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EC02-458 Heating and Cooling Systems: Saving Energy and Keeping Safe (Home*A*Syst Fact Sheet 1)

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University of Nebraska Cooperative Extension EC 02-458-S

Home*A*Syst

FACT SHEET 1

Nebraska's System for Assessing the Environment of the Home

Heating and Cooling Systems: Saving Energy and Keeping Safe

This fact sheet will help you identify possible problems with your home heating system, duct system, and the house envelope (the foundation, floors, walls, ceilings, and roof). By keeping your system in proper order, you can avoid unhealthy situations, reduce energy bills, increase your comfort level, and prevent structural damage. This publication covers:

1. Combustion Heating Appliance Ventilation Safety
2. Energy Consumption
3. Energy Efficiency (heating/cooling systems, air-sealing and insulation, and domestic hot water)

Your house should be a safe, comfortable place that is affordable and durable. How a home is constructed, insulated, and heated and cooled directly affects how well it meets these objectives. A house is affordable only when costs for heating and cooling are reasonable. Energy bills are lowest if a home is tightly air-sealed and properly insulated and if all mechanical systems are operating efficiently. Before extensively air-sealing your home, it is **critical** to ensure that doing so will not cause health or moisture problems by examining adequate air intake. Above all else, your home must be a healthy place to live.

Combustion Heating Appliance Ventilation Safety

If your furnace, wood stove, boiler or water heater burns gas, oil, wood or coal, it is important that the venting system which carries combustion gases in and out of the house is properly functioning. This also applies to a gas clothes dryer.

Are your combustion appliances safe?

When fuel is burned, carbon dioxide and water vapor are given off. Other pollutants can include carbon monoxide, nitrogen and sulfur oxides, formaldehyde, and tiny breathable particles. Most combustion appliances are vented to remove combustion byproducts from the home. However, improper maintenance can lead to problems such as blocked vents and cracked flues. Vents or flues should be checked annually to make sure they are in good working order.

Carbon monoxide (CO) is a combustion pollutant of special concern. It is an odorless and colorless gas which can kill. Symptoms of exposure such as headaches, dizziness, and nausea may be mistaken for other causes. A malfunctioning furnace or blocked flue pipe can result in fatal CO levels. While CO alarms should be installed in every house, they do NOT substitute for proper use and maintenance of fuel-burning appliances.

The three types of venting systems are natural-draft, power-vented, and sealed-combustion. Natural-draft or atmospheric-vent systems rely on the natural tendency of warm gases to rise.

Natural-draft appliances always vent into a vertical flue (either masonry or metal) and have a draft hood, which draws extra indoor air into the flue.

Natural-draft appliances are particularly susceptible to backdrafting. This problem occurs when exhaust equipment such as a clothes dryer, central vacuum, downdraft cooking range, or exhaust fan draws air out of a house, creating a negative pressure within the house. This can cause combustion byproducts to backdraft, or be pulled into the house instead of going out the vent *(Figure 1)*.

With power-vented systems, a small blower exhausts combustion byproducts from the house. Flue gases from power-vented appliances rarely backdraft.

Some newer furnaces and water heaters use sealed-combustion systems. With this type of system, air needed for combustion is brought in from outside through an intake pipe. Flue gases are vented outside through a second pipe. No chimney is needed. These systems are completely isolated from inside air, and as long as the intake and vent pipes are not blocked or damaged, sealed-combustion appliances are immune to backdrafting.

Unvented appliances, including gas fireplace logs, should only be used in well-ventilated areas and for short periods of time while being monitored by an adult. If you must use unvented appliances, open a window in the room at least 1 inch or according to the manufacturer's directions. While unvented fireplaces have been banned in some states, they are legal in Nebraska.

