RESIDENTIAL CONSTRUCTION RESOURCE GUIDE

EA 2006-01

Earth Advantage® Residential Resource Guide

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A BETTER WAY TO BUILD HOMES

As a builder, you already build a successful house. One that you know you can build and sell profitably. Earth Advantage® does not change the features that make your homes sell—it puts you ahead of the competition. Earth Advantage offers practical, cost-effective ways to make your present homes even better.

You choose a set of measures that fit your house style and budget. You choose from options that have been chosen for their comfort, practicality, efficiency, environmental, and healthier benefits. Each measure is only a small change. But when they are combined, the result is a better house that contributes to a better environment.

The Earth Advantage program takes a "whole-house" approach to new construction and remodeling. The following characteristics are taken into consideration when building systems, measures and products are considered to be part of an Earth Advantage home. The next section provides details on program concepts and measures.

- **Healthier Indoor Air**
  Earth Advantage homes have fewer allergens, irritants, smells and hazardous chemicals in the living space. Common indoor air pollutant sources are reduced. Better fresh air ventilation options remove stale air and bring in fresh air.

- **Environmental Responsibility**
  Earth Advantage homes have several features that protect the natural environment. "Naturescaping," or landscaping with native, hardy plants, reduces the need for harmful pesticides that injure wildlife. Erosion control measures protect topsoil. Rain water is put back into soils, rather than going down storm drains. Construction waste is disposed of properly and recycled as much as possible.

- **Resource Efficiency**
  Earth Advantage homes use resources wisely. They use recycled-content building materials such as drywall, insulation and carpet that are made from wastes. They help stretch our forest resources by using wood more efficiently, by finding other products to replace wood and by promoting high quality materials made from smaller trees and wood byproducts. Water is conserved through efficient fixtures, appliances and irrigation systems.

- **Energy Efficiency**
  Earth Advantage certified homes perform 15% better compared to a home built with standard building practices. They have better windows, more efficient water heating, high efficiency heating and cooling options, and efficient lighting and appliances. Interiors can be more quiet and clean with fewer drafts, cold spots and cold windows. Comfort can be improved year-round.

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The Earth Advantage staff can provide duct-testing and house tightness testing to Earth Advantage builders. These tests quickly show exactly where air leaks are, for cost-effective home sealing.

Earth Advantage homes range from small spec-built units to high-end customs, from the simplest measures to the most high tech. Costs vary accordingly. But it is possible to put together a set of measures that is affordable even on starter houses. In general, Earth Advantage measures cost the same or a little more than standard practice. Your Earth Advantage representative can help you research and identify specific measures that can maximize effectiveness at the least cost.

Earth Advantage also gives a name and an identity to your better building practices. It lets your customers recognize the added quality and extra value your homes provide.

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HOW TO PARTICIPATE

The Earth Advantage program is a working partnership between builders and Earth Advantage. Builders select from a menu of options and agree to include them in their new homes in accordance with Earth Advantage specifications. Earth Advantage provides technical support to builders and certifies completed homes as having met the Earth Advantage standards.

Meeting the Standards

It is easy to meet Earth Advantage standards. Follow the steps below:

- **Meet with an Earth Advantage representative**
  Schedule an appointment by calling 1-888-327-8433. The Earth Advantage representatives will show you how easy it is to take advantage of the program. They will explain the standards and help you identify opportunities for making your homes Earth Advantage. Together you will review the Earth Advantage Points Worksheets and Earth Advantage Agreement.

- **Select the Earth Advantage measures you prefer**
  Earth Advantage is flexible and offers many options for meeting the standards. The choice of measures is up to you.

- **Complete the Earth Advantage Agreement**
  After you've completed your final selection of measures, you and an Earth Advantage representative sign the agreement.

- **Begin construction**
  Earth Advantage logos, yard signs and other marketing materials also are available. Contact an Earth Advantage representative for details.

During construction, the General Contractor is responsible for communicating the Earth Advantage measures to subcontractors so they can provide the proper materials and installations.

This is very important

Experience has shown that miscommunications are a potential weak link. Making sure the subs and their crews understand what is different on an Earth Advantage job-site will ensure successful completion. To help you with this process, an Earth Advantage representative can provide information sheets for specific types of subcontractor work. In addition, Earth Advantage Staff may conduct on-site visits, either on request or to confirm that Earth Advantage measures have been installed.

An Earth Advantage representative can be reached at 1-888-EARTH33 (327-8433) or 503-603-1677.

Testing and Technical Assistance

Earth Advantage staff can provide blower door air tightness testing to identify any major air leaks. Buildings with forced air heating can also receive a duct tightness test. Throughout the construction process, an Earth Advantage representative is available to answer technical or programmatic questions. The cost for these tests will be part of your Earth Advantage agreement. See the Earth Advantage pricing sheet.

Certification

Following completion and certification of the house, the General Contractor receives an Earth Advantage certificate to present to the homebuyer.

EARTH ADVANTAGE CONCEPTS IN DETAIL

This section describes Earth Advantage concepts in more detail. There is an explanation for why some measures were included in the program and what environmental issue the measure addresses. Measures were selected for the Earth Advantage program by extensive research into environmental problems and evaluations of the cost and availability of solutions. Each measure makes only a small change. But taken together, a set of measures makes a significant improvement in the environmental health of a building.

Some measures, such as non-polluting interior paint, can be carried out by selecting appropriate products. Other measures, such as recycling construction waste, involve building practices and methods.

Builders are encouraged to innovate—if there is a better way, please let your Earth Advantage representative know.

HEALTHIER INDOOR AIR

The quality of indoor air is an increasingly important concern for homebuyers. Air inside new homes may contain up to 100 times the pollutants of outdoor air ("The Inside Story: A guide to Indoor Air Quality," EPA Publication [402-K-93-007, April 1995]). Earth Advantage certified homes are designed with measures to reduce sources of pollutants and improve fresh air ventilation, and to provide healthier indoor air.

Healthier indoor air requires the installation of mechanical ventilation systems. To minimize chemical pollutants, low-toxin construction materials are used throughout the dwelling. Sealers, adhesives and paints meet low volatile organic compound (VOC) specifications.

How to Achieve Healthier Indoor Air

There are three steps to take for healthier, cleaner air in a new house or apartment:

- **Eliminate or reduce sources of pollution**
  Earth Advantage focuses on several sources of pollution that can either be reduced or eliminated. The easiest pollutants to control are radon, wood smoke and other combustion byproducts, interior paint and wood finishes, and outgassing from carpet and pads. Other pollutants that are more difficult and costly to control include formaldehyde, adhesives, floor coverings and pollution from garages. All of the pollutants targeted by Earth Advantage were selected because they are: common in new homes; health hazards well documented by objective scientific research; and practical to control using standard building practice and available alternatives.

- **Remove stale air, bring in fresh air**
  All houses should have effective fresh air ventilation to control excess humidity, odors, and carbon dioxide (or "stuffiness").

- **Filter the air**
  Air filtration is the "third leg of the stool" in maintaining healthy indoor air. Air filters can do an excellent job of capturing small particles such as dust, pollen, dander, mold and large bacteria. Several filtration options are available in the Earth Advantage program such as media, electrostatic and HEPA filters.

Formaldehyde Control

Formaldehyde, HCHO, is a natural substance found in minute amounts in animals and plants. At higher levels, formaldehyde is an irritant to most people. It can cause headaches, dizziness, mental impairment and a variety of other symptoms. It may cause cancer in people exposed to very high doses. Formaldehyde is found in several different building materials, but building products of particular concern include particleboard and fiberboard (MDF) because the type of glue used can outgas formaldehyde into the air.

- **What materials outgas formaldehyde?**
  Interior-grade particleboard, and some types of medium-density fiberboards, are made with urea-formaldehyde glue. This glue readily decomposes into urea and free formaldehyde, especially in the presence of higher temperatures and humidity. Particleboard is commonly used for underlayment, cabinet frames and shelving. Fiberboard is used in cabinets and paintable trim. These materials can outgas formaldehyde for several years in a new house.

