Welcome! The 60-Hour program is made up of 8 separate courses. Many of the courses are available in both Video and/or Text. It is not necessary to complete both versions. We offer both versions to ensure your learning style is addressed. You can choose whether you want to watch the video, or read the text, but you DO NOT have to do both. You can use either version for study purposes- just be sure to take the all quizzes in one version OR the other.

This course will bring attention to methods of green building that allow homes to have less impact on the environment while providing a great economic benefit to the homeowner. Students will learn the importance of incorporating energy-efficiency into their building projects. A review of the new Michigan Uniform Energy Code is also included.

If you are taking this course as part of the 60-Hour Prelicense Program, please read the information below:

The 60-Hour program is made up of 8 separate courses listed below. Many of the courses are available in both Video and Text/Online. It is not necessary to complete both versions. You can choose whether you want to watch the video version or read the text version. As the videos for the other four courses are completed, they will be added to your registration at no additional charge.

COURSES

1. Business of Building (Video or text)
2. Contracts, Liabilities and Risk Management (Video or text)
3. Project Management for Contractors (Video or text)
4. Marketing for Building Contractors (Video or text)
5. Building Green (Video or text)
6. Residential Code Review (Video coming soon)
7. Michigan Construction Safety (Video or text)
8. Overview of Building Trades (Video or text)

PLEASE CONTINUE READING:

FREE WITH PURCHASE

These are all optional and not required in order to complete the 60-Hour program, but the math tutorial and exam prep are extremely helpful in studying for the State exam.

--3-Hour Math Tutorial video for State exam prep

--Michigan Exam Prep (sample questions for State exam prep)

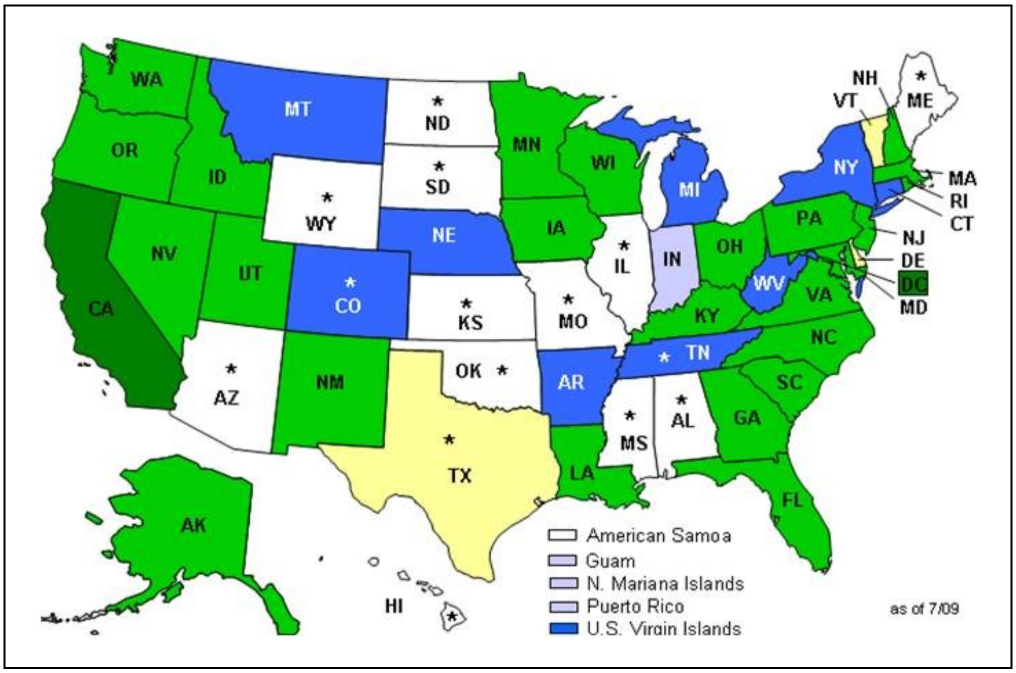
You will be sent the following via U.S. Postal Service and should receive them within 3-5 business days:
-- Applications to the state of Michigan
-- PSI Testing Information booklet
-- MIOSHA Test Review sheet
-- Books (if ordered)

BUILDING GREEN

Introduction

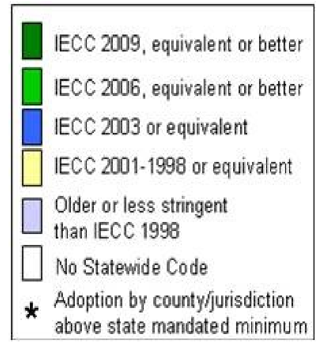
This course will bring attention to methods of green building that allow homes to have less impact on the environment, while providing a greater economic benefit to the homeowner. Practicing resource efficiency makes it possible to reduce the pressure that construction places on natural resources. Constructing and operating buildings consumes **more** materials and energy than any other single entity in the United States. (National Center for Appropriate Technology). Increasing consumer demand, combined with the growth of worldwide population, is reducing our global resource base. Even as technological innovation creates new construction possibilities, incorporating energy-efficiency into building projects can not only provide a better quality of life, but also protect the environment.

Energy efficient building techniques can, however, be expensive. It is a challenge for builders to provide their customers with the latest energy efficent systems--all within a budget that homeowners are willing to provide.



Many minimum energy efficiency standards are required by the 2009 Michigan Uniform Energy Code, but builders can choose to do more. Efficient use of materials can and will save building construction and operation costs in the long run. Building style, function, and location are all important factors that make each project unique.

The following chapters will address several energy and resource efficient building and construction practices that help builders identify important considerations and then apply those principles to a specific project.



THE BUILDING ENVELOPE

WALL SYSTEMS	ROOFS	AIR SEALING	INSULATION	FOUNDATIONS

Learning Objectives

Describe the wide variety of energy and resource efficient products and systems available.
Explain some of the cost savings in both labor and materials associated with energy efficient systems.

The building envelope includes all of the components of a residential structure that separate the indoor conditioned space from the outdoor environment. It is the part of the home that consists of the exterior walls, floors and roof. It creates a barrier from the outside elements. The ability of the building envelope to function properly, is what allows the entire building project to operate as a green system. Without an exterior shell that protects the home from weather, pests, too much sunlight etc--any measures taken to increase energy efficiency within the home are wasted. In a two story house, the building envelope consists of the foundation walls and insulated edges of the floor, the walls and roof.

ALTERNATIVE WALL SYSTEMS

Since over 90% of the homes built in this country are wood framed, reducing the amount of wood used in each frame has a tremendous multiplier effect that results in significantly lower wood utilization.

An increasing number of alternatives to wood framing are emerging in the U.S. market. Most residential builders report that during the past decade or so the quality of lumber has been going down as the price has gone up. Volatile lumber prices and the perception of declining wood quality are caused by a combination of many factors, including the harvesting of younger and smaller timber stock. The younger trees do not provide consistent long, straight, dimensionally consistent heartwood lumber that builders value. Several options have become more readily available that use less wood.

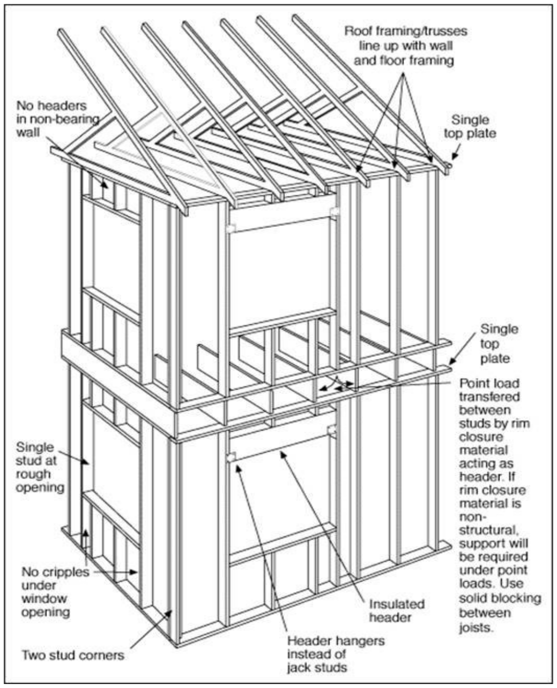
Engineered wood products are made by gluing wood veneer or strands that are graded prior to manufacturing, then bound into a composite product. The results are a consistent product with greater structural integrity and performance. Using engineered wood results in overall savings, especially if the products are being used because of the characteristics of the engineered material, as opposed to being substitutes for solid sawn lumber. Each engineered piece is stronger than its comparable solid wood counterpart--resulting in less overall material in total. Furthermore, engineered wood has fewer flaws--unlike lumber that must be culled because of warping, checking or knots.

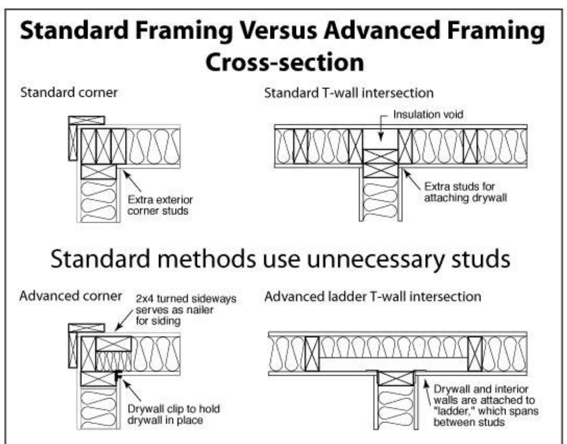
♦ ADVANCED FRAMING TECHNIQUES

By applying the techniques recommended by the National Association of Home Builders Research Center, significant savings can be realized. Though not always applicable in every building project, basic strategies can save a significant amount of framing lumber--17 to 30%, depending on the design of the home. (National Center for Appropriate Technology). Advanced Framing Techniques can save up to $1,000 in material cost alone on a 2,400 square foot home, 3 to 5% labor cost and 2 to 3% in annual HVAC costs.

Some specific techniques are:

- The use of 24" on center framing (rather than the standard 16"), and two stud corner assemblies to improve insulation coverage.
- Properly sized window headers that are insulated by sandwiching rigid insulation between the lumber.
- 2x6 studs for more insulation coverage. This uses roughly the same amount of board-feet lumber as 2x4 at 16"oc--but uses fewer pieces and can be faster to assemble.
- In line framing with a single top plate. (Loads are transferred directly from one bearing member to the next, creating a direct load path and a more efficient structure)
- The use of raised heal trusses (energy truss) or cantilevering trusses to increase insulation area over the exterior walls.
- Eliminate structural headers in non-load bearing walls.
- The use of header hangers instead of trimmer studs.
- Spacing floor joists and roof rafters at 24" instead of 16"





Comparison	Standard	Advanced
Insulation Voids	3%	0%
Framing factor	15-25%	10-15%
Batt R-value	R-13	R-13
Sheathing R-value	R-0.5 to 2.0	R-2.5
Effective Average R-value	R-11.1	R-14.6 (30% higher)

♦ STRUCTURAL INSULATED PANELS

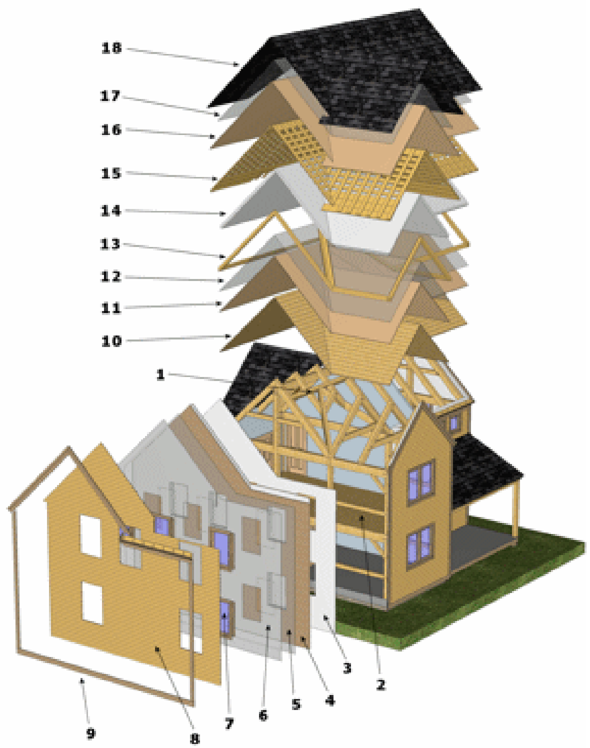
On other projects, it may be desirable to break away from conventional materials and try alternative wall systems that that reflect environmental benefits. For example, a system with a lightweight engineered content, or highly recycled materials could be selected.

Alternative wall systems like structural insulated panels or insulating concrete forms are rapidly increasing in overall use. Careful consideration of the options available, in terms of their environmental merits, will allow for the best choice in each individual project.

Structural insulated panel systems (SIPs) provide material and labor saving alternatives to traditional wood framed walls with batt or blown in insulation. SIPs have been tested and used for decades. Today they are applied across the U.S. in residential, commercial, and institutional construction. They serve as an energy efficient system that is relatively easy to erect and therefore reduces on-site labor time. Panels can be custom designed, and are generally delivered on site pre-cut and ready for installation. SIPs can be used for floors, walls and roofs. Some basic characteristics are:

- The most common type has an expanded polystyrene foam core, faced with oriented strand board (OSB)--made from fast growing trees.
- The bonded foam core provides insulation and keeps the two skins aligned.
- Because the panels are uninterrupted by studs, they provide an energy efficient wall without as many thermal bridges.
- A house built with foam core panels has a energy savings of 12 to 17% compared to a stud framed house of equal size and R-value. (Florida Solar Energy Center)
- An average wall section of SIP construction contains 25% less wood than a similar framed wall using 2x4' placed 16" on center.
- Channels at the bottom of each panel allows the wall to be slipped over its bottom plate and attached with screws through

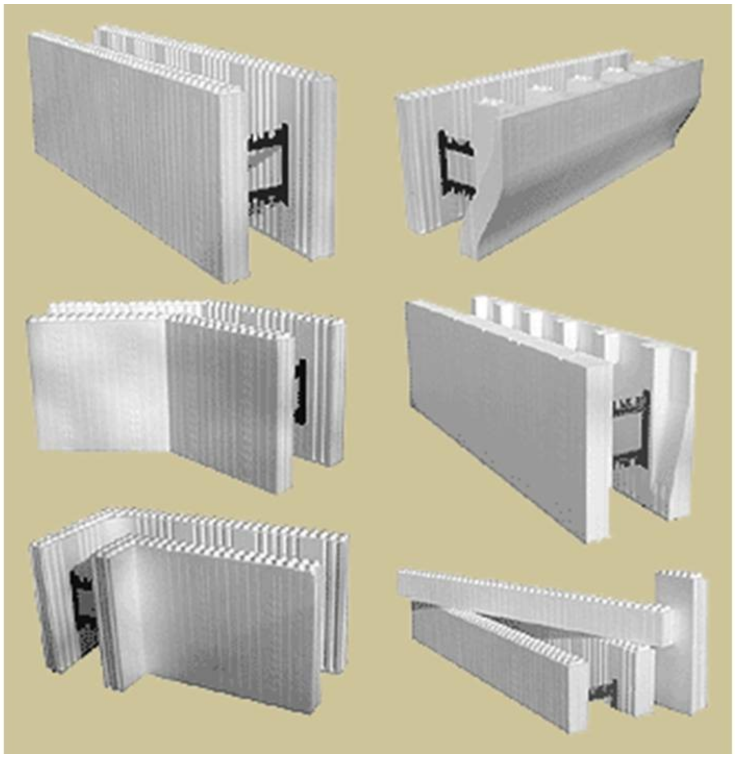
the panel's OSB skin; an identical channel at the top receives a 2-by top plate.



♦ **INSULATED CONCRETE FORMS**

Insulated Concrete Forms are an increasingly popular foundation system that uses lightweight interlocking foam blocks or foam panels as permanent insulating concrete forms. The forms can be used for both foundations and above grade walls. In these systems rebar is laid in the hollow foam cores, then concrete is poured into the cores to create a load bearing structure. This structure can be a flat panel, a grid, or a post and beam system, depending on the particular system being used. The most common types of insulating concrete forms are made from rigid foam in the form of either panels or blocks. These foam form systems provide a much higher thermal efficiency than a solid concrete foundation or wall, though R-value may vary greatly from system to system--depending on the form configuration, foam density, and the type of connector that spans the form.

- Insulating Concrete Material costs range from about $1.75 to $3.50 per square foot in addition to labor, reinforcement, bracing and concrete.
- ICFs provide a quiet, well insulated wall assembly
- ICFs are a little more expensive-- but are products that are more durable and save on labor and disposal costs associated with replacing them.
- ICFs reduce the amount of concrete used in a foundation when compared to a standard poured-in-place wall.
- Installation or construction of an ICF system requires a contractor who has experience with this building technique.



♦ **PREFABRICATED WALLS**

Manufacturers are reinventing the process of home construction using assembly line automation and prefabricated panels made from a wide variety of materials. The installed panels form an envelope that eliminates the need for conventional framing, provides integral insulation and a thermally efficient structure that can be assembled swiftly by less skilled workers. Panel systems offer a dense, uniform and continuous air barrier with few thermal bridges, and little opportunity for internal convection.(NAHB Research Center)

Prefabricated walls built in a factory, shipped by truck and lifted into place by a crane

- A factory provides a worker friendly environment with ready access to a wide variety of precision and specialty tools and materials.
- Quality control mechanisms can be implemented easily and improved workmanship promises a high quality product at a low cost.
- Material costs are minimized and deliveries are simplified.
- Job site construction time and construction waste are reduced.
- Highly skilled workers are not needed to set walls at the job site--reducing labor costs.
- This and lightweight construction provide excellent insulation value.

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ROOFS

The purpose of a roof is to prevent and minimize the chances of water intrusion. Secondarily, it protects against heat, sunlight, cold, snow and wind.
Rainwater collects in valleys--and concentrations of these increase the chances for water to run up under the surface in these areas. Dormers and chimneys should be avoided near valleys, and don't

place dormers too close together. When there is a chimney or "blind" valley, a cricket should be installed to direct water around the obstruction. Where an eave ends against a wall, kick-out flashing is needed to keep the water from running down the joint between the wall and roof.

The living space should be sealed from the attic to prevent warm, humid air from wetting the roof in cold weather. Roof ventilation is critical as it extends the life of the roof and minimizes the temperature differential between the attic and the outside. The general principle is to keep water out whenever possible, and once it is in--to allow it back out or change it to vapor so it can escape more readily. Proper ventilation removes moisture and heat from the attic areas--reducing the chances of ice dams, structural damage and leaks.

Heat loss from a roof can be substantial. A poorly designed and insulated roof can constitute a large proportion of energy loss in a home.