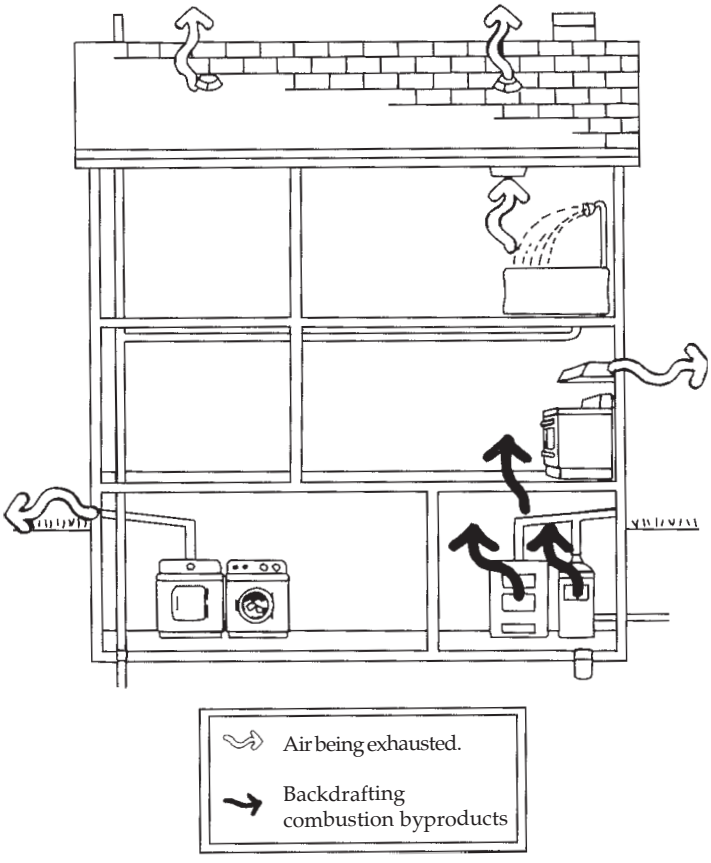

Figure 1. Combustion byproducts being backdrafted or pulled into the house instead of going out the vent.

Do your appliances get enough air?

For safe operation, it is critical that combustion appliances have enough air to work properly. The National Fire Protection Association (NEPA) codes, or local codes if they are more stringent, must be followed to ensure safe installation and operation of combustion equipment.

Sealed-combustion units draw air directly from outside the home. However, natural-draft and power-vented units draw air from the indoor space in which they are located. If you have combustion equipment in a closet or other confined space, make sure the appliance gets enough air. This is often accomplished with louvered doors. Do not place anything inside or outside of the confined space that might block air flow.

Homes need adequate fresh air and air quality levels that are safe and healthy for people and other living things. Sealing a home tightly can lead to unhealthy air, such as air containing higher levels of carbon monoxide (CO), and higher levels of carbon dioxide (CO_2) and other pollutants — especially when additional planned ventilation for fresh air is not included.

Sealing a home is a good way to conserve energy. However, it is **very important** to plan for fresh outdoor air intake and exhaust of pollutants in the home. Energy Recovery Ventilators (ERV) and Heat Recover Ventilators (HEV) are heat exchangers which bring in fresh outdoor air without losing a large amount of energy. The ERV and HRV help to reduce the indoor air pollutants, decrease levels of CO_2 and other pollutants and increase oxygen. The recommended levels of CO_2 at this time are below 1000 parts per million (ppm) with 600 to 700 ppm recommended. In comparison, fresh air is composed of 400 to 450 ppm of CO_2.

A minimum ventilation rate of 15 cubic feet of fresh air per minute (CFM) for each person in the room is recommended and should be continuous when occupied. The minimum recommended air exchange per hour is 0.35 (ASHRAE).

Using a ERV or HEV is an energy efficient method of obtaining the recommended air exchange. In the winter for example, the fresh colder outside air is brought in and passes by, but is not mixed with, the warmer exhaust air. This preconditions the colder incoming air in the winter and the hot air in the summer. ERVs or HRVs can salvage about 79% of the energy from the stale exhaust air and transfer that energy to the fresh air entering by way of a heat exchanger inside the device. They can be attached to the central forced air system or may have their own duct systems. These systems may come with other features such as a moisture control to maintain appropriate humidity levels. Some come with air filtration equipment as well.

Energy Consumption

The amount of energy consumed in your home depends on many factors, including how well the home is insulated, the efficiency of appliances and equipment, the local weather and climate, and your lifestyle. This section describes how to calculate your energy use and determine if it is high or low.