  Plywood, oriented strand board (OSB), waferboard, I-joists and all wood composites rated "Exterior" or "Exposure 1" are made with phenolic resin, or phenol-formaldehyde glue. Although this glue contains formaldehyde, the chemical bond is strong, and it does not outgas to a degree that it should cause any problems in normal use.

What are the control options?
There are three common formaldehyde control options.

- **Seal exposed particleboard areas on cabinets**
  Formaldehyde can be sealed in. Any water-resistant finish, including laminate countertop, melamine-type plastics or wood finishes, will reduce outgassing. In cabinets, it is usually the backs and bottoms of the frames that remain exposed to the indoor air. These exposed areas can be sprayed with a water-resistant finish. This is an extra step that requires careful coordination to get done before the cabinets are installed.

- **Seal particleboard underlayment**
  Sheet flooring such as linoleum laid over particleboard underlayment will seal out moisture and slow outgassing from the top side of the boards. Other particleboard surfaces can be sealed with a water-resistant paint or wood finish.

- **Use formaldehyde-free materials**
  Formaldehyde-free medium density fiberboard (MDF), such as Medex and Medite II, can be used to replace particleboard. The material cost can range from 50% to 100% more than particleboard.

Combustion Products Control

Wood smoke contains many pollutants, including:
- Respirable particulates so small they bypass the body's defense and go deep into the lungs
- Benzo-a-pyrene, a powerful cancer-causing chemical
- Aldehydes, chemicals that irritate the lungs

Wood smoke is also an irritant to people with allergies and asthma.

- **Doesn't smoke go up the chimney?**
  Fireplaces and wood stoves have the potential to spill or draft" combustion products into the living space. Fireplaces are especially prone to backdraft when the fire is smoldering and flue draft is weak.

  The powerful fans in kitchen cooktops can pull smoke from stoves and fireplaces into the home. Forced-air heating systems often cause backdrafting. When a heating system is

starved for return air, it can depressurize the house and pull air from fireplaces and wood stoves.

- **What about gas fireplaces?**
  Burning natural gas can produce several pollutants, including carbon monoxide, nitrogen oxides, water vapor and carbon dioxide. Under normal operation, gas combustion does not produce carbon monoxide, but if a malfunction occurs, carbon monoxide gas can be generated and can cause carbon monoxide poisoning can occur. This gas causes that "stuffy" feeling because it interfere with the flow of oxygen to the body. Nitrogen oxides are also known to irritate the nose, throat and lungs, and to cause more colds and respiratory problems in children.

- **Is there a safe, non-polluting fireplace?**
  The only sure way to prevent smoke from polluting a house is to not install a fireplace or wood stove. To have the cozy warmth firelight without the hazards of smoke or fire, install an electric fireplace. Electric fireplaces look just like the wood-burning type, with an attractive mantel, hearth and decorative face. The units are easy to install because they do not require safety clearances or a chimney flue. The fireplace is installed completely inside the thermal envelope, so heat does not escape to the outdoors.

- **Other fireplace options for cleaner air**
  These options do not qualify for Earth Advantage points, but can reduce pollution. Brick and masonry fireplaces, such as the Russian fireplace, or Kakkelöffen, work by heating up a large mass that then radiates heat into the living space. These fireplaces are less likely to back-draft any smoke into the house because they burn short, hot fires with a strong draft. High-mass fireplaces give off gentle radiant heat for several hours after a fire. The heat is very comfortable.

- **Sealed combustion fireplace**
  Sealed combustion gas fireplaces pull in outdoor air for combustion and exhaust pollutants to the outdoors thus they are less likely to emit or backdraft pollutants into the house.

Volatile Organic Compounds Control

Volatile Organic Compounds, or VOCs, are carbon-based compounds that evaporate readily into the air. Generally speaking, hazardous VOCs are petroleum-based or contain chlorine. VOCs can also outgas from many common construction and finish materials.

Why are VOCs hazardous?
VOCs are a large group of chemicals that cause a wide variety of health problems, including eye and nasal irritation, headache, attention deficit, loss of memory and coordination, and impaired brain and liver function. VOCs include several known carcinogens.

They can easily cross body membranes such as skin or cell walls and they can be stored in body fat.

Where are VOCs found?
In new homes, there are many possible sources of irritating potentially hazardous VOCs. The most common include:

- **Carpet**, **carpet pad and carpet adhesive**
  There is controversy about the potential health hazards of carpet. Some laboratory tests show severe health effects on mice, while others do not. Many people report health problems they attribute to new carpet. However, the carpet industry strongly denies that carpet outgasses any harmful chemicals. Because there is disagreement about what, if any, hazards exist, there are no agreed-upon standards for a "safe" carpet. Generally, wool, cotton and natural fiber carpets such as coir and sisal are less likely to outgas harmful chemicals.

- **Interior paints**
  This includes both oil and latex types. Most paints release VOCs into the home. Often low/no-VOC products are manufactured without mercury or mercury compounds, or pigments of lead, cadmium or other oxides.

- **Interior wood stains and finishes**
  Wood finishes that are on site can be of concern, especially if they are petroleum based. Examples include floor, interior door and trims. Wood finishes that are applied outside the house should not outgas harmful vapors into the house.

- **Sheet vinyl flooring and vinyl adhesive**
  Sheet vinyl contains "plasticizers:' chemicals that are added to keep the vinyl plyable. These chemicals outgas VOCs. Vinyl adhesives may outgas potentially harmful VOCs.

- **Construction adhesives**
  These include framing, panel, plastic pipe, carpet, vinyl, cove, tile countertop adhesives and countertop adhesives.

  Some potentially hazardous finish materials have warnings such as "Avoid breathing vapors" or "Use only in a well-ventilated space." However, other materials may have no warnings.

  Some VOCs, such as those from adhesives or wood finishes, outgas quickly, so they may be a short-term hazard. But, these VOCs can be absorbed by drywall or fabrics. Other VOCs, such as those from carpets, may take many months to outgas

How can VOCs be controlled?

For each of the above materials, there are safer alternatives that are readily available and cost about the same as the hazardous materials and products. The challenge is to get subcontractors

to accept using new products they may be unfamiliar with.

- **Carpet, pad and adhesives**
  Select a carpet with the CRI Indoor Air Quality Testing Program label. This label shows that the manufacturer tests carpets for VOCs. Select a waffle-type pad. Specify low-VOC or water-based adhesive.

- **Interior paint**
  Select low-VOC or solvent-free latex paints. Green Seal certified paint is a good choice as the Green Seal organization has investigated the chemical composition of the paint and certified the product as meeting their standards. If choosing a Green Seal certified paint, please note that Green Seal VOC standard may allow a higher level of VOCs than Earth Advantage standards. Earth Advantage Healthier Indoor Air points may not all be awarded if the VOC level exceeds the Earth Advantage standard you are trying to achieve. Please check the paint can for the VOC level of the paint.

- **Wood finishes**
  Water-based stains and finishes, including durable coatings for wood floors, are available from several manufacturers. Their quality and performance is similar to solvent-based products.

- **Sheet flooring**
  Install linoleum, which does not emit irritating or harmful vapors. Linoleum costs about the same as a medium-quality vinyl to install. Low-toxicity adhesives are also available.

- **Construction adhesives**
  Solvent-based adhesives are being replaced by water-based types with similar performance.

Garage Separated or Sealed

The air in garages often contains pollutants from stored chemicals such as pesticides, herbicides, cleaners, hobby chemicals and auto exhaust. If a forced air heating system is located in a garage, these pollutants can be pulled into the living space. This happens when the supply and return air are out of balance. When there is a supply register in each room, but only one or two return registers, the heating unit may be "starved" for return air, and may pull air from the garage.

- **How can garage pollution be controlled?**
  Where possible, separate the garage from the house. No pollutants can enter the living space from a detached garage.

  A forced-air heating system should be balanced so that supply and return air-flows are the same. The return side ductwork in the garage should be carefully sealed, especially around filter holders.

Air leaks between the garage and living space can be sealed by caulking and sealing all penetrations in the wall and ceiling and running a bead of caulk or adhesive between the drywall and top and bottom plates, and around the entry door.

