Key Concepts

Module will cover key concepts and practices essential to achieving energy efficient operation of space heating, cooling, ventilating and water heating equipment.

Explanation

From equipment selection to proper sizing and system design to maintenance, the HVAC system is of utmost importance in an energy-efficient home. Although you as the remodeling contractor may not design, select, and install mechanical systems, you will guide your customer through the decision-making process regarding most aspects of a retrofit project. By understanding the energy efficiency of mechanical systems, you can help ensure that the HVAC contractor places a high priority on energy efficiency and takes the necessary steps to achieve it.

In homes, water heating is typically the second largest monthly energy expense next to space conditioning. In temperate climates, water heating may, in fact, be the larger expenditure. With new equipment and materials on the market, it is important to be informed about the options available for water heating.

Action Items

After going through this module, you will be able to explain the key issues of an energy efficient HVAC system to customers.

You will be able to give customers clear and thorough information about properly operating and maintaining their system.

You will also know the proper questions to ask your HVAC trade contractor regarding the system design, the selection and sizing of equipment, and installation practices that assure energy efficient operation.

Resources

Key Concepts

Explanation

This module will help you:

•Learn the importance of design on energy efficient performance

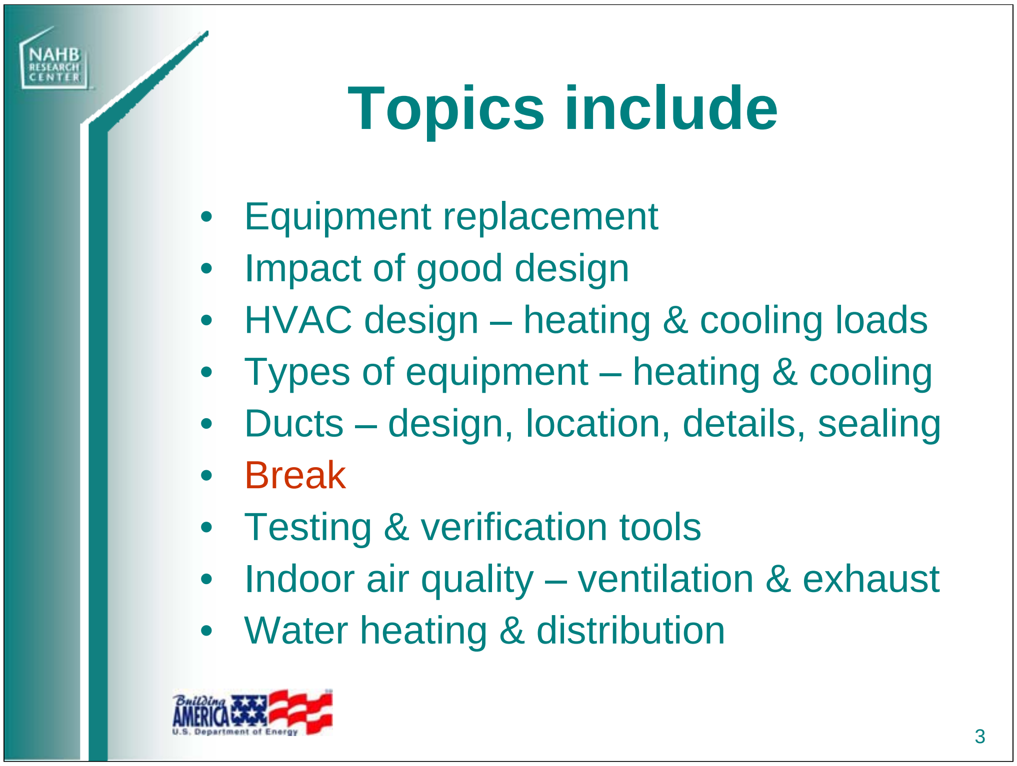
•Be familiar with equipment options

•Discover advantages and disadvantages of various systems

•Learn basic design and installation guidelines to ensure energy efficient performance

Action Items

Resources



Key concepts

This module will take several hours to present. It will include both lecture material and in-class example problems for the student to solve. There will be a break near the mid-point of the training session.

Explanation

•Impact of good design

•Types of equipment – heating & cooling

•Ducts – design, location, details, sealing

•HVAC design – heating & cooling loads

•Break

•Testing & verification tools

•Indoor air quality – ventilation & exhaust

•Water heating & distribution

Action Items

Resources

Why Mechanical Systems?

Many renovation projects will affect the performance or requirements of one or more mechanical systems

- Heating
- Cooling
- Ductwork
- Ventilation
- Hot water

4

Key Concepts

Many renovation projects will affect the performance or requirements of one or more mechanical systems

- •Heating
- •Cooling
- •Ductwork
- •Ventilation
- •Hot water

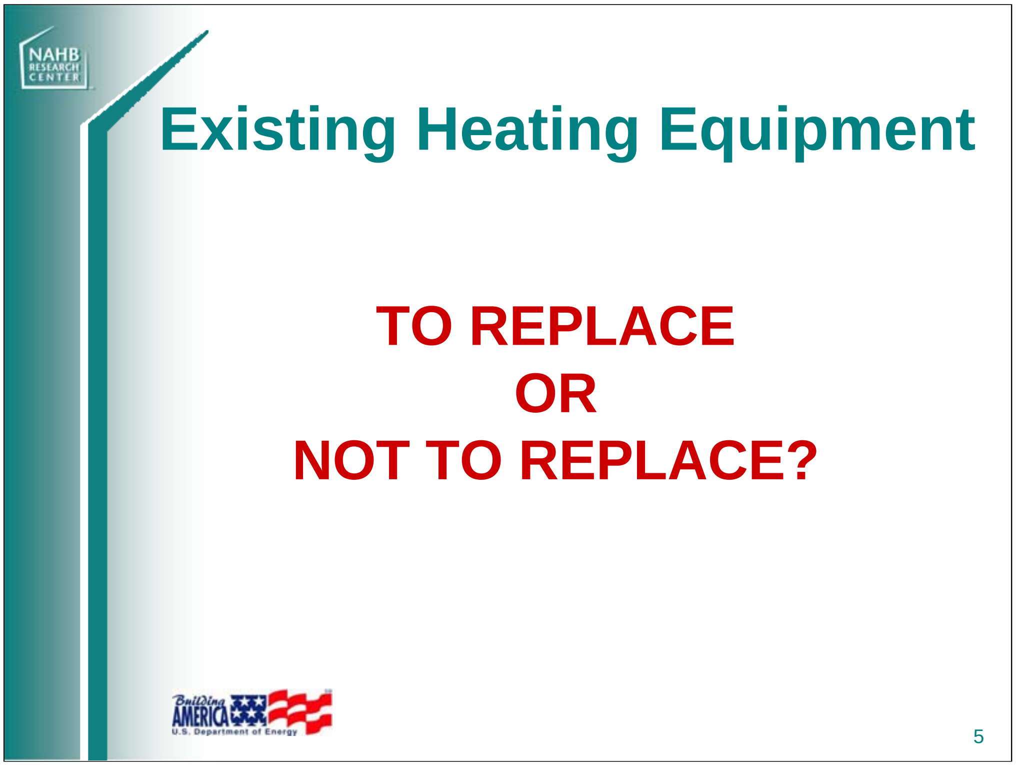
Explanation

Even though your client may not be thinking of alterations to any mechanical system when they initially contact you about a project, it is one of the aspects that you must consider when planning and estimating the project and outlining the scope of work. For a room addition or space conversion, it is imperative to ascertain whether existing equipment is adequately sized and how the distribution system can be routed. But, even for a room remodel, existing ductwork may need to be moved or additional runs added if the room is uncomfortable. If a new bathroom is to be added, the adequacy of the existing water heater needs to be considered. For example, it may be more efficient to install a demand water heater for new plumbing fixtures if the existing heater is more than about 35 feet from the new fixtures.

Action Items

Consider space conditioning, water heating, and fresh air needs and sources of supply when looking at any new project. Ask the customer questions about comfort in relation to space heating or cooling, hot water, local ventilation, and fresh air.

Resources



Key Concepts

How to assist your client in determining whether to upgrade existing heating equipment

Explanation

Start by improving the building shell to reduce heating and cooling loads. By reducing the load, the home can be more comfortable. In return, new equipment can often be downsized, potentially lowering first cost.

Action Items

Before replacing any heating or cooling equipment or making changes to the heating system, consider simple, cost-effective energy improvements that could lower the heating/cooling load including:

- ✓Caulking and weatherstripping doors, windows, attic hatches, etc.
- ✓Sealing electrical and plumbing penetrations to the exterior or unconditioned spaces
- ✓Adding attic insulation if it is inadequate
- ✓Verifying proper operation of the thermostat
- ✓Insulating Insulate ductwork in unconditioned spaces
- ✓Sealing ductwork
- ✓Improve air flow in duct system by eliminating constrictions

Always have the HVAC subcontractor perform heating and cooling load calculations to verify the size of equipment that is needed. Never assume that the existing equipment was properly sized initially.

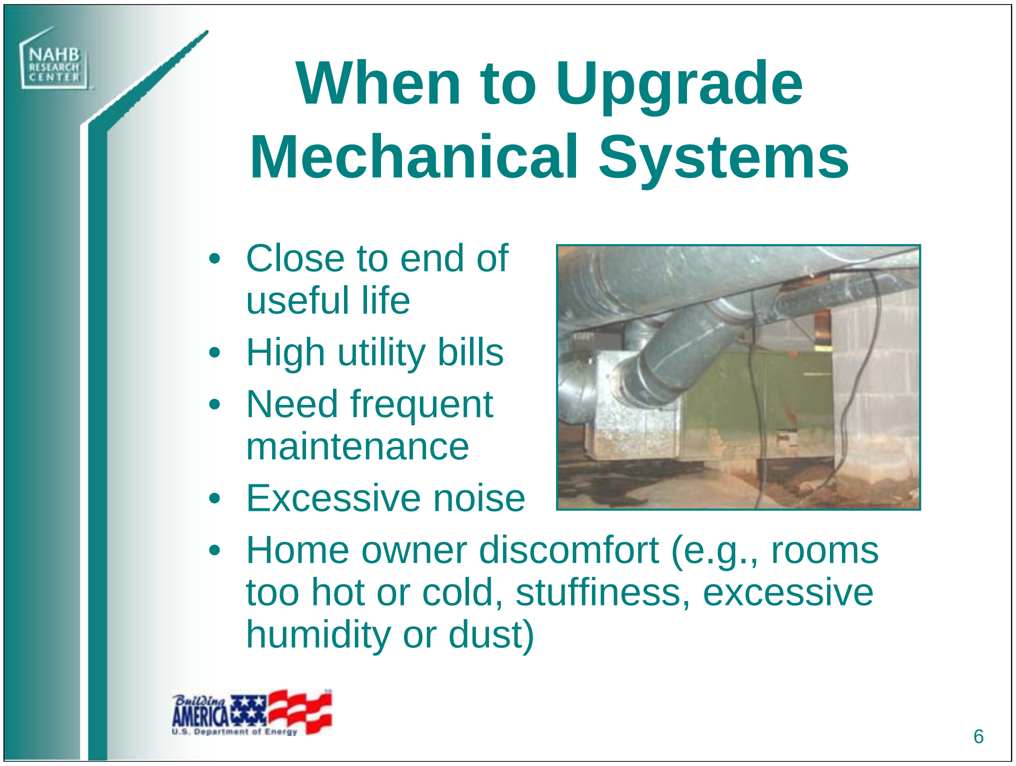
Consult your HVAC subcontractor about repairs that might improve the performance of the existing equipment.

Resources

Instructor's Note

Ask your students whether their heating/cooling contractors use some method of load calculation to determine whether new or existing equipment is properly sized.

Ask if they have heard of ACCA Manual J or Manual D for load calculations and duct sizing.



Key Concepts

You should consider replacing mechanical systems when:

Appliances are close to end of useful life

Owner experiences high utility bills, which could be the result of worn and dirty equipment (old equipment is also relatively inefficient compared to today's standards).

Equipment needs frequent maintenance

System produces excessive noise

Home owners experience discomfort (e.g., rooms too hot or cold, stuffiness, excessive humidity or dust)

Explanation

A 1993 NAHB survey indicated the following life expectancies for some types of equipment:

Central air conditioning unit – 15 years

Forced air heat pump – 15 years

Gas or oil furnace – 18 years

Boiler – 30 years (depending on type of water)

Electric water heater – 14 years

Gas water heater – 11-13 years

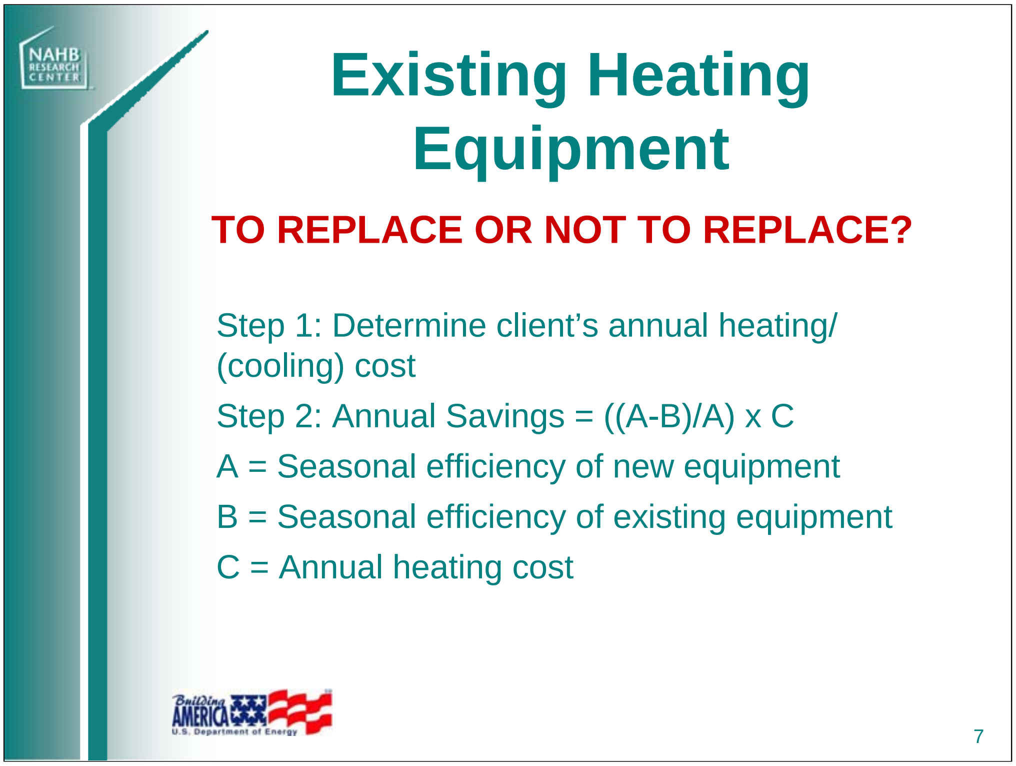
Action Items

Check the condition of the space and water heating/cooling systems

Look for tags on equipment regarding maintenance schedules

Ask homeowners about comfort, noise, odors, etc.

Resources



Key Concepts

Determining whether to replace existing equipment.

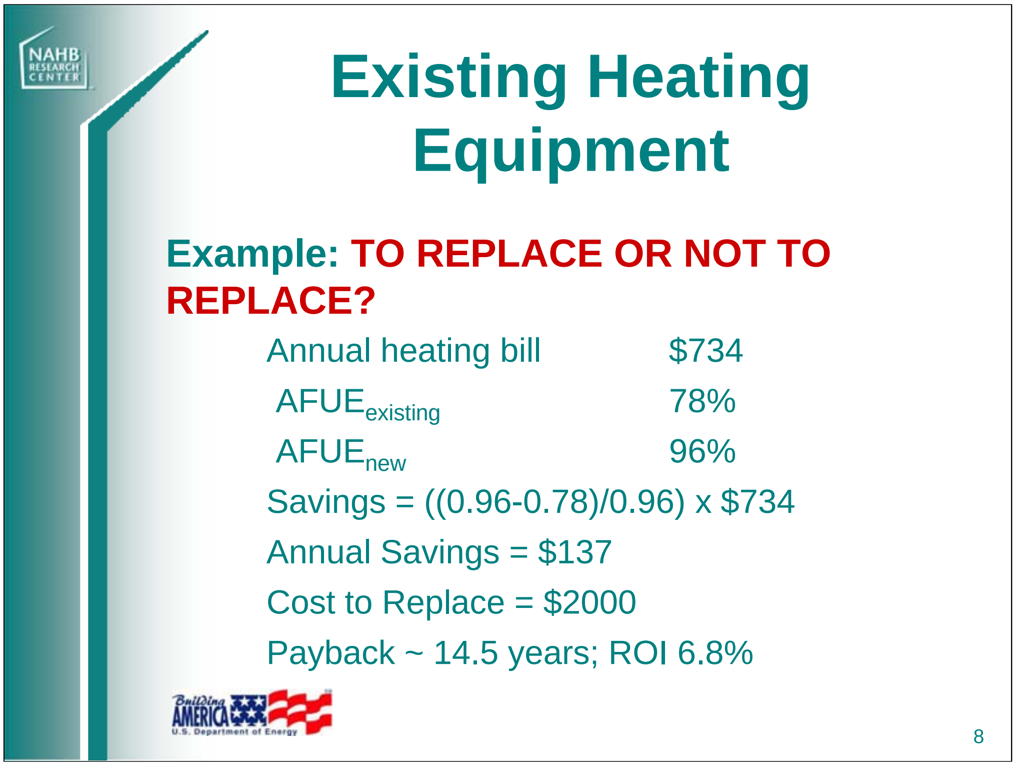
Explanation

The local utility or fuel oil company can usually determine the approximate annual cost to heat and/or cool a home.

Seasonal efficiency is typically given in one of the following factors: AFUE, COP, HPSF, or SEER.

Action Items

Resources



Key Concepts

Determining whether to replace existing equipment.

Explanation

For this example, we will assume that the annual heating bill is $734. The existing equipment has an AFUE rating of 78% and the clients are considering a condensing gas furnace with an AFUE rating of 96%. The annual savings is calculated to be $137; with the new furnace, it would cost about $597 per year to heat the home.

If it costs $2000 to replace the furnace, the expenditure would be paid back in about 14.5 years, for a 6.8% Return on Investment (ROI).

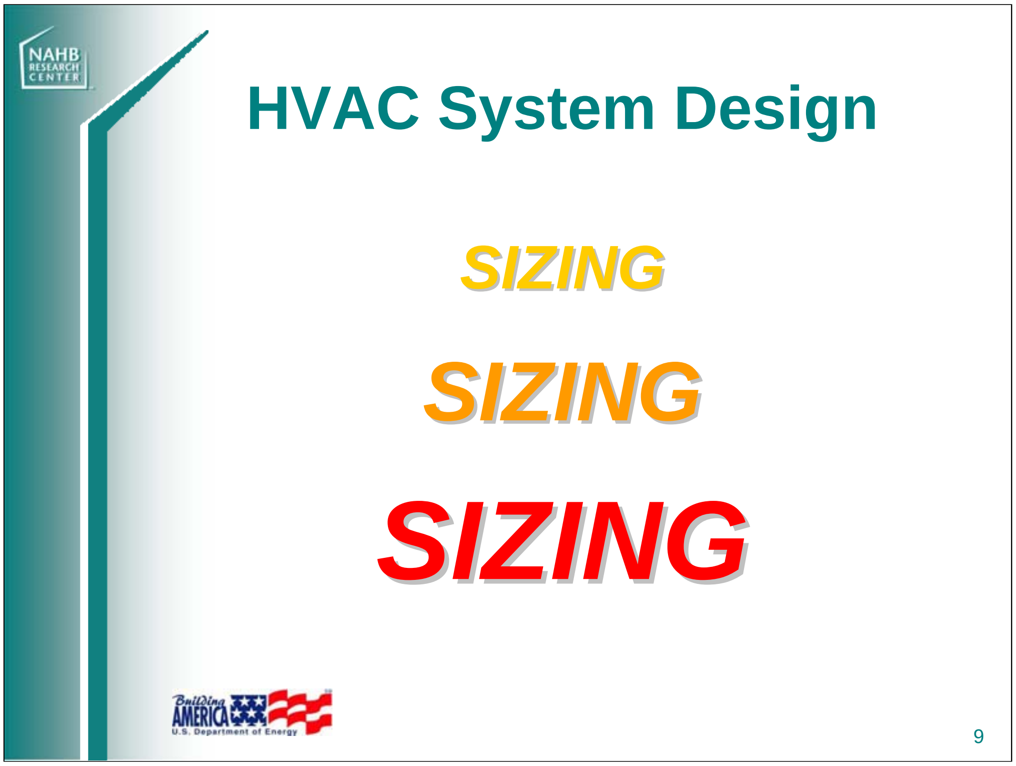
Although it is ultimately up to the client to decide, this payback period is probably reasonable given that the new furnace should last about 20 years and the existing furnace (at 78% efficiency) is probably close to the end of its useful life. A 6.8% ROI on par with many investments and more than the current interest rate on a home improvement loan.

Action Items

Show your clients the payback period, but also mention other benefits such as added value to their home and lower total monthly payments if they borrowed the $2,000.

A 15-year loan at 5.5% would carry monthly payments of $20.43 or about $240 per year or a savings of $100 per year compared to keeping the old furnace.

Resources



Key Concepts

Right-sizing is important to the efficient operation of heating and cooling equipment as well as to occupant comfort.

Both the equipment and the ductwork (in a forced air system) should be sized using one of the methods discussed in this module.

Explanation

Heating and cooling equipment that is oversized will short-cycle (turn on and off rapidly since it cools/heats the house quickly) and, therefore, never reach its optimum level of performance or rated efficiency. Short cycling can reduce equipment life.