Does your house use too much energy?

Figure 2 shows how energy is used in typical homes in the United States. The lifestyle of people living in your home will affect how energy is consumed. The best and most accurate way to determine the energy efficiency of your home is to have a home energy audit done by a service professional. Without an audit, it is not easy to know if your energy consumption is "too much." Contact your local utility to see if they offer a residential energy audit or can provide data on average energy consumption for houses similar to yours.

Alternately, you can ask them to quote you a monthly payment

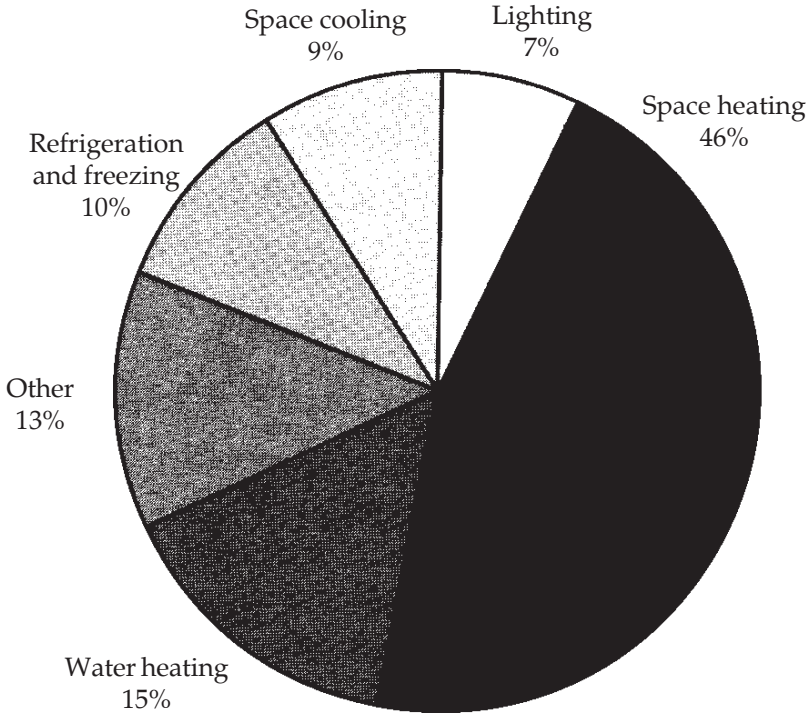

Figure 2. How energy is used in typical homes in the United States.

plan that will indicate the average energy consumption for a house in your geographic location. When you call, be sure to describe your energy and fuel uses. For example, you may have an all-electric home, or you may heat with gas and cook with electricity. It is also important to specify whether or not you have air conditioning. Make sure the utility understands that you are trying to determine typical energy usage for a home the size of yours. Otherwise, they may quote you a monthly payment plan based on your past energy use.

Use the equations in the assessment to the right to evaluate whether your energy costs are high or low. First, check your records or call your utility to determine how much you spent on energy bills over the last 12-month period. Then divide your energy costs for one year by 12 to arrive at your average monthly energy bill. Compare this with the monthly bill of an "average" home or with the monthly payment plan amount quoted to you by your utility company. If your current bill is much greater, there are probably many opportunities for improving the energy efficiency of your home. If your bills are lower than the average home, there may still be certain opportunities to make your home more energy efficient.

There are three key strategies to increase energy efficiency; air-sealing (reducing air leaks) your home, adding insulation and efficient windows, and using more efficient appliances and equipment. Each is covered in the next section.

ARE YOUR ENERGY COSTS HIGH OR LOW?

Use the equations below to calculate and evaluate your energy consumption

Total of heating/cooling bills for the past year (12 months) $_____

Divide by 12 to get average monthly bill

Average monthly bill $_____ (A)

Average monthly bill for energy efficient houses similar to yours $_____ (B)

If A is larger than B, it may indicate that your home is using more energy — and costing more money — than it should. By increasing energy efficiency, you can cut your bills and save significant amounts of money over the long run.