One benefit of checking duct tightness with a Earth Advantage "duct blaster" test is to make sure air is not pulled from a garage into the living space.

Radon Control

Radon is a natural element that is created as uranium decays into lead. It is an odorless, colorless gas found everywhere in soil and rock. When radon decays, it gives off radioactive particles (alpha particles) that can damage the lungs and cause cancer. In the PGE service territory, testing of houses has found relatively few cases of elevated radon levels. All of Oregon is either rated Zone 2 Modest potential (from 2 to 4 pCi/L) or Zone 3 Low potential (less than 2 pCi/L). Information can be found at www.epa.gov/iaq/radon/zonemap/oregon.htm and www.dhs.state.or.us/publichealth/rps/radon/levels.cfm.

- **How can radon be controlled?**
  Radon in soil can be kept out of living spaces by using standard building practices. Radon gas cannot penetrate through solid materials. So it can be blocked by a continuous barrier, such as a black-poly moisture barriers, concrete slabs or basement walls. Radon can leak through holes. The key is to seal all air leaks, because they can also be radon leaks.

- **Radon barriers**
  In crawl spaces, a 6-mil black poly moisture barrier can block radon if the edges are overlapped and sealed. The subfloor can block radon if all the air leaks and penetrations in the floor are sealed. Be sure to weatherstrip the crawl space access-hatch.

  When insulation is installed under the floor, the foundation can be left open year-round, so any radon gas that does enter the crawl space can also vent out.

  In slab-on-grade floors, black poly blocks radon when laid continuously. Seal all expansion joints, cracks, gaps or holes in the concrete slab.

  In below-grade walls, any gaps or holes, such as those around water lines, should be sealed.

- **Testing for radon**
  Inexpensive indoor radon test kits are available. For information on purchasing a radon test kit from the National Safety Council, please go to: www.nsc.org/ehc/radon/coupon.htm. As of this time, there no practical method for testing soil for radon prior to construction and predicting future radon in the completed house.

Allergen Control

There are several broad categories of allergens: mold/mildew, dust mites and pollens.

- **What are mold and mildew?**
  Mold and mildew are the same thing. Molds are fungi that release toxic chemicals into the air. Molds can cause several chronic low-level health effects, including allergic reactions, headache, dizziness, attention deficit, memory loss, sleep disturbance, nausea, skin rashes and gastro-intestinal problems. More serious effects include cancer and auto-immune diseases.

  Molds grow where surfaces are wet or damp, such as on wet framing wood or poorly drained basement walls. They can also grow where the relative humidity is high—greater than 70%. High humidity happens where there are cool surfaces, such as where the house is badly insulated (outside wall corners and top plates) or has air leaks (tongue-and-groove subfloors). For example, even in a room where the relative humidity is normal, a carpet pad over a cold floor can have a "microclimate" where the humidity is high enough to grow mold.

- **Controlling molds**
  Keep surfaces warm and dry. Make sure insulation is complete, without gaps or voids; air leaks are sealed so they don't cause cool spots; basement walls have proper drainage and damp proofing; and excess indoor humidity is controlled by exhaust fans.

  In the Pacific Northwest climate, excess indoor humidity can usually be controlled by bath and kitchen fans. High moisture sources, such as indoor spa tubs and clothes dryers, should be vented outside.

  Earth Advantage Energy Standards require better air sealing and windows, so homes are less likely to have cool spots where mold can grow. Better bath and kitchen fans designed to exhaust excess humidity are the primary way to stop the growth of mold and control areas with heavy moisture load. Ventilation options, such as the heat pump fresh air add-on, whole house ventilation systems and the heat recovery ventilator, do a good job of controlling excess humidity.

- **What are dust mites?**
  Dust mites are tiny insects so small that they can't be seen by the naked eye. Dust mites live on the skin flakes that humans continually shed, so they are found in carpets and pads, bedding and furniture—any place that humans occupy. Mite feces contain a protein that can cause an allergic reaction. About half of people with allergies and asthma react to dust mites. In some people the reaction can be very strong.

  In new homes, there are two ways to control dust mites. One is to install hard surface flooring such as wood, tile or linoleum in place of carpet and pad. These floors can be kept clean of skin flakes and mites. Carpets and pads harbor mites and special vacuums or chemicals are necessary to control them.

  The second option is to install a ventilation system that can keep the indoor relative humidity below 50%. At lower humidity, mites cannot thrive.

  In the Pacific Northwest, humidity in the house, can usually be controlled by exhausting humid

indoor air and bringing in drier outdoor air. The exception is the summertime, when air conditioning may be needed to reduce humidity below 50%. (It's important that the air conditioning system be correctly sized, so it will run long enough to dehumidify the home adequately. Oversized systems may not operate long enough to dehumidify the home and thus may lead to moisture problems in the home.)

A ventilation system for humidity control would include a humidity-sensing monitor (a humidistat), and a control to turn the ventilation system on and off. Ideally, these controls would respond automatically to changes in humidity, but manual control is an option.
In cool, damp locations, such as a very shaded site, a dehumidifier may be needed to control humidity and dust mites. Both stand-alone and built-in (to a heat pump forced-air system) models are available.

- **Pollens**
  Filtration for controlling pollens is addressed in the next two sections (Fresh Air Ventilation and Air Filters).

Fresh Air Ventilation

Whole House Ventilation options are: 1) fresh air intake; 2) fresh-air intake direct to the furnace; and, 3) heat recovery ventilator (HRV) or energy recovery ventilator (ERV).

- **Fresh Air Intake**
  This system is the minimum allowed in the Earth Advantage program and requires the installation of a central exhaust fan to ensure better day-to-day air-flow throughout the house. The system has three components:

  - A quiet central exhaust fan rated at 100 to 150 cfm (at 0.25" wg) at 1.5 sone
  - A 24-hour clock timer switch for the fan
  - Fresh air vents

  The fan is set to run for at least eight hours per day. This ensures that stale air is vented out daily. The central fan is separate from the bath and kitchen fans because these fans might not operate every day, or may come on only for very short periods.

  The clock timer switch is located in a utility area where it won't be confused with a heating control.

  The fresh air vents are located in each bedroom and one in the living area. The vents allow fresh outdoor air to flow through these rooms when the whole-house fan is running.

  There are two types of fresh air vents. The most common is a vent installed in the top of a window frame. The other type of vent is installed on an exterior wall. Closets located against exterior walls are a good location for these vents.

  This measure requires fans that actual perform as rated—that is, a 50 cfm (cubic feet per

minute) fan will really exhaust that much air. Experience has shows that fans rated at 0.1" wg, the standard measure, often don't perform. That's why the Earth Advantage program requires fans rated at 0.25" wg.

EARTH ADVANTAGE STAFF also recommends connecting all exhaust fans to smooth-metal exhaust duct for good air-flow.

- **Fresh air intake ducted directly to the furnace**
  With a fresh air intake, outdoor air is brought into the heating system and distributed through the supply ducts. This is usually done using four components:

  - An outside air duct into the return air plenum (ahead of the air filter)
  - A motorized damper on the outside air duct
  - A smart control box
  - A whole-house fan

  The smart control box includes a clock timer. When the box calls for ventilation, the outside air duct damper opens, and the heat pump fan turns on. The fan sends fresh air, mixed with room air, through the supply ducts and registers.

  The whole-house fan exhausts stale air. When the thermostat calls for heating or cooling, the outside air damper does not open and the whole-house fan does not come on. This prevents over-ventilating the house during peak heating and cooling periods.

- **Heat and Energy Recovery Ventilators**
  The heat and energy recovery ventilators are a complete fresh air ventilation system, providing the best combination of comfort, air distribution, stale air removal, air filtration, humidity control and energy efficiency. HRVs and ERVs costs range from around $1200 in a small house, up to about $2500 in large houses.

  - **Heat recovery ventilators** (HRVs)
    An HRV runs two separate air streams. One is exhaust air. The exhaust side picks up stale air in the bathrooms, utility room and kitchen, and sends it outdoors. The other side is the supply air, which delivers fresh air to bedrooms and living areas. Each side is ducted separately, and the air-flows are balanced. An HRV can be combined with a heat pump system to use the supply ducts to distribute fresh air.