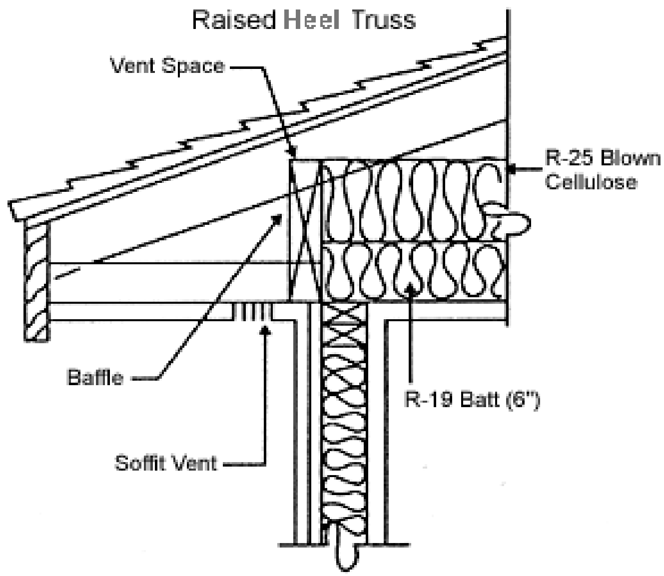
♦ RAISED HEEL TRUSSES

Trusses that are designed to accommodate increased insulation at the perimeter of the building are "raised heel" or "energy heel" trusses. Getting full insulation over the entire ceiling can be difficult. With raised heel trusses, the ceiling's insulation can maintain its full thickness all the way to the wall--providing greater energy efficiency. Raised Heel Trusses also enable an air tight vapor barrier to be installed that can reduce issues caused by condensation, dry rot and mold. It can be more expensive than other types of roof trusses due to the need for soffit siding, higher manufacturing cost and the additional insulation required, but again the payoff in long term energy savings can make the initial cost worthwhile.

1. Material: typically asphalt, metal or tile

2. Construction: framed or trussed
3. Durability: how well the roof holds up to the elements

- Raised heel trusses are very easy to request from the truss company at no extra cost.
- The Michigan Uniform Energy Code has an allowance to use R-38 in attics instead of the required R-49, if you use energy heel trusses that allow for full height insulation over the wall top plates.



AIR SEALING

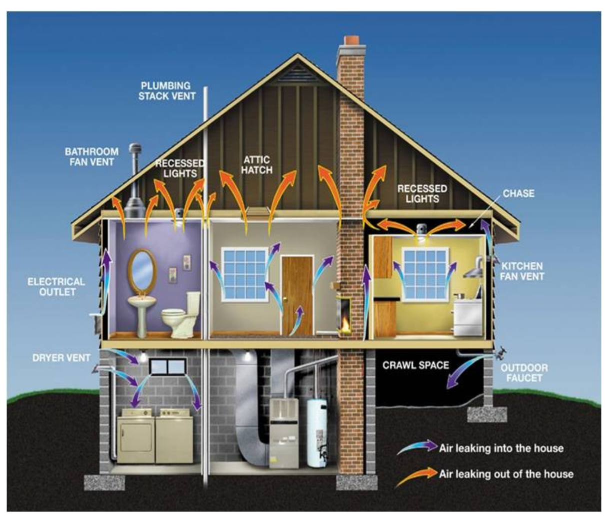
The major purpose is to reduce air infiltration into the house--dramatically increasing energy efficiency. The most common cause of air leakage is wind. Wind creates a differential pressure, causing both air infiltration and exfiltration. Temperature differences create a force known as a "stack effect". Basically the house acts as a chimney--moving large amounts of air from bottom to top. As warm air escapes from the roof, cold air is drawn in through the crawl space or basement.

If the stack effect is a big deal in two-story houses, imagine what kind of pressure it causes in high-rise buildings. This pressure is so significant, that "when skyscrapers were first developed at the turn of the century, people also had to invent revolving doors because you couldn't open the front door due to the stack effect pressure," says Straube. "The cold air was rushing in with so much pressure that it was difficult to push the exit doors open." "Air entering the building makes the downstairs people cold, so they turn up the thermostat. When the people upstairs get all that heated air, they open the windows to cool off. This increases the flow of air leaving the building, which increases the flow of air coming up from the bottom floors — so the people downstairs plug in space heaters." "You wind up with this merry-go-round — sucking air up from the bottom, heating it up, and blowing it out the top," says Straube. "There's so much airflow in the elevator shafts that you can float! You can just put out your arms and you'll float in the middle of winter in many of these buildings."(www.greenbuildingadvisor.com)

Stack effect can be a major cause of heat loss--it acts every hour of every day in cold weather! Forced air systems can create pressure imbalances as well. Unsealed ductwork can draw moisture and pollutants into the structure.

Where to look for air leaks:

--Sill plate and rim joists--seal sill plates in basements and crawl spaces. Caulk or gasket rim joists between floors in multi-story homes.



--Top plate.

--Windows and doors--windows play a critical role in creating a building envelope. The installation of windows, with flashing is critical to deflecting moisture. Use flashing pans whenever possible.

--All fenestration openings (such as electrical outlets, or plumbing accesses) in the exterior wall. Seal all penetrations with foam sealant or caulk.

--Between conditioned and unconditioned spaces.   Most of the biggest leaks occur where joists connect conditioned areas to unconditioned areas--garages, attics, vented spaces.
Things to consider:

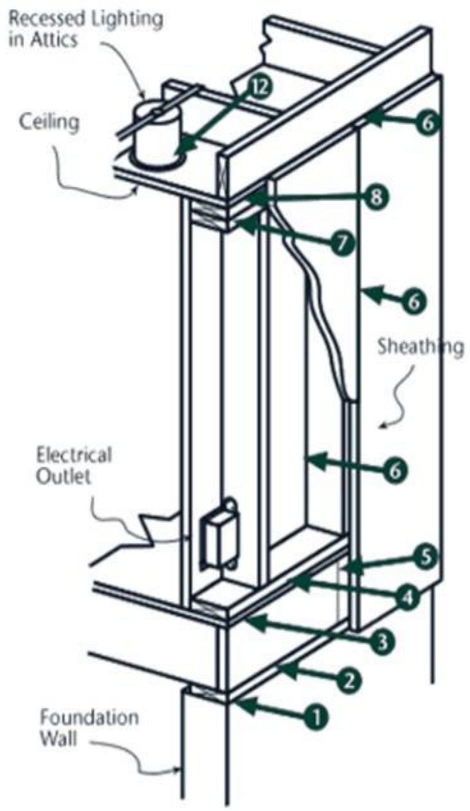
- Use vapor retarders in colder climates for areas that are NOT air conditioned
- Caulk every path of air leakage and use a moderately effective barrier like Kraft paper facing on batt insulation, or vapor retarder paint in areas that ARE air conditioned
- Avoid vapor retarders in hot, humid climates to reduce trapping of moisture and condensation
- Use flexible sealants that can bridge the leakage gap, and for larger gaps fill with rigid fill and caulk or foam around the perimeter.
- Use house wrap as an air barrier over the exterior of the house. Tape all seams, especially at all penetrations i.e. windows, doors, vents, etc.

Materials to use:

- Gasket material
- Building wrap
- Tape/foam
- Caulk

Air sealing a typical home, not including house wrap, costs about $400 to $500.

Air infiltration sources



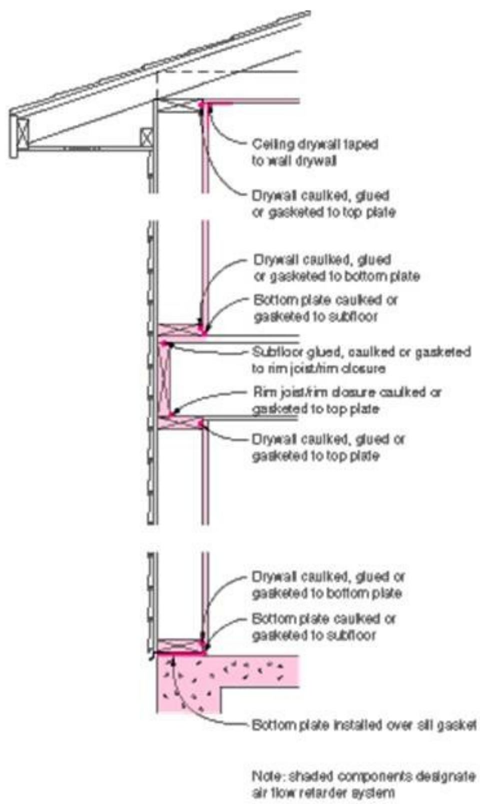
1. Sill plate/foundation wall interface
2. Sill Plate/band joist interface
3. Band joist/sub-floor interface
4. Bottom plate/sub-floor interface
5. Band joist
6. Sheathing joists/stud/cavity
7. Double top plate interface
8. Top plate/ceiling interface
9. Windows and doors (not shown)
10. Window and door frames/rough opening surface (not shown)
11. Electrical/telephone/plumbing/cable intrusions (not shown)
12. Recessed lighting in attics

AIRTIGHT DRYWALL APPROACH

The Airtight Drywall Approach can be used to create a continuous air barrier within a house. Using this technique can significantly reduce air leakage to help improve a home's energy efficiency by sealing the drywall to the building structure. Although air can’t leak through drywall seams sealed with paper tape and drywall compound, it can easily leak through cracks wherever drywall is screwed to framing lumber. The airtight-drywall approach relies on caulk and gaskets to seal these cracks

Such airtight homes often consume one-third less energy when compared to similar unsealed homes. Also, test measurements of airborne contaminants in an ADA- or SCS-detailed building (including those with mechanical ventilation) found that the reduction of air infiltration did not diminish the indoor air quality significantly. However, for health and safety, it is strongly recommended that a Heat Recovery Ventilator (HRV) or Enthalpy Recovery Ventilators (ERV) be installed in an airtight home for proper ventilation. (U.S.DOE)

- Method of installing drywall that limits air infiltration.
- Using adhesives, caulks, and gaskets to create a seal.
- Exterior and unconditioned spaces are sealed off from conditioned spaces.
- The approach seals all points where air could flow through a wall and does not rely on a vapor barrier or additional air barrier.



Interior Air Flow Retarder Using Drywall and Framing

- Air Drywall Approach (ADA)

Progress Check

- What kind of savings can be realized by using Advanced Framing Techniques?
- List 3 basic characteristics of Structural Insulation Panels.
- Which wall system is constructed on an assembly line?

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IMPROVED INSULATION

Insulation has proven itself a key component of a comfortable, energy efficient home. Some building systems are built fully insulated, while others require the addition of supplementary insulation to provide a thermally efficient structure. The range of insulating products is diverse. The choice of an insulation material is usually based on resistance to heat flow (R-value), resistance to air infiltration, availability, and cost (although toxicity, fire and moisture resistance are also factors).

♦ BATT INSULATION

Fiberglass batt insulation (or blanket insulation) is still the most common insulation material in the U.S. When installed with care, batt insulation is a cost effective way to create an energy efficient home. Many manufacturers are increasing the amount of recycled glass content--improving the resource efficiency of the product.

Batts and rolls are available in widths suited to standard spacing of wall studs, and attic or floor joists. Continuous rolls can be hand-cut and trimmed to fit. They are available with or without facings. Manufacturers often attach a facing (such as Kraft paper, foil-Kraft

paper, or vinyl) to act as a vapor barrier and/or air barrier. Batts with a special flame-resistant facing are available in various widths for basement walls where the insulation will be left exposed. A facing also helps facilitate fastening during installation. However, it's recommended that you use unfaced batts if you're adding insulation over existing insulation.
--To achieve a higher than typical insulating value using fiberglass batt insulation, some builders use 2x6 exterior or double wall construction to create a deeper wall cavity to allow for more insulation material.

--Others use high density fiberglass batt insulation and/or cover the outer walls with an insulated sheathing to increase R-values.

--When installed with care, batt insulation is a cost effective way to create an energy efficient home.

Examples of various batt configurations are:

Standard:

1. R13 (3.5" thick), in a 2x4 wall (3.5"), 3.71 R/in
2. R-19 (6.25" thick), in a 2x6 wall (5.5"), 3.04 R/in--there is some reduction in R-value because of compression
3. *R-38 (12" thick), in an attic, 3.17 R/in

High Density Batts:

1. R-15 (3.5" thick), in a 2x4 wall (3.5"), 4.29 R/in
2. *R-15 (3.5" thick), in a 2x4 wall (3.5"), 4.29 R/in
3. *R-38c (10.25" thick), in an attic, 3.71 R/in

♦ **CELLULOSE**

Cellulose insulation is an attractive choice for many builders. The material can be dry-blown or poured as loose fill into enclosed cavities, or applied by a wet-spray method. This method mixes the material with water and adhesive, and then is sprayed into the open wall or ceiling cavity. Cellulose insulation is valued not only for its thermal resistance, but for its high resistance to air infiltration and sound proofing capabilities. Sprayed cellulose leaves few voids, filling in well around studs and wiring--reducing air infiltration.

1. **Wet Spray Cellulose**

Spray applied cellulose is used for applying cellulose to new wall construction. Wet-spray allows application without the need for a temporary retainer. In addition, wet-spray allows for an even better seal of the insulated cavity against air infiltration and eliminates settling problems.

- Has a slightly higher R-value than batt insulation--the actual warmth and comfort of a home insulated with wet spray cellulose is measurably higher than that with batt.
- Wet spray resists fire, and absorbs sound better than fiberglass insulation.
- Is significantly more expensive initially--but the cost savings realized in overall fuel consumption make the investment worthwhile.
- It is important to achieve a proper mix of water and cellulose, or the material can either settle or take a very long time to dry--which can lead to structural damage due to moisture.

spray cellulose insulation

2. **Dry Blown Cellulose**

Over time, loose-fill insulation can lose its installed R-value because of *settling*, especially in attic cavities. Cellulose settles more than rock wool or fiberglass—20% compared to 2%–4%. Therefore, if you use cellulose, install 20% more in an attic to offset the settling. Cellulose manufacturers are required by federal law to provide the "settled thickness" on their bags. In many cases the manufacturers will provide the "installed thickness." (U.S. Dept. of Energy)

An easy-to-follow guideline to ensure that wall cavities are being filled at a density sufficient to prevent settling: use roughly one 30-pound (13-kilogram) bag of cellulose or about 15 pounds (8 kilograms) of fiberglass or rock wool for every three wall cavities you fill. (Assumptions: 8-foot [2.4-meter] walls, with 16-inch [41-centimeter] on-center wall cavities, and 2x4-inch framing studs.)(DOE)

- Like wet spray, dry blown cellulose is made from recycled wood fiber in the form of used newspapers or telephone books, which are ground or shredded. The insulation usually contains 75 to 85% recycled content, by weight, with the remainder constituted by fire retardants and binders.
- Dry blown application requires less skilled installers.
- Solid blocking in inconvenient cavities can be problematic.
- When packed down to the proper density, the R-value is between R-3.5 and R-3.8 per inch.

♦ SPRAY FOAM

Spray foam systems are frequently used to insulate and protect a wide variety of residential, commercial and industrial buildings. SPF adheres to, and forms to the wall and floors to create a tight seal and insulating barrier that stops air leakage. Traditional batt insulation is only stapled, or placed into the wall cavity, allowing for air infiltration. SPF seals the stud and wall cavities from end to end. Spray foam insulation is available in closed cell (R-7.0 per inch) and open cell (R-3.6 per inch) types.

Types of spray foam insulation:

1. **Cementitious**: One type of cementitious, spray-foam insulation is known as Air-Krete™. It contains magnesium silicate and has an

R-value of about 3.9 per inch. With an initial consistency similar to shaving cream, Air-Krete™ is pumped into closed cavities. After curing, it's similar to a thick pudding. (U.S. Dept. of Energy)

2. **Phenolic**: Phenolic foam was somewhat popular years ago as rigid foam board insulation. It is currently available only as a foamed-in-place insulation.
Phenolic foamed-in-place insulation has a R-4.8 value per inch of thickness and uses air as the foaming agent. One major disadvantage of phenolic foam is that it can shrink up to 2% after curing. This shrinkage makes it less popular today. (U.S. Dept. of Energy)

3. **Polyisocyanurate or polyiso**: is a type of plastic, closed-cell foam that contains a low-conductivity gas in its cells. The high thermal resistance of the gas gives this type of foam an R-value of 5.6 to 8 per inch. It is available as a liquid, spray foam, or can be made into laminated panels. The advantage of the spray variety is its ability to mold itself to all of the surfaces. (U.S. Dept. of Energy)

4. **Polyurethane**:

a. **Closed cell** insulation that also contains a low conductivity gas in its cells, but provides a higher R-value than other foam products--typically R-7 to R-8 per inch. This is also available in a panel form. When initially applied, polyurethane foam can have as high as an R-9 per inch value--but can demonstrate "thermal drift"--whereby the insulative value can drop over time--typically to around R-7.
b. **Open cell** insulation is more common than closed cell. It is less affordable than other common types of spray foam. The R-value is about 3.6 per inch. Icynene is a well known brand that is a combination of Polyiso and Polyurethane.(U.S. Dept. of Energy)

- With an R-value of 3.9 per inch in a 2x4 wall cavity--SPF is roughly equivalent to R-13 fiberglass batt insulation.

- Acts as an air barrier--reducing the potential of moisture/mold damage.
- Adds increased structural integrity to the home.
- Following installation, an approved thermal barrier-such as drywall-must cover all foam materials.

Spray foam insulation is available in two types:
Closed cell at R-6.5 per inch and open cell

♦ **SHEATHING**

1. **Insulated Sheathing**: A layer of foam sheathing on the outside of the home that provides a continuous layer of insulation. It is used to cover thermal bridges around uninsulated studs, headers and corners. It is excellent in terms of insulation and energy performance. The R-value of insulated sheathing is similar to that of spray foam. The major disadvantage is that simple foam sheathing cannot provide structural strength, or a sufficiently strong fastening base.

Examples of foam sheathing are:

- Polyisocyanurate Foam Sheathing--R-6.5 per inch
- Polystyrene Foam Sheathing-
  - Expanded polystyrene (EPS), R-4.0 per inch
  - Extruded polystyrene (XPS), R-5.0 per inch

2. **Radiant Barrier Roof Sheathing**: This is basically plywood or OSB sheathing with a thin aluminum facing bonded to a plastic or paper substrate on one side. It installs like any other roof sheathing--with the shiny side down.

When the sun heats a roof, it's primarily the sun's radiant energy that makes the roof hot. A large portion of this heat travels by conduction through the roofing materials to the attic side of the roof. The hot roof material then radiates its gained heat energy onto the cooler attic surfaces, including the air ducts and the attic floor. A radiant barrier reduces the radiant heat transfer from the underside of the roof to the other surfaces in the attic. Radiant barriers block heat transfer in the attic, reducing overall attic temperature, saving on air-conditioning bills.(U.S. Dept. of Energy)

Radiant barriers come in a variety of forms, including reflective foil, reflective metal roof shingles, reflective laminated roof sheathing, and even reflective chips, which can be applied over loose fill insulation. A spray variety, containing fine metal particles can be applied--some dry to a hard paint like finish, while some dry to a "greasy like" substance.

Radiant barrier

- Radiant barrier sheathing emits 3 to 5% of the heat falling on it (Oak Ridge National Laboratory).
- For the sheathing to work--it needs an air space of at least 3/4"--anything it touches heats up through conduction.
- Compared to conventional sheathing, radiant barrier cost is 10 to 15% higher--but the long term energy savings will be realized typically in about 6 years.
- A radiant barrier's effectiveness depends on proper installation. Therefore, it's best to have a certified installer do it.