OR

You can also log on to the Web site Home Energy Saver at **http://hes.lbl.gov/** to use the *Estimate Annual Energy Bill - Home Energy Saver* program for your Zip code and state. It will compare the information you provide on your home to an energy efficient house in your area.

Energy Efficiency

The average home in the United States wastes 30 to 50 percent of the energy it uses. If every home installed energy-efficient equipment, was well-insulated, and was well-sealed, individual homeowners and the national economy would reap tremendous savings. The following section will help you identify where energy is being lost and how you can prevent future losses.

Improving heating and cooling systems

The single greatest energy consumer in your home is the heating/cooling system (furnace, boiler, heat pump, wood stove, or air conditioner). This system has three parts: (1) heating/cooling unit(s), such as furnaces and air conditioners, (2) ducts or other distribution mechanism, and (3) a thermostat to control output. You can save energy in all three areas.

How old are the parts of your system?

If your primary heating/cooling unit is more than 15 to 25 years old, it is probably not very energy efficient. Even if it still works, you may benefit by replacing it with a new energy-efficient model. When buying new equipment, study the Energy Guide label, or look for

an Energy Star® label on some products, indicating those products have efficiency levels that fall into the top 25 percent in their product line. A new device can pay for itself in fuel savings in only a few years. Or, if you find long-term financing for the new equipment, the dollar value of the monthly energy savings may exceed the monthly payment for the equipment. There may be grants, low or no-interest loans, or other financial incentives available.

Is your system getting proper maintenance?

All machines work more efficiently and more safely if they are inspected and maintained. Your furnace, air conditioner, and other heating/cooling equipment should be checked and serviced every year by a qualified professional. Monthly (or as recommended by the manufacturer) maintenance, such as inspecting and changing or cleaning air filters, is recommended. A forced-air system includes an air filter, which removes dust and debris before it reaches the air blower and heat-exchange coils. Dirt on fan blades and coils reduce efficiency, so you should change or clean the air filter on a regular basis.

Are you using your thermostat to save energy?

One of the easiest ways to save energy is to set thermostats at a lower temperature in winter and a higher temperature in summer so that the heating/cooling system runs less often. If a house is caulked and weatherstripped and an air barrier is complete to prevent cold drafts, most people will be comfortable at 68 degrees Fahrenheit during winter if they are dressed appropriately. To save more energy, temperatures can be turned down to 50 or 60 degrees while you are sleeping or when the house is empty. During the summer, a thermostat setting of 72 degrees or higher is recommended. During times when the house is unoccupied, a summer thermostat setting of 80 to 85 degrees is recommended.

Digital or clock thermostats (also called automatic set-back thermostats) can be programmed to adjust the temperature automatically *(Figure 3)*. For example, it can be programmed to turn the heat down every night at 11 p.m. and bring the temperature back up by 6 a.m. before you get out of bed. A newer kind of residential thermostat, a home energy manager, allows many temperature settings throughout the week. Other technology, used with zoned heating systems, allows different temperature settings through the home according to individual room use and need. Depending on your lifestyle, these set-back thermostats can pay for themselves in energy savings in as little as one or two years.

Is your distribution system working well?

Unless there is a heating/cooling unit in each room, you probably have a system to distribute hot or cool air from a central heater or air conditioner. More than 90 percent of central heating systems and virtually 100 percent of central residential cooling systems in the United

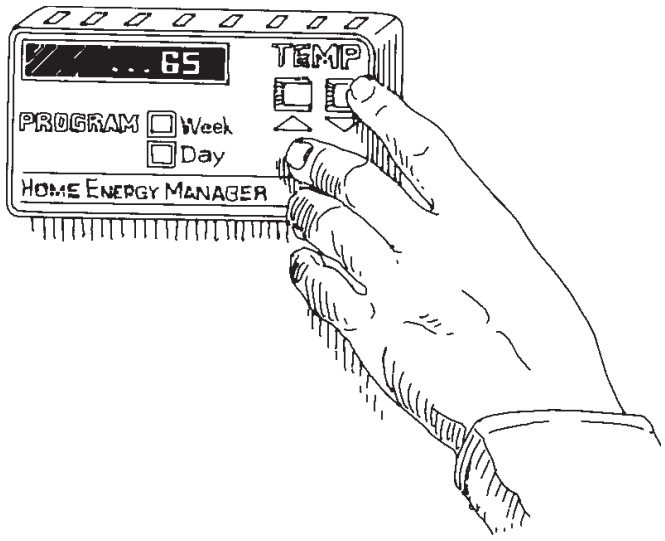

Figure 3. Digital or clock thermostats can be programmed to adjust the temperature automatically.