    Inside the HRV unit, there is a heat exchanger. In winter, heat from the stale air leaving the house is transferred to fresh air coming in, warming it and making it more comfortable. In summer, heat is removed from outdoor air to cool the house. The unit also filters the incoming air.

    HRV controls offer the option of a humidity sensor that turns or ventilation when there is excess moisture in the air. This can help allergy sufferers by maintaining humidity below 50% and controlling dust mites.

- **Energy recovery ventilators** (ERVs)
  Energy Recovery Ventilators or Enthalpy Recovery Ventilators provide the same features and benefits of the Heat Recovery Ventilator but has the added benefit of being able to transfer a certain amount of water vapor from the exhaust air to the incoming fresh air. This feature is desirable in areas where it gets and stays cold. This is because the system helps maintain the humidity level of the inside air. This can help make the indoor environment more comfortable.

Air Filters

Air filters are an option, but are highly recommended, to improve the air quality of the house. You can choose between media filters, electrostatic or electronic filters, and HEPA (high efficiency particulate arrestance) filters.

- **Media filters**
  Media filters are made out of paper, plastic and/or fiberglass. Efficiency is usually measured by a standard called "ASHRAE 52-76 Atmospheric Dust Spot Efficiency" or DSE. Using this measure, a standard furnace filter is less than 5% efficient.

  Media filters of 30% efficiency are a good alternative and are available in sizes to replace standard furnace filters, cost less than $10, and do not interfere with the air-flow through the heat pump or HRV.

- **Electrostatic filters**
  These filters create an electric charge that attracts and traps particles, making them clump up and fall out of the air stream. They are very efficient as long as they are cleaned regularly. There are two types: the "electronic" uses AC power to generate a static charge; the "electrostatic" uses the air flow itself to create a charge.

  These filters are often rated by "arrestance," so they have efficiency ratings of 95% or higher. A rating of 92% arrestance is roughly equivalent to 30% dust spot efficiency in a media filter.

  The main concern with these type of filters is the quick drop in efficiency levels if the filter is not maintained on a regular schedule. If the filter is not maintained the efficiency level drops very fast and the HVAC system can potentially blow particulate matter around the house. If the particulate matter on the filter becomes moist it can become a breading ground for molds that then can be blown around the house.

- **HEPA filters**
  Higher efficiency media filters are available. The "HEPA" type that can remove more than 99% of particles is considered the most efficient. However, higher efficiencies may require a filter box to be installed in the return plenum, and a higher-capacity fan to overcome air resistance.

ENVIRONMENTAL RESPONSIBILITY

Earth Advantage certified homes are designed to reduce the impact on the environment by promoting environmentally sound building and landscape practices. Earth Advantage measures installed in a home are evaluated for their impact on environmental conditions. Earth Advantage promotes products that reduce damage to ecosystems and species. Earth Advantage homes include measures that minimize waste and promote environmentally sound building and construction.

Recycle Construction Wastes

Studies carried out by Metro, in Portland Oregon, show that almost all the waste created during construction of new homes can be recycled. Studies also show that recycling can save money, compared to disposal.

Major construction wastes (by weight) include wood scrap, drywall scrap, cardboard and metals—all of which can be recycled. Site-clearing wastes, such as soil and organic debris, may also be recycled. When all these wastes are recycled, close to 80% or more of construction waste can be recycled.

For builders who do their own recycling, the key is to keep wastes separated. This means telling the crew and subs where to put scraps into site dumpsters. Some subs, such as drywall and electrical, can sort their own wastes.

There are also clean-up companies that will remove all scrap and see that it gets recycled. They usually do not require crews to separate materials, and they can cost less than standard disposal.

To help contractors and developers recycle construction debris, Metro in Portland has developed a Construction Site Recycling Toolkit for the web. This guide lists recycling facilities and their distance from the construction site, descriptions of accepted materials, and includes helpful maps. This interactive guide can be found at:
http://www.metro-region.org/article.cfm?ArticleID=727

Metro also publishes a very helpful recycling guide for contractors. It is available by calling 503-234-3000, or on the web at: www.metro-region.org/article.cfm?ArticleID=899

Safe Disposal of Hazardous Waste

Building a house can involve using many types of hazardous chemicals (as defined by federal laws). Examples include adhesives, solvents, oil-based paints, thinners and wood finishes, pesticides, herbicides, form oil, motor fuel, oil and grease. These chemicals and their containers should be disposed of properly, and never buried on site or dumped into the street or a storm drain.

Another waste that pollutes when it goes into storm drains is concrete waste washed from trucks. Storm drains empty into streams and rivers, so any wastes dumped into them become

water pollutants.

The most effective way to prevent pollution by hazardous waste is to switch to safer alternatives, such as water-based or low-VOC finishes, cleaners, sealants and adhesives. Many municipal waste collection stations accept hazardous wastes for a small fee.

Recharging Groundwater

Recharging groundwater means returning rain to the soil instead of letting it run off the site. Rain water that runs off impermeable surfaces, such as roofs, driveways and streets, into storm drains causes a great deal of damage to streams and rivers. This water is also lost to the soil, requiring irrigation with potable water to replace it.

When rain runs off into storm drains, local streams receive a lot of water in a short period, which erodes the stream bed and washes out animals, fish, insects and plants. Storm water also carries pollutants such as oil and grease from roadways and parking areas.

In nature, rain is absorbed into the soil and held by organic matter, so water is available to plant roots throughout the summer. The soil also acts as a natural filter where pollutants can be decomposed.

There are several options for recharging groundwater:

- **Drain roof into on-site bio-swales or dry wells**
  Roof drains can be disconnected from storm sewers and connected to a surface bio-swale system, a sub-soil percolation field or a dry well. In Washington and Clackamas Counties, where drainage goes into the Tualatin River, cleaning up non-point pollution is a priority. In Portland, the city is trying to reduce the load on the combined sanitary and storm sewers.

  The system is inexpensive if the trenching is done during foundation excavation. Drains can be plastic french drains wrapped by filter fabric and laid on a bed of gravel.

- **Use permeable paving materials**
  A variety of concrete payers that drain water are available. Some are open-cell blocks. Others are payers or cobblestones with sand in the joints to let water into the soil.

  Permeable paving reduces runoff by letting rain water drain into the soil. Concrete paving blocks provide practical surfaces walking, parking and traffic, yet allow water to pass through. A variety of styles and colors are available.

  Where water does run off impermeable surfaces, it can be routed to landscaped areas which sometimes are called bio-swales.

Protect Soil

Healthy topsoil is valuable. It contains organic matter and organisms that support healthy plants and landscaping. When topsoil is removed from a building site, new landscaping

installed over subsoil has to be supported by lots of water, fertilizer, herbicides and pesticides until it can get established. That means more chemicals are likely to be washed off into streams where they may be harmful to birds and wildlife.

Construction activities often contaminate surface water. Grading activities remove plants and other protective ground covers, resulting in exposure of underlying soil. Bare soil can then be picked up by wind or washed away by rain or snow.

Several options for protecting the soil are:

- **Keep topsoil on-site**
  In this option, healthy topsoil excavated for footings and foundations is stored on- or off-site and respread during landscaping:

- **Erosion control**
  All local jurisdictions require at least minimal erosion control on building sites, such as black poly soil fences or compost. Smart, more effective, temporary measures to protect exposed soil are recommended:

  - "Bio-Bag" recycled wood chip bags to intercept eroded
  - Geo-fabric mats to hold soil in place until new grass or plants are established
  - Temporary seeding to establish grass or ground cover
  - Compost mulch to cover soil and absorb the force of rain
  - Divert surface water flows away from, or around, exposed soils
  - Create settling basins or ponds
  - Use vegetated swales (shallow ditches) to filter soil out of surface water runoff
  - Clean out catch basins regularly (ask your local street maintenance department)

  Where the developer is designing a site, the choice of narrow streets can greatly reduce erosion and loss of existing trees.