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FOUNDATIONS

Concrete masonry and poured-in-place foundation walls are heat conductors that can cause a building to consume more heating and cooling energy. The foundation is a prime area for adopting new methods that will reduce the total amount of cement used and increase the thermal efficiency of the home.

Where a frost line is deep, homes are typically built on a crawl space or basement. Crawlspaces need to be designed to allow for inspection. If a crawlspace is insulated around the perimeter, the advantages of storing and releasing solar heat can be realized. Heat loss from a basement is a significant piece of energy consumption in a home, and should be sealed and insulated--including the walls if the basement is used for living space. An effective way to insulate walls is to use insulating concrete forms.

Moisture control is an important component of energy efficiency--and is a major problem with poorly constructed foundations. Some general techniques to control moisture are:

- Direct the downspout flow well away from the foundation
- The grade should be at least 6" for the first 10' away from the house
- Do not build slabs, floors or crawlspaces less than 1 foot above seasonal high groundwater
- Footing drains should drain to the outdoors, a sump pump, or a drywell
- Place a puncture resistant vapor retarder under the floor slab
- Use a capillary moisture break between the top of the footing and the foundation wall
- Install a gravel bed under slab-on-grade floors
- Use kick-out flashing where an eave runs into a sidewall

In colder climates, builders find it easier to build the floor over the crawlspace and then either placing the bearing walls on strip foundations independent of the slab, or to utilize frost protected shallow foundations.

Frost Protected Shallow Foundations

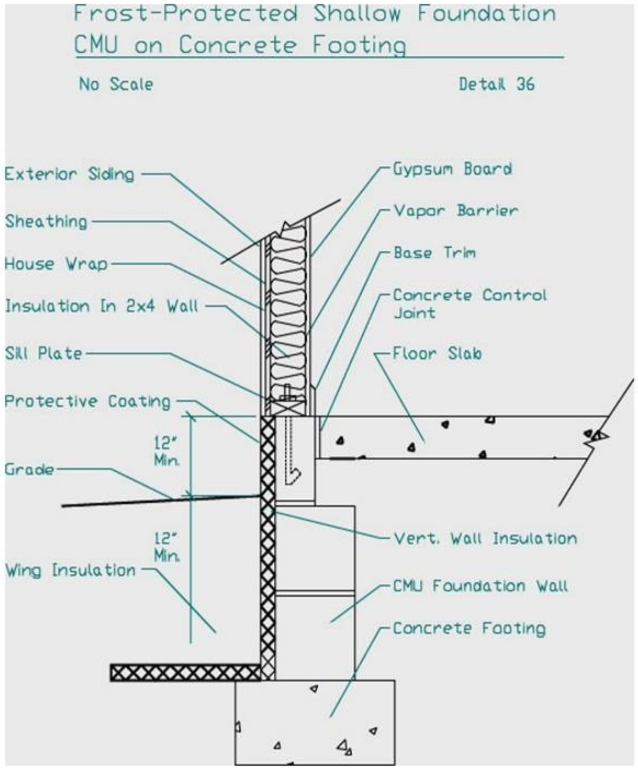
Frost protected shallow foundations combine a shallow concrete footing with rigid foam insulation placed around the foundation perimeter. The local climate and number of heating-degree days determines the thickness and width of the insulation applied. Frost protected shallow foundations reduce building costs because less excavation and backfill is required. Typically the amount of concrete is significantly reduced since the footings do not go below the frost line. By using different levels of insulation, it can be adapted to varying climates. The Michigan Uniform Energy Code requires this technique for slab edge insulation--for example: a walk-out basement where the floor is at grade.

--These are commonly used in slab-on-ground foundations, and can be used with stem walls, floating slab and unvented crawl space foundations.

--Insulation boards are placed on the outside of the foundation wall from grade to the top of the footing, then in a horizontal wing across the top of the footing.

--FPSFs offer builders a lower cost opportunity to build a structurally sound foundation.

--FPSFs are most cost effective in colder climates with deeper frost lines than in temperate climates.



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Progress Check

- What material content, when added, improves the resource efficiency of batt insulation?
- What are the benefits of wet spray cellulose?
- Describe the basic differences between a traditional foundation and a Frost Protected Shallow Foundation.

ENERGY EFFICIENT SYSTEMS

WINDOWS	HEATING/COOLING	WATER HEATING	DUCTWORK

Learning Objectives

Discuss and recognize the importance of energy efficient design in indoor systems.
Describe the characteristics of energy efficient materials and systems compared to traditional ones.

Getting started in green design and building isn't always easy. Customers want a green project and a functional home at a competitive price, yet often energy and green building requirements are stringent and cost prohibitive. Many times the best materials for one project are not the same as for another. Building style, function, and location are all factors that come into play. As hard as it is to find products that are a good fit for a certain project, it can be challenging to find the products that are the "greenest". Sometimes choosing the product or system that is the most environmentally responsible takes a great deal of research in terms of the product itself and the circumstances of the individual project.

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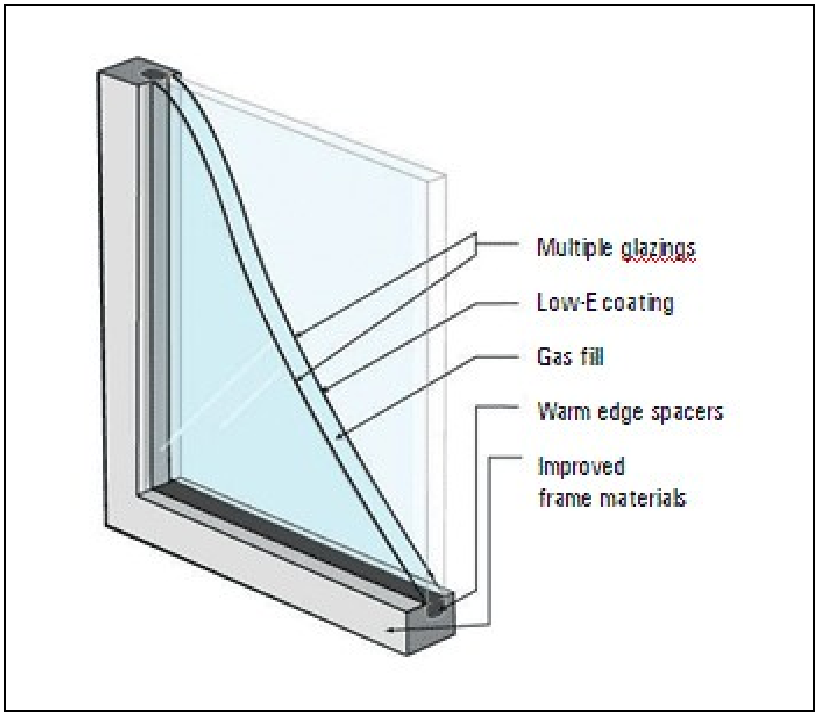
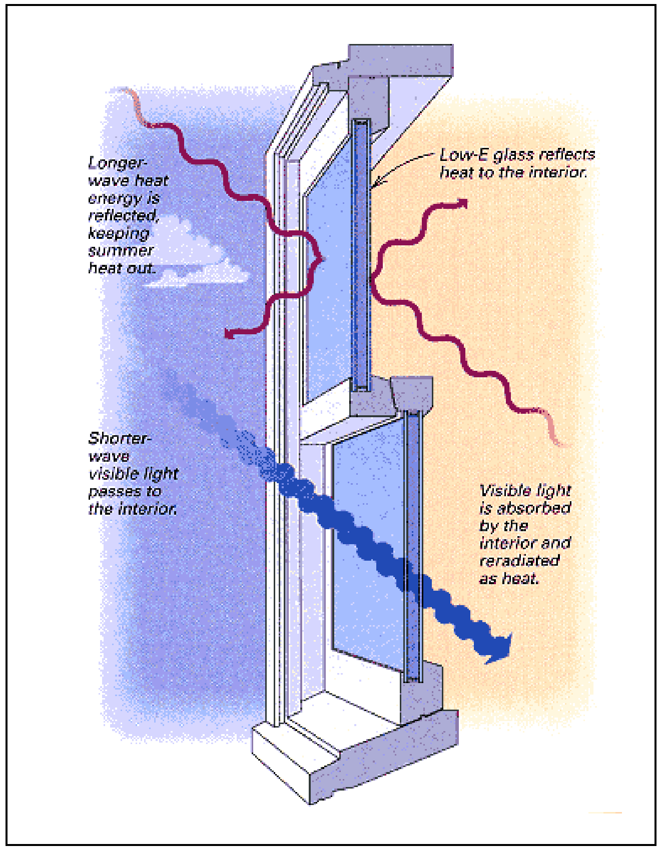
WINDOWS

Windows are thermal holes. An average home may lose 30% of its heat or air-conditioning energy through its windows. Poor installation and the low insulation value of the glass, combined with poorly constructed frames, make windows a net heat loser in colder climates, and an unwanted heat gainer in warm climates. Energy-efficient windows save money each and every month. There are some cases where new windows can be net energy gainers. Various high performance windows are available, and while many are expensive, the payback period for selecting energy-efficient units can range from two years to ten years. In new construction, the higher initial cost can be offset because a smaller, less expensive heating and cooling system will be needed. Durable windows may cost less in the long haul because of lowered maintenance and replacement costs.



New technology combines insulated frames, multiple glazings, gas filling, thermal break spacers and coatings that drastically improve performance. Double-pane windows with low-emissivity films can either reflect heat into the room, or away from the house, depending on the climate. Argon, an inert gas, is used between panes for lowered conductivity and increased R-value. Adding an extra layer of glazing can also increase R-value.



The efforts of the **National Fenestration Rating Council** (a collaborative effort between manufacturers, the Department of Energy, utility companies and others) have created a labeling system for windows that gives specific information regarding the U-factor, solar heat gain coefficient , and the amount of light transference.

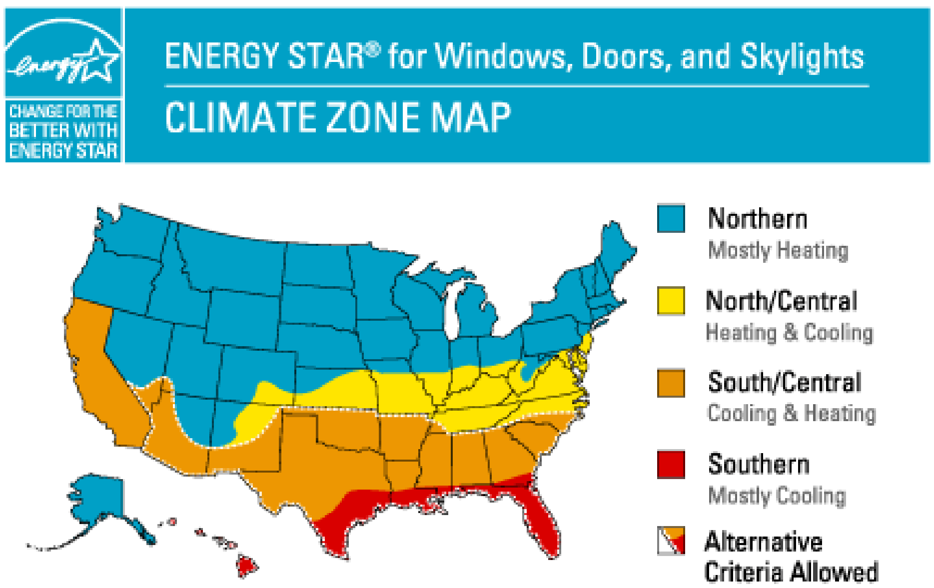
- **Solar Heat Gain Coefficient** (SHGC) represents the percentage of all the solar radiation (UV, visible light, and short-wave IR) that the whole window lets in relative to its glazing. This measure takes into account the frame, as well as the sun reflecting off the glass when it hits at an "off-angle reflection". The lower the SHGC, the less solar energy comes in.
-

The **U-factor** measures the amount of energy in Btus that transfers through a window. It is the inverse of an R-value. The lower the U-factor the better the energy efficiency and the better the insulative value of the window. One important difference between the U-factor of the glass and that of the whole window is the effect of the frame. An ordinary aluminum frame can drastically reduce the U-factor compared to that of one using an insulating frame. So if a sticker does not show the NFRC rated U-factor--the advertised U-factor probably refers to the glass only.

- The **Energy Star** label is based on Department of Energy performance standards by region.
- The best readily available windows may be R-4 to R-5.
- **Low E coatings** reflect heat. By changing the placement of the coating you can change the effect:

    - Outer surface of the inner pane increases solar gain
    - Inside of exterior window pane minimizes solar gain

- **Air leakage** is the rate of air infiltration around a window in the presence of a specific pressure differential across it. It is expressed in units of cubic feet per minute per square foot of frame area. A low air leakage rating means a tighter assembly than one with a high rating. Heat loss and gain occur by infiltration through cracks in the window assembly.
- **Visible Transmittance** (VT) measures how much light comes through a product. This is influenced by glass selection, as well as the amount of opening taken up by components like the sash and frame. VT is expressed as a number between 0 and 1. The higher the VT, the more light is transmitted--and the clearer the window.
- **Air Infiltration Rate**: Measures the amount of air leaks through a window. Air infiltration has a major effect on perceived performance--and even at a passing value--drafts can still be felt. Windows with compression seals demonstrate excellent performance.
- Helpful tools for comparing different types of windows are available at http://www.efficientwindows.org provided by the Efficient Windows Collaborative, with support from the US Department of Energy and window industry members.



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HEATING AND COOLING

Heating and cooling is a significant piece of a home's overall energy consumption. Up to 40% of a home's energy is used by heating and cooling.   Heating and cooling systems in the United States together emit 150 million tons of carbon dioxide into the atmosphere each year, adding to global climate change. They also generate about 12% of the nation's sulfur dioxide and 4% of the nitrogen oxides, the chief ingredients in acid rain. (www.energysavers.gov)

Efficient, properly sized and maintained equipment can save both money and energy. Select air conditioning units, heat pumps and other equipment with Energy Star labels.

The type of heating and cooling equipment depends on whether or not the house has ductwork. Forced air systems require ductwork, and work well in homes with air conditioning.

Heating:

Baseboard or radiator--this type of system is efficient in a green building because it is able to be zoned. Zoned heat allows rarely used rooms or areas to be kept cooler, saving energy. The equipment used to generate heat in radiator systems is always either a boiler or a water heater. Programmable thermostats can add to the efficiency of this type of heating.

Radiant floor--like radiator systems, radiant heat is easily zoned. Radiant floor heat comes in three different types: air heated, electric, and hydronic. Whether radiant floor systems save significantly more energy than other systems is up in the air--but it is a popular option as it offers very comfortable and desirable heat.

Warm air--ducted air systems are the obvious choice for homes with air conditioning, and can deliver excellent comfort. If well designed, problems such as noisy, excessive blowing air can be managed. The equipment is usually a gas furnace which heats the air directly. Ducted systems are difficult to zone.

Hydro air--heat and cool air using water by either heating the water by a water heater, or a boiler and then circulating this water through a coil that replaces a furnace as the heat source. High efficiency sealed combustion water heaters or boilers are available.

Cooling:

Unlike ducted heating systems, it is generally NOT desirable to zone air conditioning, since dehumidifying is an essential function in warm weather, so most "green" homes avoid zoning. The most common mistake is to buy an air conditioning system that is too big for the home. Oversized systems cost more, create humidity problems, and are poor energy performers.

Mini-duct: uses higher pressure to move air through much smaller ducts--the advantage being that the ductwork can be placed in smaller openings within the conditioned portions of the frame.

Variable speed units--have multi-speed compressors with variable indoor fans that are considerably more expensive than traditional units--but also more expensive. The advantages are quieter operation and better dehumidifying.

♦ Geothermal Heating and Cooling

Geothermal heating and cooling are based on the fact that while temperatures above-ground can vary greatly during the year, temperatures below ground remain fairly constant. In winter, when the temperature underground is warmer than the air temperature, tubes carrying water or freeze-resistant liquid bring heat from the ground to a heat pump that extracts the heat and distributes it throughout the house. In cooling mode, the heat pump functions like an air conditioner, extracting heat from the home and releasing it underground.

Geothermal systems are not just for new homes. The easiest retrofits tap into existing forced-air systems. Costs range from $18,000 to about $30,000, depending on site conditions and the extent of modifications required. Although geothermal is often used in conjunction with radiant-floor heating, the water it produces is not hot enough to make it compatible with hydronic baseboard systems. In that case, forced-air ductwork is usually added.

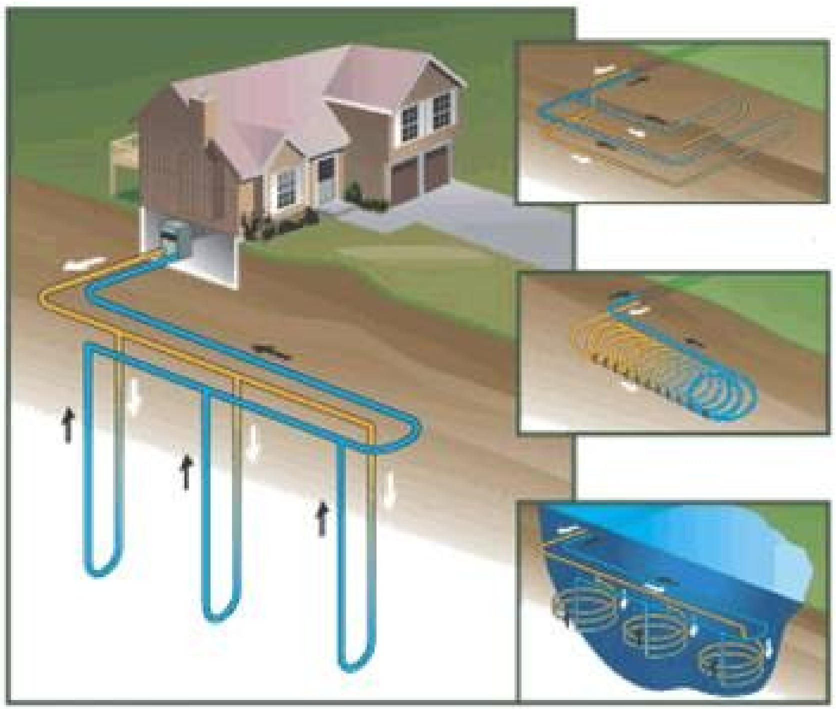
-
  - Can save up to **30 to 70%** on energy bills compared to ordinary systems.
- Is significantly more expensive (40 TO 100%) than traditional systems, but will pay for itself in time (usually 3 to 5 years)
- The EPA calls geothermal heating and cooling the single most energy efficient, environmentally clean, and cost effective system available.
- There are federal tax credits available--no cap, 30% non-refundable that expire in 2016

There are two types:

Open Loop--similar to a water well, bringing water up, extracting the heat and then returning it to a holding pond or back into the ground. Open loop is more efficient that closed loop, but corrosion in the heat exchanger quickly reduces efficiency.