States have forced-air distribution systems that use air ducts to move warm or cold air to the rooms of the house. If the duct system leaks, it can waste large amounts of energy.

Any ductwork located in an unheated space such as an attic or crawl space has a high potential for heat loss. Ducts in such spaces should be insulated. Also, all joints in the duct system, everywhere in the house, should be properly sealed with mastic and high quality foil tape to make sure all warm or cool air gets where you want it to go.

Besides providing supply registers in each room to deliver heated or cooled air, there must be a return duct to allow air to get back to the heating/cooling unit. Many newer homes do not have a return register in every room, but rely on the space under a closed door to allow supply air to return to a centrally located return. If you have a room that is uncomfortable (hard to heat or cool) when the door is shut but is fine when the door is open, you probably have an air distribution problem. You can increase the space under the door or call a heating and cooling specialist to resolve the problem.

The second most common heat distribution system uses hot water that is distributed through pipes to radiators or convectors. Pipes carrying hot water should be insulated everywhere — from boiler to radiator. Use a high quality insulation material. Low quality materials degrade over time.

Preventing loss of heated or cooled air

Once you have reached a comfortable temperature indoors, your aim is to keep it that way. Preventing unwanted air leaks and blocking heat transfer are two important approaches to making your home even more energy efficient.

Have you air-sealed your home?

Every house has openings through which outside air can enter. Some openings, such as open windows and doors, are obvious pathways. Others, such as cracks around window frames, or any place a pipe or utility penetrates the home attic or exterior wall are unintended pathways for leaks *(Figure 4)*. This uncontrolled leakage of air, known as infiltration, can account for a large portion of the total heat loss in a home. In an average home, air leaks through floors, walls, and the ceiling. In addition, air infiltrates in and out of your home through every hole, nook, and cranny including air supply and return ducts; fireplaces; plumbing penetrations; and around doors and windows, fans and vents, and electric outlets. Cold or warm air entering a home must be heated or cooled if the home is to remain comfortable.

Sealing your home against air leakage is not difficult, but it does require detailed information to be done right. Both proper materials and techniques must be used. For information on how to reduce air leaks, contact your local Cooperative Extension office or the Nebraska Energy Office.

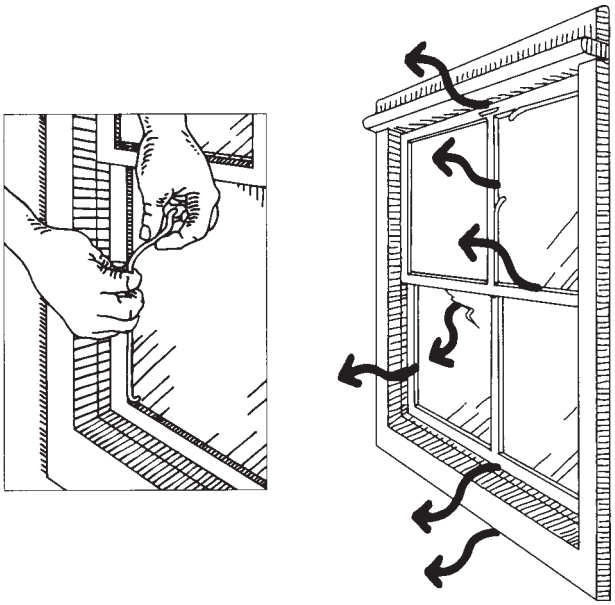

Figure 4. Cracks around window frames or any place a pipe utility or utility penetrates the home attic or exterior wall are unintended pathways for leaks.

