH_{nat}

B. Central HVAC duct leakage: Duct leakage test results:

- Leakage to unconditioned space < 5% of rated blower capacity.
- Total leakage < 10% of rated blower capacity.

C. Balanced HVAC airflows: Flow hood test results:

- Measured flow at each supply and return register within 25% of design flow.
- Total airflow within 10% of design flow

(When multiple homes of the same model are to be built by the same builder, a representative sample of homes may be tested subject to the sampling protocol.)

Intent:

Testing of the installed systems of a home such as envelope or duct tightness or airflows of HVAC systems provides an added level of assurance to the customer as well as to the builder that energy features were installed properly and will perform to expected levels.

Information / How to Implement:

Keep in mind that proper design and installation are the key ingredients; testing provides confirmation, assurance, and possibly education. With respect to blower door and duct blaster testing, the builder is able not only to gain an idea of the relative tightness of the envelope or the ductwork but also to identify potential problem areas that need correction. Duct blaster testing is less important when all ducts are located within conditioned space; under these conditions, the test may identify comfort or installation issues rather than energy lost to the outdoors.

Third-party testing is conducted by professionals who have specialized equipment for blower door and duct pressure testing. See Resources for information on finding energy specialists who can conduct testing.

Resources:

- Third-party plan review by a certified Home Energy Rating System (HERS) rater. A directory of HERS raters can be found on the ENERGY STAR website at www.energystar.gov.
- Building Performance Institute (www.bpi.org) certifies whole-house building performance contractors.
- Manufacturers of testing equipment offer databases of contractors trained on proprietary equipment (e.g., The Energy Conservatory)
- Local utility
- Yellow pages for “energy,” “energy efficiency,” or “weatherization”

3.3.7 Innovative options

A. Install drain water heat recovery system.

Intent:

To reduce energy required for heating domestic hot water.

Information / How to Implement:

Drain water heat recovery (DHR) systems recover some of the energy from hot water going down the drain. DHR systems are available from several manufacturers. One type of DHR system, the GFX, consists of flexible copper piping coiled around a copper drainpipe that is fitted into the DWV line with rubber couplings. In a typical GFX configuration, cold water running through the outer flexible copper tubing is preheated by hot water running down the drain from the main shower. The preheated water is then supplied to both the hot water tank and the cold side of the main shower—which reduces the volume and flow of hot water needed. A similar configuration can be designed for the whole house but must be more carefully designed.

Resources:

- Department of Energy—www.eere.energy.gov/consumerinfo/energy_savers/virtualhome/508/shower.html
- Drainwater Heat Recovery, NAHB Research Center technology fact sheet, www.toolbase.org/tertiaryT.asp?TrackID=&DocumentID=2134&CategoryID=947

B. Install a desuperheater in conjunction with ground source heat pump.

Intent:

Increase the efficiency of a ground source heat pump operating in cooling mode while providing “free” hot water for domestic use. Also provide hot water while heat pump is in heating mode at high efficiency.

Information / How to Implement:

A desuperheater recovers heat that is rejected from a ground source heat pump (GSHP) operating in cooling mode, increasing the cooling efficiency of the heat pump and providing “free” hot water. In heating mode, hot water is produced by the GSHP and, therefore, is produced at a high efficiency. Desuperheaters should be installed by an experience installer or come pre-installed from the factory.

Desuperheaters can be an addition to any split system A/C unit but are most commonly found on ground-source heat pump units.

Resources:

- www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3E.pdf
- Improve Energy Efficiency with Desuperheaters, U.S. EPA fact sheet, www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3E.pdf
- Geothermal heat pump manufacturer websites

C. Install heat pump water heater. Must be rated according to the current U.S. DOE test standard and shall have an Energy Factor > 1.7.

Intent:

Reduce the energy needs for electric water heating.

Information / How to Implement:

Heat pump water heaters (HPWH) operate in a similar way to space conditioning heat pumps—they use the energy in the surrounding air to preheat water. HPWH technology has been under development for many years and is now reaching the marketplace with a number of manufacturers offering products. HPWHs operate best in hot climates where the resultant cooling of the air around the heat pump can provide additional energy savings during most of the year. HPWHs can as much as double the efficiency of electric water heating, not including any additional energy savings from space conditioning.

