



If you're getting ready for a home remodeling project or you're building a new home, this design and construction checklist can help you implement energy-efficient construction practices.

These improvements are simple, straightforward, and can be readily addressed by most housing providers. Be sure to ask your builder or remodeler about energy-efficient materials and construction practices since details can vary according to your home site, house design, and other factors.

## ✓ Building or Remodeling Your Home

### Appliances

1. Select refrigerators, clothes washers, and dishwashers that are ENERGY STAR® labeled.
2. Install fuel-fired stoves and ovens that have pilotless ignition.

### Lighting

1. Install dedicated fluorescent light fixtures for all ceiling- and wall-mounted fixtures that will be on for 2 hours or more each day, especially kitchens, hallways, and often bathrooms.
2. Seal light fixtures to the drywall using caulk.
3. Install fluorescent, high-intensity discharge, or low-pressure sodium fixtures for exterior lighting unless incandescent lights are automatically controlled to be on for just a few minutes each day.
4. Use motion detectors, photosensors, and timers on exterior lighting.

### Windows

1. Follow window placement and selection guidelines.
  - For heating climates, maximize glazing areas on the south walls and reduce north-facing windows. For cooling climates, preferentially use north-facing windows and generously shade south-facing windows.
  - Minimize unshaded glazing areas on the east and west walls, especially in mixed and hot climates.
  - Select window types that meet or exceed the 2000 International Energy Conservation Code or, preferably, are ENERGY STAR labeled and that are consistent with passive solar design considerations.
  - In southern climates, use shade screens and tinting on windows facing south, east, and west that are not already shaded by the roof, porch, vegetation, or other means.
2. Install windows properly.
  - Seal the backsides of the top and side window flanges (but not the bottom) to the sheathing or weather barrier during installation using caulk.
  - Seal windows into their rough openings before drywall is installed using backer rod (preferred) and caulk, or use non-expanding spray foam.

### Water Heating

1. Select appropriate water heating equipment.
  - Consider fuel cost in selecting the system type.

- Use higher-efficiency equipment when the cost is justified (typically if hot water use and fuel costs are high).
  - Size the water heater using the first hour rating of the equipment by estimating the daily peak 1-hour hot water demand.
2. Install the water heater properly.
- Connect the hot and cold water pipes to the correct taps on the water heater.
  - Insulate the water heater tank with a jacket, following manufacturer requirements, if it is located outside the conditioned space of the house.
  - Install heat traps (inverted loops, preferred, or check valves) on both the hot and cold water pipes at the water heater.
  - Insulate the first 6 feet of the hot and cold water pipes connected to the water heater.
  - Set the water heater thermostat to 120°F.
  - Seal around the metal flue of combustion equipment using an Underwriters Laboratory (UL) approved metal collar and high temperature (450°F), fire-rated caulk.
3. For a house with a crawlspace (especially in cold and mixed climates), insulate the water pipes in the crawlspace for freeze protection.

## Exterior Doors

Install doors properly.

- Seal between the door threshold and subfloor using caulk.
- Seal doors into their rough openings before drywall is installed using backer rod (preferred) and caulk, or use non-expanding spray foam.
- Adjust the door threshold properly for an airtight fit.
- Install door weatherstripping.

## Heating and Cooling Equipment

1. Select appropriate heating and cooling equipment.
- Select the heating equipment type after comparing operating and initial costs for all available fuel types.
  - Use higher-efficiency equipment when the cost is justified (typically in larger homes in more severe climates where fuel costs are high).
  - If a programmable thermostat is desired, choose a model with an ENERGY STAR label.
2. Install heat pumps and air conditioners properly.
- Install refrigerant lines that are as short and straight as possible, properly pitched and trapped, and insulated (suction line only).
  - Install a liquid-line filter/dryer.
  - Conduct indoor air flow tests to ensure the correct air flow across the indoor coil.
  - Place an outdoor unit on a level pad at least 12 inches from any obstruction and 3 feet from landscaping to provide proper air circulation. Avoid any obstruction within 48 inches of the air discharge that would force air recirculation.

- Install an outdoor thermostat on heat pumps to control auxiliary heat use.
3. Seal around the metal flue of combustion equipment using an Underwriters Laboratory (UL) approved metal collar and high temperature (450°F), fire-rated caulk.