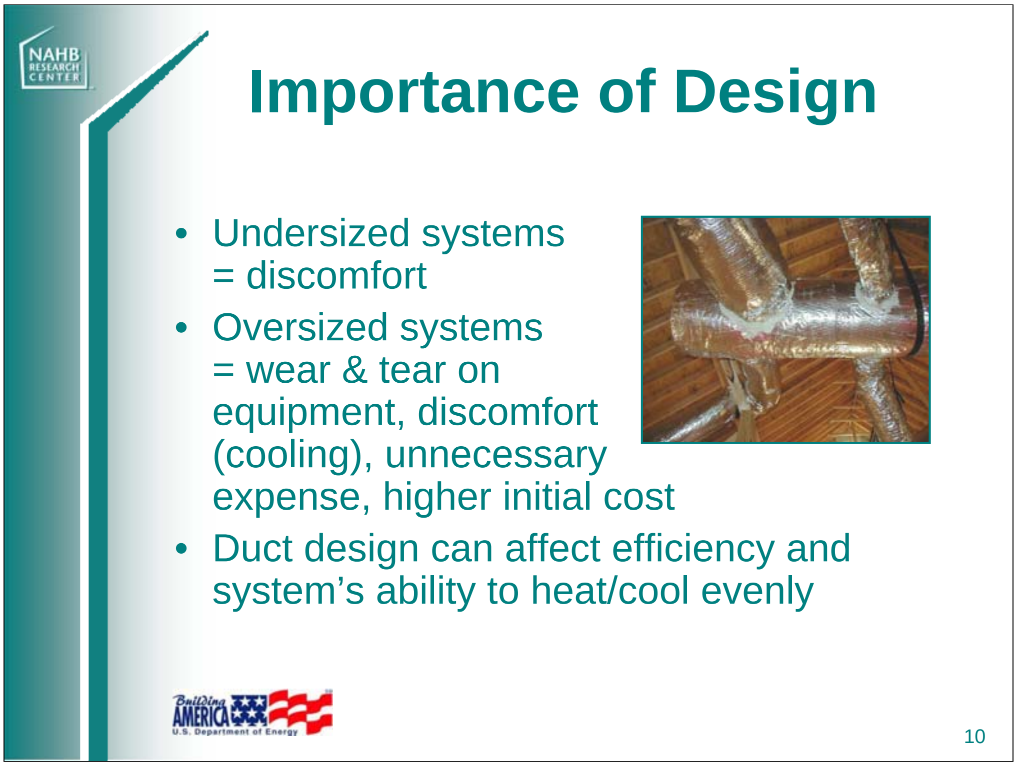
Under cooling conditions, short cycling can result in poor dehumidification. As an oversized unit runs, it quickly cools the air but does not run long enough for sufficient dehumidification. Cold clammy conditions can result—making people uncomfortable.

Action Items

Ensure that you or your HVAC contractor uses an industry-accepted method to size both the equipment and the ductwork.

If the remodeling job will add to the amount of conditioned space, perform a load calculation on the home (even if you don't plan to install new equipment) to ensure that the existing equipment is properly sized given the changes you will be making.

Resources



Key Concepts

Explanation

Undersized systems have problems maintaining setpoints at temperature extremes.

Oversized systems cycle on and off frequently, causing premature equipment wear.

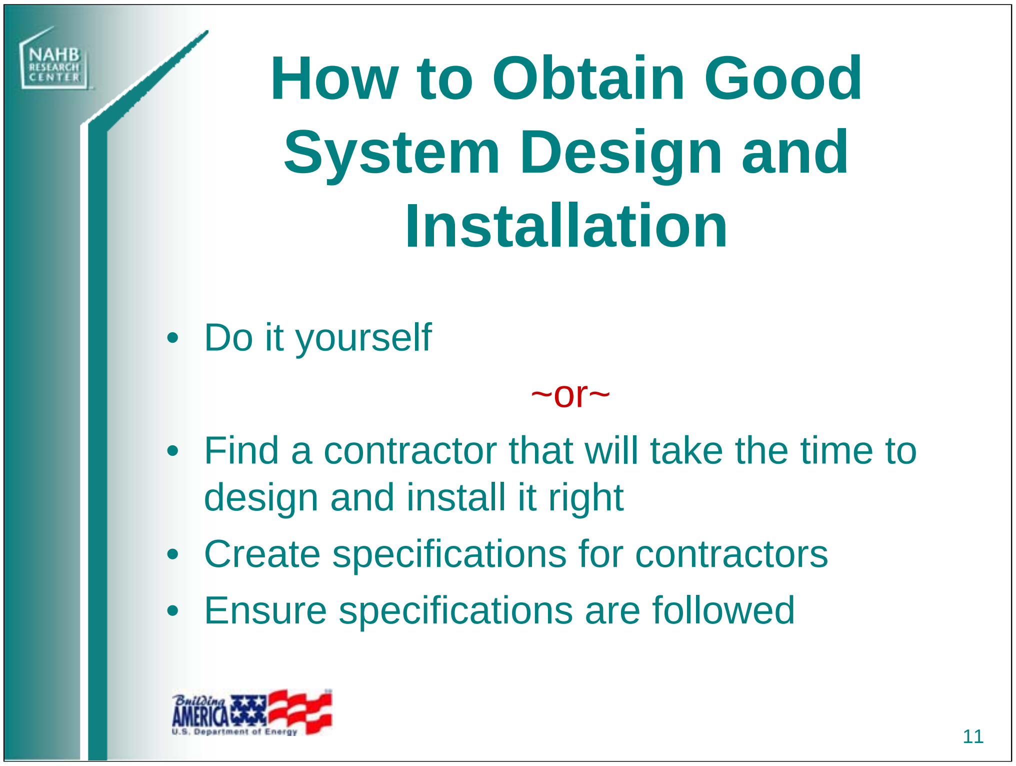
Oversized systems have a higher initial cost than systems that are properly sized.

Oversized AC systems satisfy the setpoint before the system runs enough to remove moisture from the air.

Well-designed duct systems deliver the air appropriately to where it is needed. Well designed systems minimize thermal and convection losses because they are located inside conditioned space wherever possible and are air sealed during installation.

Action Items

Resources



Key Concepts

Do it yourself

~or~

Find a contractor that will take the time to design and install it right

Explanation

All too often, space heating and cooling equipment and ductwork or piping is sized according to rules of thumb or 'seat-of-the-pants' estimates. With homes often being significantly tighter or better insulated than they were 30 years ago, these estimates are often no longer adequate. A number of design tools are available. The Air Conditioning Contractors of America provides load and equipment sizing methods for space heating and cooling. The Radiant Panel Association provides design guidance for radiant systems.

Action Items

Insist that your HVAC contractor or his supplier perform an industry-approved/recommended analysis of the home's heating and/or cooling load to determine the proper size of equipment and distribution system.

Ensure specifications are followed. Request a copy of the calculations to provide such assurance to both you and your customer.

Resources

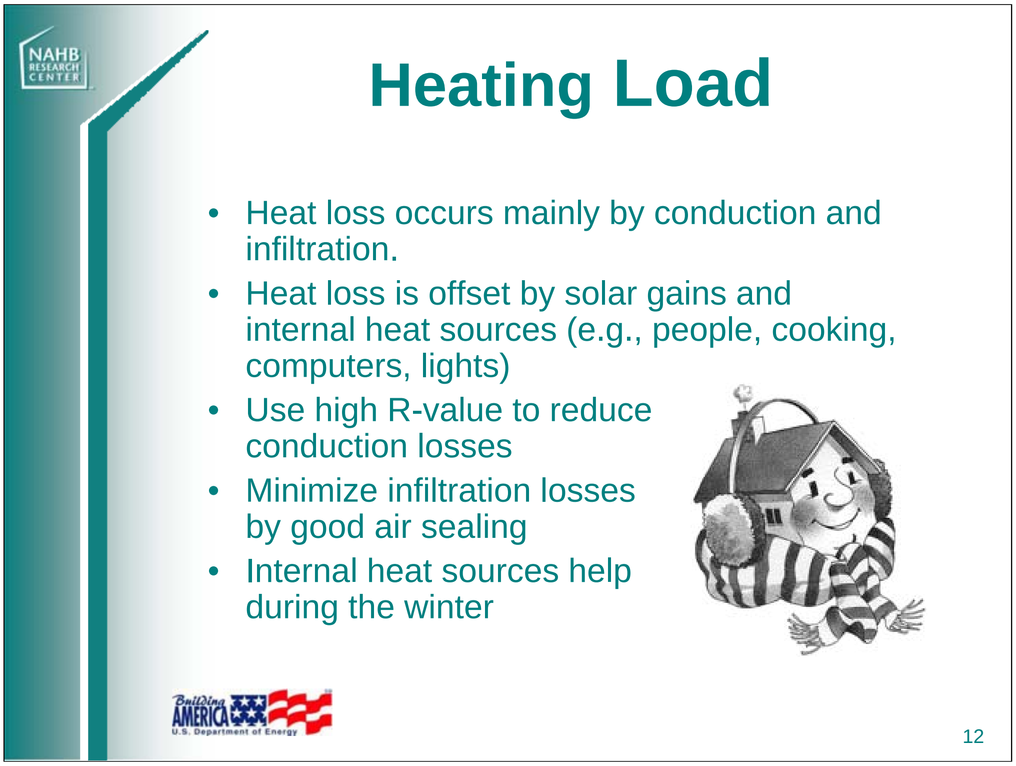
•ACCA Manuals J, S, and D, The Air Conditioning Contractors of America (http://www.acca.org)

•*Air Distribution System Design* (U.S. DOE fact sheet) http://www.toolbase.org/docs/MainNav/Energy/4074_doe_airdistributionsystemdesign.pdf

•*A Builder's Guide to Placement of Ducts and HVAC Equipment in Conditioned Spaces*, 2000, NAHB Research Center. Available for $5 from NAHB Research Center bookstore at http://nahbrc.org/tertiaryR.asp?TrackID=&DocumentID=2570&CategoryID=110

•*Design and Construction of Interior Duct System*, Florida Solar Energy Center, (2002) http://www.fsec.ucf.edu/bldg/baihp/pubs/Papers/interior_ducts.pdf

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



Key Concepts

Components of a heating load.

Explanation

As explained in the Building Science Basics section, heat is transferred by conduction, convection and radiation. The primary driver for heating load is conduction (heat transfer through walls and windows) and convection (heat loss from air infiltration). Radiation, however, can be a significant issue with respect to occupant comfort, for example the discomfort one might feel sitting in front of a window on a cold night.

Action Items

Increase insulation levels where easily accessible during the job.

Use weather stripping, caulk, and foam sealant to minimize air infiltration.

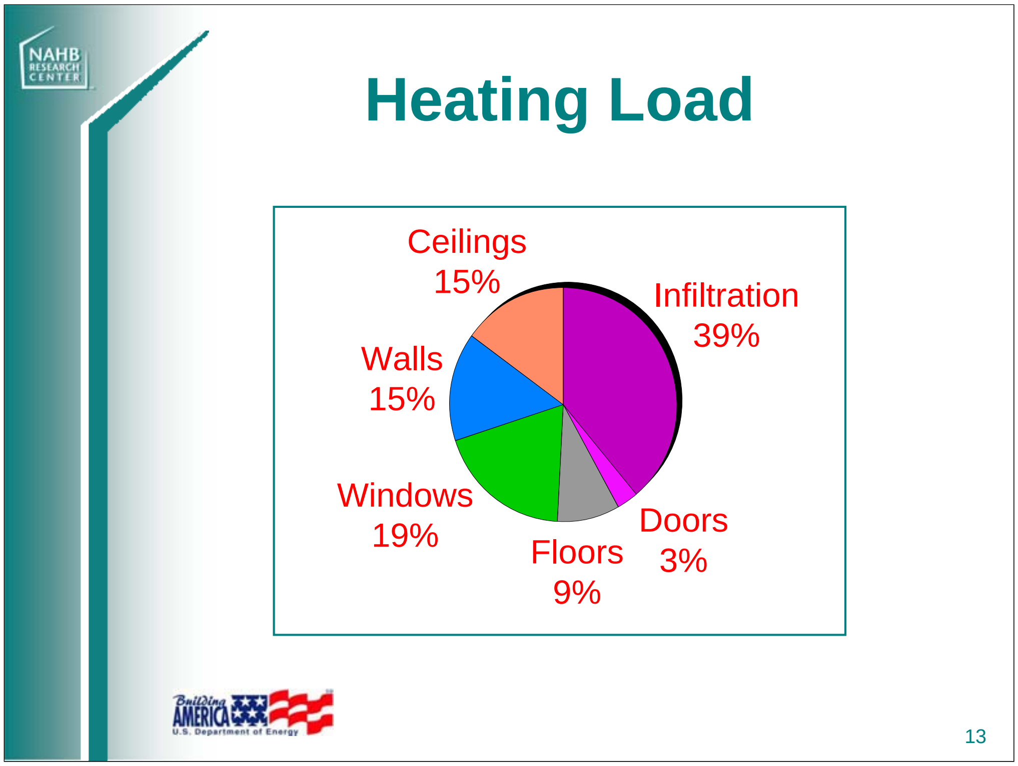
For additions, air seal between foundation and sill plate, around rim and band joist, around window and door openings, and where new framing meets old framing.

Investigate customer practices such as closing curtains at night to minimize radiation losses to very cold surfaces. Explore the possible advantages of thermal shades or curtains.

Resources

For information about passive solar design to reduce heating load, see http://www.toolbase.org

See Insulation and Air Sealing modules of this course for more information



Key Concepts

Explanation

Typical home in Southeast.

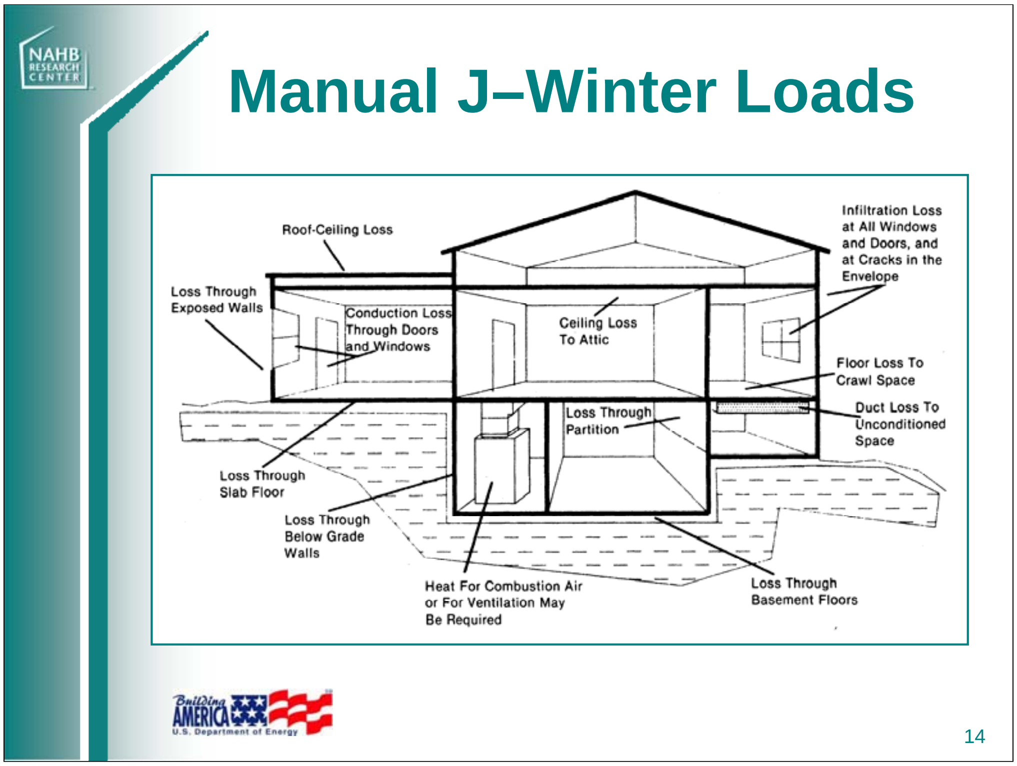
Infiltration is largest single component of heating load.

Doors are very small, a function of their % of the home surface area.

Windows vary depending on the amount of glass in any particular house.

Action Items

Resources



Key Concepts

Manual J calculates heat loads by taking into account conductive heat loss through roof, wall, ceiling, floor, and foundation assemblies, including windows. Manual J also takes into account convective heat losses due to air infiltration and exfiltration. The software version of Manual J is called Right J.

Explanation

After conducting a Manual J load calculation, heating equipment should be sized according to ACCA Manual S, which uses the results from Manual J calculations.

Other software programs are available to evaluate energy use of the house that are geared toward remodelers rather than HVAC designers. REMDesign allows a user to quickly evaluate the impact of various efficiency upgrades.

Action Items

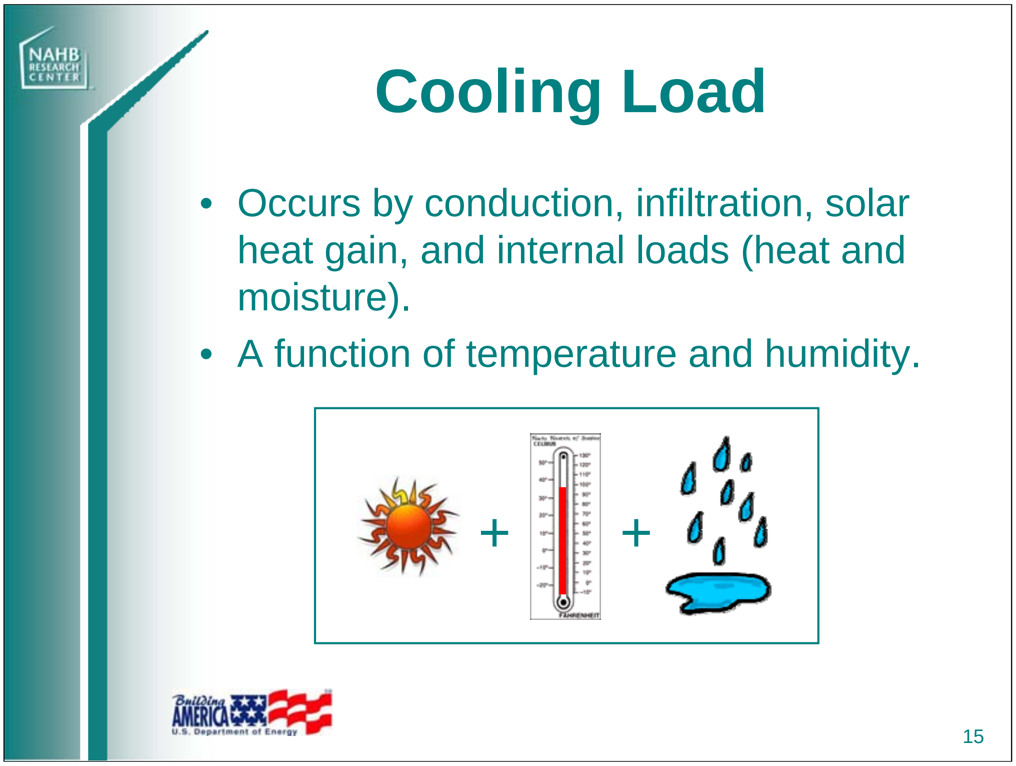
Ask your HVAC trade contractor if he uses software tools when sizing equipment and ductwork. If not, request that he use the industry-accepted methods in designing systems for your projects.

Consider obtaining a hard copy and/or software version of Manual J and Manual D to familiarize yourself with the procedure used to calculate the heating and cooling load of a home and design the duct system.

Resources

ACCA Manual J, Manual S

Right-J software



Key Concepts

Elements of cooling load

Explanation

Cooling load is made up of latent (moisture) and sensible (temperature) loads.

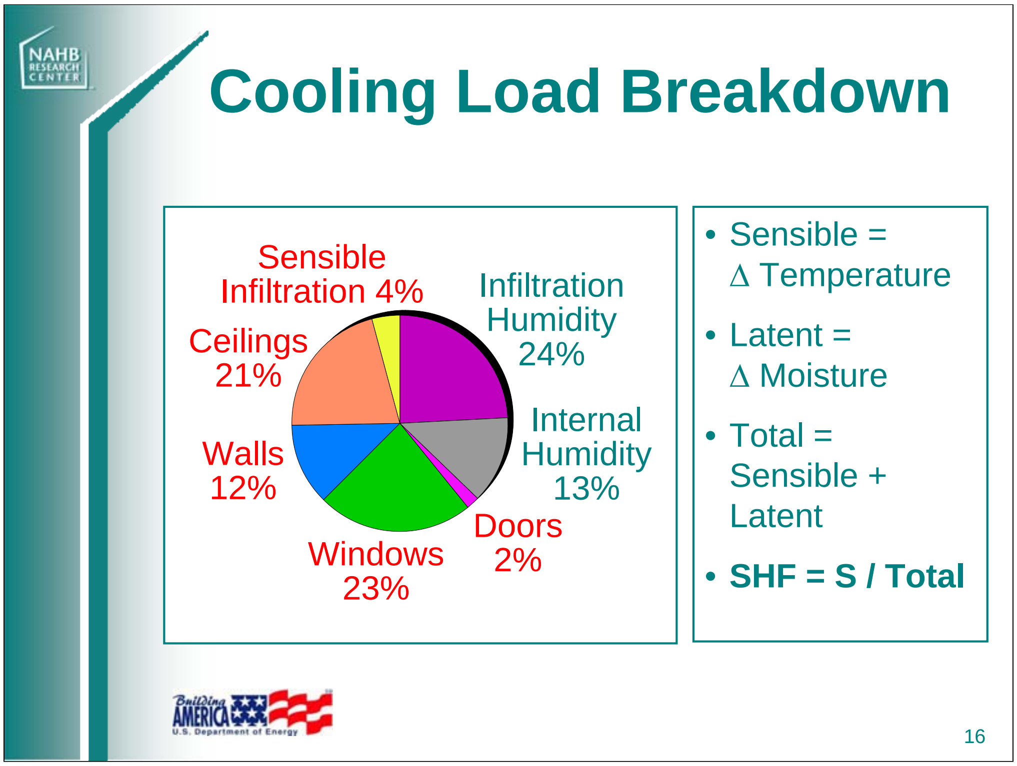
Solar heat gain through windows, conduction through walls from warm outdoor temperatures, humidity, and internal loads such as showering, cooking, lights and appliances comprise a home's cooling load.

Action Items

Understand the components of cooling load

Identify any abnormal components of cooling load, such as numerous fish tanks or extensive audio equipment, that may create a need for additional cooling capacity to certain rooms.