Closed Loop--a system of buried pipe looping back and forth. A closed loop system is a grid of buried pipe looping back and forth. About 4’ to 6’ deep on about 3’ to 5’ centers for around 400’ to 500’of pipe per ton (about 12k btu’s/ton) of heating or cooling. More length gives more capacity. The water is contained never leaving the system, only circulating around.

Because GHP systems have relatively few moving parts, and because those parts are sheltered inside a building, they are durable and highly reliable. The underground piping often carries warranties of 25–50 years, and the heat pumps often last 20 years or more.



The system holds a heat pump and a liquid pump pack, with three main heat pump types:

1. **Water to air**: Works with a forced air duct system and both heats and cools.

2. **Water to water**: Works with hot water systems and ONLY heats.

3. **Hybrid**: Works with both forced air and hot water. The hybrid variety can both heat and cool, and also heat domestic water.

♦ Solar Heating

A partial list of solar applications includes space heating and cooling through solar architecture, distilling and disinfecting water, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. To harvest the solar energy, the most common way is to use solar panels.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

- **Photovoltaics** convert light into electric current using the photoelectric effect (solar panels) without the use of steam turbines.
- **Concentrated** solar power systems produce power when the concentrated light (by lenses and mirrors) is converted to heat which drives a heat engine (usually a steam turbine) connected to an electrical power generator.
- **Building heat**: A simple solar air collector consists of an absorber material, sometimes having a selective surface, to capture radiation from the sun and then transfer this energy via air conduction as heat. This heated air is then ducted to the building.

Solar Collectors are usually:

- Flat plate collectors--insulated, weatherproofed absorber plates under one or more glass or polymer covers. Unglazed flat-plate collectors are typically used for pool heating.
- Integral collector-storage systems--also known as batch systems, are black tanks or tubes in an insulated box located on the roof. Cold water passes through the collector and preheats. It continues to the conventional backup water heater. These are viable only in mild-freeze climates because outdoor pipes could freeze in severe weather. Batch heaters typically store 30 to 50 gallons of hot water and can supply up to 15 to 40% of a family's yearly demand.
- Evacuated-tube solar collectors--parallel rows of transparent tubes with metal absorbers attached to a fin. The fin absorbs solar energy, but does not allow heat loss. These are used mostly for commercial applications.

Always have solar water heating systems installed by an experienced contractor.

Typical solar water heaters can provide 70% of the annual hot water demand.
Collectors should be located as close to the water tank to minimize piping.
Systems in colder climates require higher maintenance.
In colder climates, indirect closed loop or drain-back systems are best. In very warm climates, batch or direct systems are best.
Consider pre-plumbing homes to accommodate for future solar installation.
Insure that plenty of hot water storage is provided for the collector area.

♦ SEALED COMBUSTION APPLIANCES

Furnaces, water heaters, gas fireplaces and some gas dryers and ovens that rely on PVC pipe and power vents to bring outside air directly to the burner for combustion and to expel exhaust gases are considered sealed combustion appliances. These typically operate more efficiently than conventional appliances, and are less likely to introduce dangerous gases into the home. They also have a longer life span because less damaging by-products are produced (i.e. soot and condensation). The most efficient sealed combustion furnace converts 96.6% of the fuel to useful heat versus 89% for a natural vent appliance.

The reason so many heating contractors like Sealed Combustion Appliances is because they are safer, more efficient, usually smaller, and lastly, there is often a rebate available from the gas company (unless municipal gas service is supplied).

WATER HEATING

Heating water accounts for approximately 15% of a home's energy use and is the second biggest energy consumer. High efficiency water heaters use 10 to 50% less energy than standard models, saving homeowners money on their utility bills. Actual energy savings from high efficiency water heaters depend on family size, heater location, and the size and placement of water pipes.

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Energy Star Criteria for Water Heaters

Category	Energy Factor*	Improvement Over Federal Standard
Gas-Storage Water Heaters (as of 2009)	0.62	6.9%
Gas-Storage Water Heaters (as of 2010)	0.67	15.5%
Whole-Home Gas Tankless Water Heaters	0.82	41.4%
Integrated-Heat-Pump Water Heaters	2.00	121.2%
Solar Water Heaters	1.80**	NA
Gas-Condensing Water Heaters	0.80***	37.9%

* Energy factor is a measurement of relative efficiency: the higher the number, the greater the efficiency.

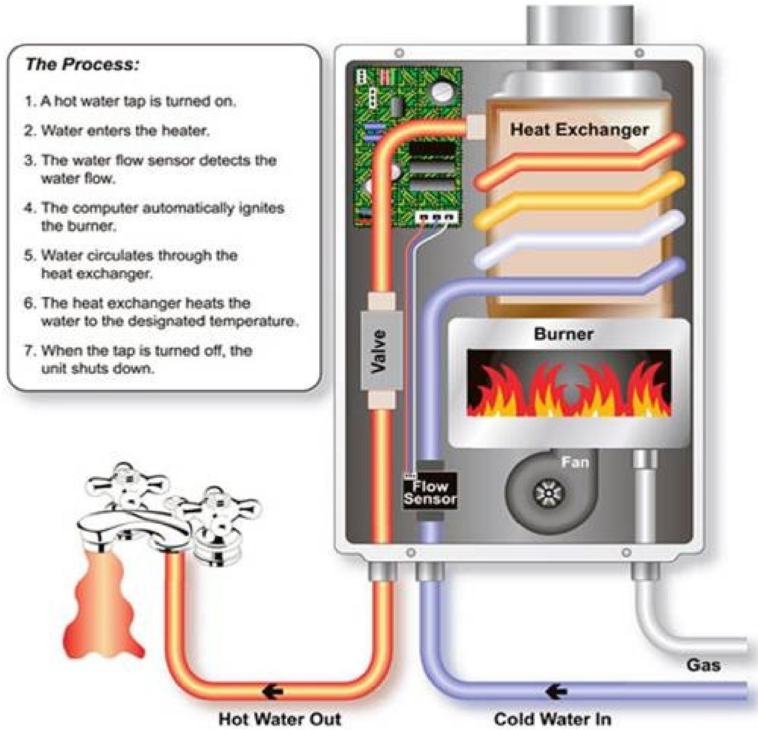
** Solar water heaters must have a solar fraction of 0.50; eligible models must also have OG-300 certification from the Solar Rating and Certification Corporation. The energy factor represents a typical system with a solar fraction of 0.50, an OG-300 certification, and a 50-gallon (190-l) auxiliary tank.

***These water heaters must also have a first-hour rating of 67 gallons (250 l) per hour or greater.

• **Storage (Tank)** Water Heaters. These are the most popular and conventional systems for the home. Water is kept hot and ready for use at all times in insulated storage tanks with capacities ranging from 20 to 80 gallons. One drawback with these units is the energy used to keep the water hot at all times, otherwise known as “standby losses.” Heavily insulated tanks can reduce heat loss, and improve overall operating costs.

• **Demand (Tankless)**Water Heaters.

Water circulated through a large coil is heated only on demand using gas or electricity; there is no storage tank continuously maintaining hot water. Cold water travels through a pipe into the unit, and either a gas burner (see Figure 1) or an electric element heats the water.



Tankless water heaters can be supplementary units or can replace a centralized tank water heater. A possible concern is the limitation on the number of fixtures
that can simultaneously use hot water. Running both a dishwasher and taking a shower can put too much demand on even the biggest units. Electric units do tend to provide water more slowly than conventional heaters, and will limit output pressure to maintain the correct water temperature.   However, there is an endless supply of hot water and standby losses associated with storage water heaters are eliminated.
For homes that use 41 gallons or less of hot water daily, demand water heaters can be 24%–34% more energy efficient than conventional storage tank water heaters. They can be 8%–14% more energy efficient for homes that use a lot of hot water—around 86 gallons per day. You can achieve even greater energy savings of 27%–50% if you install a demand water heater at each hot water outlet. (www.energysavers.gov)

• **Heat Pump** Water Heaters. Heat pumps transfer energy from the surrounding air to water in a storage tank. An air source heat pump pulls heat from the ambient air and then transfers that heat into a tank to heat the water. These water heaters are much more efficient than electric resistance water heaters and most effective in warm climates as they will not operate in a cold environment.

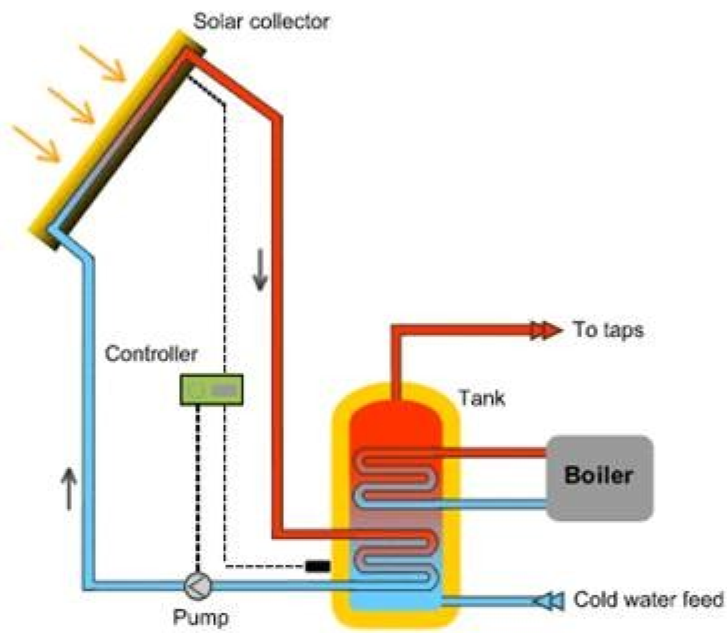
• **Integrated or Combination** Water Heaters. Water flows through a heat exchanger or heating coil installed in a furnace or boiler. When a faucet is turned on--water flows over the coils, is heated and delivered on demand. This system works best when furnaces are in regular use--so are most efficient for cooler climates.

• **Solar** Water Heating. While the initial purchase price of solar water heaters is high compared to standard models, they can be cost effective. Water heating uses about 15% of the energy in the United States and is the second largest household energy expense after space conditioning. Solar domestic hot water systems can provide up to 70% of the annual water heating load. Most solar heaters operate by preheating water for a standard water heater and act as a backup to increase water temperature.

Solar hot water systems generally are either:

- Direct circulation--pumps circulate water through the collectors--work best in mild climates
- Indirect circulation--pumps circulate anti-freeze through a pressurized heat exchanger and then flows into the home. These are best in homes with colder climates.
- Close-coupled--the storage tank is mounted directly above the solar panels. No pumping is required as the hot water naturally rises into the tank through thermosiphon flow.

- Pump-circulated--the storage tank is below the level of the collectors and a circulating pump move the water between the tank and the collectors.



Water Heating Basics

Locate the water heater as close to the destination point i.e. bathroom, kitchen, laundry in order to save on heat loss. Use the smallest heater possible--the smaller the heater the less stand-by loss is incurred. Install heat traps to reduce convective heat loss from the tank itself. Insulate the tanks and pipes--at least in unconditioned spaces. Lower the heat to 120 degrees--select dishwashers with heat boosters if needed.

Progress Check

- Describe how geothermal heating and cooling works.
- Name the new features that have improved the performance of residential windows.
- What are the 2 types of solar hot water systems?

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INSULATING AND SEALING DUCTWORK

Leaks in ductwork for heating and cooling systems are huge energy wasters. Leaks involving 20% of the total air flow will cause 50% drop in the efficiency, and a shorter lifespan of the cooling and heating equipment. Bottom line--up to 30% of the energy used to heat and cool a building can be lost through leaky ducts and poor duct design. In buildings using a central furnace--duct design, placement and sealing are crucial for desired performance.

Improper duct installation, involving all the bends and turns, can lead to poor air flow rates and incorrect air velocities, causing inefficient use and ultimately energy waste. Some common duct problems:

- Leaky duct connections
- Leaky return ducts
- Furniture blocking registers
- Leaks at furnace and air filter slot and duct tape failures
- Fallen duct insulation
- Leaky supply ducts
- Kinks in ductwork restricting airflow

If installing new air distribution systems, design and detail regarding the installation and size is important. Some installation tips are:

- Sealing ducts with water based mastic--NEVER use duct tape to seal leaks
- Using ducted returns instead of stud cavities
- Installing return ducts in bedrooms
- Insulate all duct work when possible
- Round and rectangular metal ducts must be sealed with mastic first, and then insulated

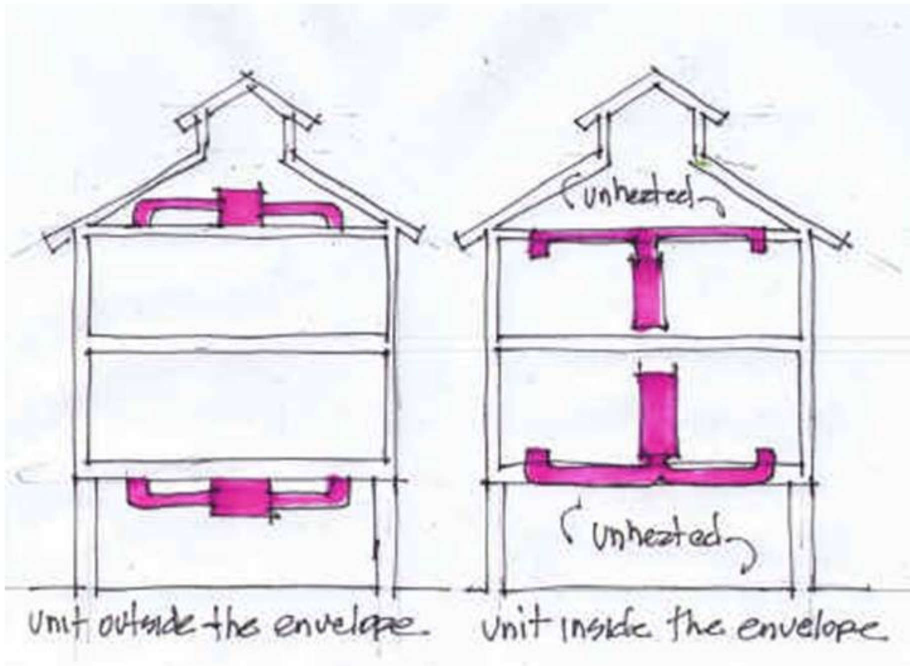
- Minimize the use of elbows and sharp turns
- Air tightness of duct work can be tested after installation using calibrated fans and procedures similar to blower door tests.

Newer, energy efficient homes place duct systems within the conditioned space of the home. The best way to do this is to place the system in dropped ceilings and in corners of the room. Ducts can also be placed in a sealed and insulated chase extending into the attic or built into raised floors. The "trunk and branch" and "radial" supply duct configurations are best for ducts located in conditioned spaces. Good duct design involves:

1. Centrally located HVACs reducing duct runs
2. Proper sizing of trunk and branch lines
3. Turning vanes in 90 degree elbows
4. Transition take-offs for each supply branch
5. Limiting the length of duct runs
6. Place ducts in conditioned spaces
7. Eliminate ducts from attics, exterior walls, unheated crawl spaces and unheated basements.

Duct Design

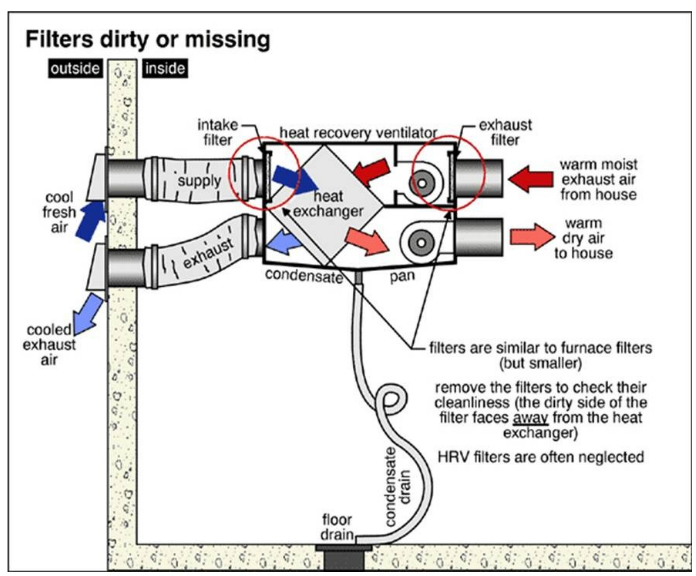
- ***Best:*** *Sealed ducts in conditioned spaces*
- ***Second:*** *Un-sealed ducts in conditioned spaces*
- ***Third:*** *Insulated, sealed ducts in unconditioned spaces*
- ***Fourth:*** *Insulated, un-sealed ducts in unconditioned spaces*
- ***Worst:*** *Un-insulated, un-sealed ducts in unconditioned spaces*
- ***Energy losses from poor duct installation can cost up to 30% in efficiency!***



Keep heating and cooling equipment inside the envelope

INDOOR AIR QUALITY

Airtight construction and high R-values may create such an airtight home that no fresh air circulation occurs. Volatile Organic Compounds (VOC) can affect the environment and human health--irritating eyes,



throat, cause headaches and fatigue, damage major organs and cause cancer. Use low VOC and no VOC primers, paints, sealants and carpets.

Heat Recovery Ventilators bring in fresh air from the outside, preheat the incoming air during the winter and pre-cool the incoming air during the summer. It can provide clean fresh air every day while helping to keep energy costs low. Tight buildings reduce energy costs by keeping in the heated or air conditioned air. But buildings without adequate ventilation trap humidity and pollutants so they feel "stuffy", aggravate allergies and cause general discomfort for you and your family. Moisture damage to windows and other parts of the building shell can result when humidity is too high.

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in the home. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels can also increase concentrations of some pollutants and moisture damage to windows and other parts of the building.

LOW VOC CONTENT™

Progress Check

- What percent of efficiency is lost from poor duct installation?
- What are Volatile Organic Compounds?
- Describe several ways to ensure proper duct installation.

GREEN JOBSITE

SOLAR DESIGN	RECYCLING

Learning Objective

Explain the benefits of energy efficient solar design and landscaping.

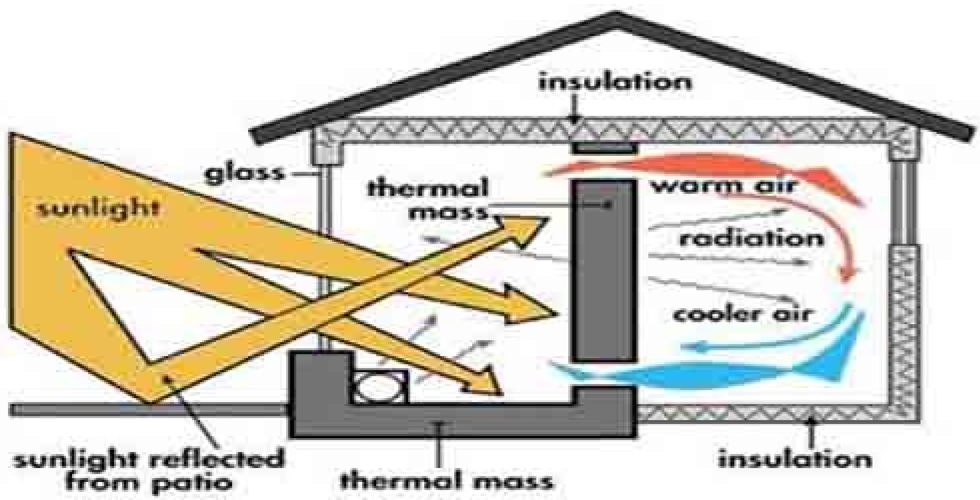
Describe some of the problems and solutions surrounding jobsite recycling.