## ✓ More Tips for Building an Energy-Efficient Home

### Overall House Design

1. Plan ahead to optimize your home's envelope and mechanical systems. Consider from the start of the design the framing and insulation, windows, air leakage control, heating and cooling equipment, ductwork, ventilation systems, water heating equipment and fixtures, lighting, and appliances.
2. Design with the sun in mind to utilize passive heating, reduce cooling loads, and use daylight to provide natural lighting.
  - Orient the house with the long axis running east/west.
  - Place and size windows according to the climate zone.
  - Integrate landscaping with overhangs to provide needed window shading.
  - Add thermal mass in the walls or floors for heat storage.
  - Consider use of natural ventilation for cooling.
3. Use advanced framing techniques to reduce the amount of lumber used and increase insulation coverage.
  - Design homes on 2-foot modules.
  - Space wall studs, floor joists, and roof rafters 24 inches on-center.
  - Use single top plates in conjunction with in-line framing designs.
  - Align windows and doors with existing studs.
4. Plan locations for ductwork, framing, plumbing, and electrical wiring simultaneously to avoid conflicts between systems.

### General Air Sealing

Use caulk, spray foam, sheet goods (e.g., rigid board insulation, plywood, drywall, polyethylene sheeting, housewrap) and other materials as detailed in the following guidelines.

1. Seal before drywall is installed.
  - Seal between the bottom plate of exterior walls and the subfloor during construction using a double bead of caulk or durable gasket (sill seal).
  - Seal the inside edge of the bottom plate of exterior walls to the subfloor using caulk after the frame walls are erected.
  - Seal the band joist of a multi-story home or a home with a conditioned basement using caulk, spray foam, or gaskets. Seal between the band joist and the top plate or sill plate, and between the band joist and subfloor.
  - For bathtubs on an exterior wall, insulate the exterior wall and then airseal behind the tub before the tub is installed, using sheet goods or plastic sheeting stapled and caulked to the wood framing.
  - Seal the bathtub drain and water line penetrations through the floor after the tub is installed and the plumbing is connected, but before any floor insulation is installed. Use rigid board insulation, plywood, or other sheet goods with caulk or spray foam.

- Seal dropped ceilings and soffits, duct and flue chases, and open partition walls before any attic insulation is installed, using rigid board insulation, plywood, or other sheet goods with caulk or spray foam. Alternatively, construct dropped ceilings and soffits after the entire ceiling is drywalled and taped to avoid this type of attic bypass.
- Seal all electrical wire; plumbing; and heating, ventilation, and air-conditioning penetrations (at the top and bottom plates; through the ceilings, floors, and exterior walls; and at other framing locations) between conditioned and unconditioned spaces using caulk or spray foam.
- Seal the wiring and knockouts in all electrical boxes with caulk.
- Seal outdoor-mounted electrical boxes to the exterior sheathing.

## 2. Seal during drywall installation.

- Seal the drywall to the top and bottom plate using construction adhesive, caulk, or gaskets.
- Seal the drywall to the rough openings of windows and doors using construction adhesive, caulk, or gaskets.

## 3. Seal after drywall is installed.

- Seal electrical boxes (e.g., switches, outlet receptacles), light fixture boxes, circuit breaker boxes, and medicine cabinets to the drywall using caulk or foam.
- Seal plumbing or electrical wiring penetrations through the drywall (e.g., the electrical wire behind the kitchen range hood, refrigerator water supply) using caulk or foam.
- Seal between a masonry chimney and the attic framing using sheet metal or other noncombustible sheet goods and high-temperature (450°F), fire-rated caulk.
- If a whole-house fan is installed, seal gaps around the whole-house fan frame using spray foam (preferred) or housewrap tape and fabricate a whole-house fan cover using rigid board insulation or fibrous duct board.

## Foundation

### 1. Provide drainage and moisture control.

- For a basement and slab, install a capillary break beneath the slab floor using 6- to 10-mil polyethylene placed over at least 4 inches of gravel.
- Establish a foundation drainage system adjacent to the entire perimeter of the footing using 4-inch perforated drainpipe, gravel, and filter fabric.
- For a basement or crawlspace, dampproof all below-grade portions of the foundation wall and footing and place a continuous drainage plane (e.g., commercial products, gravel) over the dampproofing.
- Install a protective membrane (e.g., caulked metal flashing) between the foundation and the sill or bottom plate to serve as a capillary break.
- Establish drainage swales to direct rainwater around the house.
- Grade slopes 5 percent or more away from all sides of the house for at least 5 feet.
- Provide gutters to conduct rainwater away from the house.
- For a crawlspace, close the crawlspace vents after making sure the crawlspace is dry and use manual rather than thermostatically controlled vents. Also, install 6-mil polyethylene across the crawlspace, overlapping the seams by 12 inches and sealing the polyethylene 6 inches up the crawlspace walls.

## 2. Use foundation insulation strategies.

- For a house with a conditioned basement, insulate the basement walls by insulating the exterior, insulating the interior (by furring out the interior), or using insulated concrete forms. For a house with an unconditioned basement, insulate the underfloor.
- For a house with a crawlspace, insulate the walls of the crawlspace or the underfloor.
- For a slab foundation, install rigid board insulation around the perimeter of the slab during slab construction using a code approved method.