Resources



Key Concepts

Explanation

Typical Southeastern home – humidity removal is the single most critical issue (approx 37%). Infiltration humidity is ¼ of cooling load.

Sensible Load = Reducing temperature

Latent Load = Dehumidification

Latent Load is from infiltration, occupants, and miscellaneous other sources.

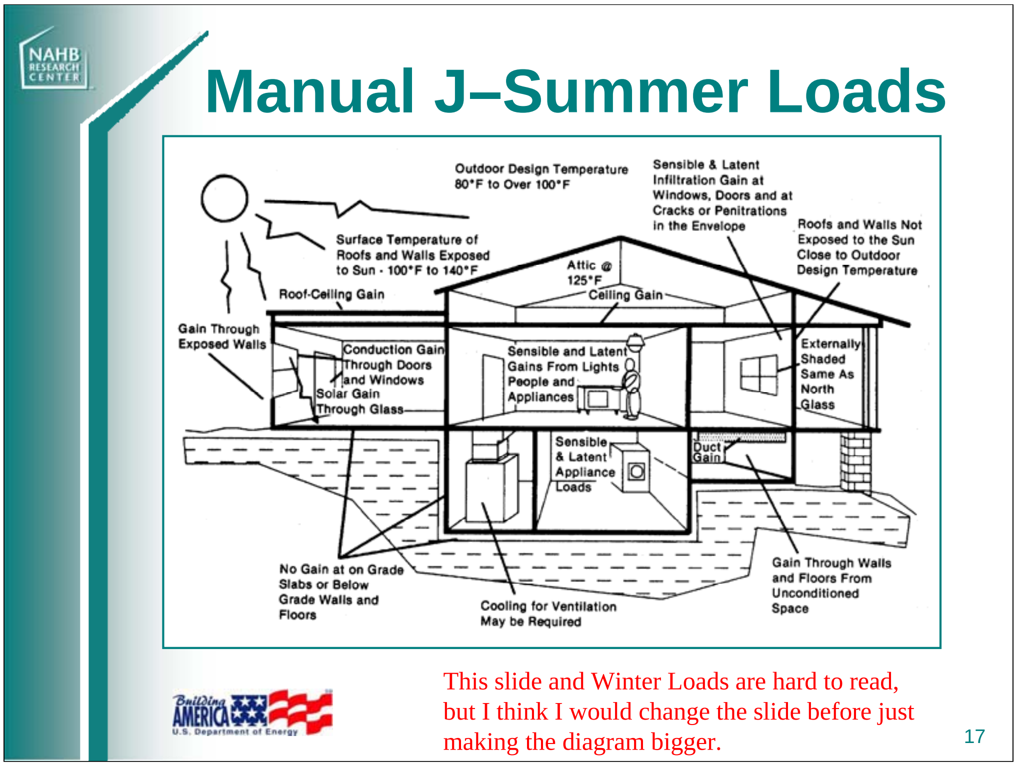
Latent Load is often 25% to 40% of total load in energy efficient homes.

The Sensible Heat Fraction is the Sensible Load divided by the Total Load.

(1 ton of A/C = 12,000 Btus/hour; Airflow is roughly 400 cfm per ton)

Action Items

Resources



Key Concepts

Manual J takes into account conductive heat gain through roof, wall, ceiling and floor assemblies, including windows. Manual J also takes into account convective heat and humidity gains due to air infiltration. Also taken into account are the radiative heat gain through windows and internal heat gain from lights, appliances, and people.

Explanation

Using rules of thumb to size equipment is more problematic for cooling than for heating!

Oversizing of cooling equipment is a big cause of poor dehumidification.

Action Items

Be sure your contractor performs load calculations using as much information from the job as possible.

Resources

Air Conditioning Contractor's Association (www.acca.org) has software and manuals for load calculation

ASHRAE Fundamentals Handbook (www.ashrae.org) has step-by-step instructions for load calculations

Instructor's Note

Cooling Loads

Minimized by thoughtful placement and selection of windows, good design, good insulation and air sealing, and high efficiency lighting and appliances.

18

Key Concepts

Planning can be a key component in providing a comfortable, remodeled space.

Explanation

Cooling loads can be minimized (often to the detriment of heating load) by careful selection and placement of windows (see Windows Section), good insulation and air sealing, and high efficiency lighting and appliances.

For example, fluorescent lamps contribute about ¾ less heat to a room than incandescent lamps.

Action Items

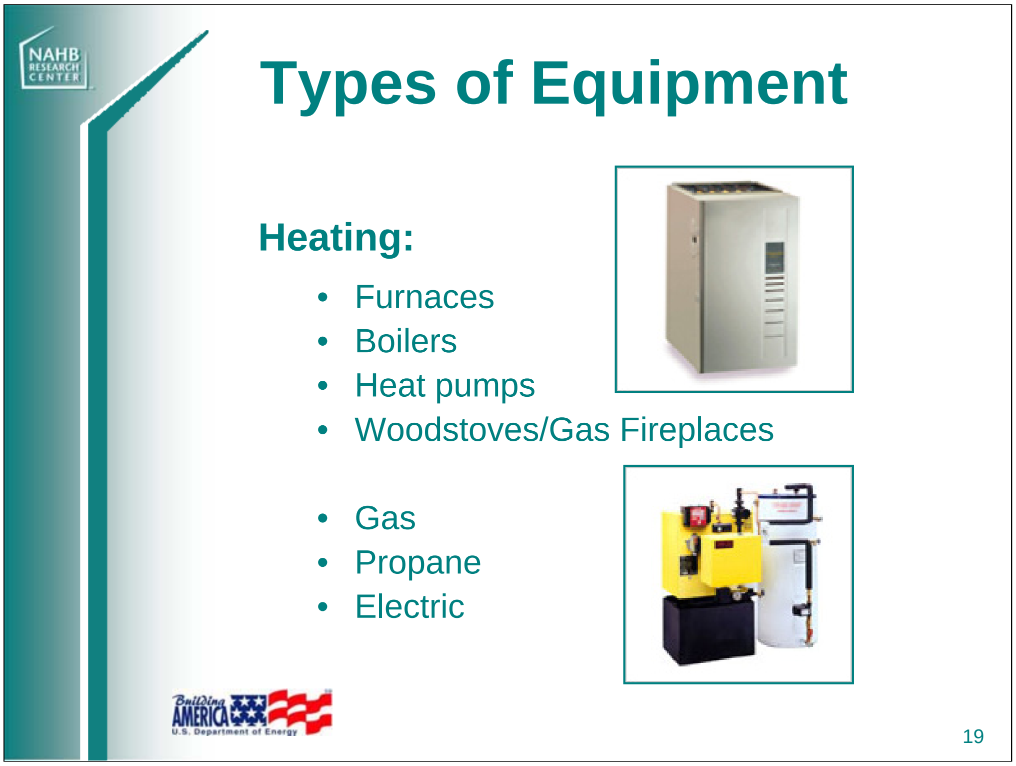
When adding or selecting windows, consider placement in terms of solar gains. Will overhangs be helpful in shading the window? Would a window with low solar heat gain properties be beneficial?

When adding lighting, consider that a 100-watt bulb will add 1365 Btus/day to a home if it operates 4-hours per day. A 26-watt fluorescent replacement, which can supply equivalent amounts of light, will add only 355 Btu/day.

Resources

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Fundamentals Handbook– contains information about cooling load added by various appliances.

www.energystar.gov – covers appliances labeled with the Energy Star. An appliance that is 25% more efficient will also produce 25% less heat.



Key Concepts

General overview of different types of heating and cooling equipment/systems.

Explanation

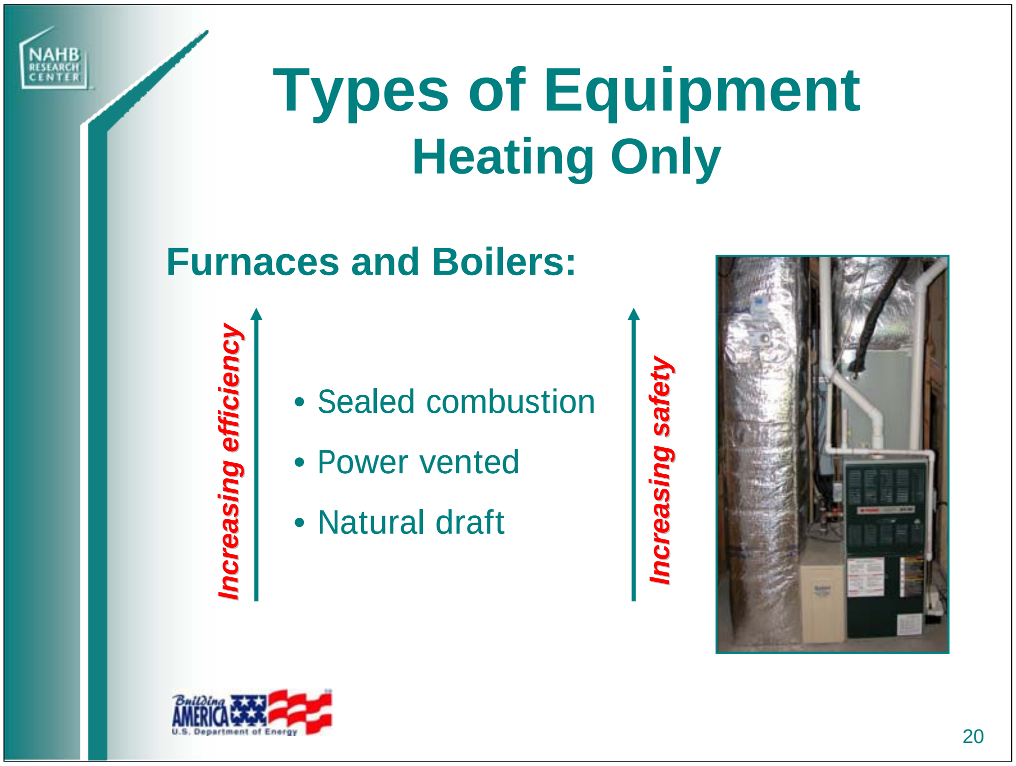
There are several types of heating equipment and several common fuels used for heating.

Frequently, certain types of equipment are more popular in particular geographic regions due to availability and pricing. For instance, oil-fired furnaces and boilers are most likely to be used in more rural areas of the Northeast where natural gas pipelines may not be available. Likewise, electric resistance heat might be typical in municipalities that have their own source of electricity at inexpensive rates.

Electricity is not the most efficient heat source – even though it may be the least expensive. Although the onsite conversion of electricity to heat is 100% efficient, e.g., all the electrical energy is converted to thermal or heat energy, the overall efficiency of electricity from the generating plant to the final point of use is only about 33% efficient. That is, 2/3 of the total energy of a given unit of electricity is lost in distribution before it even gets to the point of end use. For this reason, electricity is best suited for "higher" end uses such as lighting or refrigeration rather than "lower" end uses such as heat.

Action Items

Resources



Key Concepts

High efficiency equipment often offers other benefits in addition to monetary savings.

Safety and indoor air quality need to be considered with fuel-burning equipment.

Explanation

Natural Draft: (typical AFUE ~78-85%) Natural draft equipment can be identified if the system exhausts into a masonry chimney or stovepipe. This type of system relies on the "chimney effect" of hot air rising for exhaust gases. These systems are less efficient than other types because a lot of heat goes up the chimney with the flue gas. Natural draft equipment takes its combustion air from the area around the equipment rather than from outside. This is fine in a leaky home where plenty of fresh air is available. However, in a tightly-built home there may be difficulty getting enough air drawn into the equipment, causing the airflow to come through the chimney (and combustion byproducts to be drawn into the home). Natural draft equipment has an increased risk of backdrafting (spillage of combustion products like carbon monoxide into a home) over other heating equipment. Backdrafting can also occur if wind or outdoor air pressure exerts a stronger downward pressure than the upward pressure of natural convection; or if exhaust fans in the home such as range hoods and bath fans create a strong negative pressure in the home that draws combustion byproducts into the house rather than up and out the chimney. This danger can be reduced or eliminated by using sealed combustion or power vented equipment.

Power-vented equipment (AFUE about 80-83%) uses a small fan in the flue chamber to assure a positive draft to the outdoors. Power-vented furnaces, boilers, or water heaters still draw combustion air from the surrounding space.

Sealed combustion equipment has a combustion chamber that receives outdoor air directly through a dedicated pipe and vents combustion byproducts directly to the outdoors from the sealed chamber. Furnaces, boilers, and water heaters can be sealed combustion.

Condensing furnaces are among the most efficient sealed combustion units (typical efficiencies of 90 to 97 AFUE). Condensing furnaces, typically gas furnaces, have secondary heat exchangers that extract more heat from exhaust gases. The exhaust gas is cooled to the point that the water vapor contained in it condenses, giving up what is known as the latent heat of vaporization. Because of the cooler flue gas temperature, condensing furnaces vent through plastic PVC pipe.

Action Items

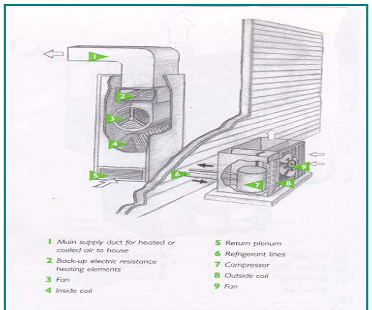
Be aware of various types of furnaces, their associated efficiencies, and the safety and health benefits of using higher-efficiency equipment.

Resources

Types of Equipment

Heating and Cooling

Air source heat pumps



An air source heat pump

21

Key Concepts

Air source heat pumps

- •Basic principles of operation.
- •Best applications.

Explanation

A heat pump uses electricity to heat and cool a home, but at a higher efficiency than electric resistance heating.

Heat pumps work like air conditioners (or refrigerators) using the vapor-compression cycle. However, they have the ability to operate in reverse, that is, to heat as well as cool a space.

There are two basic types of heat pumps: air source or ground source.

Air source heat pumps extract heat from the outside air in the winter and bring it indoors; and take heat from the house in the summer (and dump it outside). Most air source heat pumps have a back-up resistance heating coil for times when adequate air delivery temperature cannot be reached (e.g., when it is too cold outside to raise the air temperature or during the defrost cycle).

Some people associate discomfort with air source heat pumps, because, when in heating mode, even 90°F delivery air (a typical delivery temperature if outdoor air is 30°F) can feel cool (because it is at or below skin temperature).

Air source heat pumps operate less effectively and efficiently as the outdoor air temperature drops, thereby causing delivery air temperature to drop. Typically, air source heat pumps lose efficiency once the outdoor temperature drops below 35 to 40°F.

Higher efficiency equipment performs better at lower temperatures but comes with a cost premium.

Air source heat pumps for heating are not particularly well-suited to cold climates because as outdoor temperatures get colder, the refrigeration cycle cannot produce sufficient heat to achieve comfortable indoor temperatures and electric resistance backup must be used. Higher SEER units, however, will perform better at lower temperatures. Dual fuel units, with natural gas or propane for backup heating, are also available.

Action Items

Consider air source heat pumps in moderate climates where winter temperatures do not often drop below 40°F – especially if the region also has a cooling season.

Consider the price of all available fuels in the area.

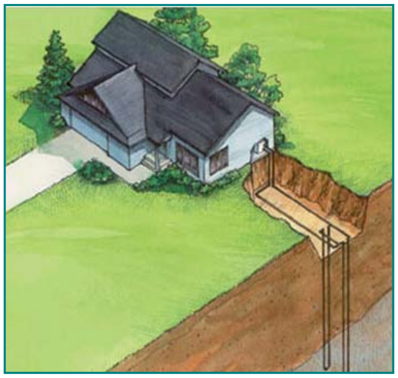
Encourage your client to select a heat pump with a SEER rating of at least 12.

Resources

http://www.eere.energy.gov/erec/factsheets/airheatpump.html

Types of Equipment
Heating and Cooling

Geothermal heat pumps



22

Key Concepts

General information about geothermal heat pumps.

Explanation

Geothermal heat pumps (GHP) take advantage of the consistently moderate temperature of the ground, along with heat pump technology, to supply heating and cooling to a home. GHPs consist of an indoor air handler (like a conventional heat pump) and a ground loop (which serves the same function as the outdoor unit in a conventional heat pump). The ground loop is where heat is picked up (in heating mode) or dumped (in cooling mode).

There is no outdoor unit with GHPs (and hence, no outdoor noise).

Geothermal heat pumps operate at higher efficiencies than air-source heat pumps (under most operating conditions) because they are starting with a higher temperature source in winter (in the example, 52ºF versus 15ºF) and a lower temperature "sink" in summer (for example, 60ºF ground versus 95ºF air). They use anywhere from 25-50% less energy than a conventional heating and cooling system.

Ground source heat pumps have higher air delivery temperatures than air source heat pumps.

Geothermal systems are about twice as expensive as air source heat pumps to install, but are less costly to operate.

It is imperative that you employ a knowledgeable and experienced contractor for a geothermal installation. Proper load calculations and installation details are extremely important when using geothermal systems (because of the high upfront cost).

Action Items

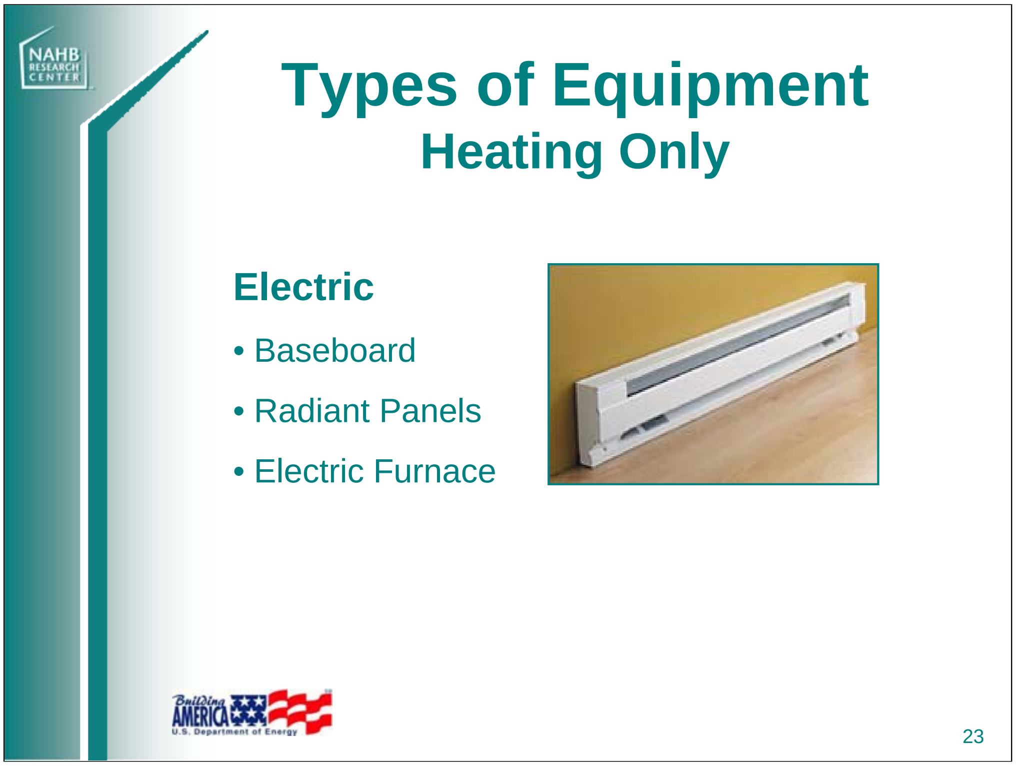
Consider geothermal heat pump systems although it may be difficult to justify the initial cost strictly on energy payback.

Resources

http://www.ghpc.org/home.htm/ (888) 255-4436 –The Geothermal Heat Pump Consortium website has general information on ground source heat pumps and a list of contractors by region.

http://www.eere.energy.gov/erec/factsheets/geo_heatpumps.html – site of the U.S. Department of Energy that also gives background information on ground source heat pumps.

http://www.igshpa.okstate.edu/ (800) 626-GSHP – Site of the International Ground Source Heat Pump Association. Offers publications, training, and research into geothermal systems.



Key Concepts

Electric resistance heating equipment – types, benefits, and drawbacks.

Explanation

Heating with electric resistance is usually the least efficient option (it takes about 3 Btus at a power plant to produce 1 Btu of electricity at a house, so already you have reduced efficiency by 2/3). It is often the most expensive way to provide heat (unless electric rates are very low) and the least expensive to install.

However in certain instances you may be asked to install resistance heating. The types of resistance heating available are:

- *Electric Baseboard* – Finned heaters that are run along the base of the wall and allow room-by-room temperature control. They are relatively inexpensive to install, and eliminate the need to use fuels that might raise backdrafting or spillage concerns. However, they can interfere with furniture placement.
- *Radiant Panels* – Radiant panels warm occupants directly by radiant heat. Radiant panels typically consist of a high-density fiberglass insulation board, a solid-state heating element, and a textured surface coating mounted in a frame. They are typically installed behind the ceiling and wall finish materials. Radiant panels are often considered to provide a very comfortable heat as long as the person is in view of the panel (e.g., if furniture is between the person and the panel, the person will not feel most of the warmth). They may improve efficiency because, since surfaces are warmed directly by radiant heat, thermostats may be set slightly lower. Radiant systems also allow for zoned temperature control.
- *Electric Furnace* – A ducted central system using electric coils and an air handler to deliver heat to the living space. An electric furnace is probably the least efficient method for heating a home, because of the inherent inefficiency of electric heating combined with the efficiency losses of the distribution system.

Action Items

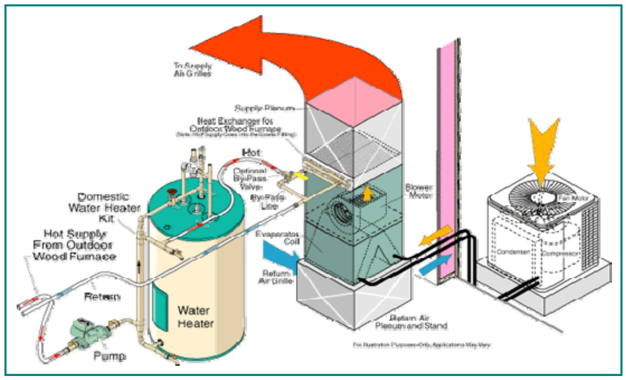
If a home has electric heat, strongly encourage your client to consider insulation and air sealing improvements to reduce heating and cooling loads.