Protect Existing Trees

Existing mature trees are a valuable feature in a new home. They increase worth and livability. Trees:

- Clean the air by intercepting particulates
- Absorb carbon dioxide
- Provide cooling during summer by transpiring soil moisture into the air
- Provide shade
- Enhance privacy
- Add beauty

Usually, if existing trees are damaged or killed during construction, it is through accidental injury—cutting off roots when trenching, crushing roots with heavy equipment, or smothering roots by dumping soil over them. Knocking off bark also weakens or kills trees.

Preventing such accidents requires clear communication between the general contractor and the subs that operate heavy equipment on the site.

Trees to be protected should be clearly marked. The drip zone of each tree should be marked with a fence or tape-line to keep equipment from working under the tree.

Where necessary, trees should be trimmed or pruned by a professional arborist.

Naturescaping

"Naturescaping' means using native plants in landscaping. Many native plants are already popular, such as vine maple, Oregon grape, salal and rhododendrons. Others, such as red currant, bunchberry or wild rose, are less well known, but also fit well into landscaping designs.

Two naturescaping options are:

- **Use Hardy Native Plants**
  Native plants offer several benefits. They grow well in Oregon soils, so they require less supplemental water and fertilizer. They are resistant to many diseases and pests, so they need less herbicides and pesticides. Their flowers and fruits provide food and habitat for birds, butterflies and wildlife. They are well-adapted and hardy in our climate.

  A list of some common, readily available and popular native plants can be found at www.cleanrivers-pdx.org/pdf/native_plant_list.pdf or www.audubonportland.org/pdf/native_plants.pdf.

- **Use Less Lawn**
  In this option, the total area of lawn on the site is reduced. Lawn is replaced by other landscaping.

  Lawn grass usually requires a lot of irrigation water—about the same amount as we get in annual rainfall, 35 to 40 inches. However, lawn needs most of the water during the driest time of year, so natural rainfall isn't adequate to keep a lawn green.

  Lawns also requires a lot of fertilizer, pesticides and herbicides to stay green and lush. Birds are especially prone to getting sick from eating insects treated with yard chemicals.

  Few homeowners are willing to reduce the water and chemicals and let their lawn be less than perfect. The most practical way to reduce the environmental effect of lawn is to reduce the amount, or area, and use ground covers.

Safe Outdoor Wood

In the past, wood has been preserved from weather, insects and rot with very hazardous chemicals, such as creosote and pentachlorophenol. Wood preservatives, such as CCA (Copper-Chromium-Arsenate) were an improvement, but still can be hazardous and can escape into the

environment. CCA is being phased out, but may still show up in some lumberyards until existing stock is depleted.

Two options for outdoor wood:

- **Use Safer Wood Protection**
  Wood treated with less hazardous chemicals is available. When treated wood is used as mudsill or foundation post, the material has an extended life in moist conditions, reducing maintenance and enhancing longevity. Alkaline Cooper Quat (ACQ), Copper Azole, and Borate treated wood or similar is required for these points. No CCA or ACA type treated wood is allowed to claim these points. The phase out of the sale of CCA and ACA chemicals took effect December 31, 2003. Existing stock of chemicals and treated wood can continue until existing stocks are depleted.

  Note: ACQ and copper azole are corrosive to untreated metal fasteners. Check manufacturer's specifications for approved fasteners.

  Earth Advantage discourages use of naturally rot-resistant woods, such as cedar and redwood, because these trees are scarce.

- **Use Plastic Lumber**
  Waste plastics are being recycled into several types of "plastic lumber." Usually, the plastic is mixed with wood, fiberglass or other fiber to give it tensile strength. High-quality plastic lumber appears to be weatherproof, insect-proof and rot-proof, without any hazardous chemical treatments. One manufacturer claims its plastic lumber is much less slippery than wood when wet. Plastic lumber can work well in outdoor applications such as decks, fences and walkways.

Land Use

Within Oregon, the urban growth boundaries have been established limiting the land available for development. Using the available developable land effectively is important.

- **Size of Lot**
  The Metro 2040 planning goals in Portland call for increasing density around light rail stations and at designated areas where facilities, such as streets, have the capacity for serving higher densities. Projects that support these goals help reduce urban sprawl and the loss of farm and forest lands, support transportation options, and make efficient use of public facilities and infrastructure (roads, sewers, water). Density levels that qualify for bonus points in the Earth Advantage program are 10 single-family units per acre and 24 units for multifamily developments of developable land.

- **Size of Home**
  This measure rewards smaller houses. The average size house being built in the United States is 2,500 sq feet. This is more than double the size of an average house built in 1950 (1,200 sq feet). Projections are that the average size of a house will continue to get larger. Larger houses mean that more raw materials need to be consumed to build the house. Couple this

with the average size family becoming smaller, much more raw material resources are being consumed to house the average homeowner.

While there are no measures associated with these concepts, they are recommended by Earth Advantage.

- **One-car or No Garage**
  Autos consume large amounts of energy and produce large amounts of air and water pollution. Reducing auto trips directly benefits the environment. More and more homeowners are willing to reduce auto travel and use public transportation for trips such as commuting. A one-car garage indicates that the buyer will have one instead of two cars. This option is most practical for houses located near bus or light rail.

  No garage indicates that the homeowner will walk, use public transit, or other options such as bicycles.

- **Locate on Transit Line**
  If you select this option, the dwelling must be located close enough to a bus or light rail line to make it very easy to use public transit. The distance is negotiable, but generally is not more than two blocks.

  The 1995 "City Life" project, a mix of townhouses, condominiums, and a duplex, is located in a Portland neighborhood, one block from a major arterial and bus lines. No garages were included in the project. All the units sold within two months of completing construction.

- **Mixed Use Development**
  Developments that mix housing, shopping and work are becoming more common. For example, the Earth Advantage Belmont Dairy project in southeast Portland is designed with lofts above on-street retail stores. The Earth Advantage Hollywood Library project has affordable housing apartments above the library. The Earth Advantage Museum Place South project incorporates a grocery store at the ground level and apartments and condos above.

  The River District in Portland mixes houses, retail shopping, public buildings and office buildings. These developments encourage walking and bicycling by making distances convenient for short trips and shopping.

Sunlight/Solar Options

Sunlight kills pathogens. It is also important to mood, helping prevent Seasonal Affective Disorder—a type of depression associate with dark winters.

Orienting major glazing areas to the south is the simplest way to ensure sunny interiors as well as the benefits of solar heating and natural cooling.

- **Sun Tempering**
  Sun tempering orients major glazing areas to the south to take advantage of solar warming

during winter, and natural shading and cooling during summer. Sun tempering can reduce annual heating energy use by about 5 to 10%. It can add daylighting to provide a sunny interior, and experience shows that Pacific Northwest buyers like daylighting. Sun tempering adds no cost; it is a design measure.

Sun tempering design guidelines include:

- 50% or more of the summer sun dwelling's glazing area faces south, within ±30°.
- The south glazing is open to the sun in winter (between 9:00 am and 3:00 pm on December 21st) and won't be shaded by buildings or trees.
- South roof overhangs are 1-1/2 to 3 feet deep for summer shading.

- **Natural cooling**

  In the Willamette Valley, natural cooling can keep a house comfortable through all but the hottest days of summer.

  Natural cooling includes a combination/mix of the following measures:

  - West-facing glazing on living spaces is not more than 10% of the total glazing area. The purpose is to prevent summer overheating by low afternoon sun.
  - Overhanging eaves shade walls and windows in summer. The overhang should be 1-1/2 to 3 feet wide.
  - Vents along the full length of eaves or soffits and the roof ridge reduce the buildup of hot air in attics.
  - Large shade trees near a building cool it in two important ways. First, a tree absorbs hot sun before it reaches the building. Second, a tree transpires water from the ground into the air. As this water evaporates from leaves, the air is cooled. Trees also temper the brightness of summer sunlight, which makes it more comfortable for most people. This adds to the feeling of coolness.

- **Solar Water Heaters**

  In Oregon's climate, solar panels can provide about half a family's annual energy for hot water. Today solar systems offer improved, more reliable protection from freezing as well as lower maintenance. With the Oregon State income tax credit for solar water heaters, the initial cost of a system is reduced and the payback is shorter. Solar panels are also a good choice for heating outdoor swimming pools.