ENERGY EFFICIENT SOLAR DESIGN

Passive solar design and landscaping can dramatically reduce energy use and costs for heating and cooling without adversely affecting the comfort level in the home. On

average, these techniques provide enough energy savings to return an initial investment in less than 8 years.

Passive Solar Design: The difference between a passive solar home and a traditional home is the design. Passive solar homes are designed to take advantage of the local climate, and involve using a building's windows, walls and floors to collect, store and distribute energy. A comprehensive list of design strategies also include daylighting, natural ventilation, ground-coupled cooling, and peak load reduction (or shifting) with thermal mass materials such as brick, concrete, masonry etc.



♦ **The primary benefit gained from the sun is daylight**. In colder climates minimizing glass is a high priority in order to reduce heat loss. But maximizing glass is also a priority, to compensate for cloudy days, shorter winter days and lower angle of the sun in the winter. Maximizing glass facing south is a good way to balance these demands. In southern latitudes, longer winter days, higher sun angles, and more intense sunlight make protection from the sun a high priority. In a northern climate a southern exposure is ideal, with the house design aligned along an east-west axis--with as many rooms facing south as possible. South facing windows are sized for solar gain, north facing windows provide ventilation and natural light. The use of overhangs, or extending the roof's eaves in the summer to shade the southern exposure can control the amount of blazing summer heat.

♦ **Heat from the sun is desirable in cold weather and undesirable in warm weather**. Windows facing approximately 30 degrees of true south can be designed with overhangs to control the sun. Full sunlight is acceptable from mid-September to mid-March. This approach brings in desirable solar heat during the winter, and is a compromise during spring and fall. Because trees can block 30 to 50% of the sun, they are not desirable on the southern exposure in areas where substantial amounts of solar heat are desired. In climates where summer heat is a problem, trees toward the south can make a difference in the cooling load of the home. It is also important to control solar heat at east-west exposures. The simplest way is to avoid large amounts of glass on those sides of the house (the west in particular since afternoon heat is more intense).

♦ **Landscaping**: Can help improve energy efficiency by protecting the house from the summer sun and winter winds. Simple landscaping calls for leaving tall trees standing, shading outdoor air-conditioning units, minimizing shading on southern exposures, and planting deciduous trees near south or southwest facing windows, coniferous trees near north or northwest facing windows. Consider planting or building windbreaks to slow winds near buildings, which prevents heat loss. Other energy efficient landscaping techniques include using local materials, on-site composting and chipping. Other ideas include:

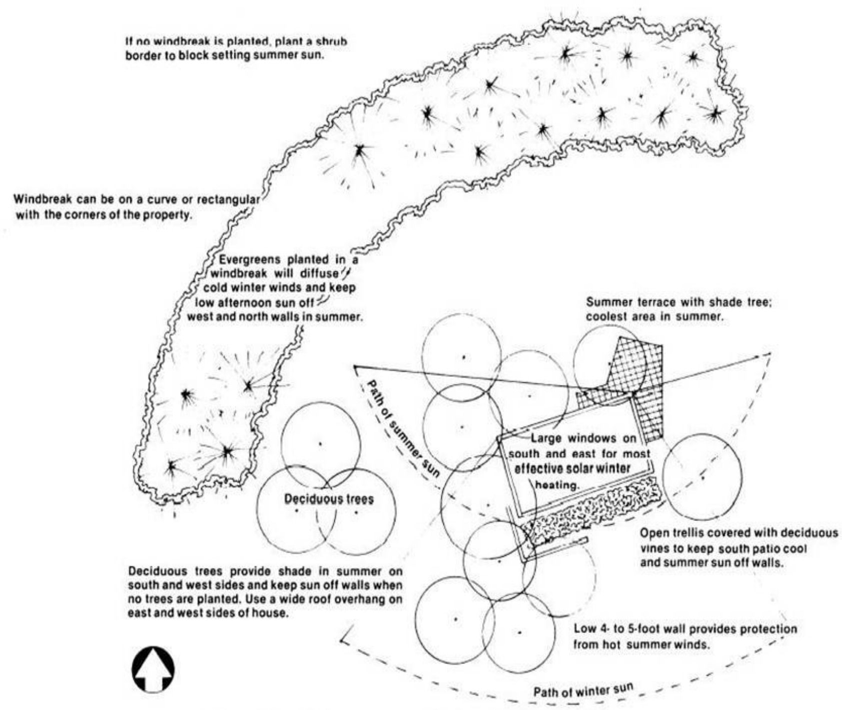
1. Wall sheltering trellises and vines along east and west sides of the home.

2. Reduce glare and heat from paved areas by planting shrubs and other plantings.

3. Plant trees for the purpose of providing shade--reducing cooling costs. Plant evergreens on the northern edges of the property to create a windbreak.

4. Trees, fences, shrubbery, or other plantings to direct and take advantage of summer breezes.

5. Deciduous trees on the east and west sides of the house to take advantage of solar gain in all seasons.

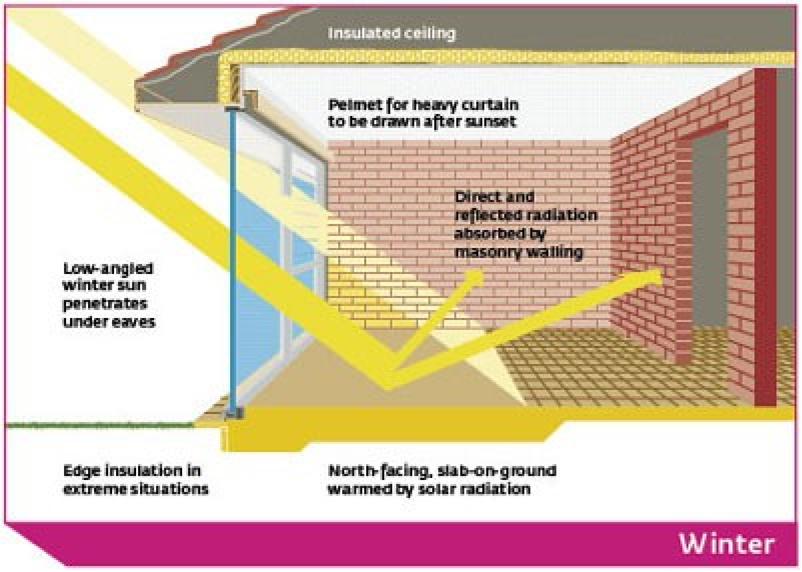


Major Plant Arrangement for Energy Efficiency

♦ **Thermal Mass.** Thermal mass is a concept in building design which describes how the mass of the building provides "inertia" against temperature fluctuations. For example, when outside temperatures are fluctuating throughout the day, a large thermal mass within the insulated portion of a house can serve to "flatten out" the daily temperature fluctuations, since the thermal mass will absorb thermal energy when the surroundings are higher in temperature than the mass, and give thermal energy back when the surroundings are cooler. Thermal mass is effective in improving building comfort in any place that experiences these types of daily temperature fluctuations—both in winter as well as in summer. When used well and combined with passive solar design, thermal mass can play an important role in major reductions to energy use in active heating and cooling systems. High performing thermal mass materials such as brick, masonry, poured concrete, precast concrete, or tile are usually placed in the floor or interior walls where sunlight will fall directly on them (this is called "direct gain" or "direct storage"). To ensure cost effectiveness, try to use thermal mass materials that serve multiple purposes within the home, such as providing structural support or dividing rooms. Generally thermal mass should be relatively thin, as mass thicker than 4" does not absorb and release heat quickly enough to be effective.

***** In most cases, the easiest way to add thermal mass is to use an exposed concrete slab. It is important that it be exposed to direct sunlight and not covered by rugs or carpets. A strip about 8' wide along a south wall, with a dark, matte finish will reduce glare and capture the most radiant heat. If the goal is to dissipate heat in a hot climate, do not insulate under the slab. But if the winters are cold, it pays to insulate completely so stored heat is not transferred to the ground below.

***** A layer of 2" to 4" dense material (brick, stone, tile or concrete) used on wall surfaces in rooms facing south can function as thermal mass. It does not matter if the wall gets direct sunlight--just as long as there is sunlight that will bounce around the room. Outer walls of masonry can also effectively store solar energy.



PASSIVE SOLAR DESIGN--PRACTICAL APPROACHES

Increased glazing in passive solar designed homes provides an attractive environment--large windows, sunny interiors, large living spaces can all lead to customer satisfaction and increased resale values.
Windows with low e glass can stop the loss of heat and improve the energy efficiency of almost any home.
Thermal mass effectiveness increases up to a thickness of about 4 inches--do not exceed 6 inches
Denser thermal mass materials are more effective at storing and releasing heat.
Thermal mass materials in direct sunlight perform best.
If the thermal mass is not exposed to direct sunlight, plan to use 3 to 4 times as much area.
Effectiveness of passive design can be compromised by carpets and drapes.
Select an appropriate color and finish--dark colors absorb more solar energy.

Xeriscaping: a more elaborate type of landscaping that reduces or eliminates the need for supplemental water using drought tolerant plantings, native vegetation and shrubbery.

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JOBSITE RECYCLING

Building demolition and remodeling produce huge amounts of construction waste. New construction produces waste in the form of scrap, defective and damaged material and empty packaging. Most of this waste is sent to local landfills. Currently only a small proportion of jobsite waste is recycled even though the potential exists to recycle or reuse much of the material.

On average, at least 25% of discarded construction material is dimensional lumber, 15% is drywall, 12% is masonry and tile, and 10% is waste from manufactured wood products. The remainder is typically discarded cardboard, paper, plastic packaging, asphalt, fiberglass, metals and other miscellaneous materials. One study, done by REIC Consulting Ltd in Toronto Canada, showed that the construction on an average house results in the discarding the equivalent of 200 2x4 studs, 400 standard bricks, and 10 to 12 sheets of drywall. The NAHB reports:

Construction Waste

2 to 7 tons for each new single-family detached house. Average of 4 pounds per square foot for new single-family detached house.

30 to 35 million tons of building construction, renovation, and demolition waste each year.

Construction of typical 2,000 sq.ft. home results in 4 tons of waste (wood/paper: 46%, drywall: 25%, masonry: 13%, other: 17%, hazardous material: 1%)

"Typical" Construction Waste Estimated for a 2,000-Square-Foot Home

Material	Weight (pounds)		Volume (cu. yd.)
Solid Sawn Wood	1,600	20%	6
Engineered Wood	1,400	18%	5
Drywall	2,000	25%	6
Cardboard (OCC)	600	8%	20
Metals	150	2%	1
Vinyl (PVC)	150	2%	1
Masonry	1,000	13%	1
Hazardous Materials	50	1%	-
Other	1,050	13%	11
Total	**8,000**	100%	**50**

Note(s): Volumes are highly variable due to compressibility and captured air space in waste materials.

Source(s): NAHB's Internet web site, www.nahb.org, Residential Construction Waste: From Disposal to Management, Oct. 1996.

Disposal, however, can be problematic. In many areas landfills do not accept typical construction waste. The cost of disposal can be expensive--making up anywhere from 3 to 5% of the overall budget. Effective waste management begins with a company waste management policy and waste management plan. It should set forth the company's general approach to waste reduction, reuse and recycling. It should be tailored to meet the challenges encountered in the community and at the specific jobsite. The plan should be posted at the jobsite, in the office, and given to suppliers and subcontractors. The three basic components of a waste management plan are:

1. Identify the components of what you waste and determine disposal costs. Understand what types and the quantity of waste that will be generated.

2. Assess the job before work begins. Determine what conditions have been created that affect how waste will be handled. Waste management plans are site specific--depending on local tipping fee, homeowner preferences, the size and length of the job etc. Local

ordinances may also play a role in determining waste container placement or storage.

3. Reduce, Reuse, and Recycle. There is a process involved in waste reduction--reduce the amount of materials , reuse as much of that material as possible, and then recycle any that is left over at the end of the project. Minimizing the amount of scrap and packaging materials will ultimately reduce construction waste. Recycling and disposal costs can vary depending on the time of year as well as the region.

Reduced waste will reduce costs! Reusing materials and implementing jobsite recycling can reduce costs. When salvaged, materials can often be sold to offset costs.

STRATEGIES TO MINIMIZE WASTE GENERATION

On-site, efficient framing techniques and reuse of materials are the best waste reduction opportunities. Wood waste is the single largest portion of the construction waste by both weight and volume. Some ways to achieve waste reduction are:

- 25% of a site's waste comes from packaging. When ever possible, require suppliers and manufacturers to limit the amount of packaging. Look for materials in recyclable packaging--i.e. cardboard.
- Increase the spacing of joists and studs. This can reduce the amount of framing material by 30%.
- Create a central cutting area for wood.
- Separate reusable lumber, such as 2x wood cut-offs which can be used for bridging, stakes, bracing, shims, drywall nailers, and blocking. Cutoff sheathing waste can be used for drywall stops and furring. Grind remaining wood on-site for mulch.
- Use cardboard or drywall off-cuts to grind into a soil amendment.
- Ask subcontractors to remove their own waste from the job site, rather than supplying a dumpster for their use. While they

may increase their prices to include disposal, the overall benefit is usually improved and more efficient use of materials.

- Consider precast or poured concrete or insulating concrete forms (ICF) because they create little to no job site waste. Separate waste for recycling at the site--sort wood, cardboard, metals, cladding, flashing, plumbing, drywall, glass, plastics, and non-recyclables.

STRATEGIES FOR WASTE RECYCLING

There are 4 approaches to waste recycling:

- **Job site cleanup service.** With this system, the subcontractors and crews take the waste to the waste containers. The hauler designates an area for the container, and then separates, transports and tips the material. Costs are determined by the size of the project--often based on square footage of the building.
- **Job site commingled recovery**. Some processing facilities will accept mixed waste and recover materials such as wood, metal and cardboard from the waste. The contractor does not have to separate the waste--a method that can be very appealing to remodelers.
- **Job site separation.** This requires the builders to separate the material and schedule container service. The waste contractor delivers and tips the materials, the difference being that greater savings can be realized through separation of more valuable materials and generally lower tip fees since the material has been separated.
- **Self hauling.** This entails the builder handling all phases of the process--separating, containers, transport, and tipping. Disposal costs and recycling revenues are determined by vehicle cost, tipping fees and labor.

WASTE RECYCLING--PRACTICAL APPROACHES

Know that a builder's job site waste is 60% to 80% recyclable.
Create and post a waste management policy and plan.
Try to get written agreements with subcontractors likely to create a large amount of hazardous waste.
Evaluate and update your waste management plan periodically.
Insist that subcontractors adhere to the waste management plan.
Consider using Material Safety Data Sheets to manage and report potentially hazardous substances..
Know local and state laws.

Hazardous Waste

There are two approaches to responsible hazardous waste disposal:

1. Use, or switch to nonhazardous material. An example would be using water based paints as opposed to oil based. They have dramatically improved in their performance and price. Using non-toxic paints eliminates solvents and cleanup materials that can be considered hazardous.

2. Recycle or dispose of hazardous waste at permitted facilities. The largest source of potentially hazardous materials generated on a residential jobsite are solvents, paints and coatings, and adhesives. Given liability issues, it is important to verify subcontractors disposal methods.

Progress Check

- What are the benefits of passive solar design?
- What percent of discarded construction material is masonry and tile?
- How long will it take to see a return on the energy savings when landscaping efficiently?

****Source: Green Building Guidelines Meeting the Demands for Low-Energy, Resource-Efficient Homes, U.S. Dept. of Energy**

NEW TECHNOLOGY

LIGHTING	PHOTOVOLTAIC	WIND	FUEL CELLS	APPLIANCES

Learning Objective

Understand the features and benefits of new technology available to builders and homeowners.

LIGHTING

The science of lighting has undergone many changes. How lighting makes us feel, along with the impact on the environment, has changed the kind of fixtures, the kind of power, and the kind of bulbs we use. A conventional incandescent bulb produces only about 5 to 10% of the consumed energy into light, the rest goes out as heat. According to the U.S. Environmental Agency, if every American replaced just one light with a bulb that has earned the Energy Star designation we would save enough energy to light 3 million homes for a year, save about $600 million in annual energy costs, and prevent 9 billion pounds of greenhouse emissions per year.

The problem is that we have become accustomed to incandescent light, with its silent, pleasing output, wide range of sizes and voltages, and very inexpensive price point.

Incandescent light bulbs are, however, gradually being replaced by newer technologies that improve the ratio of visible light to heat generation. New light sources, such as the fluorescent lamp, high intensity discharge lamps and LED lamps offer higher efficiency, and can generally be fit into existing fixtures. These devices light by luminescence, instead of heating a filament to incandescence.

- An Energy Star **Compact Fluorescent Light** (CFL) can save more than $40 in electricity costs in its lifetime, uses about 75% less energy and lasts 10 times longer than a standard incandescent bulb. It also produces far less heat.
- Consistency across the market is spotty, however--findings are that many CFLs and LEDs are not living up to their longevity expectations. It's best to stick to recognized brands--which may cost more but tend to be more reliable.
- One major drawback with CFLs is the mercury content which complicates their disposal. Some retailers are offering free take-back programs to dispose of old bulbs.
- CFLs do experience some "output decay"--producing 70 to 80% of their original output by the end of their life.
- **Light Emitting Diodes** (LED) are the most expensive, but have the longest life cycle. Again, inconsistency in longevity, as well as "color shift" can reduce the desirability of LEDs.
- An assortment of LED light bulbs are commercially available as of 2010 as replacement for screw in bulbs, including floodlights, reading lights, household lamps and low-power accent lights.

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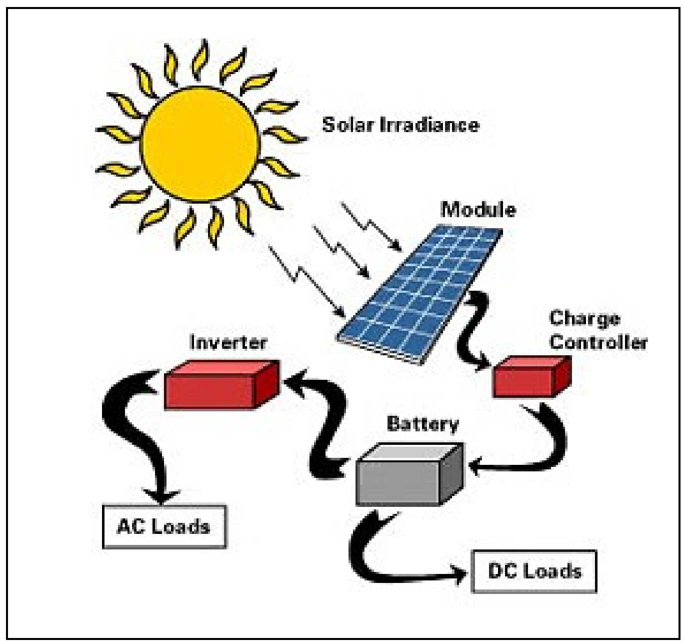
PHOTOVOLTAIC ROOFING PRODUCTS

Photovoltaic systems use solar electric panels to directly convert the sun's energy into electricity. The solar electricity fed through electronic equipment is converted to utility grade electricity for use in the home. It can be used to offset the cost of utility provided electricity, or, if the PV produces more than the home needs--can provide all of the household electrical needs. A PV system is essentially a mini-utility plant.