Encourage your client to consider alternative heat source/system or a solar electric system – especially if electric rates are high or if they are replacing the existing system.

Resources

Types of Equipment
Combined Systems

Combined space and water heating



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Key Concepts

Objective - Understand the circumstances under which combined space and water heating may be advantageous.

Explanation

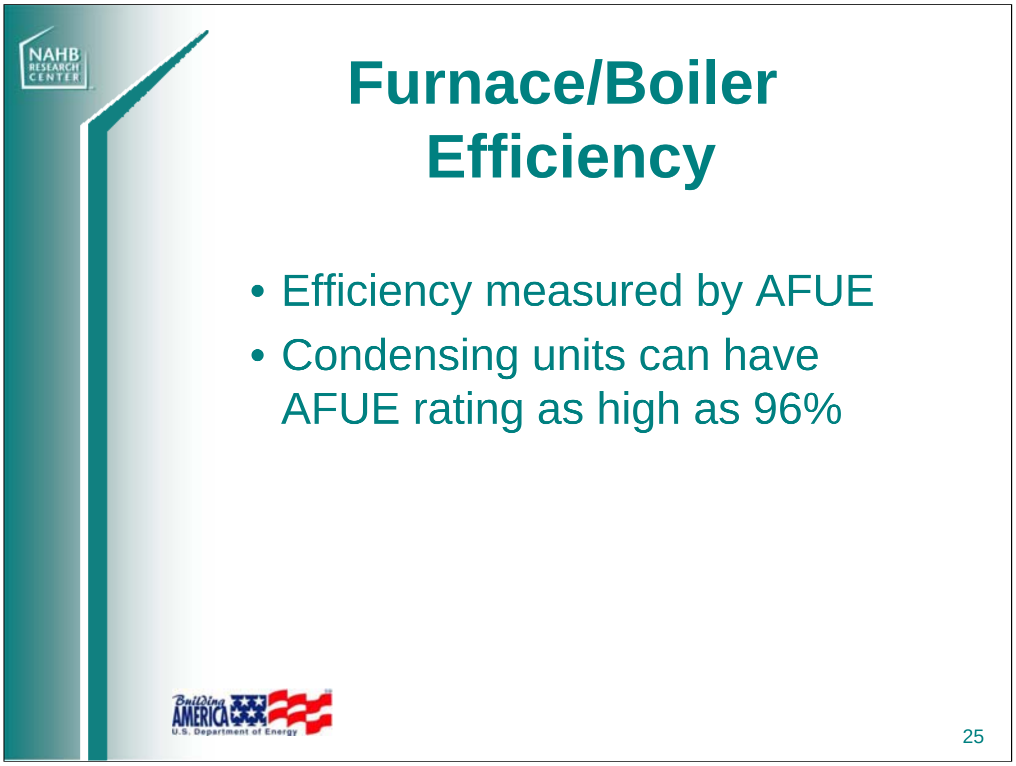
Combined space and water heating can be advantageous when:

- Both water heating and space heating systems need to be replaced (only one piece of equipment needs to be purchased).
- The home is well-insulated, tight, and has a very low heat load. Therefore, a large boiler is not needed.

Action Items

When assessing the condition of the space heating/cooling system, also consider the condition of the water heating system as well to determine whether both units might need to be replaced.

Resources



Key Concepts

Terminology that describes equipment efficiency.

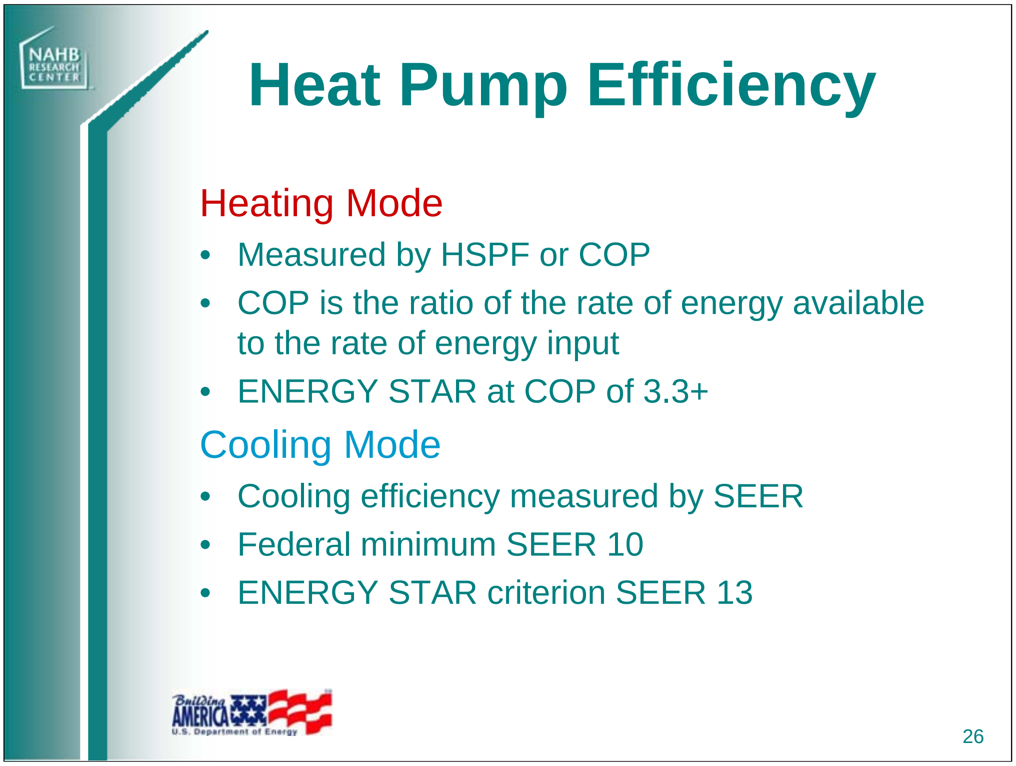
Explanation

AFUE – Annual Fuel Utilization Efficiency is the seasonal efficiency of a furnace or boiler, taking into account chimney losses, jacket losses, and equipment cycling losses. AFUE does not include losses associated with the distribution system or fan/pump energy.

Federal minimum furnace or boiler efficiency is set at 78%. ENERGY STAR rated furnaces have an AFUE of 90% or greater. Condensing furnaces, which recover heat from flue gases, have AFUE ratings of about 96%. Condensing furnaces are safer than natural draft furnaces: because they use outdoor air for combustion, the risk of bringing combustion byproducts into the home is extremely low.

Action Items

Resources



Key Concepts

In heating mode, efficiency is rated by Heating Season Performance Factor (HSPF), or amount of heating energy provided per unit of electrical energy input (in Btu/kWh), measured over a season. Federal minimum standards for HPSF is 6.8; ENERGY STAR criterion is 8.0.

HSPF takes normal operating losses into account – e.g., furnaces do not operate at peak efficiency during start-up and shut-down. Therefore, when furnaces frequently start and stop (e.g., during mild weather), overall efficiency declines.

Coefficient of Performance (COP) usually refers to geothermal heat pump heating system efficiency. COP is the efficiency with which a geothermal heat pump converts electrical energy (watt-hours) into heat energy (watt-hours). For a geothermal heat pump to qualify for an ENERGY STAR label, it must have a COP of 3.3 or greater.

Explanation

Cooling efficiency is rated by Seasonal Energy Efficiency Ratio (SEER). SEER is defined as the amount of cooling energy provided per unit of electricity purchased. SEER takes into account the efficiency losses from cycling over a season. Federal minimum SEER for heat pumps is 10; to be rated as ENERGY STAR, equipment must have SEER 13. (Federal minimum SEER will increase to 13 in January 2006.)

A rule of thumb: for every 1 SEER increase over 10 SEER, energy costs for cooling are reduced by 10%.

The equipment selected will depend on climate, budget, existing systems, and personal preferences.

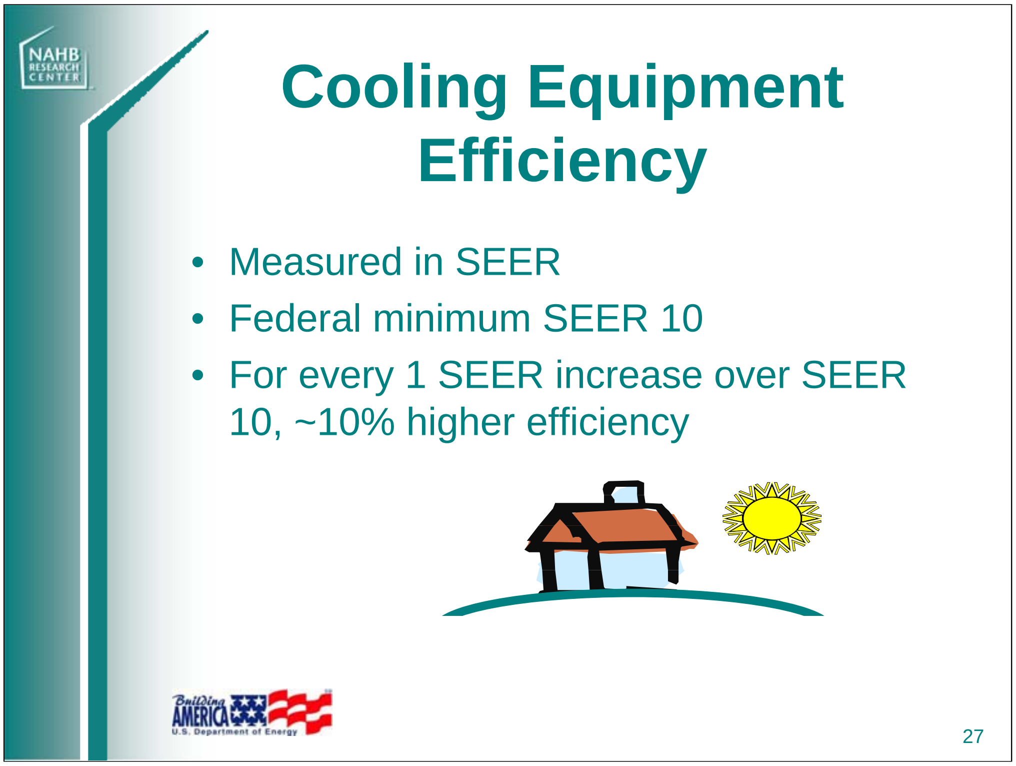
Action Items

If selecting air source heat pumps for a remodeling job, be aware of efficiency terms and the energy savings that may be attributed to a higher efficiency model.

When getting bids for systems from subcontractors, ask for two prices: one for a lower-efficiency system and one for higher efficiency system. Recommend the higher efficiency equipment if it makes sense in the situation.

Resources

www.energystar.gov – ENERGY STAR website which offers a list of equipment meeting efficiency criteria.



Key Concepts

Objective - Understand terminology that describes equipment efficiency.

Explanation

The efficiency of central air conditioners (as described for heat pumps operating in the cooling mode) is rated by Seasonal Energy Efficiency Ratio (SEER). The federal minimum SEER is currently 10 (but in process of being raised to 12) and the highest efficiency system currently on the market has a SEER 19.2.

You may also see the term EER or Energy Efficiency Ratio. EER = Cooling Capacity ÷ Electrical input. EER refers to instantaneous performance rather than performance over an entire season.

Action Items

Resources

www.energystar.gov -- List of equipment meeting ENERGY STAR efficiency criteria.

Key Concepts

Objective - recognize high-efficiency equipment

Explanation

EnergyGuide and ENERGY STAR labels on boilers, furnaces, and heat pumps indicate the equipment's level of efficiency. Equipment bearing the ENERGY STAR label meets efficiency criteria set by the ENERGY STAR program. (AFUE 90+; HSPF 8.0+; COP 3.3+; SEER 13+)

The yellow EnergyGuide label can be used to compare equipment. The label's sliding scale and annual operating cost data indicate where a particular model falls in the energy efficiency spectrum when compared to similar models.

ENERGY STAR is a program jointly sponsored by the Environmental Protection Agency (EPA) and the Department of Energy (DOE). DOE takes the primary responsibility for labeling products and equipment as ENERGY STAR-rated.

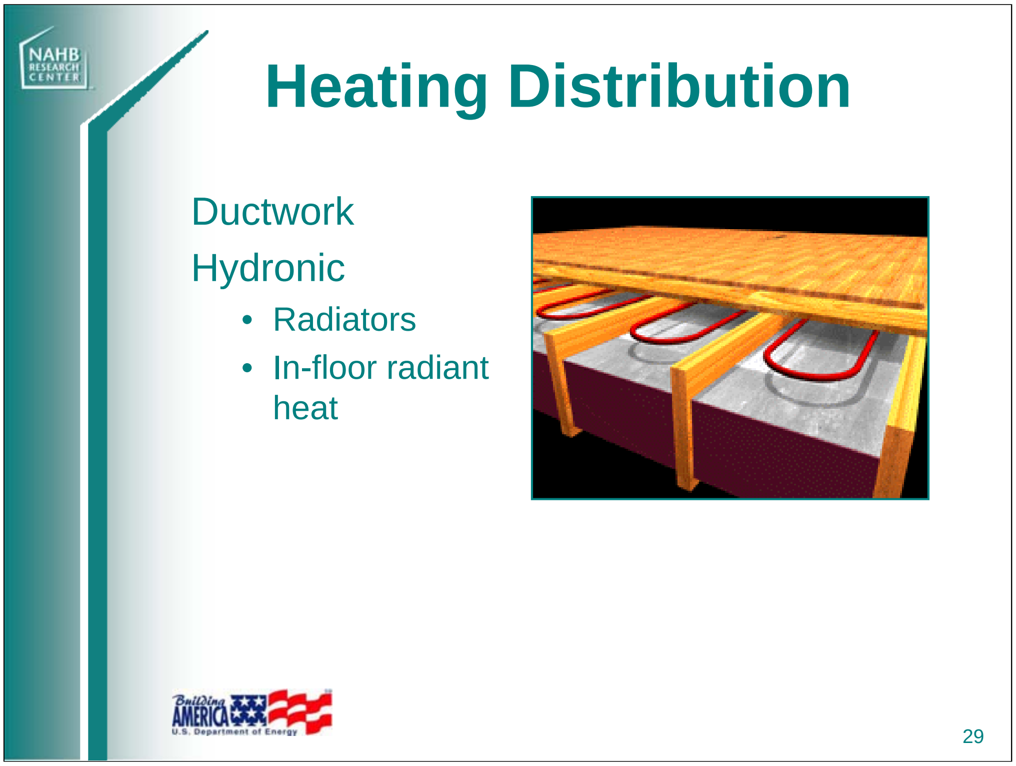
Action Items

Resources

www.energystar.gov lists equipment that meets the ENERGY STAR criteria

www.aceee.org offers information on the most energy-efficient furnaces and boilers.

www.eere.energy.gov is the Department of Energy site and also offers recommendations about purchasing energy-efficient equipment.



Key Concepts

Objective – Learn options for distributing heat around house

Explanation

There are two basic ways to distribute heat throughout a house: ductwork (air) or hydronic (hot water) pipes.

The old-fashioned radiators are one type of hydronic distribution system. Today, hydronic distribution usually takes the form of finned baseboard or in-floor heating. Hydronic heating is often not cost effective if central air conditioning is also to be installed in the home, due to the additional expense of installing ducts.

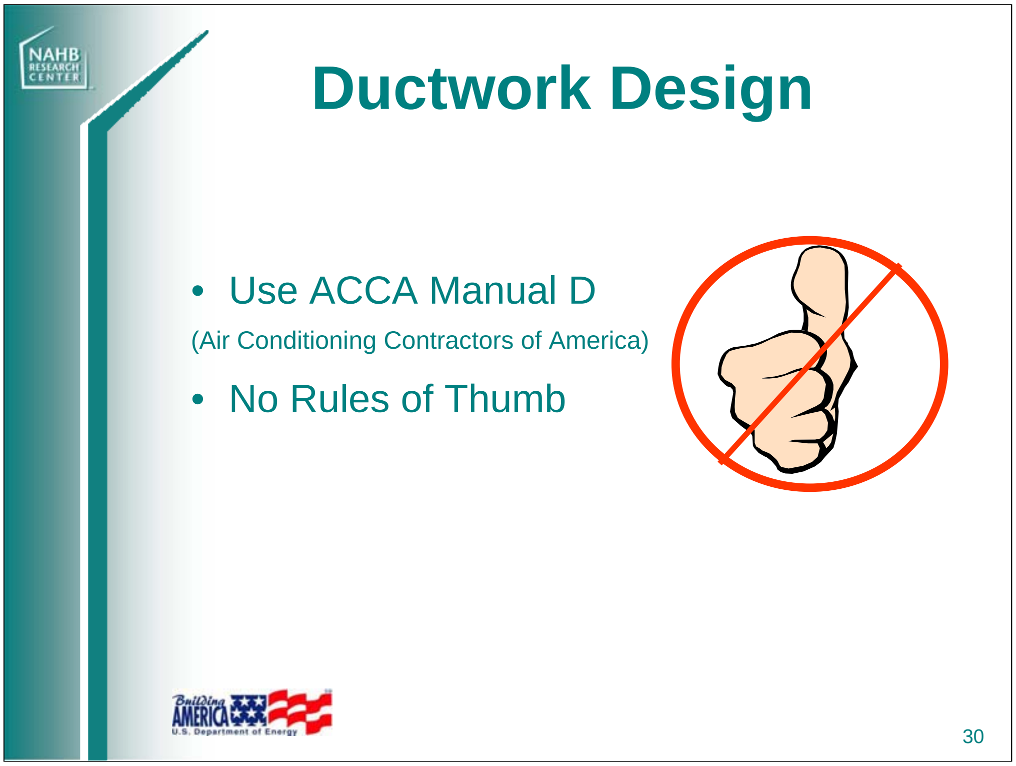
Efficient duct design will be discussed later. Radiant floor heating is typically efficient and comfortable (and has minimal distribution losses), but is expensive.

Hydronic systems comprise less than 15% of the housing market, but are dominant in certain regions of the U.S. such as the north central and Northeast. Usually, hydronic systems in older existing homes will be zoned either by room or by floor and may include radiators or finned baseboards. In very old homes, steam systems may be encountered. In such cases, it is very important to provide a room-by-room analysis to determine appropriate distribution capacity.

Action Items

Understand various heating system distribution options and how they affect efficiency.

Resources



Key Concepts

Understand the importance of duct sizing.

Tools to help properly size ductwork.

Explanation

Properly sized ductwork helps deliver air efficiently throughout the house, improving comfort and overall system efficiency. Properly sized ductwork will ensure that an adequate amount of warm or cool air gets to every room in the house—thereby avoiding typical problems such as rooms being too hot or too cold. Properly sized ducts can reduce noise caused by air “tumbling” through a duct that is too small.

Air Conditioning Contractors of America (ACCA) has a standard for duct sizing, ACCA Manual D, which prescribes duct sizing techniques.

Action Items

Ask your HVAC contractor to use ACCA Manual D in sizing the ductwork for a new installation.

When replacing an existing furnace or heat pump, ask your HVAC contractor to use Manual D to check that the ductwork is appropriately sized.

Resources

ACCA Manual D, The Air Conditioning Contractors of America (www.acca.org)

Ductwork Location

When possible, locate ductwork within the conditioned space

- Increase comfort
- Reduce utility bills
- Potentially lower construction costs

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Key Concepts

Benefits of placing ducts (and HVAC equipment) in conditioned space.

Explanation

According to the U.S. Environmental Protection Agency, keeping ducts within conditioned space can prevent the loss of 20 to 35% of conditioned energy to the outside. To visualize this loss, think about cool ductwork located in a hot attic in the summer. Even if the ductwork is sealed and insulated, some conditioned air escapes into the attic. In addition, the hot attic will conduct heat towards the air running through the ducts—raising the temperature of the cooled air. When ducts are inside the insulated building, they not only lose energy at a much lower rate (due to the small temperature difference between the living space and the air in the ducts), but the conditioned air that leaks out of the ducts is still contained within the insulated building envelope.

Furthermore, in the summer, condensation from the hot humid attic air is more likely to condense on cool ductwork and potentially cause moisture problems.

Keeping ductwork in conditioned space can lower construction costs by enabling the downsizing of heating and cooling equipment and eliminating the need for insulated ductwork.

Where possible, place supply registers on interior walls rather than near windows and exterior walls to reduce construction costs. In an energy efficient building (one having good insulation, air sealing, and efficient windows), high-throw diffusers placed on interior walls can provide comfort while eliminating long duct runs.

Action Items

When planning an addition or extensive remodeling project, consider designing so that new ductwork will be located within the conditioned envelope.

Consider re-routing existing ductwork to bring it into conditioned space whenever walls will be opened up.

Where possible, place supply registers on interior walls rather than near windows and exterior walls to lower construction costs.

Communicate with your HVAC subcontractor to develop the best strategy to locate (or re-locate) ductwork within conditioned space.