RESOURCE EFFICIENCY

Earth Advantage certified homes are designed to use resources wisely. Earth measures include durable, long lasting products made of recycled materials or natural materials that reduce the use of natural resources such as timber and petroleum products. Earth Advantage homes include measures that minimize waste and promote environmentally sound building and construction practices.

Efficient Use of Wood

There are two ways to reduce the amount of wood used during construction.

- **Use Composites**

  Composite wood products make much better use of trees than solid lumber. When dimensional lumber is sawn from a tree, only about half the tree is used. When a tree is chipped up and then reformed into composite products, such as oriented strandboard, nearly all the tree is used.

  Composites, such as floor trusses, offer higher strength with less material. A truss uses about 40% less wood than the same size lumber joist. And composites are usually pre-cut to fit the house plan, so very little scrap is generated.

  Dimensional lumber must be cut from high-strength trees such as Douglas fir. Composites can be made from less valuable trees, such as aspen or poplar.

  Wood, especially wood from second-growth trees, is often flawed. Lumber may be warped, cracked or checked. Lumber shrinks as it dries out, which can cause problems such as drywall corner cracks and squeaky floors. Composites are straight and uniform and do not shrink.

  Examples of composite materials are:

  - Floor trusses and subflooring
  - Studs
  - Rafters and beams
  - Interior trim
  - Decking

- **Use Advanced or Intermediate Framing**

  "Advanced Framing" includes several different measures that can reduce the amount of lumber. These can include:
  - Wall framing on 24" module
  - Ladder blocking to replace stud channels
  - Sandwich headers
  - Reducing non-structural components, such as excess window cripples or headers on gable ends
  - Drywall fasteners to replace blocking and nailer studs

These measures were all developed by the National Association of Homebuilders in a research report titled "Reducing Home Building Costs with OVE (Optimum Value Engineering) Design and Construction." These measures have been accepted in codes. They have been widely adopted in practice. (CABO Code includes a chart showing when 24" framing modules can be used.)

Half-inch drywall can span 24" framing without waviness. But if this is a concern, "high density" ceiling board can give more confidence at only slightly more cost (about 10%). Sidings such as 5/8" T1-11 (Channel and Reverse Board-and-Batten) are rated for 24" span. Insulation batts are available in 22-1/2" width to fit the cavities.

Intermediate Framing includes all the features of Advanced Framing, except the module can remain at 16" on center.

Sustainable or Salvaged Wood

Another option is to use low-impact wood that has either been recycled or sustainably harvested.

- **Use Salvage Wood or Wood Replacements**
  Earth Advantage encourages the reuse of wood. Many builders have tried resawn lumber for flooring, beams and trims with excellent results. Clear, tight-grain wood is getting difficult to find, and is very expensive. So salvage wood is a viable alternative.

  New wood-like products have appeared that replace wood. For example, bamboo flooring that looks and performs like wood is available. Bamboo is a type of grass that grows quickly.

  Some forests are managed to harvest trees, yet keep the forest healthy. Trees are harvested individually and removed without damaging surrounding trees. Cut branches and trimmings are left to decay into new soil, instead of being burned or chipped. The healthiest and biggest trees are left to seed future generations, instead of being cut. Harvesting is designed on a long rotation, so young trees have time to grow back and replace cut trees.

  These sustainable forests have been independently certified by organizations such as Scientific Certification Systems and the Rainforest Alliance using the Forestry Stewardship Council (FSC) certification system.

- **Non-wood Structures**
  Several structural systems have been developed to replace wood framing. The most common at this time are foam-core panels, foam-filled blocks filled with rebar and concrete, and steel framing. These systems have many performance benefits compared to wood, and may be cost-competitive, depending on the type of building and the price of wood.

- **Structural Insulated Panels (Foam Panels)**
  Foam panels sandwich expanded polystyrene (EPS) foam plastic between two sheets of composite oriented strandboard (OSB). The assembly is glued together under high pressure. The panels are stronger than framing and more earthquake-resistant.

EPS contains no chlorofluorocarbons (CFCs) or chlorine, and does not outgas harmful chemicals. To make EPS foam, one quart of oil is expanded to make 40 quarts of foam. Note that EPS is not the same as "blueboard."

EPS does not burn or sustain a flame. When exposed to high heat, it does smoke. The smoke is toxic to humans, but probably no more so than smoke from other building components or furnishings.

The panels have several benefits. They are pre-cut to the house plan, so they can go up very fast. Because little cutting is needed, not much waste is produced. They contain about 75% less wood than a framed wall. Panels have higher insulation value, reduce air leakage, and resist moisture and rot. Some panels are treated with borates to keep insects from burrowing into them. Siding and drywall can be nailed into the panels.

- **Insulated Concrete Forms**
  There are several ICF block systems on the market. Most use (expanded polystyrene) EPS blocks or panels that are laid up in courses, rebar installed, and concrete poured into cavities in the blocks. There are other systems such as Rastra uses recycled foam and a concrete mix to create the blocks. Another system uses waste wood shredded up and a concrete mix to create the blocks.

  Like foam panels, concrete-filled ICF block walls are very strong and earthquake-resistant, and they go up quickly. They also have high insulation values, are airtight, and are moisture resistant.

  ICF blocks lend themselves to stucco exterior finishes. Interior drywall is glued on or screwed into metal strips embedded in the blocks. Some builders furr out interior walls. Blocks can also be treated to resist insects.

- **Recycled-content Products**
  Many building products are being made with materials that were once thrown away. These materials deliver performance and quality at competitive prices.

  For example, recycled polyethylene terpthalate (PET) carpet made by Image Industries uses plastic from soda pop and catsup bottles. The company recycles more than 200 million pounds of bottles per year into carpets.

  Recycled content products "close the loop," by diverting wastes from landfills and turning them into new materials.

- **In-house Recycling**
  To make it easier to recycle household wastes, kitchens can be designed with built-in recycling stations. These stations can range from simple wire baskets on a cart, to built-in cupboards and drawers with removable containers.

Recycling storage can also be located in the garage or another utility area, such as a laundry room. Household recyclables include newspaper, magazines, scrap paper, metals, plastic containers, dairy cartons, glass and deposit bottles and cans.

- **Drywall**
  Recycled drywall products include all types, such as underlayment, soffits and green board. All drywall is covered with recycled paper.

- **Insulation**
  Blown-in cellulose insulation is made from recycled newspaper and wood fiber. The insulation can be blown into attics and walls, and some companies can wet-spray into open wall cavities.

  Some fiberglass insulation contains recycled glass. Rock wool is made from recycled mineral slag left over from metal smelting. Amoco green foamboard contains more than 50% recycled post-consumer foam scrap.

- **Carpet**
  Image carpet is made from recycled plastic bottles. The bottles are chipped up and melted. The plastic (PET) is then extruded into fiber, which is then dyed and woven.

  PET carpet is suitable for residential uses. It is naturally stain-resistant, and does not outgas any harmful or irritating chemicals.

  Commercial carpet companies, such as Shaw, Collins & Aikman and Interface, recycle worn carpet. They are also recycling in-house at their manufacturing plants.

- **Ceramic Tile**
  Recycled-content tiles look and perform like any other ceramic tile. The difference is that they contain recycled glass.

- **Paint**
  Recycled unused waste paint is collected, filtered and mixed to consistent colors and sold through retailers in Portland and other areas.

- **Brick**
  Mutual Materials makes bricks that contain about 15% recycled used brick, saving on energy to fire the new brick and reusing a waste material.

- **Wall Coverings**
  The Homasote Company makes fabric-covered "DesignWall" boards in a variety of colors. The board is 100% recycled cellulose, and the fabric is jute. The boards make good tack walls.

- **Roofing**
  Several new roofing products include recycled materials. Cern-Wood roof shingles are made with a mix of wood fiber and cement.

Classic Products shakes are recycled aluminum. Also available are recycled plastic roof, gable and soffit vents.