## 3. Install underfloor insulation properly.

- Install batts flush against the subfloor.
- A vapor barrier is optional. If present, install it facing upward against the subfloor.
- Cut the batts to the full length of the joist.
- Slit the batts to fit around wiring and plumbing.
- Cut batts lengthwise to fit into joist spaces with nonstandard widths.
- Insulate between air distribution system ducts and the subfloor as space permits.
- Use insulation hangers spaced every 12 to 18 inches to hold the batts in place without compressing the insulation more than 1 inch.

## Exterior Walls and Sheathing

### 1. Use advanced framing to improve insulation coverage.

- Use insulated corners (2-stud or equivalent) with drywall clips or vertical 1x4-inch nailers.
- Provide a surface for attaching drywall at the connection of interior partition walls to exterior walls by using drywall clips, vertical 1x6 lumber, or horizontal nailers (ladder) rather than additional studs.
- Eliminate headers in non-load-bearing walls; use single-ply headers when possible; and use insulated headers when headers are needed.
- Limit the use of blocking.
- Use rigid board insulation in place of structural sheathing in non-corner areas.
- Use cross or let-in bracing to allow rigid board insulation to be used in place of structural sheathing in corners.

### 2. Incorporate a weather-resistive barrier into the wall system.

### 3. Install sheathing properly.

- Seal the sheathing seams with housewrap tape or caulk, or install housewrap.
- Repair any deficiencies in the exterior sheathing or exterior rigid board insulation.
- Seal exterior penetrations in the sheathing (e.g., porch light fixtures, outside outlets, phone, cable, electric service holes, faucet hose bib) using caulk or spray foam.

#### 4. Install housewrap properly.

- Cover and seal the housewrap to the top and bottom plates and sills using housewrap tape or caulk.
- Cut the housewrap for window and door openings using the modified “I” cut (an inverted “Y” pattern), fold back, and staple or nail to the inside.
- Overlap and seal housewrap seams using housewrap tape or caulk.
- Seal all cuts, penetrations, and openings in the housewrap using housewrap tape or caulk.
- Use plastic-capped nails or staples to mechanically fasten the housewrap to the house.

#### 5. Install wall insulation properly.

- Identify all walls (including bandjoists and walls next to garages, mechanical rooms, etc.) that need to be insulated.
- Insulate the exterior walls behind a stairwell and cover them with sheet material before setting the stair stringers.
- Cut batts to the full length of the cavity to be insulated.
- Cut batts lengthwise to fit into cavities with nonstandard widths.
- Slit batts to fit around wiring, wall outlets, and plumbing.
- For cold and mixed climates, staple the kraft paper facing of the batts to the front of the studs every 12 inches (in other climates, the kraft paper may need to face away from the interior, or an unfaced batt may be used).

## Roof and Attic

#### 1. Design the roof and attic for energy conservation.

- Ventilate the attic using continuous soffit and ridge vents.
- Size overhangs to shade south-facing windows without interfering with passive heating. Roof overhangs can also be sized to provide some marginal benefit for windows facing east and west.
- For open-framed attics, use raised-heel or oversized (cantilevered) trusses or a raised top plate to allow for complete attic insulation coverage over the exterior walls and soffit ventilation.
- For cathedral ceilings, use scissor trusses or frame the ceiling to provide adequate clearance for recommended insulation levels and soffit ventilation.

#### 2. Install attic insulation properly.

- Elevate any attic decking to allow full-height insulation to be installed.
- Install blocking (metal flashing) to maintain clearance around heat-producing equipment (e.g., flues, chimneys).
- When using loose-fill insulation, install rafter baffles (e.g., commercial products, felt paper) before ceiling drywall is installed to preserve soffit ventilation and obtain maximum insulation coverage over the exterior wall; use insulation dams (e.g., commercial products, rigid board insulation, batt insulation, solid sheet goods) at the soffit, porch, garage, and attic access to prevent insulation from spilling; and install attic rulers to ensure complete and full coverage.
- When using batts, cover the top of the ceiling joist or the bottom cord of the truss with insulation, completely fill the joist cavities, and fluff the batts to their proper loft.

- For cathedral ceilings, install vent baffles between the insulation and roof decking for ventilation.
- For attic knee wall areas, insulate the knee wall and attic floor after air sealing the open joist ends below the knee wall (plug the opening with stuffing material and seal the material to the joist using caulk or spray foam). Alternatively, insulate and air seal the rafter space along the sloping ceiling of the knee wall.