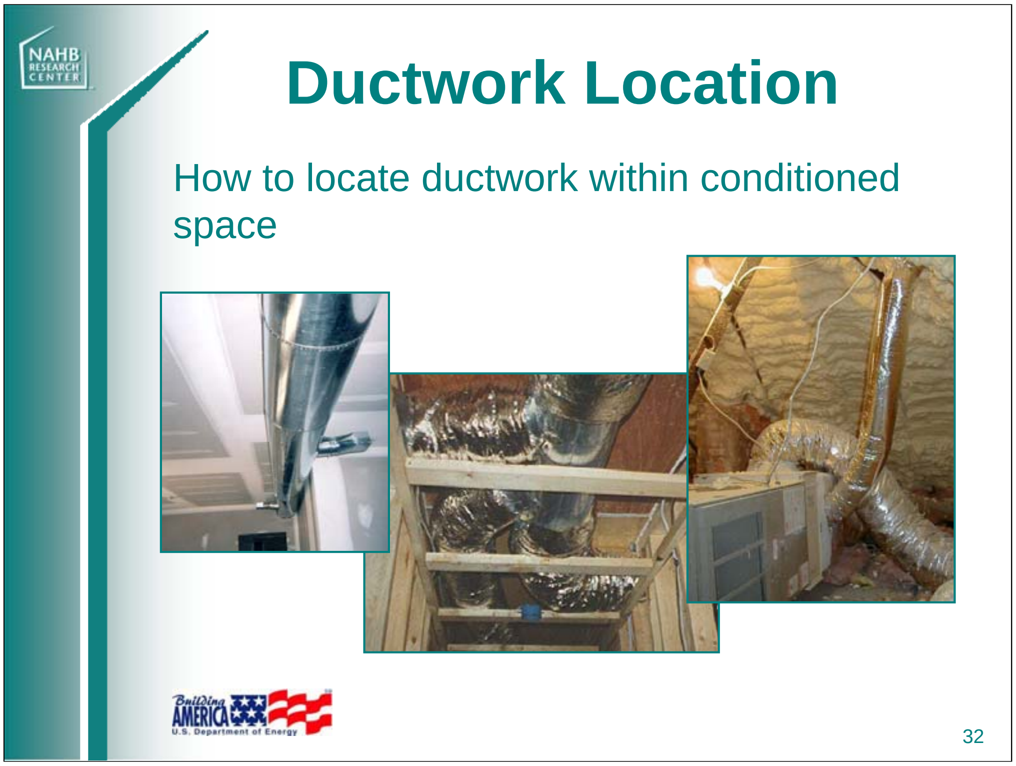
When ductwork cannot be located in conditioned space, be sure to seal joints and seams with mastic (a gooey paste-like substance) or tape designed for the job (NOT duct tape) and insulate the ducts well.

Resources

The following resources are applicable to this slide as well as the next slides.

“A Builder’s Guide to Placement of Ducts and HVAC Equipment in Conditioned Spaces”, NAHB Research Center (www.toolbase.org).

“Residential Duct Systems,” Air Conditioning Contractors of America, (www.acca.org).



Key Concepts

Methods of keeping ducts (and HVAC equipment) in conditioned space.

Explanation

Running ducts in an insulated basement, crawl space, or sealed attic is the easiest way to keep ductwork and HVAC equipment within conditioned space.

Running ductwork through the webs of floor trusses is an easy and effective method for first and second floor installations.

For additions on concrete slabs, PVC ductwork can be embedded in the slab to deliver conditioned air. The perimeter of the slab and the ductwork must be well-insulated. Careful installation is a must in order to prevent condensation and possible mold problems.

Dropped ceilings or soffits are another means of routing ductwork in conditioned space. When carefully planned, such soffits can be incorporated as an aesthetic design feature.

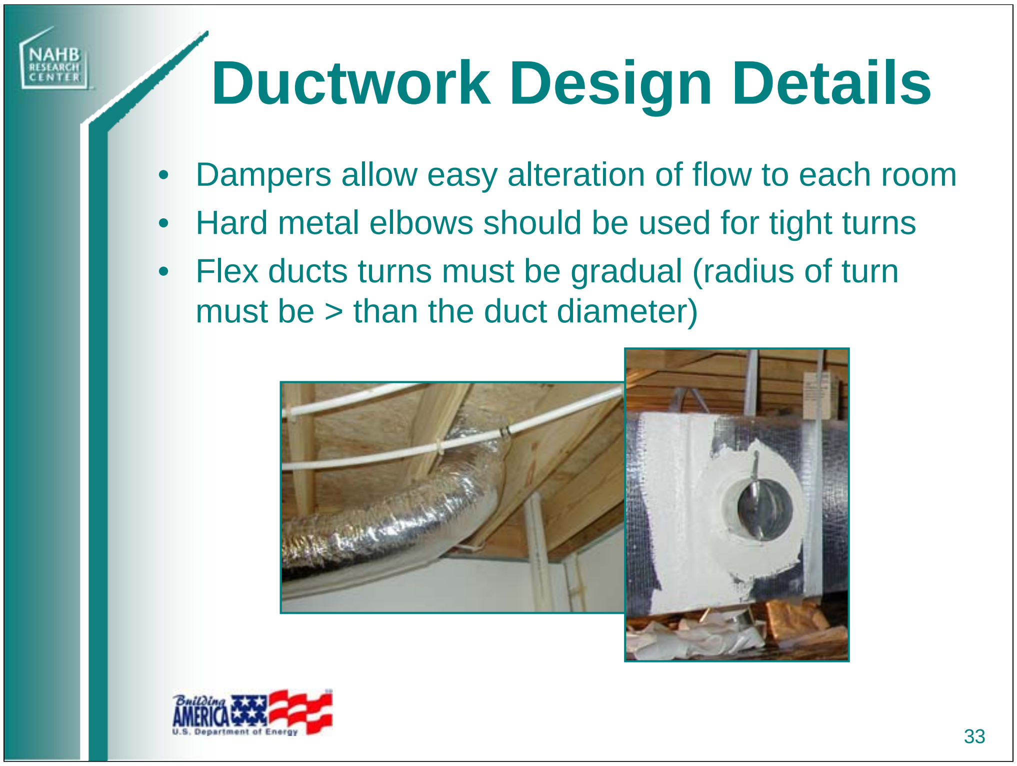
Insulated, unvented attic – Although somewhat more expensive than a conventionally-vented attic, this is another possibility to consider regarding keeping ducts within conditioned space. This approach has also been recommended as a means of reducing potential moisture, mold, or condensation problems – especially in hot, humid climates.

Action Items

Consider adding architectural interest, such as coffered ceilings, while incorporating ducts in conditioned space.

Resources

See previous slide



Key Concepts

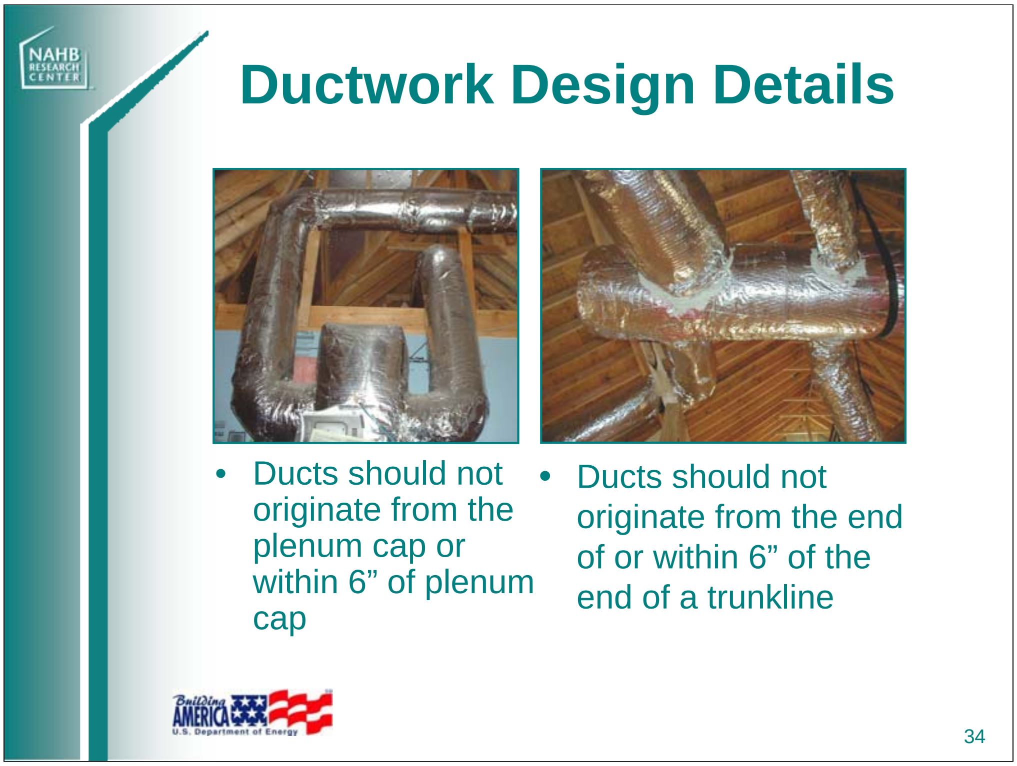
Duct flows can be adjusted more effectively with dampers than at the grille.

Hard metal elbows for tight turns reduces the chance that flex duct will crimp or restrict air flow.

Explanation

Action Items

Resources



Key Concepts

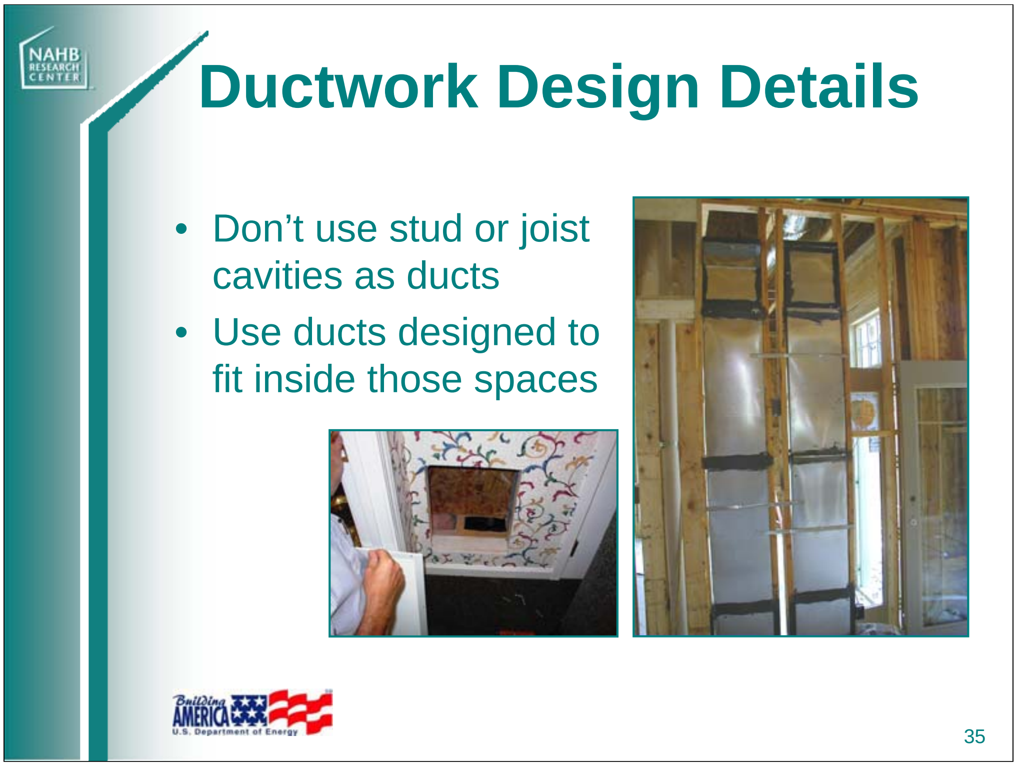
Ducts that originate at the end of plenums or trunklines receive a disproportionate amount of air.

When ducts are held back a minimum of 6” from the plenum cap or end of trunkline, the static pressure is maintained inside the trunk or plenum, helping to ensure the desired airflow into each duct run.

Explanation

Action Items

Resources



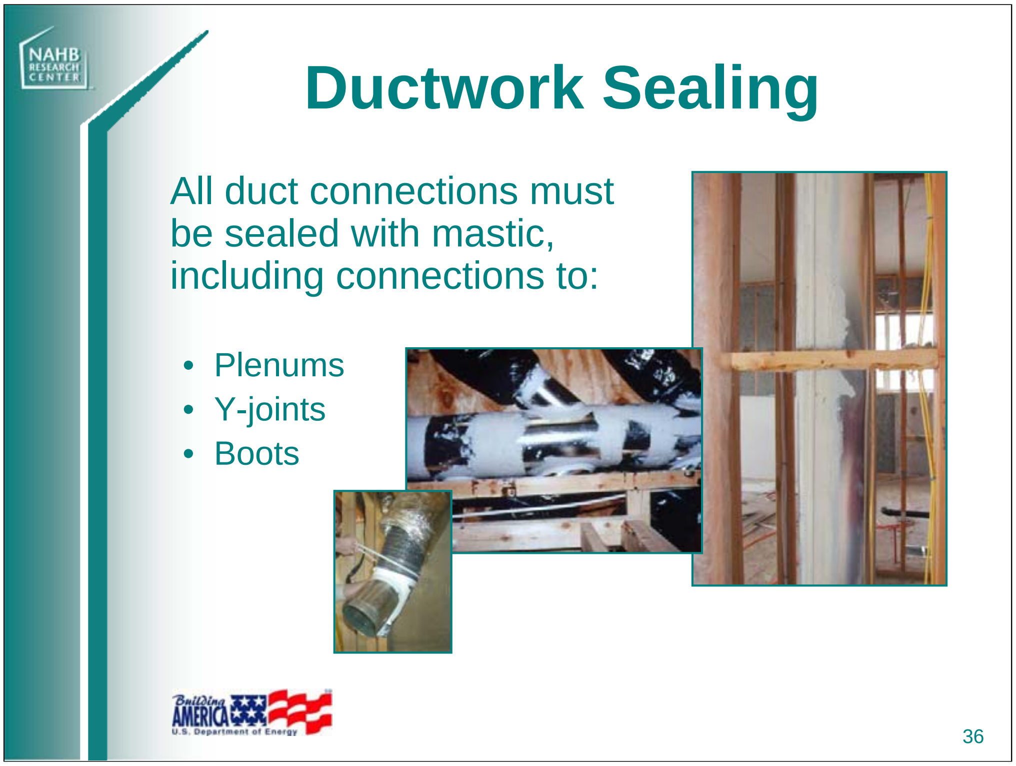
Key Concepts

Explanation

When building component cavities are used as ducts, it is almost impossible to seal them tightly.

Action Items

Resources



Key Concepts

How to seal ductwork

Explanation

Over the last 25 years or so, a lot of attention has been placed on improving the building envelope and increasing the efficiency of heating and cooling equipment. But the distribution network for forced air systems has been relatively ignored.

Leaky ductwork has been attributed to about 25% energy loss.

Many codes require “sealed ductwork,” but the interpretation and enforcement of such measures is still variable.

Without proper sealing of joints, insulation, and sizing, much of the conditioned air never gets to where it is needed.

Even ductwork that is contained in conditioned space should be sealed in order for the delivery system to operate as designed.

Ductwork joints should be sealed with mastic, a sticky paste-like substance, or a UL-listed foil-tape.

Mastic usually comes in one-gallon container and it can be purchased from any HVAC supplier or from a more general building supply store like Lowes or Home Depot.

Mastic is best applied with a brush but some simply use their hand.

Foil tape, a shiny, silver tape should be used to seal areas on fan cabinet, flex duct connections, and other joints/areas that may have to be accessed later.

Duct tape should never be used; it will loosen and fall off in a very short time.

Action Items

When installing new ductwork, seal the joints and other areas to ensure the highest efficiency and comfort level.

If not installing new ductwork, recommend that accessible ductwork be sealed and insulated.

Resources

Ductwork Sealing

Mastic must be installed on seams & joints of ductwork, not the insulation!

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Key Concepts

Explanation

This system failed the DuctBlaster test. We found significant leakage at the collar-duct liner connection. The duct liner was fastened with a zip tie and then the insulation was fastened to the collar with a zip tie and had mastic applied to the insulation.

Action Items

Resources

Sealing at the HVAC Unit

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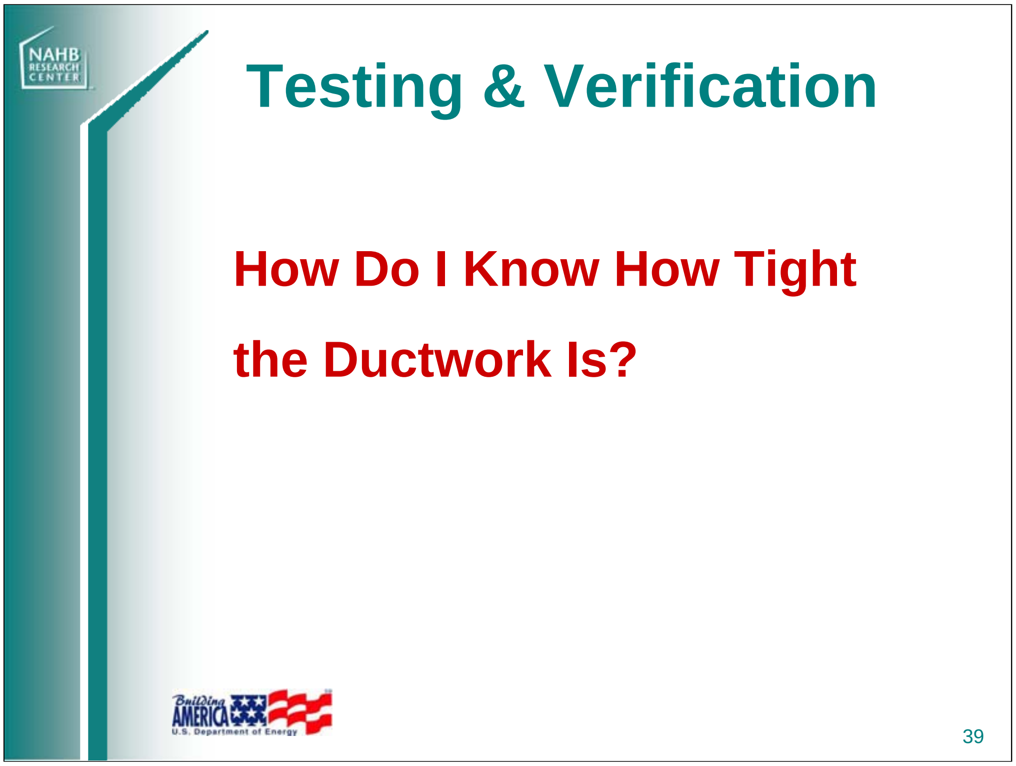
Key Concepts

Explanation

Seal the air handler at all joints and corners of plenums. Mastic the collars to the plenums on the inside or outside. Mechanically fasten the plenum to air handler. Mastic or tape exterior of duct board seams and joints. Don't forget to seal the terminal end of the duct run as well. The liner must be sealed to the boot and the boot sealed to the floor or ceiling.

Action Items

Resources



Key Concepts

Testing air tightness of the building shell and duct system

Explanation

There are equipment and tests to determine a building and duct system's air tightness. These tests can be used in sizing software and for demonstrating improvement in efficiency by renovations. The tests may be required to demonstrate adherence with efficiency programs.

Action Items

Understand that there are ways to "show" energy efficiency: both to yourself and the customer.

Resources

www.toolbase.org has more information about verification testing

Key Concepts

Understand the methods and equipment used to measure air leakage through the building envelope, duct leakage, and supply and return flow at HVAC registers

Explanation

Blower Door: A blower door is used to measure air leakage through the building envelope. To perform this test, exterior doors and windows are closed and the home is pressurized or depressurized by a large fan fitted into an exterior doorway. Calibrated instruments (manometers) are used to measure pressurization (in Pascals) and corresponding fan flow (in cfm). Air leakage is typically reported at 50 Pascals and expressed in either cubic feet per minute or air changes per hour. Air leakage of less than 0.35 air changes per hour is typically considered a "tight" building.

Ductblaster: A ductblaster works along the same principle as a blower door to measure air leakage in the HVAC duct system. Registers are sealed off and the duct system is pressurized. Again, a manometer is used to read corresponding pressure and fan flow. Air leakage is typically reported at 25 Pascals. There is no universally accepted threshold of what constitutes "tight ductwork". A range of 5-8% of system flow is usually considered tight or 3-5% of the conditioned floor area.

Duct leakage to unconditioned space only can also be measured using both the blower door and the ductblaster. The house is pressurized to a certain point – typically about 25 Pascals. The duct system (registers unmasked) is then pressurized until a pressure reading of zero is obtained. The corresponding fan flow is read. This is the flow required to achieve an equal pressure to the house, thereby providing a measure of duct leakage to the exterior. If there were no duct leakage to the exterior, the flow required to achieve equivalent pressure would be zero cfm.

Flow Hood: A flow hood is a calibrated instrument designed to read very low flows. Both supply and return flows can be read. These measurements are used to verify design flow in each room or area in the home.

Action Items

Investigate energy professionals in your area that might have the equipment and capability to measure these parameters. This can be a way to document the improvements you have made to your customer by performing "before" and "after" testing.

Resources

A list of Home Energy Raters can be found on the ENERGY STAR website (www.energystar.gov)

Duct Testing: Flow Hoods

Flow hoods:

- Measure CFM from each register
- Compare to system tonnage

  (400 cfm/ton)

41

Key Concepts

Flow hood testing is one way to measure the performance of an existing system or to verify the installation of a new duct system.

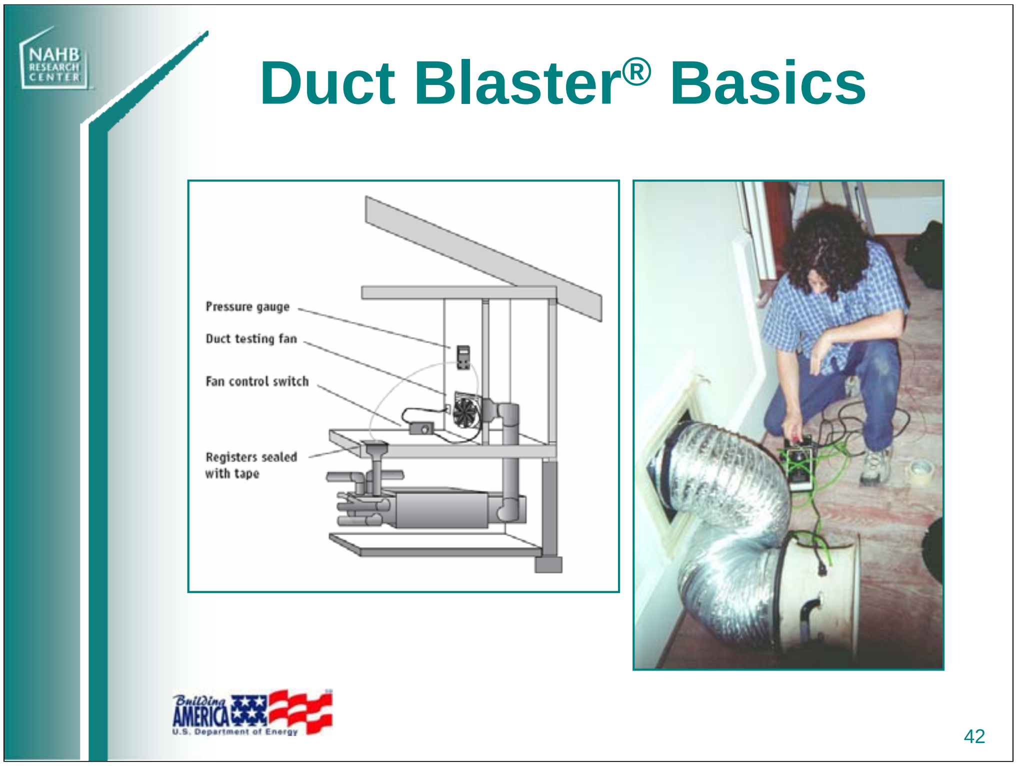
Explanation

One way to use a flow hood is to measure duct leakage by depressurizing the house and measuring the flow (leakage from outside conditioned space) from each grille, to obtain a total leakage.