- **Landscape Walls**
  A Portland company, The Wall, recycles concrete into outdoor landscape walls. Recently the company has developed an exterior recycled wall finish that looks like stone.

- **Natural Flooring**
  Linoleum is made from natural non-toxic materials such as wood flour, ground limestone, pine resin, linseed oil, cork, jute and natural pigments. It has excellent wear characteristics and is available in a variety of colors and styles. Linoleum is non-toxic and replaces sheet vinyl flooring—an oil-based product that may outgas harmful chemicals.

  Flooring is also available that is made from natural fibers, including jute, coir (husk of coconut) and sisal. These fibers are very tough and long-lasting. For flooring, they are woven into handsome fabrics in natural colors and dyed patterns.

- **Concrete with Fly Ash**
  Fly ash is precipitated from coal smoke by "scrubbers" in smokestacks. Fly ash has been mixed into concrete for many years. You can let your concrete supplier know you are interested in using fly ash, and ask if it is suitable for your application.

Water Efficiency

Earth Advantage offers multiple ways to use water more efficiently:

- **Water-efficient Fixtures**
  Lavatory faucets with low-flow aerators can reduce water use by restricting

- **Water-saving Appliances**
  New energy and water efficient clothes washers and dishwashers offer an excellent opportunity to reduce household water use.

  Efficient clothes washers can save both water and energy, while reducing wear on clothes. The key is a design that uses a horizontal drum, so the washer is front-loading. These washers use much less water. (For example, the Asko model uses 14 gallons per load, as compared to 47 for a conventional washer—saving a typical family about 15,000 gallons of water per year.) Because these washers can spin faster and get more water out during the rinse cycle, less drying is needed—using less energy.

  The washers have no central agitator, so clothes wear out less quickly. They also use only about half the detergent, and rinse it out more thoroughly.

  New dishwashers use less than half the water and energy of conventional units. They are also much quieter. Some have stainless steel interiors for extremely long life.

Irrigation Systems

Irrigation systems can be operated by timers and moisture sensors to ensure that water is not wasted. Timers are available from all major irrigation manufactures.

Other water-saving irrigation options:

- Multi-cycling (for multiple start timers)
- Low trajectory nozzles and pressure-compensating devices, or micro-spray nozzles
- Zoned systems
- Low-volume (drip is an example) irrigation systems

ENERGY EFFICIENCY

Earth Advantage certified homes are designed to perform at least 15% better than local building practices. High efficiency appliances, lighting, windows and doors all make a difference in Earth Advantage homes. In addition, tighter house-sealing practices and higher insulation levels help reduce energy use. Higher furnace and water heating efficiencies also improve the performance of the house.

Key Features of Energy Efficient Homes

When properly used in home construction, energy features can help a home operate more energy efficiently, improve the indoor air quality, enhance the comfort of the homeowners, minimize moisture problems, and increase long-term durability of the home.

The following features are ways to improve the energy efficiency of new homes:

Create a continuous air barrier system

By creating a continuous air barrier system the air leakage between conditioned and unconditioned spaces can be minimized. Understanding how air moves in and out of a home is important. The following describes the forces that can cause air to move between conditioned and unconditioned spaces.

Air Leakage Driving Forces

Experience has shown that the air sealing measures in the 1992 Oregon Energy Code have helped ensure much more comfortable, draft-free new houses. However, Code-minimum sealing may leave some gaps—enough to cause discomfort problems and significant energy losses.

All homes allow some amount of air infiltration through gaps, holes, and penetrations in the building envelope. The air exchange rate can be highly variable from house to house. Recognized standards recommend a maximum of 0.35 air changes per hour (approximately 1/3 of the air in the dwelling is replaced in one hour). The problem with a house that is not sealed well, the air infiltration comes in from crawlspaces, attics, garages and wall cavities. This air can bring pollen, dust, mold, radon, humidity, insulation fibers, and other contaminates into the house.

The most important air leaks to seal are those at the top and the bottom of the house, especially on multi-story houses. This includes any air channels that run all the way from the bottom to the top of the house, such as duct or flue chases.

Air leakage in a home are brought about through:

- Holes – the larger the hole, the greater the air leakage. Large holes have higher priority for air sealing efforts.
- Driving force – a pressure difference that forces air flow through a hole. Holes that experience stronger and more continuous driving forces have higher priority.

The common driving forces are:

- Wind – caused by weather conditions
- Stack effect – upward air pressure due to the buoyancy of air.
- Mechanical blower – induced pressure imbalances caused by operation of fans and blowers.

Wind is usually considered to be the primary driving force for air leakage. When the wind blows against a home, it creates a high-pressure zone on the windward areas and a low-pressure zone on leeward areas. Outdoor air from the windward side infiltrates into the home while air exits from the leeward side. Wind acts to create areas of differential pressure which cause both infiltration and exfiltration.

The temperature difference between inside and outside causes warm air inside the home to rise while cooler air falls, creating a driving force known as the stack effect. The stack effect is weak but always present. Most homes have large holes into the attic and crawl space or basement. Because the stack effect is so prevalent and the holes through which it drives air are often large, it is usually a major contributor to air leakage, moisture, and air quality problems.

Poorly designed and installed forced-air systems can create strong pressure imbalances inside the home which can increase air leakage whenever the heating and cooling system operates. In addition, unsealed ductwork located in attics and crawl spaces can draw pollutants and excess moisture into the home. Correcting duct leakage problems is critical when constructing an energy efficient home.

Pay close attention to these areas:

- **Recessed lights**
  One common air leakage area at the top of a house is created by recessed light fixtures. The fixtures not only leak air; when the lights are on, the heat of the light bulbs can actually drive warm air into the attic or vault—causing the fixture to act just like a warm chimney. "Air-lock" type fixtures do not leak air. Correct installation of these fixtures is important to keep the integrity of the home's envelope.

- **Tub drains**
  Another big leak is the hole cut in the subfloor for the drain under tubs and showers. This hole may be as much as a foot-square. One way to seal it is to cut a piece of foamboard or plywood to fit around the drainpipe, and seal with expanding foam.

- **Flue chases**
  Metal flues located inside chases may leak a lot of air because the chase is tall and it acts like a chimney, letting warm room air leak out. One way to stop this leak is to seal between the flue and the chase at the fire blocking. A sheet metal collar can be cut to fit snugly between the framing and the flue.

- **Windows**
  The Earth Advantage window U-value minimum is 0.35, instead of the Code minimum of 0.40. Usually, a Code window can be improved to Earth Advantage efficiency by adding argon gas fill. Manufacturers also offer different types of low-emissivity, or low-e, coatings. The more efficient windows may have a better coating and wider air space.

Heating Systems

Heat Pump
- Heat pump efficiency of HSPF 8.0 or better for split systems (separate indoor and outdoor units)
- Ductwork leaks sealed

The HSPF, or Heating Season Performance Factor, of 8.0 is recommended. New units are now available that are even much more efficient.

The most efficient heat pump unit can be compromised by leaky ductwork. Duct leaks can restrict the amount of supply air reaching rooms, reducing comfort. Leaks on the return can pull in air from an attic, garage or crawlspace.

Research studies conducted in the Pacific Northwest have shown that air leaks in typical forced-air system ductwork can cause 15 to 30% of the conditioned air to be lost. Typically, supply and return ducts are in unconditioned spaces such as attics and crawls. Ducts may leak at joints, especially at distribution plenums, air handlers and at floor boots. Panned joists are no longer allowed in Oregon. The air handler blower pressurizes the ducts, forcing air out at the supply leaks and pulling air into the return.

The same studies have shown that unbalanced supplies and returns increase the overall leakage of the house substantially. This usually happens when there are more supplies than returns, so the return side "balances" the system by pulling in make-up air from attics, garages or crawlspaces.

Mastic, or approved foil tape with thick adhesive, is required for duct sealing. Field studies have shown that cloth duct tape may not stay sealed over time.