### Attic or Knee Wall Access

1. Locate an attic access (e.g., attic hatch, pull-down stairs) in an unconditioned part of the house (e.g., carport, garage, gable end of the roof) rather than inside the house. Provide a locking mechanism for security.
2. If the attic or knee wall access is located in a conditioned space, insulate and seal it carefully.
  - Construct it with a rigid frame (e.g., use 1x4-inch framing rather than molding) and use a cover that will not warp.
  - Weatherstrip it and install a tight latch or latch bolts to hold the access tight against the stripping material.
  - For an attic hatch, insulate the cover to the same R-value as the ceiling by glueing 3 to 4 pieces of rigid board insulation and/ or stapling an insulation batt (R-15 or greater preferred) to the top of the cover.
  - For a knee wall door, insulate the door to the same R-value as the wall by glueing 3 to 4 pieces of rigid board insulation to the attic side of the door.
  - For an attic pull-down stair, seal the stair to the rough framing using caulk or non-expanding spray foam, and insulate it by fabricating an insulated cover from rigid board insulation or fibrous duct board or using a commercial product.

### Air Distribution System

1. Design ductwork for efficiency.
  - Locate ducts inside the conditioned space rather than in the attic or crawl space.
  - Design the distribution system so it is all “hard” ducted. Avoid using building cavities as part of the duct system.
  - Consider supply outlet locations near interior walls to reduce duct lengths.
  - Specify volume dampers to facilitate balancing.
  - Include a return on each level of a multi-story house.
  - Specify transfer grills or jumper ducts to ensure air circulation in each room with a door but no return.
2. Install ducts properly.
  - Install ducts with proper support, without kinks or restrictions, and with a minimum number of bends and turns.
  - Stretch flexible duct to its full length and cut to fit (do not compress it).
  - Connect all joints in the ductwork with mechanical fasteners (e.g., screws, staples, drawbands).
  - Seal all joints in the ductwork (including connections to the air handler, duct boots, and elbows) with approved tapes or preferably mastic.
  - Seal holes, seams, wire penetrations, refrigerant and condensate line penetrations, access panels, and other openings at the air handler with mastic, caulk, or tape.

- Seal the return duct plenum (e.g., sheet metal, floor joist panning, drywall) and any penetrations in the plenum using mastic (preferred) or caulk.
- Seal duct boots to the floor or drywall using caulk, foam, or mastic (AS, CI).
- Install duct insulation to be continuous (no gaps or voids).
- Permanently secure duct insulation using drawbands, wire, staples, or approved tapes.

## Combustion Equipment Safety

1. If a combustion furnace and/or water heater is being installed in a conditioned space, use sealed-combustion, fan-assisted equipment or isolate the equipment closet from the conditioned space.
  - Insulate and seal the walls and ceiling of the equipment closet as if they were exterior walls and ceilings.
  - Install a solid (non-louvered) door with weatherstripping and a threshold.
  - Seal all fuel lines, water lines, and electrical penetrations through the equipment closet.
  - Provide two air inlets for combustion and a vent for flue gases following code requirements.
2. Install a carbon monoxide detector if any fuel-burning appliance (e.g., heating system, water heater, stove, fireplace) is installed in the home.
3. Measure carbon monoxide levels on all fuel-burning appliances after installation.

## Ventilation

1. Design an appropriate whole-house ventilation system.
  - Select a general ventilation design strategy appropriate for the climate.
  - Select equipment and controls to meet the determined ventilation requirement.
  - Incorporate bathroom, kitchen, and other spot ventilation systems into the design at points of moisture generation.
2. Select and install ventilation equipment properly.
  - Select energy-efficient and quiet fans (2 sones or less), or install the fan remotely outside the living space.
  - Size fans based on type, length, and layout of the associated duct system.
  - Install ventilation ducts that are smooth, as short as possible, as straight as possible with a minimum of elbows, adequately supported, properly sized, sealed, and insulated if outside the conditioned space.
  - Exhaust ventilation ducts directly to the exterior through the roof or sidewall, not in attics or crawlspaces.
  - Equip ventilation ducts with backdraft dampers.
  - Install transfer grills or undercut doors to facilitate air flow between rooms.
  - Balance and test all ventilation systems after installation. Make sure the backdraft damper is free swinging and seals when the fan is off.

3. Select and install bathroom fans properly.

- Use ENERGY STAR-labeled fans to be energy-efficient.
- Select fans with a noise rating of no more than 2 sones but preferably less than 1 sone.
- Slope the ducts to the outside if a sidewall discharge is used.
- Seal the fan housings to the drywall using caulk or foam.

4. Select and install the kitchen range hood fan properly.

- Use an ENERGY STAR-labeled fan to be energy-efficient.
- Select a fan with a noise rating of no more than 4 sones but preferably less than 2 sones.