Another use of the flow hood is to operate the air handler blower only and measure total supply and total return flows, then compare these results to the intended flow through the system. This test can help to determine if there are either significant leakage or significant duct constriction or both.

Action Items

Resources



Key Concepts

A duct blaster is hooked up to the duct system and the other grilles are taped. By running the duct blaster fan, a measurement of air leakage in cubic feet per minute is obtained.

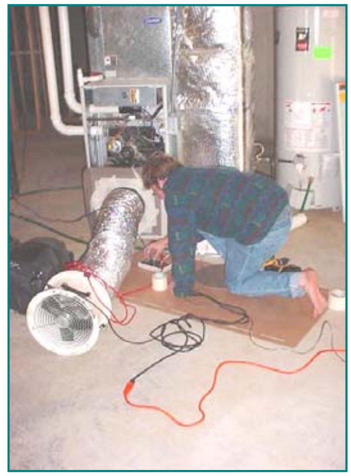
Explanation

Action Items

Resources

Duct Pressure Test

Pressure test finds leaks and estimates air flow



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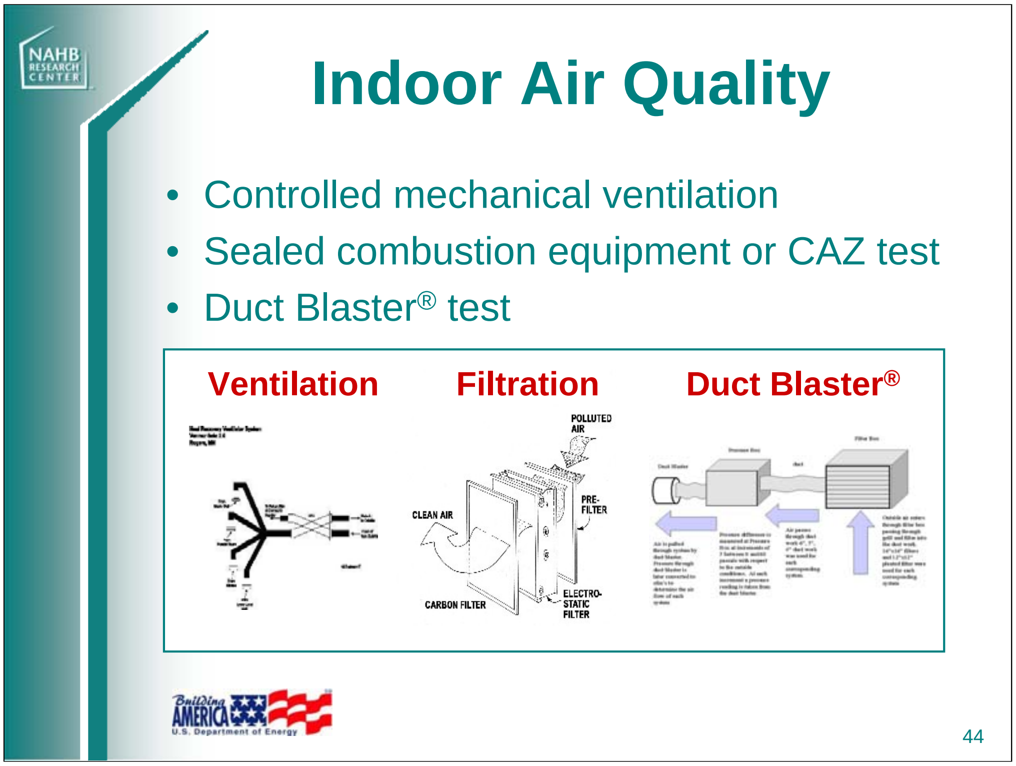
Key Concepts

A duct blaster used alone can measure total duct system leakage. Used in conjunction with a blower door (left graphic), the duct blaster will measure leakage to outside conditioned space, the largest energy penalty.

Explanation

Action Items

Resources



Key Concepts

Conscientious design and careful installation of HVAC system contributes to good indoor air quality.

Good indoor air quality adds value.

Explanation

Indoor air quality is something more and more people are familiar with and concerned about. Given recent extensive media coverage of mold and moisture issues and more available information about contaminants present in building materials as well as furnishings, your clients may already be aware of the value of "avoided costs" – whether it be in expensive repairs or in doctors' visits and medications.

Some relatively low cost improvements or testing that you can suggest include:

•***Ventilation:*** Most homes usually have bath fans and range hoods, but the homeowners need to turn them on…as well as off. Putting one or more bath fans on an automatic timer can assure low-level air exchange. Replacing an existing fan with a quiet, more efficient fan offers additional advantage. Neither of these improvements are big-ticket items in terms of initial cost or operating cost.

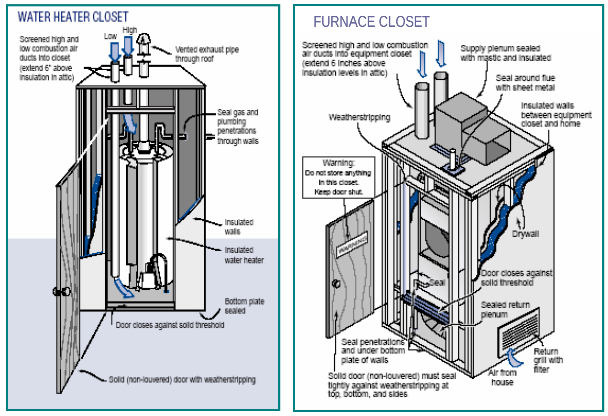
•Many people say "Oh, I'll just leave the house a little leaky and let it breathe." If this is a view that you have heard before, you might point out the following issues:

- •If your building envelope or your ductwork is leaky, you tend to get more air exchange than you want want on very cold (or hot), windy days and not enough during more moderate periods.
- •Air moving through wall cavities carries moisture and in fact, can be one source of a mold or moisture problem. As warmer air cools, it condenses and this moisture can become trapped in a wall cavity which may not dry out readily. It is much preferable to bring in air in a controlled manner.

•***Filtration:*** If your customer has a forced air heating or cooling system, it is easy to check the filter to make sure it is in good condition, has been regularly replaced, and is effective. A pleated filter is more effective than standard air filters. A more expensive and effective option is a HEPA filter. It is also a good idea to check the reservoirs of humidifiers as well as the settings. Often, homeowners add too much moisture to the house – both a potential for mold growth and a waste of energy.

•***Testing and diagnostics:*** Tests such as the ductblaster, blower door, and/or combustion appliance zone (CAZ) test are energy as well as indoor air quality indicators. The CAZ test assures that fuel-fired

Combustion Safety– Furnace, Water Heater



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Key Concepts

Combustion closets are one way to isolate combustion equipment in order to eliminate possibilities of backdrafting. Combined with sealed ductwork (and not using building components as ducts) infiltration is reduced and indoor air quality can be improved.

Explanation

When atmospherically-vented combustion equipment is located inside conditioned space, the equipment's air for combustion is conditioned air. As homes become tighter, it becomes more difficult for the air consumed to be made up with air infiltrating from outside. If a pressure imbalance is created in the house, the possibility exists that the combustion gases could spill into the home rather than exit the home via the flue, thus potentially creating a lethal situation.

The possible solutions are to 1) use electric equipment rather than combustion equipment, 2) use sealed combustion furnaces and power vented or direct vent gas water heaters, 3) locate equipment outside the envelope, or 4) isolate combustion equipment that is conventionally vented inside a closet that has a supply of combustion air piped directly from outside.

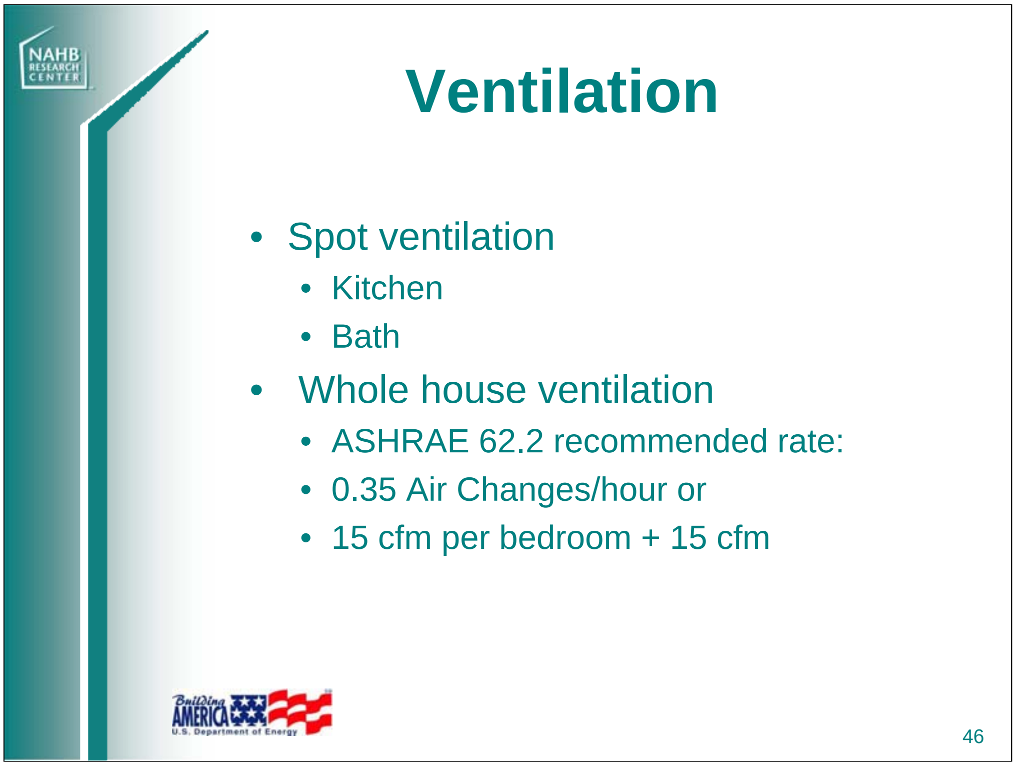
This diagram shows one way of locating an 80% AFUE (natural draft) furnace inside a closet, with a shelf below the unit providing space for the return plenum.

Action Items

Resources

Southface fact sheet:http://www.southface.org/web/resources&services/publications/technical_bulletins/CES-Combustion-safety%2000-784.pdf

Southface fact sheet: http://www.southface.org/web/resources&services/publications/factsheets/28_comustioncloset4PDF.pdf



Key Concepts:

Spot ventilation removes moisture, odors, and contaminants at the source.

Whole house ventilation can be thought of as low flow “background” ventilation.

Explanation:

As was discussed in more detail in the kitchen and bath modules, the primary purpose of spot ventilation is to remove moisture, odors, and possible contaminants at the source. This is typically the most direct and effective way to maintain acceptable indoor air quality – that is, if ductwork is sized properly, run as short a distance as possible, and free of kinks and sharp bends. Poorly designed or installed ductwork can cut the actual flow rate of a fan in half.

With typically tighter construction, many believe that whole house ventilation is important to assure a periodic exchange of indoor air and dissolution of possible contaminants. The ASHRAE Standard 62.2 recommends a ventilation rate of 0.35 air changes per hour or 15 cfm per bedroom plus an additional 15 cfm – considering two people in the master bedroom.

Some states such as Minnesota and Washington have incorporated a requirement for mechanical ventilation in new homes into their energy code. The national ENERGY STAR program is also considering a ventilation requirement for certification.

In severe heating or cooling climates, there may be a severe energy penalty by providing mechanical ventilation. In these areas, it is wise to consider heat recovery or energy recovery ventilators.

Action Items:

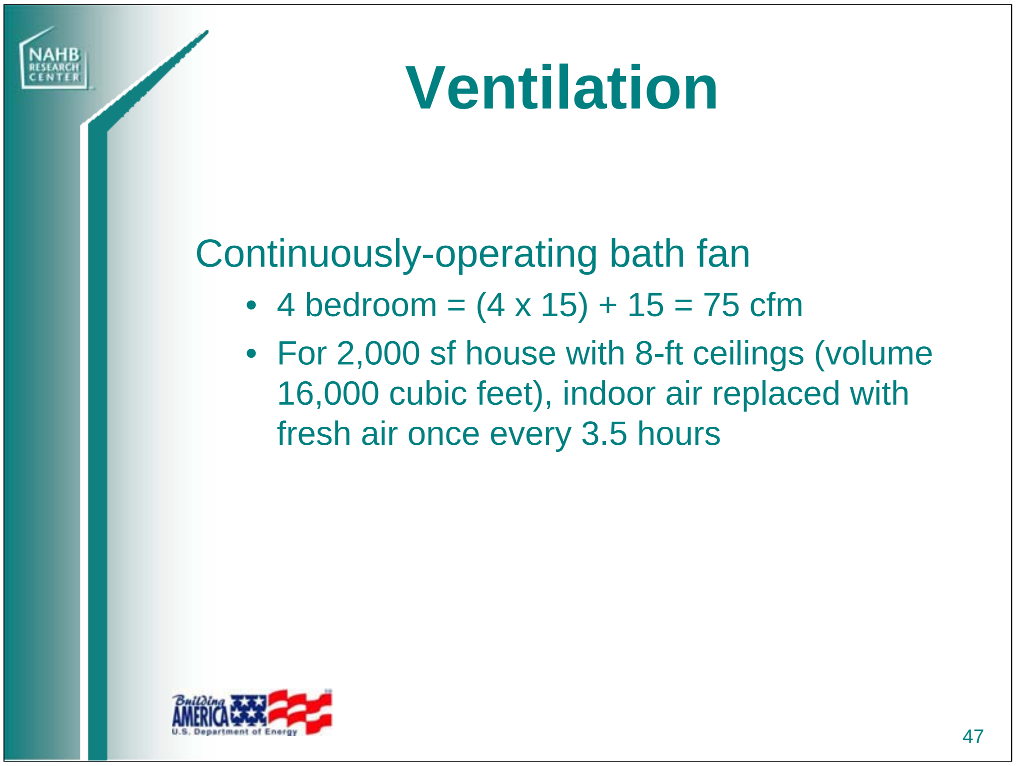
Check existing bath fans and range hoods to ensure that they are working properly.

Discuss the use of these fans with your clients. Do they use them? Do they remember to turn them off?

Discuss the possibility of upgrading existing fans and/or installing automatic controls.

Consider the possibility of adding some sort of whole house ventilation if:

- the house was built in the last 7-8 years and appears to have been carefully air sealed,
- the owners complain of stuffiness, or
- a blower door test indicates a very low exchange rate before or after you complete your work.



Key Concepts

This type of ventilation system works best for colder climates

Explanation

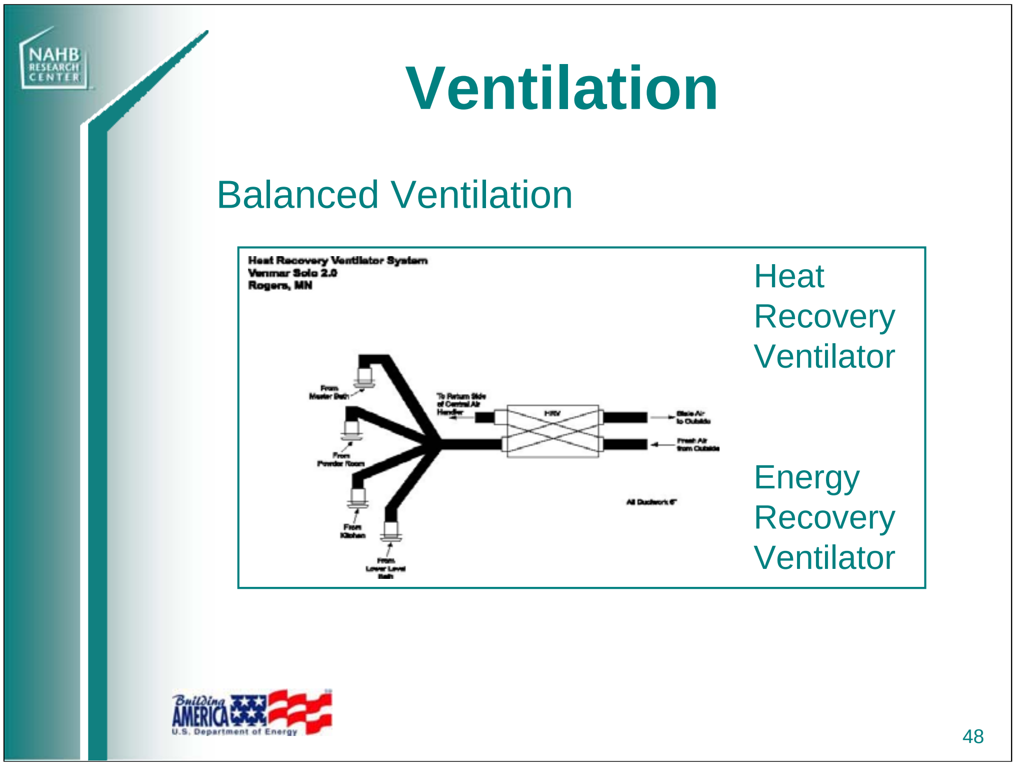
Ventilation example: In a 2,000 sf home, a 75 cfm fan operated continuously would replace indoor air with outdoor air once every 3.5 hours.

Action Items

Resources

Instructor's Notes

If possible, obtain two different bath fans – one an inexpensive model and the other a low-sone, energy efficient model like one of the Panasonic or Broan-Nutone fans. Wire them with a plug and bring them into class to demonstrate the difference in operating noise. Using the rated wattage of the fans, develop some examples about cost of operation over several hours per day.



Key Concepts

Understand the options available for providing whole house ventilation

Explanation

Heat recovery ventilators preheat (or precool) incoming outdoor air with outgoing indoor air by an integrated heat exchanger. An HRV can recover about 70 percent of the heat in the outgoing air stream. An energy recovery ventilator also recovers or removes humidity (also called latent energy) and can have a higher efficiency.

Dedicated supply and exhaust ductwork can be installed. A more cost effective approach is to use the central HVAC duct system for distribution of fresh air and duct the exhaust air independently. The central duct system should not be used for both supply and exhaust as short-circuiting is likely to occur.

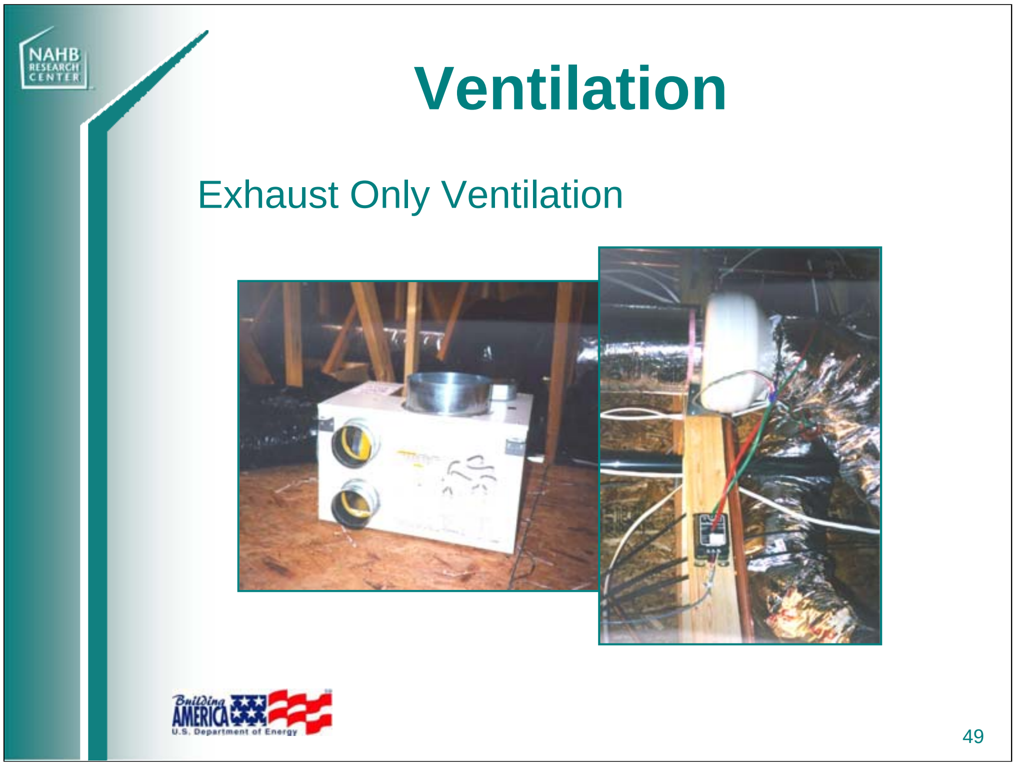
A heat or energy recovery ventilator is probably the most energy efficient means of introducing outdoor air. However, it is at the high end of the cost spectrum. An HRV or ERV runs about $800 to $1,000 plus ductwork and installation.

Action items

Discuss different ventilation options with your HVAC contractor.

Ask for an estimated cost to install an HRV or ERV.