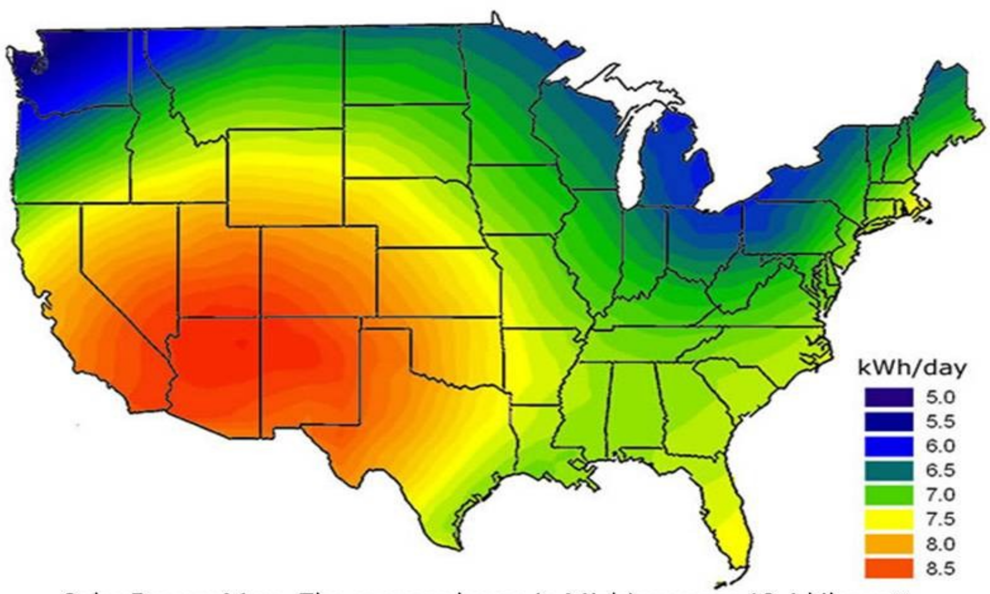


- Building Integrated Photovoltaic (BIPV) systems are incorporated and installed into roofing materials.
- BIPV products include electricity generating roofing products that resemble:

    - Asphalt shingles
    - Standard seam metal roofing
    - Slate or concrete tiles
- The system usually consists of BIPV that produces the electricity, batteries that store it, and an inverter that converts the PV current (DC) to standard household current (AC)
- In some instances, the batteries are eliminated when the power company becomes the storage and back-up power supplier.
- BIPV units do not produce pollution or carbon monoxide emissions like fossil based power.
- Unlike utility provided electricity, the cost remains constant.
- A professional is necessary for installation.

Generally, a southern exposure is best, but roofs that face east or west are also acceptable. To determine if your site is appropriate for a PV system, consider the following:

♦ The modules should be able to be exposed to the sun during the peak hours of 10 a.m. to 3 p.m.
♦ The modules need to be clear of obstructions--trees, buildings, chimneys etc.
♦ Seasonal variations can affect feasibility--climate, orientation and altitude will play a factor in how many panels will be necessary and how much electricity can be generated.



Solar Energy Map. The average home in Michigan uses 19.4 kilowatt hours per day with the appropriate system it would be possible to capture 31% of the electrical energy needs in Michigan

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WIND POWER

Wind power should be considered an important component of any long-term energy strategy, because wind power generation uses a natural and virtually inexhaustible source of power—the wind—to produce electricity. Wind energy, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, and produces no greenhouse gas emissions during operation. That is a stark contrast to traditional power plants that rely on fossil fuels.

And wind power generation is clean; it doesn't cause air, soil or water pollution. That's an important difference between wind power and some other renewable energy sources, such as nuclear power, which produces a vast amount of hard-to-manage waste. As the need for clean, renewable energy increases, and the world more urgently seeks alternatives to finite supplies of oil, coal and natural gas, priorities will change. And as the cost of wind power continues to decline, due to technological improvements and better generation methods, wind power will become increasingly feasible as a major source of electricity and mechanical power.

Small wind turbines, mounted on towers between 80 and 120 feet tall, can generate electricity from the wind for home use. With on-site installations documented in at least 47 states, wind is a recognized renewable energy source for distributed generation of power on residential home sites. Small wind generation grew by 78% in 2008. A wind-powered generator, or turbine, situated at the

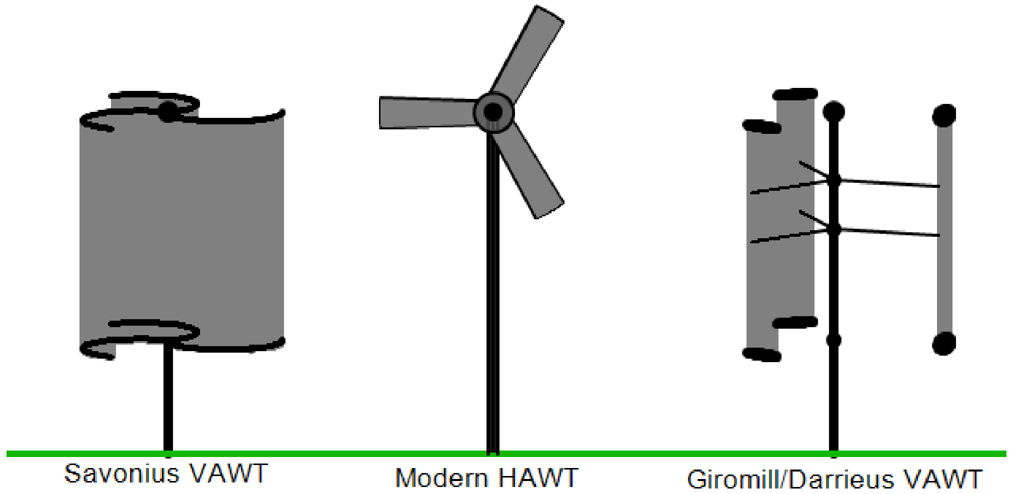
top of a high tower, has blades which spin to generate electricity. The electricity can either be used locally or sold to the utility company if an excess is generated.
There are two general types of turbines:

1. Vertical Axis wind turbine (VAWT)

- Rotor shaft is vertical and does not need to be pointed into the wind--an advantage in locations where the wind direction is highly variable.
- Much less common than a horizontal axis turbine
- Typically shorter than a HAWT
- Easier to set up and maintain
- Almost all are considered small wind turbines--in the 1 to 5 KW range
- Are 50% less efficient than HAWT

2. Horizontal Axis wind turbine (HAWT)

- Horizontal shaft and generator at the top of the tower, and must be pointed at the wind
- More common than VAWT
- More efficient than VAWT
- Most have a gearbox, which turns the slow rotation of the blades into a faster rotation that can better drive an electrical generator.



In a typical residential application, the power from the wind turbine is connected to the main electric service wire to the home. Special interconnection equipment will allow powering the home, or sending the excess power generated by the turbine back to the utility grid.

Otherwise, a distributed wind turbine can be designed as an "off-grid" type using batteries for storage of excess electricity. Many utilities credit the homeowner's account for power produced by wind turbines that is fed back to the grid and require that special safety features be installed to assure the safety of line workers during power outages.

* Savings of up to 10 to 40% can be realized

* Payback ranges from 10 to 50 years, depending on several factors--

- The cost of utility produced electricity
- The amount of local wind
- Distance from other tall obstructions
- Available state and federal tax credits
- The size of the turbine--the smaller the turbine, the longer the payback will be realized

The amount of power generated by a wind turbine depends on the capacity of the turbine (rated in kilowatts, or kW) and the wind speed. Manufacturers will provide a power curve which shows the turbine's output (in watts) at given wind speeds. For a typical home that uses 9,400 kilowatt hours (kWh) per year, a unit rated at between 5 and 15 kW will meet most of the home's electricity needs.

Due to their height, wind turbines are best suited for remote or low-density residential lots of one acre or more. Developments that have adopted restrictive covenants may not allow wind turbines to be erected. The construction of wind farms on a large scale is not universally welcomed because of their visual and noise impact, but any effects on the environment are generally the least problematic of any power source.

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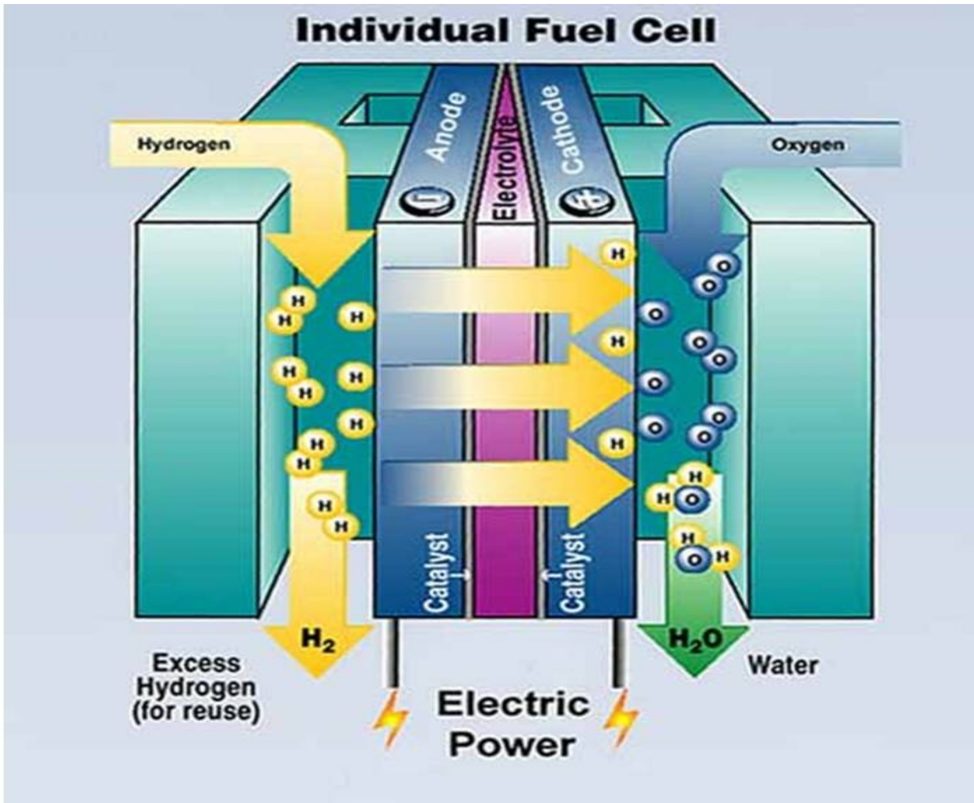
FUEL CELLS

Fuel cell technology is under development that could permit a freezer chest-sized fuel cell to power an entire home. Fuel cells produce electricity through a chemical reaction rather than burning the fuel, and therefore have very low emissions. Fuel cells work like batteries that do not run down or need recharging. In residential applications, fuel cells are expected to eventually compete with current electricity generation, depending on costs of natural gas and electricity in a given region.

While fuel cells are not yet commercially available for residential use, they are available for large-scale power production, and may be commercially available for residential use within the next five years.(NAHB)

Fuel cells not only offer an efficient means of generating electricity from fossil fuels, but also have very low emissions. Up to 70 percent of the energy obtained from fuel can be converted to usable electric power and heat (compared with about 35 percent from a central power plant).

- Fuel cell technology now under development converts fuel, (natural gas, gasoline, propane, ethanol, hydrogen, or other fuels) into direct current (DC).
- Fuel cells bypass the combustion and generating process found in conventional power plants and simply convert fuel into electricity, water, heat and carbon dioxide.
- It will be more efficient than fossil fuel powered generating plants.
- Can be up to 80% more efficient producing electricity and heat.
- A home unit would need to use a storage system or net metering with the electric utility company.
- Residential fuel cells are not yet commercially available, although field trials are underway.



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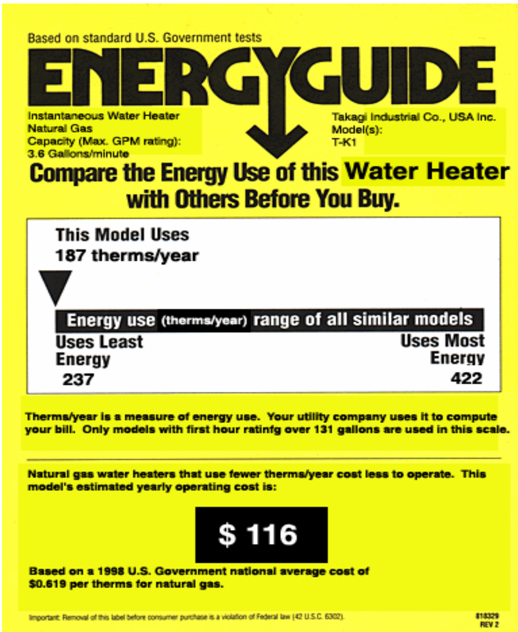
HIGH EFFICIENCY APPLIANCES

Today's major appliances must now meet minimum federal energy efficiency standards. The appliances on the market today will typically use less than half the energy that a model that is 12 years or older. (NRDC)

- Look for the Energy Star rating--these are the most efficient in any product category--exceeding even the minimums set by the federal government. In some parts of the country, utility and state governments will offer rebates on Energy Star rated models.
- Look for the yellow Energy Guide label--this allows you to compare the annual energy consumption and operating

cost from one model to another, but does not guarantee that the product has met federal standards.

- Compare different manufacturers and select the most energy efficient
- www.energystar.gov is a great place to find energy efficient appliances.



ENERGY STAR

Progress Check

- How much of the energy consumed by an incandescent bulb is turned into light?
- What are some differences between CFLs and LEDs?
- Describe the general properties of photovoltaic roofing products.
- What is the difference between the Energy Star rating and the Energy Guide?

Michigan Uniform Energy Code

Incorporating the 2009 edition of the International Energy Conservation Code

Excerpted from Impacts of the 2009 IECC for Residential Buildings in Michigan

Energy Efficiency & Renewable Energy/U.S. Department of Energy (www.eere.energy.gov/informationcenter)

SCOPE	**COMPLIANCE**	**BLDG. ENVELOPE**	**AIR LEAKAGE**	**SYSTEMS**

Learning Objectives

Explain the changes made to the 2009 Michigan Uniform Energy Code since 2003.
Understand what measures can be taken to incorporate these changes into construction projects/design.
Recognize how the changes can ultimately reduce and conserve energy consumption.

The adoption and enforcement of stringent residential energy codes offer considerable benefits and challenges. Constructing and operating buildings consumes **more** materials and energy than any other single entity in the United States (National Center for Appropriate Technology). Improved residential and commercial building codes could reduce primary energy use in buildings by approximately 0.5 quadrillion Btu per year by 2015. Total annual dollar savings would be more than $4 billion, and CO_2 emissions would be reduced by roughly 3%. (U.S. Dept. of Energy) Energy codes are designed to incorporate and regulate practices that will reduce the use of fossil fuel and non-renewable resources.

Builders are often challenged with the responsibility of complying to building codes, and justifying the added expense of energy-saving measures to their customers. Home owners want an energy efficient and functional home at a competitive price—yet many energy requirements are stringent and cost prohibitive. Builders must choose products and materials that fit the design of the building and meet the requirements of the energy code.

As of March 2011 the state of Michigan has adopted the 2009 International Energy Conservation Code (IECC) as its' energy code. The new code reflects several changes in energy efficiency for the **Michigan Uniform Energy Code** compared to the 2003 edition. Generally, the purpose of these changes is to conserve energy through improved efficiency in envelope design, mechanical systems, lighting, and new materials and techniques. It sets the baseline for the building envelope, systems, and equipment. These requirements affect the overall efficiency of a structure and apply to:

- Walls, floors and ceilings
- Doors and windows
- Heating, ventilation, and cooling systems and equipment

- Lighting systems and equipment
- Water-heating systems and equipment

The new codes are designed to incorporate and regulate practices that will ultimately reduce the use of fossil fuel and non-renewable resources. According to the Department of Energy, these changes may result in saving approximately $256 to $292 in energy costs for an average new home.

LARA
Department of Licensing and Regulatory Affairs

Scope

The scope of changes to the 2009 International Energy Conservation Code include residential, single and multi-family homes that are three stories or less (above-grade), meant for permanent residence. This code applies to new buildings as well as additions, alterations, renovations, and repairs.

Exemptions to the scope include:

1. Structures with no conditioned space—i.e. garages

2. Historically significant buildings.

3. Very low energy use buildings (less than 3.4 Btu/h-ft^2), and buildings (or portions of) that are neither heated or cooled.

Existing Buildings

All **permit holders** (builders, remodelers and homeowners) are required to comply with 2009 MUEC. Replacement fenestrations must comply. Existing electrical, lighting, and mechanical systems may remain as is. The exceptions surrounding existing buildings are:

- Storm windows over existing windows.
- Glass-only replacements.
- Where the existing roof, wall, or floor cavity is not exposed.
- Reroofing where neither sheathing or insulation is exposed during the project, roofs without insulation shall be insulated either above or below the sheathing.
- Interior lighting alterations that do not increase the installed power—less than 50% of the luminaries are replaced and alterations that replace only the bulb and ballast of the existing fixtures.
- A building that is moved into or within a jurisdiction. A manufactured home that is shipped for initial installation/assembly on a building site shall not be considered a moved building.
- Spaces undergoing a change in occupancy that would result in an increase in demand for energy shall comply with this code. Any non-conditioned space that is altered to become conditioned space shall be required to be brought into full compliance with this code. Examples would be either converting a garage into a family room or heating a basement.

NEW 2009 IECC CHANGES

1. Focus on the building envelope (ceilings, walls, windows, floors and foundations). Insulation and fenestration levels, and solar heat gain coefficients are mandated. Infiltration control must be implemented through sealing and caulking to prevent air leaks.

2. Ducts--emphasis on sealing and insulation. Mandatory duct pressure testing along with allowable duct leakage rates is required when any portion of the system is outside the conditioned space.