Careful design of the heat pump water heater system is necessary to ensure adequate performance in all seasons.

Resources:

- www.toolbase.org/tertiaryT.asp?DocumentID=2100&CategoryID=946
- Heat Pump Water Heaters, Federal Technology Alert, List of heat pump water heater manufacturers at ACEEE's Web site: www.aceee.org/consumerguide/topwater.htm

D. Install occupancy sensors for lighting control. (Points per sensor)

Intent:

Reduce the electricity consumption associated with lighting in unoccupied rooms.

Information / How to Implement:

Purchase lighting controls from a supplier of energy-efficient products or your local lighting supply store.

Resources:

- Retail outlet of energy-efficient products, e.g.,
www.EFI.org, www.positive-energy.com, www.sheltersupply.com

UNDERSTANDING HVAC SYSTEM DESIGN ISSUES

When designing a comfort system, it is not adequate to merely produce a heat loss and heat gain estimate. Heat loss and heat gain estimates are part of a design procedure that flows from system selection decisions and the actual load calculations to equipment selection procedures, placement and selection of air distribution hardware, duct routing and airway sizing.

Documents such as ACCA Manual RS provide valuable information about zoning, system concepts, equipment capability, and design procedures. It is strongly recommended that system designers be familiar with the material in Manual RS.

Manual J or equivalent load calculations affect every aspect of the system design procedure. The calculations must be as accurate as possible.

- Equipment capacity that matches the size of the applied heating and cooling loads will deliver comfort, efficiency, and reliability over the entire range of operating conditions.
- Heating and cooling loads determine the total air delivery requirement (blower CFM) and the airflow requirement for each room (room CFM). This airflow information is then used to select supply air outlets and to size the duct runs.
- Load information also is used to estimate purchased energy requirements and to estimate annual operating cost. In this regard, the energy and operating cost estimates will only be as accurate as the load estimate.
- The design concept must be suitable for the application:
 - Contemporary architecture tends to produce dwellings that require a zoned system and/or variable capacity equipment.
 - Custom homes that feature a large amount of architectural glass that provides a panoramic view or architectural theme may not have internal shade, or the shading device may be completely open when the room is occupied. In such cases, the performance of the glass (U-value and solar heat gain coefficient) has a significant effect on comfort, equipment size, and energy use. If there is a large amount of south glass, cooling may be required during cold weather. These dwellings must be carefully zoned and may require year-round cooling.
 - People may be uncomfortable when bathed by sunlight pouring through a window. During cold nights or cold overcast days, radiation from the occupant's skin to cold glass surfaces may cause discomfort.
- External overhangs or some type of internal shading device are desirable because they provide comfort for the occupants (overhangs provide shade without interfering with the view).

Manual S (or Equivalent) and Manufacturer's Data to Select Equipment

In general, the effective capacity of heating and cooling equipment shall, as closely as possible, match the load when the equipment is subjected to design conditions. For instance, Manual S explains how to use Manual J output and manufacturer performance data to obtain this result. Manual S also provides guidelines pertaining to the acceptable amount of excess capacity and manipulating heat pump balance points.

ACCA Manual T (or Equivalent) and Manufacturer's Data to Select Supply Outlets and Return Grilles

Supply outlets (grilles and registers) shall be the appropriate style and size for the application and shall be in an appropriate location for the application.

- Supply outlets shall not produce objectionable noise. Design guides and manufacturers' information establish limits for face velocity.
- Supply outlets shall provide the appropriate throw for the installed location. Floor outlets shall throw the supply air to the ceiling; ceiling outlets shall throw the supply air to the wall, etc. Size depends on product performance, the supply CFM value, and the face velocity limitation.
- Never blow supply air directly into the occupied zone. Occupants will complain about drafts.
- Floor outlets that blow air straight up the exposed wall are best for cold-climate heating and, if properly selected, adequate for cooling.
- Ceiling outlets are best for cooling but will not warm slab or exposed floors during the winter.
- If high sidewall outlets are used for cooling, supply air shall not drop into the occupied zone during cooling. These devices will not warm slab or exposed floors during the winter.
- The relation between supply CFM, throw, face velocity, and drop is established by manufacturer performance data. Performance is very sensitive to size, and devices that appear to be generally similar can have substantially different performance characteristics.
- A low-resistance return path shall be provided for every room that receives supply air—a wall opening with no door, a transfer grille, or a ducted return. Door undercuts are not acceptable.
- Return grilles shall be the correct size for the grille flow rate. Filter grilles have a lower face velocity than plain grilles.
- The location of the return grille does not affect room air patterns, which are controlled by the supply outlets and will not have a significant effect on pockets of stagnant air. Low returns do pull warm air down to the floor, and high returns do not pull cool air up into the occupied zone.