Create a continuous insulation barrier

Install insulation continuously as possible between conditioned and unconditioned spaces. Areas of most concern are:
- Exterior walls
- Floor systems over unconditioned or exterior spaces
- Ceilings below unconditioned or exterior spaces
- Wall areas adjacent to attic space – such as knee walls and attic stairways
- Wall areas that extend into unheated basements – such as basement stairways

Select and install energy efficient windows

- Design home with minimal east and west glass area, locate additional glass on south side for passive heating in winter months

- Use double-glazed windows with U-vales of 0.35 or better
- Use low-emissivity coatings and other high performance features
- Shade windows in summertiime

Design heating and cooling system for efficiency

- Select high efficiency equipment designed for local climate conditions
- Size and install equipment properly
- Use Manual S, Residential Equipment Selection, to help select the equipment for the home published by the Air Conditioning Contractors Association (ACCA)
- Use Manual J calculations for sizing the heating and cooling system published by ACCA
- Eliminate potential for backdrafting of combustion appliances
- Install fresh air ventilation systems to bring in outside air when needed

Seal ductwork

- Design ductwork using Manual D published by ACCA
- Size ductwork to meet the heating and cooling load of each room
- Lay out ductwork to supply proper airflow; measure airflow to assure comfort
- Seal all duct leaks, except those in removable components, with mastic or mastic plus fiber mesh
- Seal leaks around removable components with the proper tape

Domestic water heating

Water can be heated by a variety of sources, electric, gas, warm waste-water, propane, and the sun. No matter what the source is to heat the water, using efficient equipment and products that control the use of water will make for a cost-effective operation. The following are measures that should be considered for incorporated into your project:

- **Electric**
  Tank Energy Factor (EF) of 0.93 or higher.
- **Gas**
  Tank Energy Factor (EF) of 0.61 or higher
- **Instantaneous Gas**
  The use of demand water heater can eliminate up to 33% of the stand-by loss from conventional tank models. The unit must meet the Oregon Department of Energy Residential Energy Tax Credit specifications for credit.
- **Solar**
  A solar hot water system consists of a solar panel positioned on the roof of a dwelling facing south or within 30° of south collecting the solar heat and transferring that heat to an exchanger in a holding tank. The pre-heated water from that tank flows into the main water heater, which allows the primary tank to use less energy to heat the water.
- **Set tank thermostat at 120° F**
  Setting the hot water tank temperature to 120° F saves energy and helps protect occupants from accidental scalding. The dishwasher can heat up its own water with its internal booster heater.

Choose energy efficient appliances

Major appliances can use a significant amount of energy to operate. Most appliances last for many years with some last 20 or more years. Therefore, an appliance that isn't as energy efficient as other models will lock the homeowner into paying higher operating costs over the life of the appliance.

In general, look for the Energy Star® label, which ensures your client that the appliance is in the upper tier of energy efficient models. In the State of Oregon, the Oregon Department of Energy has a Residential Energy Tax Credit program that offers a tax credit on qualified major appliances. Please see www.energy.state.or.us/res/tax/taxcdt.htm for more information on systems and tax credit amounts.

Dishwashers

Things to think about when selecting a dishwasher:

- Water heating accounts for close to 80% of energy use
- Models using less water use less energy
- Look for models that have light, medium, and heavy cycle options
- Select models with supplemental or booster water heater and then set the water heater to 120%
- Model should have energy saving "air dry" or "no-heat dry" switch

Clothes Washers and Dryer

Things to think about when selecting a clothes washer:

- Select an energy and water efficient model – typically a front-load washer, though some top-load washers use as little water to wash the same size load as a front-loader
- Select a model that offers several wash and rinse cycles

Refrigerator

Things to think about when selecting a refrigerator:

- The most efficient models are in the 16 to 20-cubic foot range

Energy efficient lighting

Compact Fluorescent fixtures

These fixtures are designed to only accept fluorescent lamps. The variety of available fixtures has increased dramatically over the past few years.

Compact fluorescent lamps

The number and sizes of compact fluorescent lamps has increased dramatically in the past few years. The options to look for are lamps that will provide the same type of light quality of incandescent models. Look for lamps with a color rendering index of 82 or better and a color temperature of 2700 to 3000 kelvin.

T8, T5 and T2 options

Many new fixtures have been developed that incorporate the T8 (1") fluorescent technology. This smaller diameter bulb allows the fixture to have a smaller profile allowing it to be used in many more locations than the T12 (1 1/2") lamp fixture. Newer developments have made the fluorescent tube even smaller in diameter with the introduction of the T5 (5/8") and T2 (1/4") lamps. This has

allowed the incorporation of the fluorescent lamps into applications such as under the base cabinet and under top cabinet applications.

Dimmer Switches
Dimmer switches are designed for lowering the light output of lamps. This corresponds to using lower energy though it is not an equivalent lowering of the energy consumption for all sources. Please note that not all fluorescent lamps can be dimmed. Please check the manufacturer's directions for the lamp.

Motion Sensor / Occupancy Sensor
Motion sensors control the lighting by detecting either motion or heat in a space. This can lower the consumption of energy. Please note that not all fluorescent lamps are compatible with these controllers. Please check manufacturer's directions for the controller and lamp.

Passive solar designs

Your home's windows, walls, and floors can be designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design because, unlike active solar heating systems, it doesn't involve the use of mechanical and electrical devices, such as pumps, fans or electrical controls to move the solar heat.

Five Elements of Passive Solar Design:

Aperture (Collector): the large glass (window) area through which sunlight enters the building. Typically, the aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9 a.m. to 3 p.m. each day during the heating season.

Absorber: the hard, darkened surface of the storage element. This surface—which could be that of a masonry wall, floor, or partition (phase change material), or that of a water container—sits in the direct path of sunlight. Sunlight hits the surface and is absorbed as heat.

Thermal mass: the materials that retain or store the heat produced by sunlight. The difference between the absorber and thermal mass, although they often form the same wall or floor, is that the absorber is an exposed surface whereas storage is the material below or behind that surface.

Distribution: the method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes—conduction, convection, and radiation—exclusively. In some applications, however, fans, ducts, and blowers may help with the distribution of heat through the house.

Control: roof overhangs can be used to shade the aperture area during summer months. Other elements that control under- and/or overheating include: electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

Performance Testing

To help ensure a properly designed and installed air handler system and the air tightness of the shell of a home, several performance tests can be conducted. These tests will help identify weaknesses in the systems being tested and help show where corrective measures can be taken to improve the performance of the system being tested.

- **Duct Testing** – The best method to ensure airtight ducts is to pressure test the entire duct system, including all boot connections, duct runs, plenums, and air handler cabinet. Much like a pressure test for plumbing, ductwork can be tested during construction so that problems can be easily corrected.

  In most test procedures, a technician temporarily seals the ducts by taping over the supply registers and return grilles. Then, the ducts are pressurized to a given pressure – usually 25 Pascals. This pressure is comparable to the pressure the ducts experience when the air handler operates.

  The ducts are usually tested for tightness using a duct testing fan. Measuring the airflow through the fan gives an estimate of the air leakage through unsealed seams in the ductwork.

- **Blower Door Testing** – While there are many well known sources of air leakage, virtually all homes have unexpected air leakage sites called bypasses. These areas can be difficult to find and correct without the use of a blower door. This diagnostic equipment consists of a temporary door covering which is installed in an outside doorway and a fan which pressurizes (forces air into) or depressurizes (forces it out of) the building. When the fan operates, it is easy to feel air leaking through cracks in the building envelope. Most blower doors have gauges which can measure the relative leakyness of the home.

  One measure of a home's leakage rate is air changes per hour (ACH), which estimates how many times in one hour the entire volume of air inside the home leaks to the outside. The example, a home that has 2,000 square feet of living area and 8-foot ceilings has a volume of 16,000 cubic feet. If the blower door measures leakage of 80,000 cubic feet per hour, the home has an infiltration rate of 5 ACH. The leakier the house, the higher the number of air changes per hour, the higher the heating and cooling costs, and the greater the potential for moisture, comfort, and health problems.

To determine the number of air exchanges per hour, many experts use the blower door to create a negative pressure of 50 Pascals on the home. Fifty Pascals is approximately equivalent to a 20 mile-per-hour wind blowing against all surfaces of the home.