Resources



Key Concepts

Options available for providing whole house ventilation

Explanation

In this type of system, air is exhausted from the house by one or more fans. This depressurizes the home and air is pulled in from outdoors through small cracks in the building envelope. Even the tightest home will undoubtedly have some pathways where air will enter. No building is completely airtight.

Exhaust-only ventilation for the whole house often serves double-duty as bath ventilation, too. The fan(s) might operate at low speeds continuously with the capability of being “boosted” when someone is using the bathroom.

Fans can be remotely located in the attic or basement as shown here or directly in the room as is typical of most bath fans.

Typically, exhaust-only ventilation is not recommended for hot humid climates because it may encourage humid outdoor air to migrate through the wall cavity, where condensation is likely to occur when the air meets a cool surface.

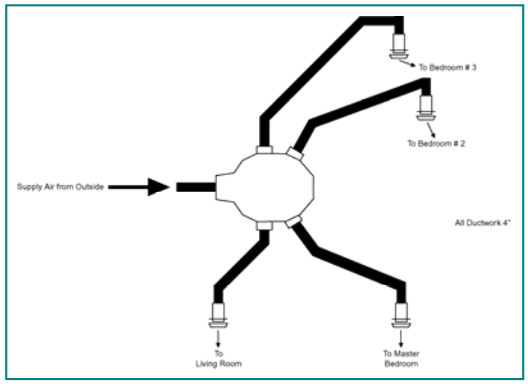
Exhaust-only ventilation is an option for a predominate heating climate. In cold climates, the outdoor air is usually colder than the indoors and will dry out as it moves into the warmer area.

Action Items

Resources

Ventilation

Supply Only Ventilation



50

Key Concepts

Options available for providing whole house ventilation.

Explanation

Supply-only ventilation is simply the reverse of exhaust-only ventilation. Often, a similar type of tube fan is used to deliver outside air to main living spaces or bedrooms.

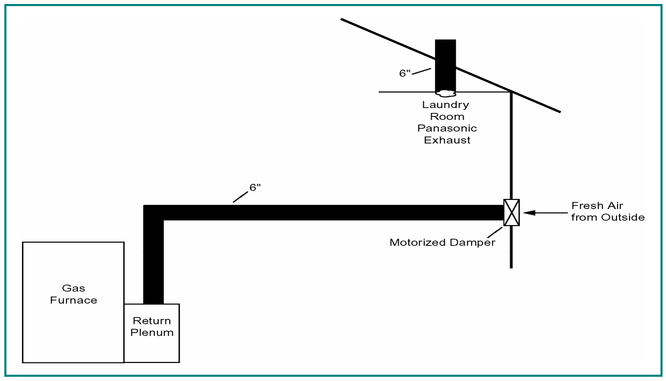
As you might guess, supply-only ventilation is not recommended for cold climates since condensation might occur within the wall cavity as warmer indoor air moves to the cooler outdoors. Supply-only ventilation may be used in warmer or hot climates.

Action Items

Resources

Ventilation

- Semi-Balanced Ventilation –
- Combined Systems



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Key Concepts

Whole house ventilation options

Explanation

A central fan integrated system brings in outdoor air through a single duct and delivers it to the return plenum of the forced air heating or cooling system. It is then filtered, and heated or cooled prior to being delivered to the house through the central duct system. A motorized damper can be installed to prevent excess introduction of outdoor air. This system slightly pressurizes the house when the air handler blower is operating, causing pollutants to be driven out of the home. Electronic controls, like the Aprilaire Ventilation Controller, shut the air intake off when RH is high and temperatures are very low.

In the case depicted here, a single fan located in the laundry room exhausts air from the home. Supply and exhaust rates are similar.

A central fan integrated system coupled with a bath fan can be a good solution for a retrofit or remodeling situation. Ductwork can usually be brought into the basement relatively easily. An existing (or new, more efficient) bath fan can be put on a timer to exhaust air periodically.

The ductwork for a central fan integrated system must be sized carefully in extreme climates to avoid bringing in too much very cold air across the heat exchanger or too much warm, humid air across cooling coils that would result in significant condensation.

Action Items

Consult your HVAC contractor about proper sizing of a central fan integrated system in your climate.

Resources

Water Heating–Overview

- Energy Use
- Water Conservation
- Water Heaters
- Distribution Systems
- Performance Issues

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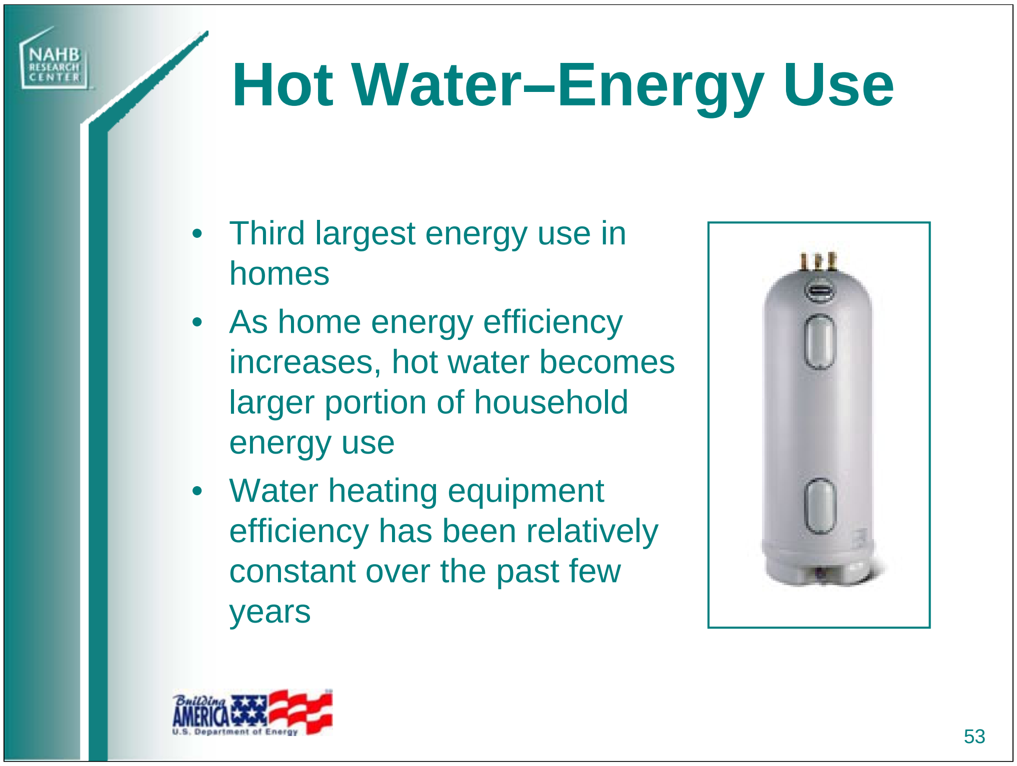
Key Concepts

Overview of water heating section

Explanation

Action Items

Resources



Key Concepts

Importance of water heating in overall household energy use

Photo: Marathon high efficiency electric water heater

Explanation

Hot water is typically the largest use of energy in homes next to heating and cooling. Nationally, hot water accounts for 15%-25% of residential energy consumption. And, as homes become better insulated and heating and cooling equipment becomes more efficient, water heating is increasing as a portion of a home's energy use.

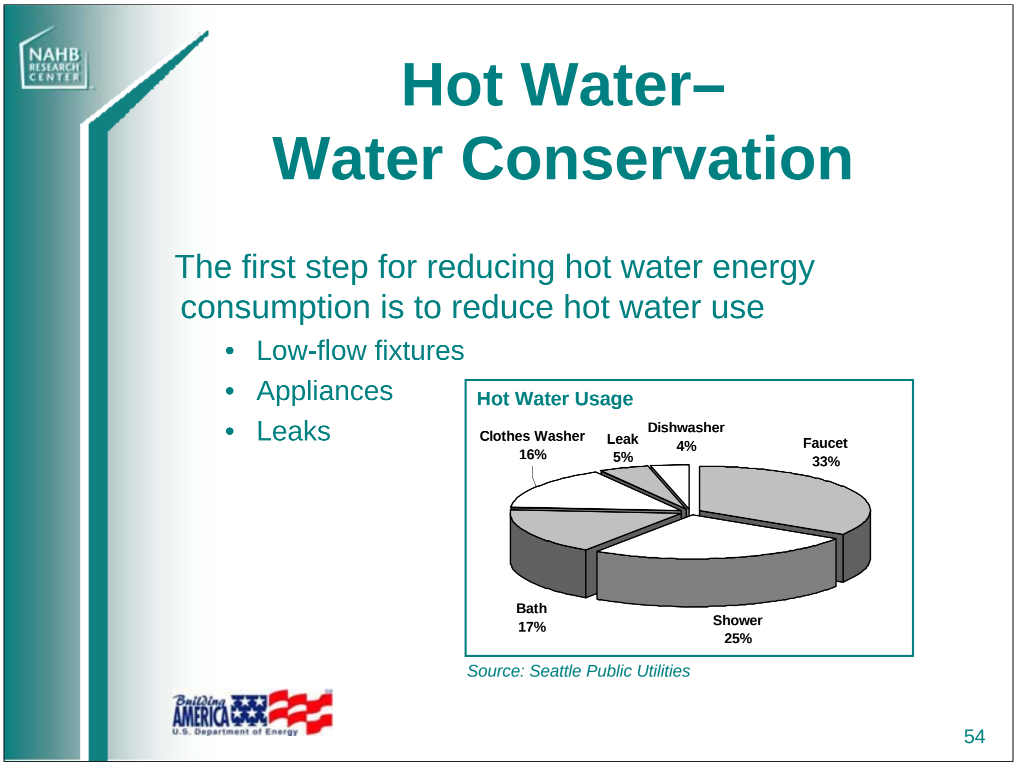
Action Items

Be aware that hot water can be a significant portion of a home's energy use and look for opportunities to save hot water in the remodeled home.

Resources

Water Heating: Energy Efficient Strategies for Supplying Hot Water in the Home, U.S. DOE fact sheet, available at http://www.southface.org/web/resources&services/publications/technical_bulletins/WH-Waterheating%2001-785.pdf

Consumer's Guide to Home Energy Savings, 1996, Chapter 6 Water Heating, American Council for an Energy-Efficient Economy, Washington, DC.



Key Concepts

Saving water will also save hot water energy

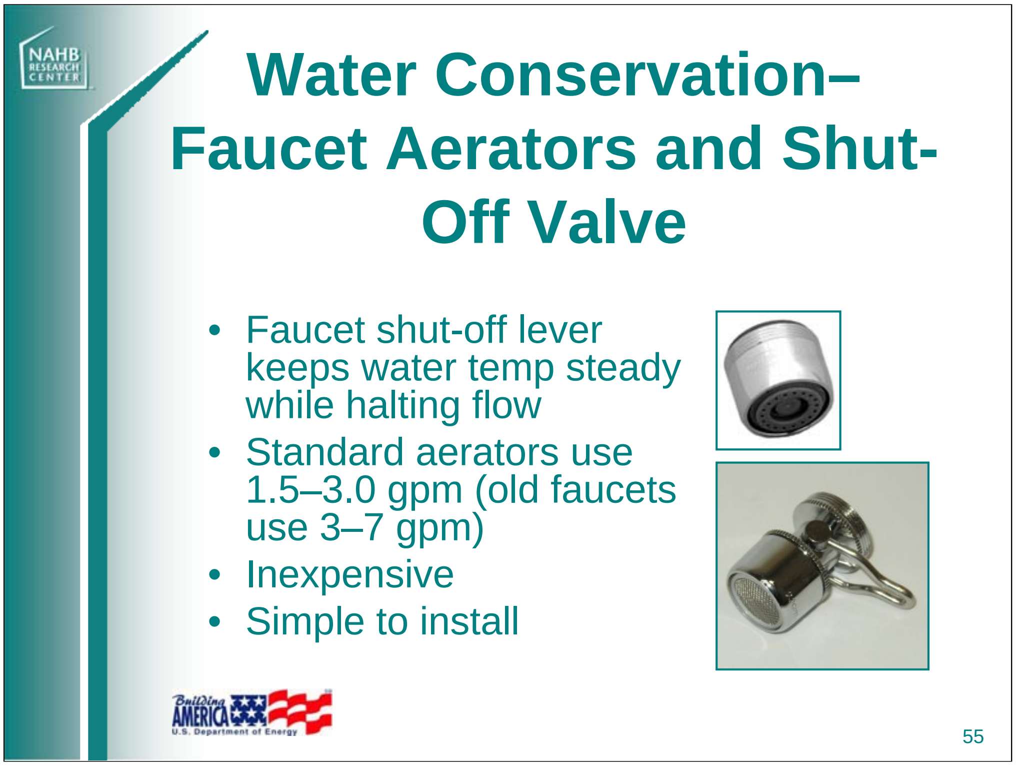
Explanation

The figure shows where hot water is used in a typical home. A lot of water can be saved by switching out old showerheads and faucets for newer, low-flow faucets. All new faucets (post-1993) adhere to the low flow standards--most people can't tell the difference between old faucets and new. In addition, if homeowners have a tank water heater and experience problems with running out of hot water, low-flow fixtures and appliances can help solve the capacity problems.

Action Items

Look for opportunities to save hot water during a remodeling project—not only saving money for your customers but also potentially resolving water heater performance issues.

Resources



Key Concepts

Reducing hot water energy use attributed to faucets.

Explanation

Screw-in aerators can reduce water usage by half or more. They cost a few dollars at most and can be very simple to install (depending on the existing faucet). For a home that does a lot of handwashing of dishes, a faucet shut-off valve can be a handy and efficient device. The water tap remains open, but water is shut off at the faucet (see photo) by a small lever. That way, the temperature and flow rate can be held constant while the water is flipped on and off numerous times.

Action Items

Look for opportunities to install inexpensive faucet aerators or other water conservation devices.

Resources

Energy conservation supply store, e.g., www.efi.org

See Bath Module for more information about low-flow fixtures, faucets, and showerheads.

Water Heater Replacement

Consider replacement if:

- There are performance problems
- Equipment nearing end of useful life (10-20 years)
- Equipment needs costly repair

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Key Concepts

Replacing water heating equipment

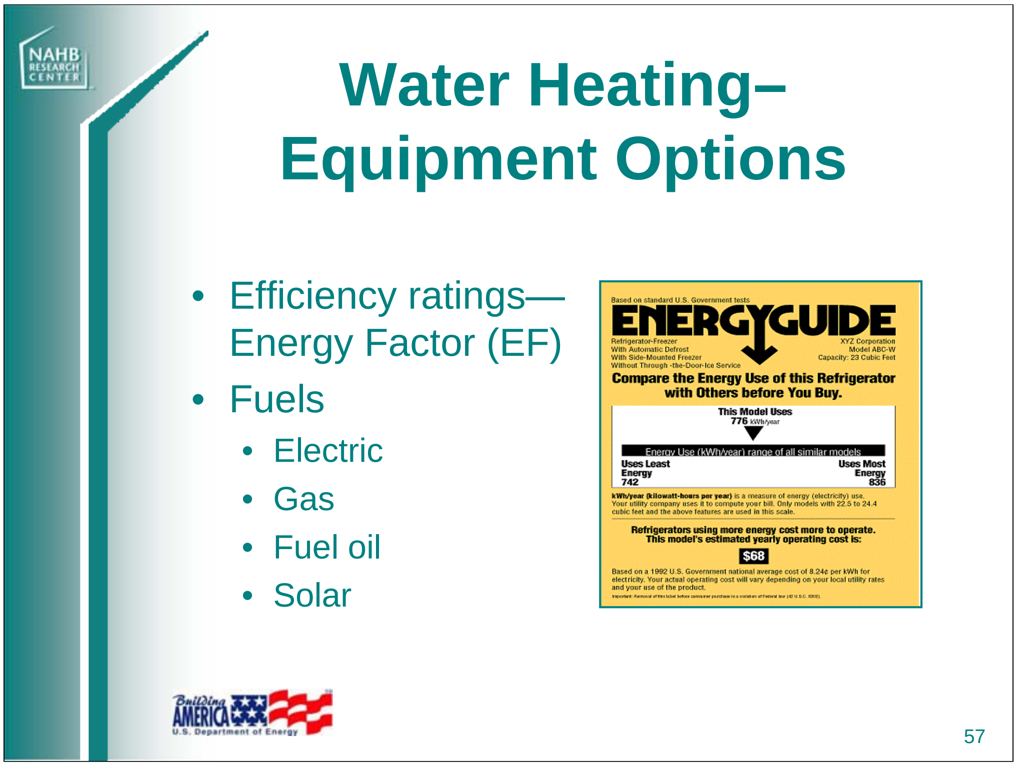
Explanation

Tank-type water heaters typically last 10-15 years while tankless water heaters can last about 20 years. If there are performance issues with the existing water heater or if the equipment is nearing the end of its useful life, the remodeling process might be a good time to replace the existing water heater.

Action Items

If you are working with a client to replace water heating equipment, consider the options available to improve the performance and energy efficiency of the existing water heating system.

Resources



Key Concept

Options for water heating equipment

Explanation

Most water heating equipment—whether operated by electric, gas, or fuel-oil—is rated by an energy factor, or EF—although it is often fairly difficult to find a water heater's EF anywhere on the equipment. An easier choice for determining equipment efficiency is the yellow EnergyGuide label. The label compares "apples to apples"—for example, it will compare a 50-gallon electric water heater to another 50-gallon electric water heater. The arrow on the sliding scale shows where this water heater falls in comparison to other similar water heaters. EnergyGuide labels are prominently displayed in many stores. Websites such as www.sears.com have easily accessible EnergyGuide labels.

Even though electric water heaters have a higher EF than other fuels, they are typically more expensive to operate…This is because EF does not take into account the inefficiency of delivering electricity to a house (which is about a 3:1 ratio, three units of fuel at a central power plant produce one unit of electricity at a home).

Solar water heaters are an option in many areas and tend to be most efficient in cold dry climates.

There is currently no ENERGY STAR label for water heaters.

Action Items

Be aware of equipment options and what the yellow EnergyGuide label means.

Resources

The Most Energy-Efficient Appliances 2002-2003 (American Council for an Energy-Efficient Economy) http://www.aceee.org/consumerguide/mostenef.htm

U.S. DOE, How to Read the EnergyGuide Label, http://www.eere.energy.gov/consumerinfo/energy_savers/label.html

Database of State Incentives for Renewable Energy http://www.dsireusa.org (solar water heaters)

Solar Water Heating (fact sheet) http://www.toolbase.org/tertiaryT.asp?TrackID=&DocumentID=3216&CategoryID=949

Types of Water Heaters

- Tank-type (storage)
- Tankless (instantaneous)
- Heat pump

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Key Concept

Types of water heating equipment

Explanation

The most common water heater is a storage tank which keeps a tank of heated water ready for use in a home. They typically hold between 20 and 80 gallons and run on electricity, gas, oil, or solar energy. Because the hot water is kept in a tank, there are standby energy losses in this type of water heater. Newer storage water heaters typically have high levels of insulation and built-in controls (anti-thermosiphon valves) to prevent energy loss. Tankless water heaters, also called on-demand or instantaneous water heaters, produce hot water as it is needed and therefore do not have standby energy losses. However, because they do not have a cache of hot water waiting to be used, they have limitations on the amount of hot water that can be run simultaneously (especially electrical tankless heaters that are limited to 28-kW, or the equivalent of raising 3.8 gpm by 50 degrees F). Heat pump water heaters are a less common technology that has promise for reducing energy needs of water heating—especially in warmer climates where electrical water heating is common.

Action Items

When replacing a water heater, consider the available types of equipment and the benefits of each to the homeowner.

Resources

Instructor's Notes

Fuel-Fired Water Heaters

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Key Concepts

Explanation

Direct vent water heaters:

•Require no electricity

•Use double wall vent pipe (one cavity for exhaust gases, one for combustion air piped directly inside)

•No chimney to install.

Power vented water heaters:

•Use 3” PVC or CPVC or ABS vent piping, vented horizontally or vertically, blower on top of unit

•High efficiency- up to 11% more than a standard 0.55 EF water heater, electronic ignition

•Use house air for combustion

Sealed Combustion water heaters:

•Same as power vented but with combustion air brought in from outside.

Action Items

Resources

Solar Water Heaters

- Silent
- Cut water heating 40-80%
- Low maintenance
- +/- 20º Solar South

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Key Concepts

Cuts water heating by 40-80%.

Explanation

The typical Georgia household hot water costs are about $300 per year. In a PER FSEC website: Savings depends on water usage, fuel used for backup and storage tank size. The average family of 4 uses 70 gallons/day of hot water, or 3990 KWH/yr to heat the water electrically. At $0.10/KWH, costs are $399 for water heating. Depending on the latitude, solar water heating can provide 40-80% of hot water needs, thus saving in this example, $160-$240/year.