Manual D (or Equivalent) to Size the Duct Runs

The resistance (inches water gauge of static pressure) of the longest circulation path (longest supply run plus longest return run) shall be compatible with the performance of the blower that is supplied with the heating-cooling equipment. Airway sizes that are compatible with the blower performance shall be increased if airflow velocity creates a potential noise problem. All systems shall have adequate provision for balancing airflow.

- The length of the longest circulation path and the available static pressure determine the friction rate used for airway sizing.
- The length of the circulation path includes the straight runs and the equivalent length of the fittings along the path. One fitting can add from 5 feet to more than 60 feet to the length of the path.
- External static pressure is determined from the equipment manufacturer's blower performance data, preferably for medium-speed operation.
- The available static pressure equals the external static pressure minus the pressure drop through all the air-side devices in the circulation path. Refer to blower table footnotes and manufacturer pressure drop data for devices that were not in place when blower performance was laboratory-tested by the equipment manufacturer.

- Accessory or after-market filters (or any device) that produce a substantial increase in system resistance shall not be installed if the blower cannot accommodate the increased resistance by speed change. An arbitrary increase in system resistance may cause low airflow to rooms, a high temperature rise across a furnace heat exchanger, or low suction pressure at the cooling coil.
- The room heat loss and heat gain estimate (Manual J or equivalent) and the heating and cooling factors (Manual D or equivalent) determine the design value for room airflow.
- Airway size is determined by sectional flow rate and the design friction rate value.
- The friction chart or duct slide rule used for airway sizing shall be technically correct for the type of duct material.
- Airway velocities shall not exceed specified design limits.
- Branch (runout) ducts shall be equipped with a hand damper (for balancing).

Related Comfort Conditioning System Design Considerations

Impact of Incorrectly Sized Heating and Cooling Equipment

- The obvious problem with significantly undersized equipment is that it will not maintain the desired set-point temperature when a passing weather system imposes a design load on it. However, slightly undersized cooling equipment—by a margin of 10 percent or less—may actually provide more comfort at a lower cost.
- Oversized equipment causes short cycles, marginalizes part-load temperature control, creates pockets of stagnant air (unless the blower operates continuously) and degrades humidity control during the cooling season (more information on this subject is provided below). Oversized equipment also requires larger duct runs, increases installed cost, increases operating cost, increases the installed load on the utility grid, and causes unnecessary stress on the machinery.

Humidity Control During the Cooling Season

- Sensible and latent cooling loads are imposed on dwellings in climates that have a substantial amount of moisture in the outdoor air during the cooling season (wet-coil climates). When the summer design condition occurs, properly sized equipment will operate continuously or almost continuously, both loads will be completely neutralized, and the occupants will be comfortable. But, the design condition occurs for only a few dozen hours per season.
- Reduced latent capacity at part load will cause the indoor humidity to drift above the design value, which is acceptable, providing the relative humidity stays below 60 percent. The possibility for experiencing comfort problems at part-load conditions is minimized by using the default indoor and outdoor design conditions recommended by the design manual, providing a code or regulation does not specify a different set of conditions.
- Some climates are too dry to produce a latent load on the indoor coil. In this case, the indoor humidity depends on the moisture content of the outdoor air, the infiltration rate, and the amount of moisture generated by the occupants. If the outdoor air is very dry, these factors will combine to produce an indoor relative humidity of less than 50 percent and could even be lower than 40 percent. But if the relative humidity stays above 30 percent, the indoor air condition will be in the comfort zone.

Humidity Control During the Heating Season

During the heating season, dry air causes a sensation of coolness, a desire to increase the thermostat set point, problems with static electricity, and dry sinuses. Adding a humidifier to the heating system moderates these problems, but if a humidifier is installed, it must not produce a visible or concealed condensation problem. (See the unabridged version of Manual J for more information on this subject.)