3. Limited space heating, air conditioning, and water heating requirements are set by federal code--not IECC.

4. No mechanical trade-offs allowed for high efficiency heating, cooling, or water heating equipment.

5. Lighting equipment--50% of "lamps" must be high efficiency. The 2003 IRC has no lighting requirement.

6. Pool controls and covers--covers are required for heated pools.

7. Controls for driveway/sidewalk snow melting systems.

8. Moisture control requirements (i.e., vapor retarders) moved to the Michigan Residential Code (MRC).

9. No appliance requirements.

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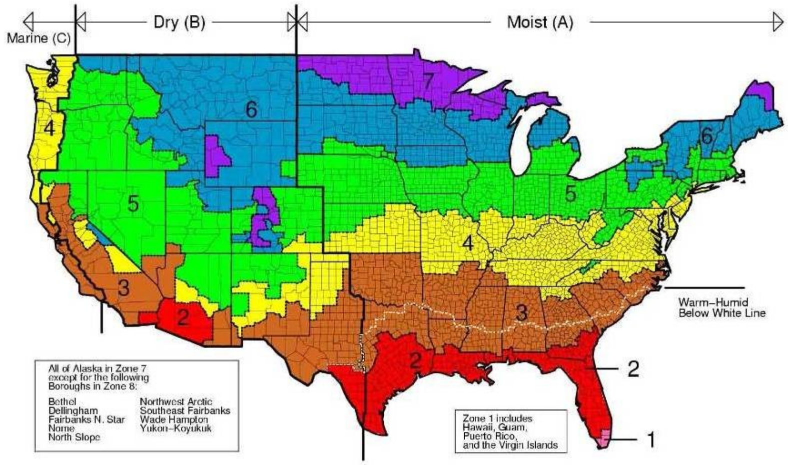
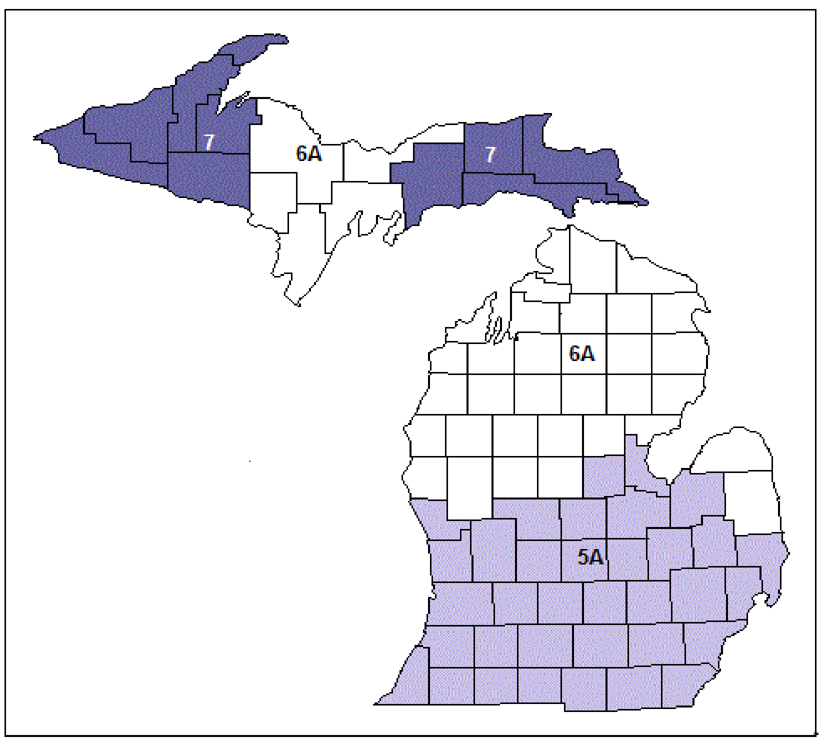
Compliance and Documentation

Michigan Uniform Energy Codes are based on the 2009 International Conservation Code (IECC). The key differences between the 2003 and 2009 editions surround key mandatory envelope requirements (the project design must meet these requirements regardless of location) which include moisture and infiltration control and duct insulation. Other envelope requirements such as insulation values and window efficiency are based on the climate of the project locations.

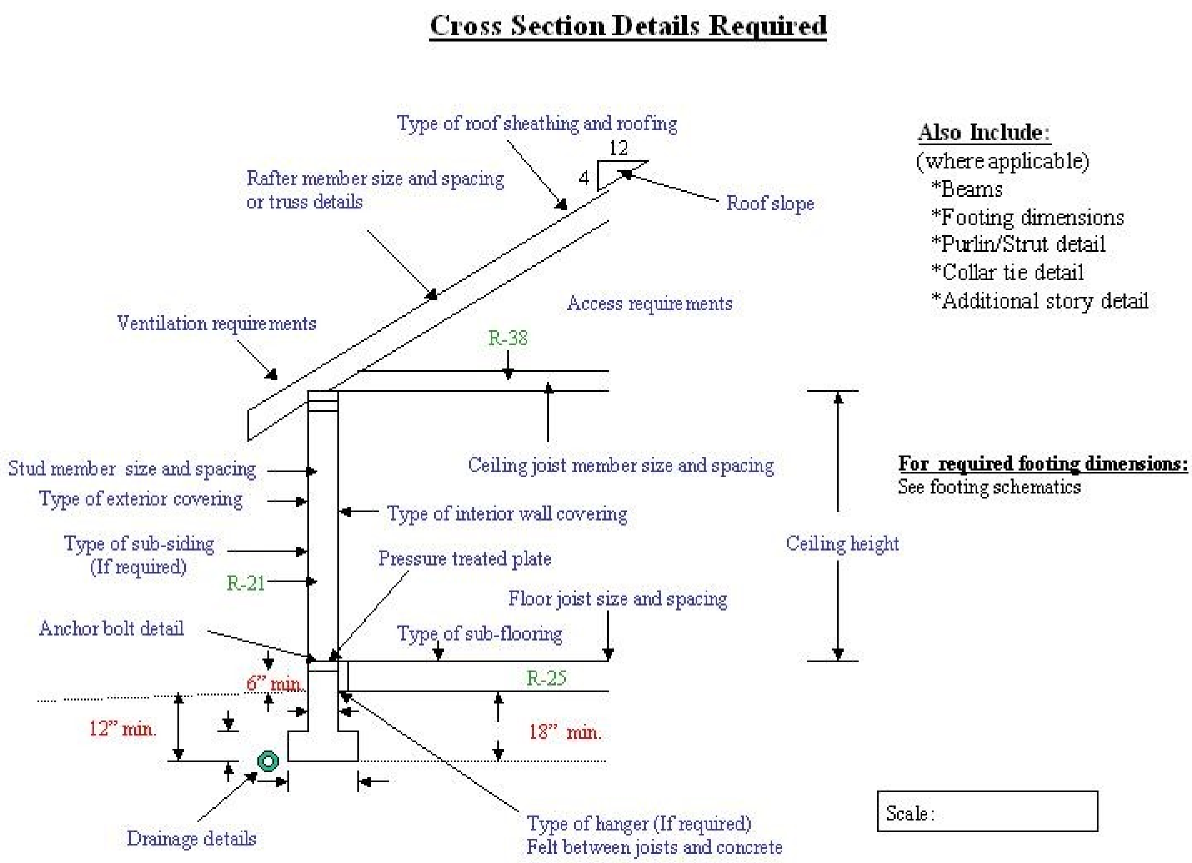


The new Michigan code has combined climate zones splitting the state into three sections--slightly different from the 2003 zones.



Plans and specifications must show sufficient detail regarding the building features and equipment systems as they pertain to Michigan code. This includes detail pertinent to:

- Thermal insulation and their R-values
- Exterior envelope component materials and U-factors
- Design criteria
- Sizes and types of equipment and systems



Insulation products (blown and sprayed) must be documented and posted with the date and name of the installer, manufacturer, R-value, type and thickness (settled) of the material at the attic entry. A Building Certificate for New Construction is also required to be posted at the site. Ventilation systems must be labeled as well.

The new prescriptive envelope requirements are basically the same as the 2003 IRC table. (see below) For homes with higher glazing area percentages, the IRC recommends using the 2003 IECC -- which has more stringent requirements.

Prescriptive Requirements in the Michigan Code

TABLE 402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT[a] *U*-FACTOR	CEILING *R*-Value	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[f]	FLOOR *R*-VALUE	BASEMENT[b] WALL *R*-VALUE	SLAB[c] *R*-VALUE AND DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
5A	0.35	0.60	38	20 or 13 + 5[e]	13/17	30[d]	10/13	10, 2ft	10/13
6A	0.35	0.60	49	20 or 13 + 5[e]	15/19	30[d]	15/19	10, 4ft	10/13
7	0.35	0.60	49	21	19/21	38[d]	15/19	10, 4ft	10/13

a. The fenestration *U*-factor column excludes skylights.
b. The first *R*-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.
c. R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less, in zones 1-3 for heated slabs.
d. Or insulation sufficient to fill the framing cavity, R-19 minimum.
e. "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, R-5 sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.
f. The second *R*-value applies when more than half the insulation is on the interior.

Table 402.1.3
Equivalent U-Factors[a]

Climate Zone	Fenestration *U*-Factor	Skylight *U*-Factor	Ceiling *U*-Factor	Frame Wall *U*-Factor	Mass wall *U*-Factor[b]	Floor *U*-Factor	Basement Wall *U*-Factor[d]	Crawl Space Wall *U*-Factor[c]
5A	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6A	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7	0.35	0.60	0.026	0.057	0.057	0.026	0.050	0.065

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation, or an approved source.
b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be the same as the frame wall *U*-factor in Zones 5 to 7.
c. Basement wall *U*-factor requirements shown in Table 402.1.3 include wall construction and interior air films, but exclude soil conductivity and exterior air films.
d. Foundation *U*-factor requirements shown in Table 402.1.3 include wall construction and interior air films, but exclude soil conductivity and exterior air films. *U*-factors for determining code compliance in accordance with section 402.1.4 (total UA alternative) of section 405 (simulated performance alternative) shall be modified to include soil conductivity and exterior air films.

Compliance

Compliance with the energy code can be demonstrated by the prescriptive, trade-off (e.g., REScheck), or simulated performance approach. In evaluating building compliance, the prescriptive approach should be assumed unless documentation is provided by the builder with either the trade-off or simulated performance approach.

There are **three** options to compliance paths:

1. PRESCRIPTIVE MEASURES:

This is considered the most simple route. The requirements do not change by building size, shape, window area or other features. The IECC has one single table of requirements for insulation R-values and window/door U-factors and SHGC. (Table 402.1.1) There is a corresponding U-factor table (Table 402.1.3) that allows for compliance when using less common components.

2. U-FACTOR AND UA ALTERNATIVES:

This includes the total building envelope UA (U-factor multiplied by area). This path uses the REScheck™ software. (The 2009 IECC will be implemented into REScheck and is expected to be available later this year). This alternative is similar to the Prescriptive R-value, but uses U-factors instead. (Table 402.1.3) It allows for innovative or less common construction techniques such as structural insulated panels or advanced framing. Based on the prescriptive U-factor table, trade-offs are allowed when one energy efficient measure cannot meet code--as long as one of the other measures in the project can EXCEED code--balancing out the requirements.

3. SIMULATED PERFORMANCE (requires software programs with specified capabilities):

This path allows compliance if the home has an annual energy consumption that is equal to or less than standard code. This path is the most flexible, and allows for crediting energy efficient measures that are not accounted for in other paths, such as renewable energy. This path includes both envelope and some systems, but the changes in the 2009 code do NOT allow credit for space heating, cooling or water heating equipment. (Section 405)

Progress Check

- What types of buildings are exempted from the new IECC/MUEC?
- List at least 5 changes in the 2009 IECC that pertain to Michigan Code.
- Are Michigan's climate zones the same as they were in 2003?

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The Building Envelope

All new energy codes focus on the building envelope (ceilings, walls, windows, floors and foundations). The building envelope includes all of the components of a residential structure that separate the indoor conditioned space from the outdoor environment. The ability of the building envelope to function properly is what allows the entire building project to operate as an efficient system. Without an exterior shell that protects the home from weather, pests, too much sunlight etc., measures taken to increase energy efficiency within the home are wasted.

The building envelope consists of ceilings, walls (above grade, below grade, and mass walls), fenestrations, floors, slabs, and crawl spaces that must be caulked and sealed. A number of thermal envelope requirements have changed in the 2009 IECC. These are highlighted below.

Ceilings

Requirements are based on assembly type, continuous insulation and the insulation between the framing (cavity insulation). Ceilings **with** attics require the insulation R-value to assume standard truss systems. The Prescriptive R-value path encourages raised heel trusses. Insulation must be full height over the exterior wall top plate--R-38 complies where R-49 is required. This can be accomplished by either using an oversized truss, a raised heel truss, or by installing insulation with a higher R-value per inch thickness such as rigid board insulation. Typically fiberglass batt insulation can be installed over the exterior wall plate line to the desired R-value and the remaining attic can utilize blown-in insulation.

Note: This allowance ONLY applies to the R-value prescriptive path, NOT the U-factor or Total UA alternatives.

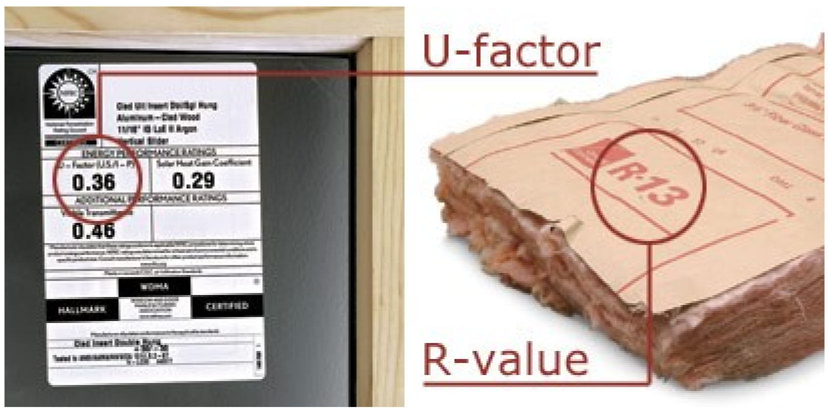
Climate Zone	Ceiling R-Value
5A	38
6A	49
7	49

-Roof insulation in buildings with attics must be installed to allow for free circulation of air through the attic eave vents.

-R-values for roofs represent either cavity insulation (between framing) or insulating sheathing (continuous insulation).

-The first thing to look for is whether the attic access hatch is insulated to the same R-value as the plans and that weather-stripping has been installed around the hatch door to reduce infiltration.

-R-values are to be printed on the batt insulation or rigid foam board.



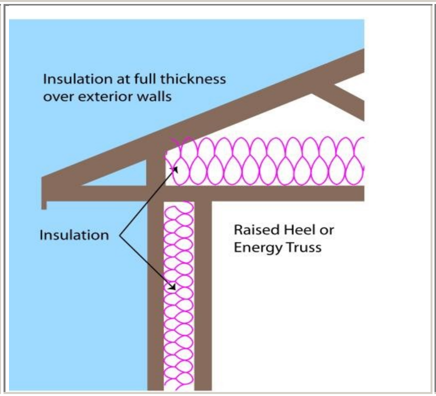
-Blown-in insulation shall have an insulation certificate at or near the opening of the attic. The certificate should include:

- R-value of installed thickness
- initial installed thickness
- installed density
- settled thickness/settled R-value
- coverage area
- number of bags installed

-Insulation markers must be installed every **300 square feet** and are marked with the minimum installed thickness and affixed to the trusses or joists.

-Check that insulation is installed uniformly to an even thickness throughout the attic and extends over the top of the exterior wall.

-If needed, baffles should be installed at each soffit, cornice or eave vent to direct vent air up and over the top of the insulation



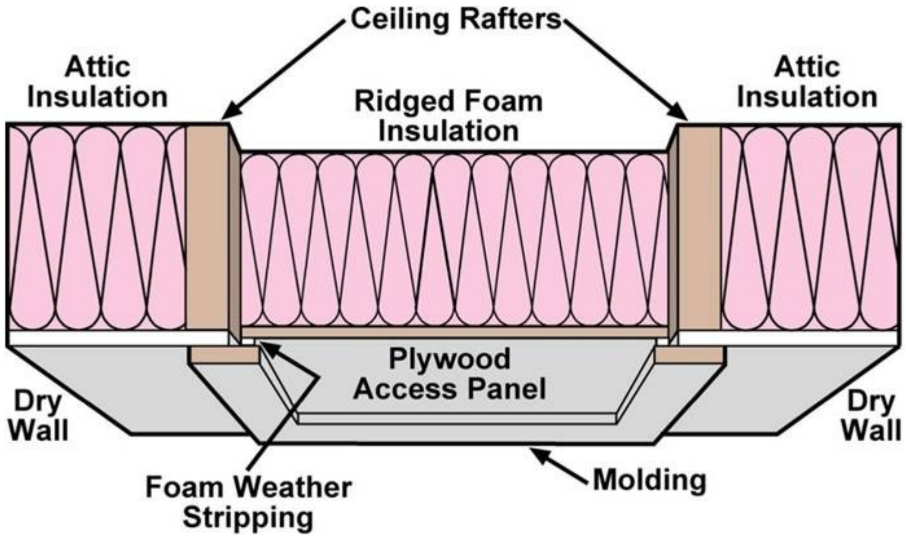
In climates where insulation requirements are greater than R-30, and there is not a sufficient amount of space in the roof assembly design to meet required higher levels, R-30 is allowed, but limited to 500 square feet, (or 20% total insulated ceiling area) whichever is less, for ceilings **without** attics (vaulted).

Access Hatches and Doors

-Weather strip and insulate doors from conditioned spaces to unconditioned spaces (i.e., attics and crawl spaces). The insulation level must be equivalent to surrounding surfaces--for example if the required ceiling insulation is R-38, then the attic hatch must be insulated to R-38 as well.

-Provide access to all equipment that prevents damaging or compressing the insulation.

-Install a wood framed or equivalent baffle or retainer when loose fill insulation is installed.

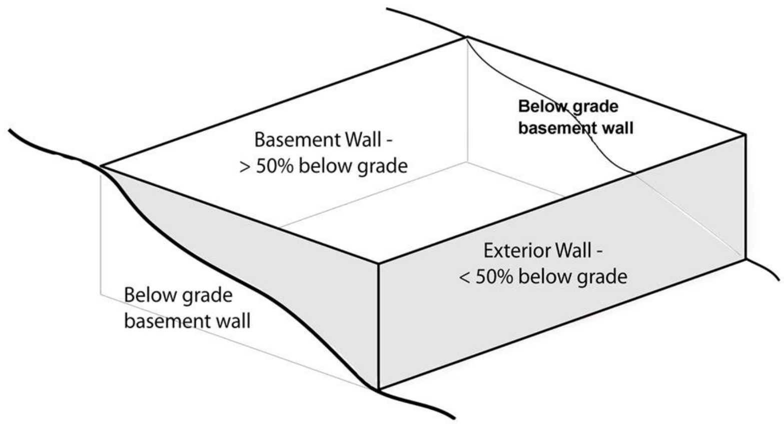


Mass Walls

1. **Above Grade Walls**--Insulate walls including those next to unconditioned spaces, including rim joists. Insulation should not be compressed behind the wiring or plumbing; this reduces the R-value of insulation. Be sure the insulation has filled the entire cavity, batts that are cut too short will leave voids. For continuous insulation make sure there are no voids and the insulation is well bonded to the outside framing. Perimeter joists between floors must be insulated. While not a requirement, in some climates it is important to insulate exterior corners; either on or in the headers over doors and windows, to eliminate heat transfer through the surfaces.