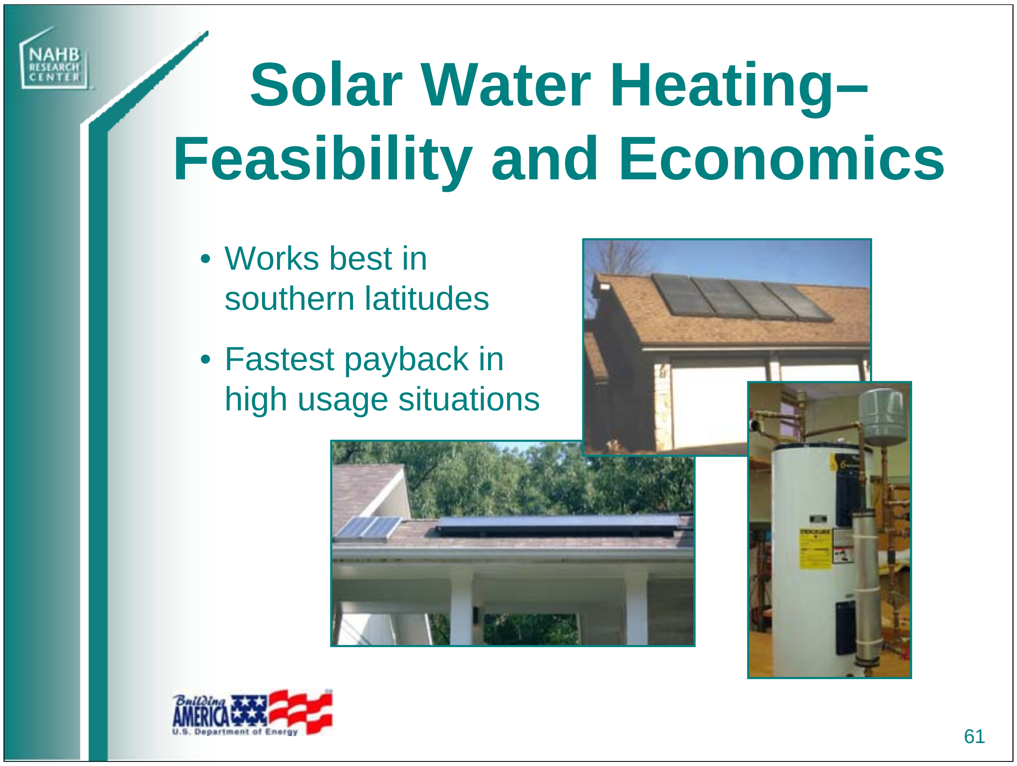
Maintenance can be quite low if installed by an experienced contractor, for example typical regular maintenance on a passive system is none. On an active system, usually only the glycol needs replacing every 5-15 years. If the system uses potable water instead of distilled water, flushing of the pipes may be needed depending on the mineral content in the water.

Used by more than 1 million homes and over 200,000 businesses in the US

(usually $2,000-$4,500).

Performance is the best if the solar collector is oriented within 15 degrees of solar south. However, even greater deviations can work, but efficiency and collector sizing will be affected.

Action Items



Key Concepts

Solar intensity is higher and lasts longer in southern latitudes, but solar water heating for residences can be used in most areas of the U.S.

Savings per month are greatest when household usage is greatest.

Explanation

Action Items

Resources

HWDS Simulation Results– Annual Waste

One Story, Two Bath, 2010 ft^2

System/Option Evaluated	Annual Water Waste (Gallons)	Annual Energy Waste ($)	
		Electric @$0.116/kWh	Gas @$0.683/therm
Conventional, Attic, Copper - Central Water Heater	1400	35	11
Conventional, Attic, CPVC - Central Water Heater	1400	**34**	**11**
Conventional, Attic, Copper	2400	59	18
Conventional, Attic, Copper - Insulated	2300	58	18
Conventional, Attic, CPVC	2300	55	17
Conventional, Attic, CPVC - Insulated	2200	55	17
Conventional, Slab, Copper	10100	273	85
Conventional, Slab, Copper - Insulated	2300	60	19
Conventional, Slab, CPVC	9200	224	70
Conventional, Slab, CPVC - Insulated	2300	56	17
Demand Recirculation, Attic, Copper	**900**	**27**	**8**
Demand Recirculation, Slab, Copper	**800**	**26**	**8**
Demand Recirculation, Attic, CPVC	**900**	**24**	**8**
Demand Recirculation, Slab, CPVC	**800**	**23**	**7**
Parallel Pipe, Attic, PEX	2400	60	19
Parallel Pipe, Slab, PEX	3400	89	28
Continuous Recirculation, Attic, Copper – Insulated *****	**900**	146	46
Continuous Recirculation, Slab, Copper – Insulated *****	**800**	427	133
Continuous Recirculation, Attic, CPVC – Insulated *****	**900**	158	49
Continuous Recirculation, Slab, CPVC – Insulated *****	**800**	389	122

***** Pumping power consumption for these systems adds $88/yr. to both gas and electric totals shown above

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Key Concept

The length of the system, pipe material, location of the pipes, and recirculation capability all impact overall hot water distribution system (HWDS) performance.

Explanation

In study for the California Energy Commission Oak Ridge National Laboratory (ORNL) compared the performance of various HWDS to determine the amount of hot water and energy that were wasted waiting for the temperature to rise to an acceptable level of 105^{o}F. Moving the water heater from the garage to a more central location reduced pipe lengths and saved energy and water. Systems buried in the attic insulation outperformed those buried below the floor slab. CPVC pipe was somewhat better than copper pipe. Both demand and continuous recirculation systems save a lot of water, but continuous recirculation systems (always on) consume the most energy of all options.

Action Items

Resources

HWDS Simulation Results– Wait Time in Seconds

One Story, Two Bath, 2010 ft^2

System Characteristics	Wait Time for HW (Sec.)		
	Min	Typical	Max
Conv Attic Cu - Central	2	5	40
Conv Attic CPVC - Central	2	5	39
Conv Attic Cu	2	5	99
Conv Attic Cu-Ins	1	5	99
Conv Attic CPVC	2	5	95
Conv Attic CPVC-Ins	2	5	95
Conv CS Cu	3	9	103
Conv CS Cu-Ins	2	5	102
Conv CS CPVC	2	8	98
Conv CS CPVC-Ins	2	5	98
Conv Slab Cu	32	54	109
Conv Slab Cu-Ins	2	4	102
Conv Slab CPVC	28	50	98
Conv Slab CPVC-Ins	2	5	98
Demand Recir Attic Cu	2	5	9
Demand Recir Slab Cu	2	4	8
Demand Recir Attic CPVC	2	5	9
Demand Recir Slab CPVC	2	4	8
Parallel Attic PEX	2	11	36
Parallel Slab PEX	9	19	38
Recir Attic Cu-Ins	2	5	9
Recir Slab Cu-Ins	2	4	8
Recir Attic CPVC-Ins	2	5	9
Recir Slab CPVC-Ins	2	4	8

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Key Concept

Short wait time for hot water to arrive at the fixture is important to homeowner. Many homeowner find a more than 30 second wait unacceptable.

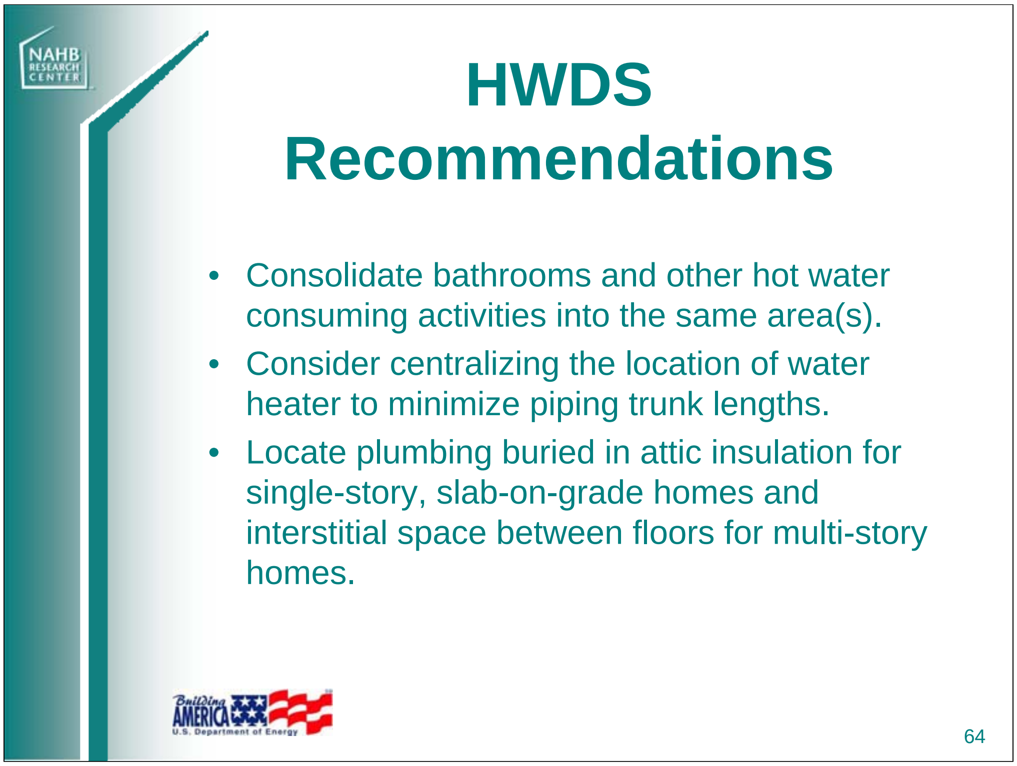
Explanation

The ORNL study also identified the waiting time for hot water to arrive at various fixtures. All of the options that did not include recirculation had a maximum wait above what most homeowners find acceptable (30 seconds). The maximum wait was usually the first use of the day, typically the master shower. Once hot water had been drawn into the pipes, the systems performed similarly with the exception of those with uninsulated pipes below the floor slab.

Action Items

Consider adding a demand recirculation pump if current wait times for hot water are too long for your customer.

Resources



Key Concept

These recommendations can improve hot water distribution system performance.

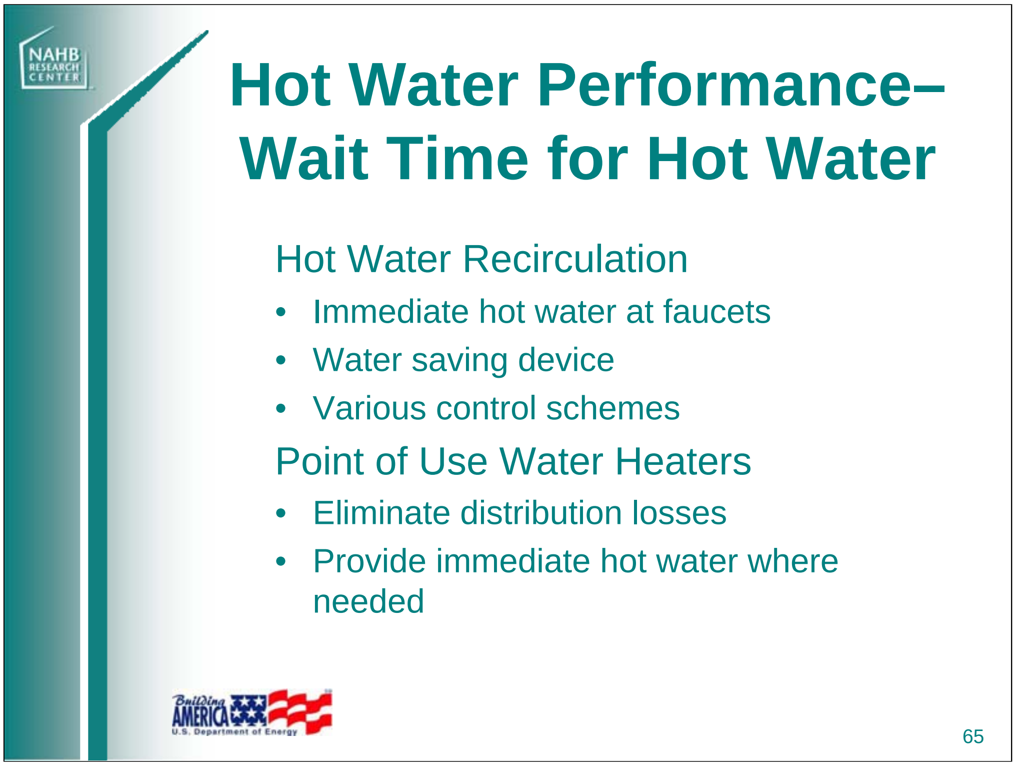
Explanation

When your project includes adding bathrooms or replacing the kitchen, try to cluster the hot water consuming devices together to minimize the length of the piping. If a new or replacement water heater is called for, consider locating it near the center of hot water usage. For slab on grade additions it is preferable to run the hot water lines in the attic or between the floor rather than below the slab.

Especially with tank-type systems in heating-dominated climates, the water heater is best kept in conditioned space. This reduces the amount of standby losses. For very warm climates, it may be best to keep the water heater outside of the conditioned space (where it will add to the cooling load). By keeping the water heater in a central location, distribution system losses can be minimized. Heat pump water heaters, which take energy from the surrounding air to heat water, can be beneficially located in conditioned space in cooling-dominated climates.

Action Items

Resources



Key Concepts

Resolving hot water system performance issues during the remodeling process.

Explanation

Hot water recirculation systems are intended to conveniently supply hot water at outlets without waiting. They save water by allowing hot water use to occur immediately when the faucet is turned on, rather than purging the cooled water from the pipe first. A recirculation system uses a pump to deliver hot water to a tap that is located far from the water heater.

Continuous recirculation systems, by constantly recirculating water throughout the house in order to get immediate hot water (as would be the case in an apartment building), cause significant additional energy use (see earlier slides with simulation results) due to heat loss by the pipes and pumping energy.

Controls are available to limit pump operation. Most notably is the hot water on demand system (Metlund and others) that turns the hot water pump on with the flip of a switch (or another control mechanism such as an occupancy sensor) near the outlet. These demand recirculation systems save both water and energy

In retrofit situations, a hot water recirculation system would be installed under the sink at the faucet farthest away from the water heater. These systems have automatic controls that stop the pump once hot water is detected in the pipe, thereby minimizing the temperature increase in the cold water line.

Point-of-use water heaters, typically a small, undersink water heater or a larger tankless water heater that serves a bathroom are served by cold water only and produce hot water where it is needed. Therefore, they eliminate distribution system losses and wait time for hot water. However, they can be expensive to install due to electrical requirements or gas venting requirements. Small undersink tanks usually have relatively high standby losses, also, but the energy loss maybe offset by distribution system energy savings.

Action Items

If installing a new bath or kitchen which is far away from the existing water heater, consider a point of use water heater to serve the room or an on-demand hot water recirculation system.

If the homeowner complains of excessive wait time for hot water, offer potential solutions.

Resources

HWDS Recommendation

- Do not oversize hot water piping. Use code permitted minimums. Bigger isn't better.
- Consider CPVC or PEX plastic piping in lieu of copper when appropriate quality and durability can be demonstrated.
- Consider installing a demand recirculation system to reduce wait times and waste.

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Key Concept

These recommendation can improve HWDS performance. The first two will also reduce the initial cost of the project.

Explanation

Oversized pipes hold excess hot water that cools down between uses. This water must be displaced by more hot water when another use occurs. The tepid water and the energy used to heat it are wasted "down the drain". There is more than twice the volume in a ¾-inch pipe than a ½-inch pipe of the same pipe length).

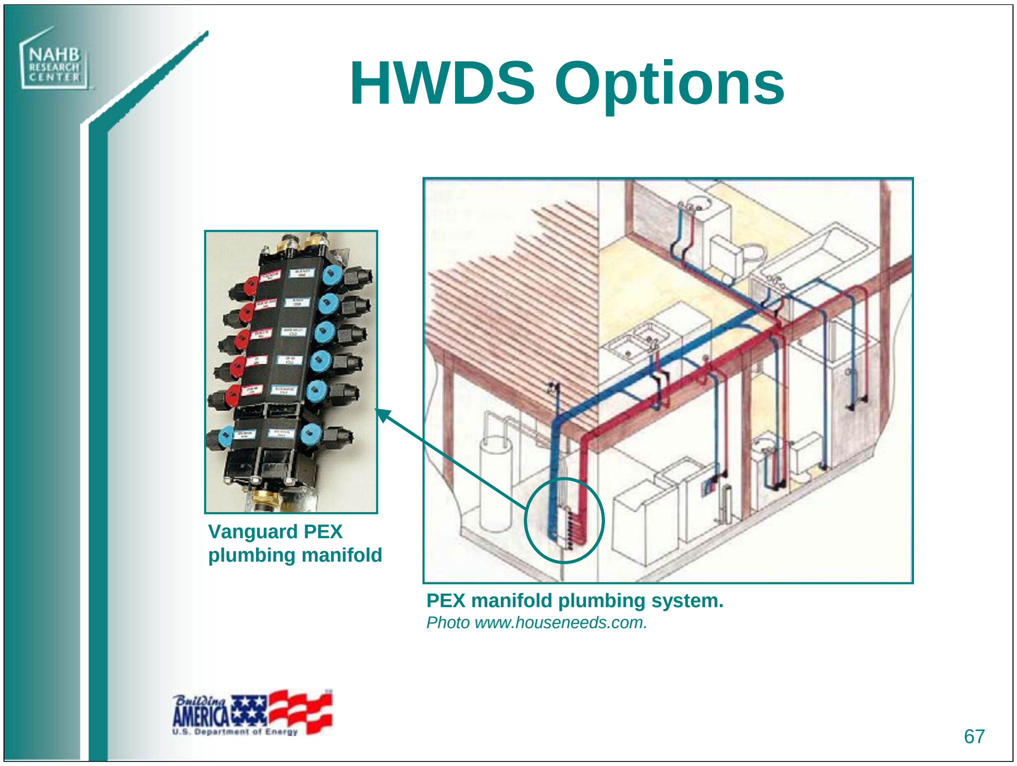
Plastic pipes have a lower conductivity than copper and therefore lose heat less quickly. This also can help reduce waste in the HWDS. Some early plastic pipe systems performed poorly. However, most currently available materials have demonstrated a history of satisfactory performance.

If you customer has commented on long waiting times for hot water to arrive, check out the demand recirculation systems currently on the market. These are available from most Home Centers and include Metlund and other brands.

Action Items

Talk to your plumber about the pipe materials and locations for the HWDS in your project.

Resources



Key Concept

Hot water distribution system options

Explanation

If piping needs to be replaced or you are plumbing an addition, you might consider a home-run or manifold distribution system in which one pipe is run to each fixture. Typically, PEX (cross-linked polyethylene) is used for this type of plumbing system. The semi-flexible piping can be run through walls (similar to electrical wire) without the need for joints and can have significant advantages for use in remodeling. Plumbing codes typically allow a nominal one-size reduction in piping diameter for manifold plumbing systems.

An NAHB Research Center study showed using a smaller diameter piping in a parallel configuration (such as the PEX manifold system) can save 6% to 13% in hot water energy.

Action Items

When replacing or adding hot water piping, consider the use of a PEX manifold system. Use the smallest diameter piping allowable to serve each fixture.

Resources

Wiehagen, J. and J.L. Sikora, 2002, *Performance Comparison of Residential Hot Water Systems,* NAHB Research Center, available from http://www.nahbrc.org/docs/MainNav/Energy/3831_hotwatersystems.pdf

Hot Water Performance–Capacity Issues

Capacity

- Tank-type water heater
- Tankless water heater

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Key Concepts

Resolving hot water system performance issues during the remodeling process.

Explanation

If homeowners note that they have issues with getting enough hot water, you may be able to help resolve the issues during the remodeling process. For example, if the homeowners often “run out” of hot water during successive showers, a tankless water heater may be an effective solution. Tankless water heaters heat water instantaneously, and therefore have an effective unlimited supply of hot water for successive hot water uses. However, the capacity of tankless water heaters can be limited for simultaneous hot water uses.

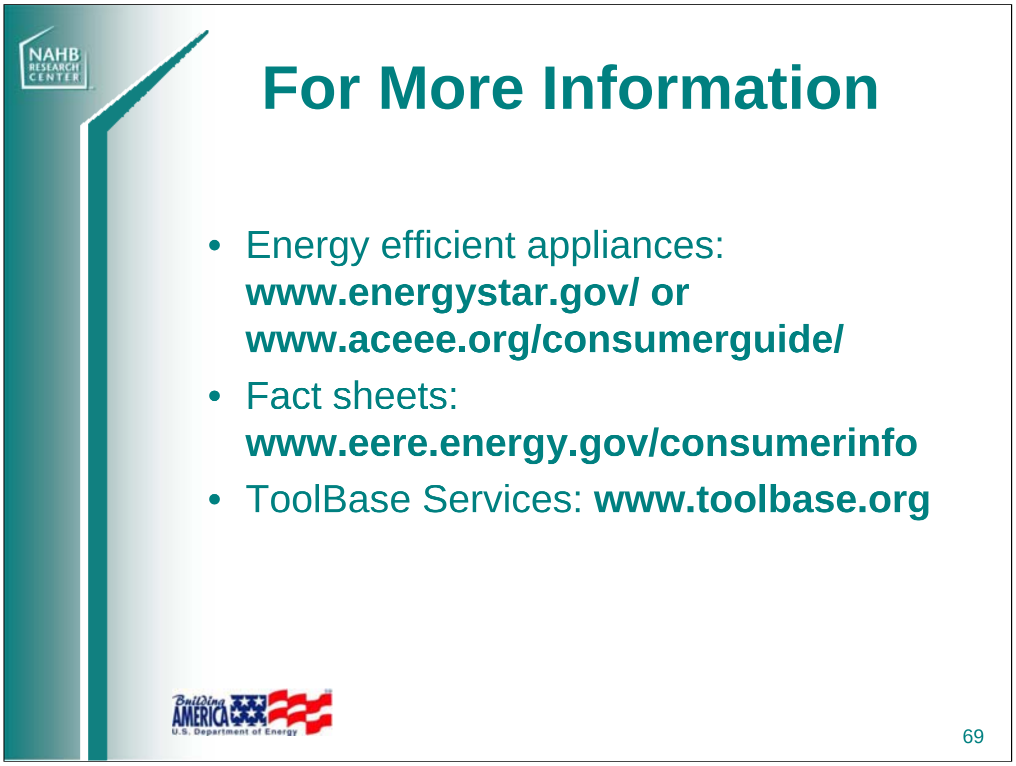
Action Items

Note any changes in hot water uses that may occur due to the remodel, and make sure that the equipment is suitable for the remodeled home.

Look for ways to improve the residential hot water system during the remodel to save energy and improve the system performance.

Resources

Weingarten, Larry and Suzanne, *The Water Heater Workbook,* available from http://www.heatinghelp.com/shopcart/product.cfm?category=2-20



Key concepts

Throughout this module we've provided resources for further information. Here are some sources for additional information and to help you keep apprised of the latest energy efficiency news

Explanation

We recognize we can cover only so much information during this course. In addition, new technologies come out every week, so what you learn about here might be trumped by another product by this time next year.

Action Items

We suggest you visit these Web sites at least quarterly to see if there is any new information available. In addition, add these URLs to your Bookmarks in order to easily access the web sites for each new project.

Resources

http://www.energystar.gov/

http://www.aceee.org/consumerguide/

http://www.eere.energy.gov/consumerinfo/

http://www.toolbase.org