ENERGY CONSERVATION IN

THE HOME

Small Homes Council-Building Research Council
University of Illinois at Urbana-Champaign
ENERGY COSTS IN THE FUTURE

Although the use of energy in the United States has not increased as rapidly in recent years as in the past, it is still increasing. The same is true of the rest of the world. Since there is a limited supply of fuels, the price of oil, gas, and electricity can be expected to rise. Enormous expenditures are required to:

- explore for oil and gas at greater depths and in remote areas, including the ocean floor, and to move them to the consumer.
- pay prices arbitrarily established by foreign nations, which are already supplying more than half of our petroleum needs.
- construct nuclear power plants, especially those with advanced technology.

THE BROADER CHALLENGE

Even though your contribution toward energy conservation may seem small, the last decade has proven that the combined efforts of millions of people can greatly reduce total energy use. There are many factors to consider in saving energy:

**Quality.** A wide range of quality and efficiency exists in appliances such as furnaces, air conditioners, washers, dryers, vacuum cleaners, etc. To save materials and energy, as well as operating and service costs, greater emphasis on quality and efficiency is needed.

**Obsolescence.** Throw-away items and planned obsolescence violate the principles of conservation and best use of resources.

**Fire Losses.** Valuable materials are wasted by fire, as well as the energy expended in their production and assembly.

**Vandalism.** Replacement costs of broken windows, damaged furnishings, and graffiti removal in schools and public facilities are outrageous wastes of funds and resources.

**Safety.** Accidents in the home, at work, and on the highway waste lives and energy.

CHECKLIST FOR ENERGY CONSERVATION IN THE HOME

Future shortages of some fuels may require shifts in energy sources. Heating systems should be planned for possible conversion to other fuels or electricity. Oil may be too valuable as petrochemicals or as a transportable fuel to be used for home heating.

**Multi-family Dwellings.** For equal floor space, multi-family dwellings require less energy to build, heat, and cool than single-family homes.

**Ventilation.** Reducing ventilation rates in public and commercial buildings, particularly during periods of low occupancy and in no-smoking areas, as well as reducing infiltration in homes, produces significant energy savings.

**Illumination.** Much commercial lighting is brighter than needed. Reducing illumination saves energy used to produce the light and that used to remove the heat given off by the lights. Outdoor lighting should be reappraised.

**Transportation.** Energy requirements for transportation are large, and portable fuels, such as gasoline and diesel oil, are in shortest supply. Mass transportation, smaller vehicles, lower speeds, and more efficient engines will save energy.

**Industrial Heat.** While great strides have been made, additional engineering improvements can continue to find ways to use the heat now lost from power stations, smelters, kilns, heat-treatment furnaces, and other industrial plants.

Energy conservation requires a constant awareness of how resources can be conserved. A major breakthrough in research could make an unlimited energy supply commercially feasible. Meanwhile, we need to live as though our energy supply is not to be consumed as if there were no tomorrow.

More than one-fifth of our total energy usage is for the heating and cooling of dwellings, offices, schools, and factories. To help you in your efforts to reduce energy usage, this publication provides a checklist of ways to reduce heat loss in the winter and heat gain in the summer. Most successful energy conservation plans consist of many small items rather than any one large step. Whether large or small, each reduction pays dividends for years.
CONSERVATION THROUGH OPERATION

Winter

1. Windbreak planting. Winter winds increase heat loss from buildings. A tall fence or a dense growth of evergreens will reduce wind impact.

2. Fireplaces. Be sure to close the damper when the fireplace is not in use. Glass doors for the fireplace can also be effective. An outside air intake for the fireplace will reduce the amount of house air flowing up the flue.

3. Ventilation. Exhaust fans in the kitchen and bath remove heated air from the house. Downdraft range fans exhaust about three times as much air as range hoods. Less smoking and cooking odors will reduce the need for ventilation.

4. Air leakage. Enough air leakage occurs in most houses without opening windows or doors. The only need to open windows in cold weather is to reduce odors or humidity. Tight houses may need an air-to-air heat exchanger.