Safety Note

When air-sealing a home, proceed with caution. As stated before, your home must be a healthy place to live. Air-sealing may save energy, but it can also trap deadly pollutants. Air-sealing can cause a dangerous situation by reducing the air available for combustion appliances. Do not attempt to air-seal your home until you have taken care of these problem areas:

- Unvented gas or kerosene heaters or unvented gas fireplaces/logs must be removed or vented outdoors.
- If you have a gas cook stove that is not vented to the outside, install and use a power-vented hood vented to the outside. If your home is extensively air-sealed, open a kitchen window 1/4 inch wide while cooking and running the exhaust hood.
- It is not recommended to extensively reduce air leakage without first managing fresh air intake and exhaust. This can be accomplished by installing a whole-house ventilation system such as a heat recover ventilator or energy recovery ventilator, or otherwise ensuring adequate spot or whole-house ventilation. Seek the advice of a qualified professional.

Does your home need more insulation?

Even if you air-seal your house, you still need to prevent the transfer of heat or cold air through walls, floors, foundations, and ceilings. Insulation acts like a blanket to retain the warm or cool air your system produces. Insulation materials are assigned an R-value, which is a measure of how well they resist the flow of heat energy into or out of your home. The larger the R-value, the greater the resistance that material has to the transfer of heat energy.

The recommended amount of insulation for a home varies with geographic location. The following R-values are recommended in Nebraska based on climate, housing structure, and installation. Ranges are used due to varying recommendations, base recommendations, and variations in products and their performance after installation. Check with local code officials for requirements.

Ceiling below a ventilated attic	- R 38 to 49
Exterior walls	- R 19 to 24
Floors over unheated crawlspaces and basements	- R 19 to 25
Crawlspace walls if crawlspace includes plumbing and ducts	- R 16
Above grade masonry	- R 10 minimum
Basement walls	- R 10 to 15
Slab-on-grade	- R 5 to 10

The chart below gives nominal R-values for various thickness of insulation. Determine the type and amount of insulation in your home. Then calculate the R-value of insulation of your home. Compare the R-value in your home to that recommended for Nebraska. The decision to add more insulation will depend on several factors including new or existing construction, cost and benefit, ease of installation, and types of materials in the structure.

Nominal R Values for Various Thicknesses in Inches of Insulation

R Value	*Batts or Blankets*		*Loose and Blown Fill*				
	glass fiber	*rock wool*	*glass fiber*	*rock wool*	*cellulose fiber*	*vermiculite*	*perlite*
R 11	3 1/2 - 5 1/4	3 - 3 3/4	5	4	3 - 3 3/4	5	4
R 13	4	3 1/2	6	4 1/2	3 1/2	6	5
R 19	6	5 - 6 1/4	8 1/2	6 1/2	5 - 6 1/2	9	7
R 22	6 - 7 1/2	6	10	7 1/2	6	10 1/2	8
R 26	8	7	12	9	7	12 1/2	9 1/2
R 30	9 - 10	8 - 9 1/2	13 1/2	10	8	14	11
R 33	10 1/2	9	15	11	9	15 1/2	12
R 38	12 - 13	10 1/2 - 12	17	13	10 - 13	18	14

Rigid Insulation Board/Foam - R Values Given Per Inch

expanded polystyrene molded beads	*polystyrene extruded*	*polyisocyanurate unfaced*	*glass fiber board*	*polyurethane foam*	*expanded perlite*	*isynene foam*
R-Values/inch 3.85 - 4 1/2	5	6.26 - 7.04	4 - 4 1/3	6.25 - 5.56	2.78	3.6

NOTE: Consult the manufacturer's recommendations for applications and R-value as products may deviate from these R-values and thicknesses. Specific R-values depend on density, aging, installation, moisture, settling, and the structure of the home. Some insulation products shift or decrease in thickness after installation due to compaction. Infiltration at seams is a factor. Sources: ASHRAE, U.S. Dept. Of Energy for Zones 1, 2 and 3 for NE.

Increasing efficiency of domestic hot water systems

After heating and cooling your home, heating water for domestic consumption is the next largest energy user. There are several ways to reduce the amount of energy you use to heat water. The simplest is to turn down the water heater temperature. Each 10-degree reduction will save you 3 to 5 percent on your annual water heating bill. Lowering the water temperature will also increase the lifetime of your water heater and reduce the risk of someone being burned by the hot water.