2. **Below Grade Walls**--Any part of the house or structure that is underground or beneath ground level. More specifically, are defined as being >/=50% below grade, below the grade of the basement wall, and if there is an exterior wall, it is <50% below grade. Define each wall individually--if the grade is sloping, the average height of the grade over the wall would be used to determine whether it's a below-grade or above-grade wall. Below grade walls are insulated from the top of the basement wall down to 10 ft below grade, or the basement floor, whichever is less. Walls associated with

unconditioned basements must meet the requirements unless the floor above the basement is insulated accordingly.

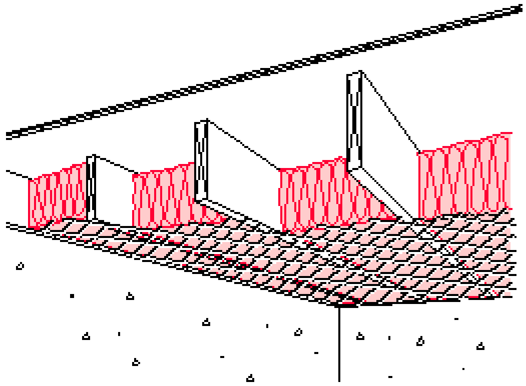


Climate Zone	Basement R-Value
5A	10/13
6A	15/19
7	15/19

Floors

-Unconditioned space includes unheated basements, vented crawlspace, or outdoor air.

-Insulation must maintain permanent and continuous contact with the underside of the subfloor decking.



Climate Zone	Floor R-Value
5A	30*
6A	30*
7	38*

Exception: R-19 is permitted if the cavity is completely filled.

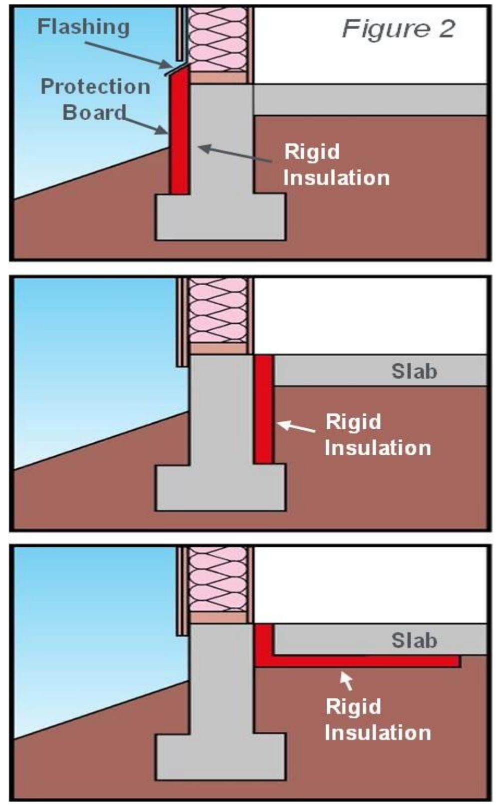
Slabs

Slab Edge Insulation

-Applies to slabs with a floor surface above grade and up to 12" below grade.

-Slab-edge insulation may be installed vertically or horizontally on the inside or outside of foundation walls. If installed vertically, it must extend downward from the top of the slab to the top of the footing. If installed horizontally, it must cover the slab edge and then extend horizontally (to the interior or exterior).

-An additional R-5 is required for heated slabs.



-Exposed insulating material applied to the exterior of foundation walls shall be protected to a minimum depth of 6 inches below the finished grade.

Climate Zone	Slab-Edge R-Value	Depth of Insulation
5A	10	2 ft.
6A	10	4 ft.
7	10	4 ft.

Crawlspace

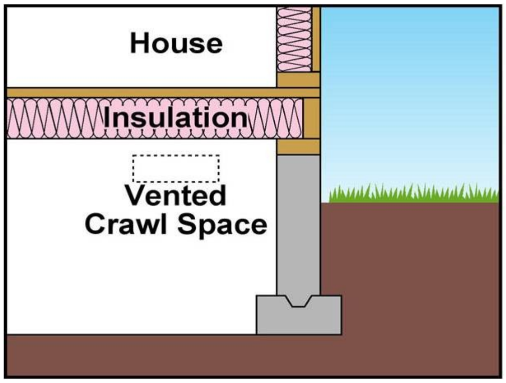
Crawlspace Wall Insulation:

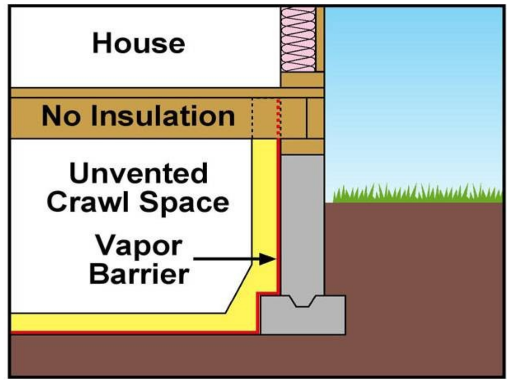
• The crawlspace may not have ventilation openings that communicate directly with outside air.
• The crawlspace must be mechanically ventilated or supplied with conditioned air (this is not directly stated in the IECC).
• The crawlspace floor must be covered with an approved Class 1 vapor retarder material, the joints must overlap 6” and be sealed, the edges should extend at least 6” up the stem wall and be attached to the stem wall.

The IRC allows the construction of unventilated crawlspaces. To meet the requirements, the crawlspace walls must be insulated to the R-value specified in the energy code. The crawlspace must either be provided with conditioned air or with mechanical ventilation. The code does not specify the quantity of conditioned air to supply the crawlspace.

If mechanical ventilation is selected, the crawlspace must be ventilated at 1 CFM per 50 square feet. The ground surface must also be covered with an approved vapor retarder material. To eliminate moisture from the crawlspace the sill plate and perimeter joist must be sealed. Also, while not a code requirement, all joints in the vapor retarder should be overlapped and taped. This includes the connection between the vapor retarder and crawlspace wall.

Climate Zone	Crawlspace R-Value
5A	10/13
6A	10/13
7	10/13





Fenestration

Doors and Windows:

U-Factor is a measure of how well the assembly conducts heat. The lower the number, the better the assembly acts as an insulator. A window U-factor is based on the interior surface area of the entire assembly, including glazing, sash, curbing, and other framing elements.

-The code requires windows, glass doors, and skylights to be rated by the National Fenestration Rating Council (NFRC) and to have labels that show the rated U-factor and SHGC values for the glazing unit, but allows default values (see appropriate table).

-There are no glass area limits

-Exemptions (prescriptive path only) are:

- Up to 15 square feet of glazing per dwelling unit (Section 402.3.3)
- One side-hinged opaque door assembly up to 24 square feet (Section 402.3.4)

Climate Zone	Fenestration U-Factor	U-Factor Hard Limits Vertical Fenestrations

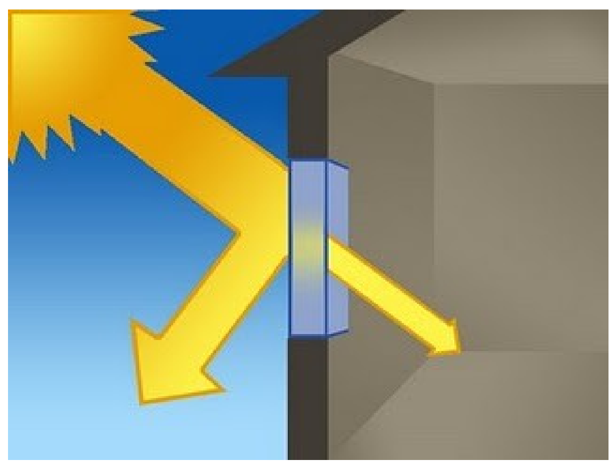
5A	.35	10/13
6A	.35	15/19
7	.35	15/19

Area Weighted Average:

The area weighted average is the combined Solar Heat Gain Coefficient of all the glazed fenestration products in the building.

-Can be used to satisfy U-factor and SHGC (Solar Heat Gain Coefficient) requirements. SHGC is a measure of how much solar gain is transmitted through the window by solar radiation. The lower the SHGC value of a window the less sunlight and heat can pass through the glazing.

-Are subject to hard limits, even in trade offs.



-U-0.75 for skylights in Zones 5-7.

-These are based on building average; U-factors of individual windows or skylights can be higher if the maximum area-weighted average is below these limits.

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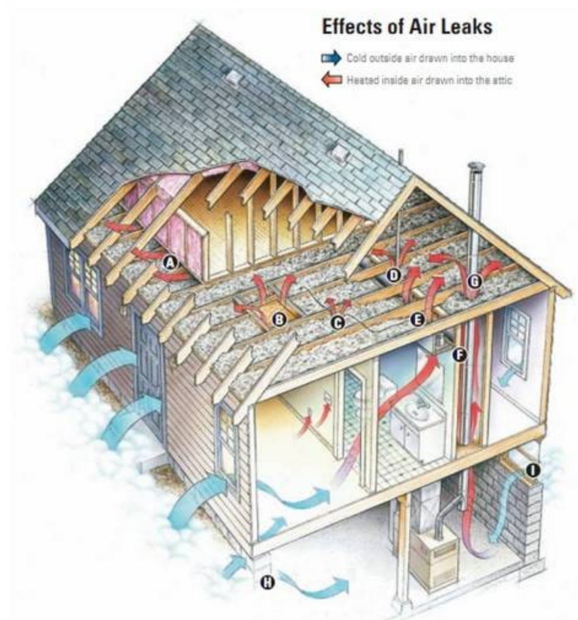
Air Leakage

Air leakage is the rate of air infiltration in the presence of a specific pressure differential. It is expressed in units of cubic feet per minute per square foot of area. Heat loss and gain occur by infiltration through cracks in the envelope assemblies. Basically—it is the random movement of air into and out of a building through cracks and holes in the building shell, otherwise known as “drafts”.

There are several places where air leakage (infiltration) can occur:



- Site built windows, doors, and skylights.
- Openings between window and door assemblies and their respective jambs and framing.
- Utility penetrations.
- Dropped ceilings or chases adjacent to the thermal envelope.
- Recessed light fixtures—must be Type IC and labeled in a sealed or gasketed enclosure. It should be sealed with a gasket or caulk between the housing and interior wall or ceiling covering.
- Walls, floors, and ceilings separating a garage from conditioned spaces.
- Behind tubs and showers on exterior walls.
- Common walls between dwelling units.
- Attic access hatches.

Controlling air leakage in the building envelope can be achieved by sealing with caulking materials, gasket systems, weather stripping, and sealing joists and seams with tape or a moisture vapor-permeable wrapping material.

Two options that can demonstrate compliance with air sealing and insulation are:

• **Whole-house pressure test**--testing may occur any time after rough in and installation of building envelope penetrations.

• **Field verification** of items by an approved party independent from the installer of the insulation shall inspect the air barrier and insulation per Section 402.4.2.

Fenestration Air Leakage

Doors and windows are thermal holes. Poor installation, combined with poorly constructed frames, make windows and doors net heat losers in colder climates and unwanted heat gainers in warmer climates.

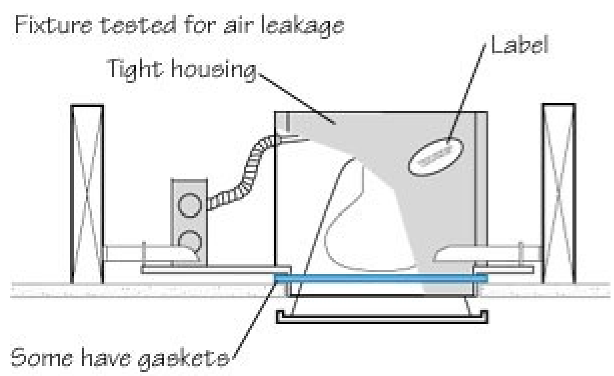
Energy efficiency of doors and windows are defined in terms of heat loss and gain—depending on whether heating or cooling is the goal. Michigan code requires that windows, skylights, and sliding glass doors must have an air infiltration rate of no more than 0.3 cubic foot per minute per square foot [1.5(L/s)/m2)], and swinging doors no more than 0.5 cubic foot per minute per square foot [2.5(L/s)/m2)].

Recessed Lighting

According to the Department of Energy, a home loses costly heat and cooling through these ceiling openings. The energy losses from recessed lights often account for 50% of the total thermal losses of a ceiling. Improper installation of recessed lighting can result in uncontrolled air movement—allowing moisture, condensation and mold. Recessed lighting fixtures must be airtight. This can be accomplished by:

- IC (insulation contact permitted) rated—sealed and gasketed

- IC rated—in accordance with ASTM E283 where the fixture meets pressure testing requirements
- IC rated-installed in an airtight box with specific clearances from insulation



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Mechanical Systems

Heating and cooling is a significant piece of a home's overall energy consumption. Up to 40% of a home's energy is used by heating and cooling. Heating and cooling systems in the United States together emit 150 million tons of carbon dioxide into the atmosphere each year, adding to global climate change. They also generate about 12% of the nation's sulfur dioxide and 4% of the nitrogen oxides, the chief ingredients in acid rain. (energysavers.com)

The equipment efficiency for mechanical systems and equipment is set by Federal law, not the I-Codes. Mandatory requirements for systems (Section 403) include:

Controls--if the primary heating system is a forced-air furnace, at least one programmable thermostat per dwelling unit is required. It must have the capability to set back or temporarily operate the system to maintain zone temperatures. It should be programmed with heat no higher than 70° F and cooling no lower than 78° F.

Heat pump supplementary heat--heat pumps having supplementary electric resistance heat shall have control, except during defrost, and prevent supplemental heat operation when the heat pump compressor can meet the heating load.

Duct Sealing and Insulation

Leaks in ductwork for heating and cooling systems are huge energy wasters. Leaks involving 20% of the total air flow will cause 50% drop in the efficiency, and a shorter lifespan of the cooling and heating equipment. Bottom line--up to 30% of the energy used to heat and cool a building can be lost through leaky ducts and poor duct design. In buildings using a central furnace--duct design, placement and sealing are crucial for desired performance.

Sealing (mandatory)--joints and seams shall comply with MRC, Section M1601.4.1

Insulation (Prescriptive)--supply ducts in attics must be insulated to R-8. Return ducts in attics and all ducts in crawlspaces, unheated basements, garages, or otherwise outside the building envelope must be insulated to R-6. The only exemption is duct insulation is not required if all ducts are located completely inside the building thermal envelope.

Building framing cavities shall not be used as supply ducts.

Duct Tightness Tests--All ducts, air handlers, filter boxes and building cavities used as ducts must be sealed and either:

1. *Verified by pressure testing post construction*-the duct system has to be tested and the air leakage out of ducts must be kept at an acceptable maximum level.

-Leakage to outdoors: ≤8cfm/per 100 ft² of conditioned floor area or

-Total leakage: ≤12cfm/per 100 ft² of conditioned floor area

-All register boots must be taped or otherwise sealed

2. *Installed entirely within the building* thermal envelope.

-Total leakage : ≤6cfm/per 100 ft² of conditioned floor area

-Exemption--testing is not required if all ducts are inside the building thermal envelope (for example in heated basements), though the ducts still have to be sealed.

HVAC Piping Insulation

Mechanical system piping capable of carrying fluids above 105 degrees F or below 55 degrees F shall be insulated to a minimum of R-3.

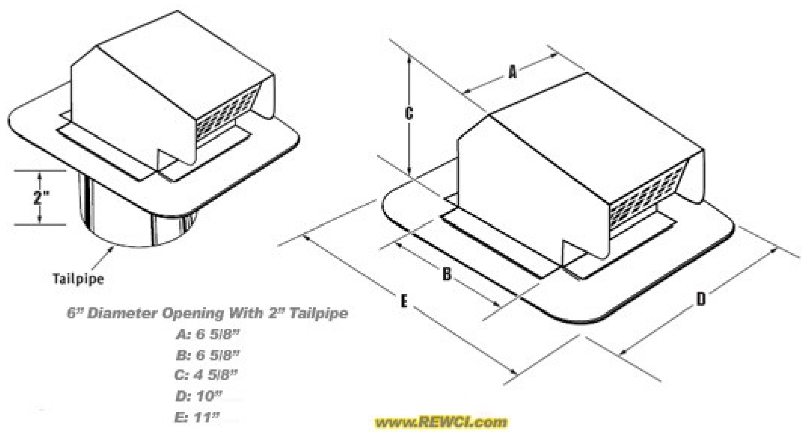
Circulating Hot Water Systems

Circulating hot water systems shall include an automatic or readily accessible manual switch that can turn off the hot water circulating pump when the system is not in use and be insulated to at least R-2.

Mechanical Ventilation

Mechanical systems or equipment create conditioned air or temperature controlled water—which is then moved through the home via ducts and plenums, or pipes. They automatically regulate the amount to be moved through the system by way of recirculation or exhausting.

Code requires minimum ventilation compliance in all conditioned areas of the building. The mechanical ventilation system shall provide sufficient outdoor air. All outdoor intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.



Oversized HVAC equipment has a higher initial cost, a higher operating cost, provides less comfort, and the short-cycling reduces the equipment life expectancy. Any one of these is a good reason not to oversize. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with the procedures described in **Section M1401.3 of the International Residential Code** calculated in accordance with the **ACCA Manual J**, or other approved method.

Systems serving multiple dwellings must comply with Section 503 and 504 in lieu of Section 403.

Snow melt controls--controls for driveway/sidewalk snow melting systems must include controls capable of shutting off the system when the pavement temperature is above 50 degrees F.

Pools--pool controls and covers are required for heated pools.

Electrical Power and Lighting Systems

A conventional incandescent bulb produces only about 5 to 10% of the consumed energy into light, the rest goes out as heat. According to the U.S. Environmental Agency, if every American replaced just one light with a bulb that has earned the Energy Star designation we would save enough energy to light 3 million homes for a year, save about $600 million in annual energy costs, and prevent 9 billion pounds of greenhouse emissions per year.

Incandescent light bulbs are, however, gradually being replaced by newer technologies that improve the ratio of visible light to heat generation. New light sources, such as the fluorescent lamp, high intensity discharge lamps, and LED lamps offer higher efficiency, and can generally be fit into existing fixtures. These devices light by luminescence, instead of heating a filament to incandescence.

50% of the lighting lamps (bulbs, tubes, etc.) in a building must be high efficiency. Compact fluorescents qualify, standard incandescent bulbs do not.

Certificate

The 2009 IECC requires a permanent certificate posted on the electrical distribution panel. The certificate shall be completed by the builder or registered design professional. It should list the R-values of insulation installed for the building envelope, U-factors and SHGC for fenestration, HVAC efficiencies and types, and service water heating equipment. This certificate must not cover or obstruct the visibility of other required labels.

Progress Check

- List and describe the differences between the three options to compliance.
- What constitutes a building envelope?
- What should an insulation certificate include?
- What is the definition of a "below grade"wall?
- What are the two options that Can demonstrate compliance with air sealing and insulation?