5. Clothes drying. Air drying of clothes reduces dryer use. Venting an electric dryer into the house in cold climates conserves heat but can cause moisture and lint problems. A lint trap should be installed and indoor venting discontinued if there is a moisture problem. Gas dryers must be vented outside the house.

6. Closing rooms. Unoccupied rooms can be closed and the heat shut off. Do not close return air grilles or more than one-third of all supply registers. Room temperatures should be at least 40°F.

7. Attached garages. Outside doors should be closed except for use. Garages housing the furnace and/or water heater should be fully insulated.

8. Storm sash (or double glazing). Install or close storm windows early in the heating season or leave them closed year around where windows are not used for ventilation. Triple-glazing, double glazing with low-emissivity coatings, or argon-filled glazing may be justified.

9. Outside doors. Install a storm door with a door closer or an insulated metal door with a magnetic weather-stripping system.

10. Caulking. Caulk all cracks around window and door frames, where wood meets masonry, and where pipes penetrate walls. Acrylic, urethane, or silicone-based caulks last longer than oil-based.

Summer

11. Shade planting. Tall deciduous trees on the East, South, and West sides will reduce solar gain of walls, windows, and roofs. See B3.1, Landscaping for Energy Conservation.

12. Cooling unit. New units may take 30-40% less energy than older ones. The minimum acceptable SEER rating for a new unit is 9.0. The compressor-condenser unit should be shaded by a building, fence, or plantings. Remove leaves, grass, and dust from the condenser fins.

13. Lighting. Lighting should be adequate but not excessive. Smaller bulbs may be appropriate. Fluorescent lights are more efficient than incandescent bulbs. Turn off lights when the room is not occupied.

14. Clothes drying. Air drying of clothes out of doors is more practical during the summer and uses the least energy. All dryers should be vented outdoors in mild or warm weather. Damp drying, then finishing on a hanger, reduces wrinkling.

15. Appliances. Operation of dishwashers, clothes washers and dryers, and ovens (including the cleaning cycle) should be delayed until late evening when power loads are less and air conditioners more efficient.

16. Microwave units. Microwave cooking units use less energy than a range for heating small quantities of food, or even a cup or so of water. Using a microwave for thawing frozen food is a waste of energy during the cooling season.

17. Water conservation. Any saving of water in bathing, laundry, cooking, or gardening saves pumping energy. Hot water should be used conservatively and at the lowest practical temperature (dishwashers need water at 140°F). Insulate the water heater tank to reduce the operating cost and the heat gain to the house.

18. Pipe insulation. All hot water pipes in crawl spaces should be insulated to reduce heat loss from pipes and waste of water during each faucet operation. Insulating water piping reduces the chances of freezing in the winter and warming of the cold water supply during the summer.
Winter

19. **Basement.** When the basement is used for other than storage, the walls and windows should be insulated. If used only for storage, the ductwork and the floor above should be insulated and the basement be kept unheated.

20. **Crawl-space vents.** Vents should be closed during the winter unless the furnace is in the crawl space, or there is a moisture problem. Moisture control is discussed in *F4.4, Crawl-Space Houses.* If the vent cannot be closed, an insulating panel can be inserted. The vents may remain closed during the summer if there is no moisture problem.

21. **Mobile home foundation.** Insulated skirtng should be installed to reduce air flow and raise the temperature below the structure.

22. **Attics.** Vents must be left open to allow moisture to escape from the attic. Therefore, adequate ceiling insulation is a necessity. (See page 6.)

23. **Attic ducts.** All air ducts in the attic should be insulated (2" or more), since heat lost from attic ducts is totally wasted.

24. **House insulation.** A well-insulated house is comfortable at a lower air temperature than a poorly-insulated house. (See page 6.)

25. **Clothing.** Warmer clothing, including the covering of arms and legs, will enable a person to be comfortable at lower air temperatures.

26. **Thermostat setting.** Each 1°F reduction in the room thermostat setting can save 2-3% in fuel. Vacation settings should not be below about 50°F.

27. **Night setback.** A setback of 10°F at night may save as much as 7% in fuel for poorly insulated houses and much less for well-insulated houses. Do not use night setback if the outdoor temperature is below 0°F because the morning recovery takes too long.