Most water heaters are factory set around 140 degrees Fahrenheit. For most household use, that is higher than necessary. Usually, 120-degree water is adequate unless you have an automatic dishwasher without a temperature booster. In this case, you may need to keep the temperature set at 140 degrees for optimal dishwashing performance.

Water temperature can be adjusted manually, lowering the temperature when hot water is least likely to be needed and increasing the temperature when hot water is desired. Automatic setback thermostats are available for water heaters to accomplish this task more conveniently. Time clocks can turn the tank off according to needs.

Wrapping your water heater with insulation can reduce water heating energy use by 4 to 9 percent. Except for some new water heaters that come with high levels of foam insulation and do not need any more, the addition of insulation usually pays for itself in less than one year. Water heater insulation blankets are widely available at hardware stores and come in standard sizes to fit 40-, 60-, and 80-gallon water heaters. Be sure to follow both the water heater manufacturer's and the insulation manufacturer's instructions for installation. Hot water pipes should be insulated wherever they are accessible. Either preformed foam insulation or wraparound fiberglass insulation can be used.

Reducing hot water consumption will reduce the amount of energy needed. Fix any leaking pipes and consider installing low-flow shower heads and aerators on faucets. Washing laundry in warm or cold rather than hot water will also save energy, but could affect cleaning performance. Front loading washing machines use significantly less water than top loading although some manufacturers are working on making top loading machines more water efficient.

CONTACTS AND REFERENCES

Who to contact about energy management . . . .

- Nebraska Energy Office; P.O. Box 95085 1111 0 Street, Suite 223, Lincoln, NE, 68509-5085, (402) 471- 2867. **www.nol.org/home/NEO/**
- U.S. Department of Energy (DOE) Office of Conservation and Renewable Energy; 1000 Independence Avenue, SW, Washington, DC, 20585.
  - Energy Efficiency and Renewable Energy Clearinghouse (EREC); 800-DOE-EREC, 800-363-3732. **www.eren.doe.gov/erec/factsheets**
  - DOE Consumer Information; 800-342-5468. **www.eren.doe.gov/consumerinfo**
  - DOE **www.eren.doe.gov/consumerinfo/refbriefs/ea5.html**
  - DOE Animated Website - Energy Savers: Tips on Saving Energy and Money at Home; **www.eren.doe.gov/consumerinfo/energy_savers**
  - DOE Energy Star®; 888-782-7937. **www.energystar.gov**
  - DOE Building Technology, State and Community Programs; **http://www.eren.doe.gov/buildings/**
  - DOE Sustainable Energy Program; **www.sustainable.doe.gov**
- American Council for an Energy Efficient Economy; 1001 Connecticut Avenue, NW, Suite 801, Washington D. C., 20036, 202-429-0063. **www.aceee.org** (Consumer guide section.)
- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE); 1791 Tullie Circle NE, Atlanta, GA, 30329. **www.ashrae.org**
- Consumer Federation of America; 1424 16th Street NW, Suite 604, Washington, D.C., 20036. 202-387-6162 **www.buyenergyefficient.org**
- Healthy Indoor Air for America's Homes; **http://www.montana.edu/wwwcxair/**
- Indoor Air Quality Information Clearinghouse; PO Box 37133, Washington, D.C., 20013-7133, 800-438-4318. **http://www.epa.gov/iaq**
- Oak Ridge National Lab - Office of Building Technology; 423-574-5178 **http://eber.ed.ornl.gov/REDCB.html**
- National Center for Appropriate Technology - Affordable Sustainability Technical Assistance for HOME; **www.homeasta.org/resources**

Web sites on history of performance of various household appliances and heat and cooling equipment are available at:

- AGA **http://www.aga.org/** American Gas Association
- GAMA Gas Appliance Manufacturers Association **http://www.gamanet.org/**
- EnergyStar® 888-782-7937; **www.energystar.gov**

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Notes

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Elbert C. Dickey, Dean and Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.

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