28. **Register settings.** Balance the heating system with duct or register dampers to prevent overheating some rooms. Partially close bedroom registers to keep them cooler. Unused rooms should be maintained at 50°F or above. Do not close more than one-third of the supply registers in the system.

Summer

29. **Recycling.** All materials require energy in their production. Any reuse or recycling of materials will save energy spent in production or disposal.

30. **Cooking.** The oven is more efficient than surface units when several dishes are cooked at one time. Use lids on pans to retain heat and moisture. Microwave units are more efficient for small quantities. Outdoor cooking reduces odors and heat input to the house.

31. **Storm windows.** Double glazing reduces summer heat gain. Leave storm windows closed except on windows needed for ventilation.

32. **Register settings.** Re-balance the air distribution system for cooling. Close basement supply registers. Close doors on stairwells or room doors on the upper levels to control downward flow of cooled air.

33. **Dehumidification.** When a dehumidifier is used in the basement, keep basement doors and windows closed.

34. **Drainage.** Landscaping should be sloped to divert water away from the foundation. Water collecting around the foundation may cause a damp basement or crawl space, requiring a dehumidifier. Window wells and areaways can be covered with glass or plastic to divert rain water.

35. **Crawl space.** A polyethylene vapor barrier should cover the entire soil surface to control moisture evaporation into the house.

36. **Crawl-space vents.** These may be opened in summer if there is a standing water problem. Condensation on the bottom of the polyethylene vapor barrier is normal and not a problem. Opening vents can cause condensation on uninsulated cooling ducts in humid climates.

37. **Attic.** Open attic windows for ventilation to reduce attic temperatures, which can reach 140°F in a closed attic.

38. **Windows.** In air conditioned houses, keep windows closed in humid weather, even with mild outdoor temperatures, and operate the cooling system to control indoor humidity.
ENERGY CONSERVATION THROUGH PREVENTIVE MAINTENANCE

39. Servicing and adjustments. When serviced annually, heating and cooling equipment will operate more efficiently and replacements will be deferred. The following adjustments by a competent service person will produce energy savings with greater comfort.

40. Warm-air systems. Check and clean burners, oil fan and motor bearings, inspect fan belt (if there is one), and replace or clean air filters. Return-air grilles should be vacuumed as necessary. Adjust controls for continuous air circulation during average cold weather. The start setting of the blower switch should be about 110°F and the cut-out about 85°F. Approved automatic vent dampers may be cost-effective in multi-story houses with a strong chimney draft.

41. Hydronic (hot-water) systems. If the boiler is being used for space heating only, for maximum economy, the thermostat should operate both the burner and the circulating pump. If the boiler is used for both space heating and heating domestic hot water, the boiler set temperature should be at the lowest point which will provide the required hot water temperature. In gas-fired systems, it may be justifiable to install a separate water heater and use the boiler only for house heating.

ENERGY CONSERVATION THROUGH EQUIPMENT SELECTION

High-efficiency heating systems. There have been significant advances in the design of furnaces and boilers in the last 15 years. Heating units converted from coal to gas or oil may have an efficiency as low as 45%. Gas- and oil-fired units made before 1965 often have AFUE efficiencies as low as 55%. Units produced from 1960-1975 seldom had efficiencies greater than 65-75%. The current market still includes atmospheric furnaces and boilers, both gas- and oil-fired, with efficiencies in the 65-75% range. A second category of heating units, using electric ignition and an automatic flue damper or an induced draft fan, operate in the 78-85% range. A third category of very high efficiency furnaces and boilers operates in the 88-96% efficiency range.

As the efficiency increases, so does the price and the complexity of servicing. Units of the highest efficiency may be difficult to justify economically, but the 78-85% range can nearly always be justified in the new or replacement market. After 1991, the manufacture of units having an AFUE efficiency of less than 80% will be prohibited. It is difficult to justify replacement of a working furnace or boiler with an efficiency of 65% on the basis of efficiency alone. Units with efficiencies below 50% unquestionably should be replaced.

High-efficiency cooling systems. The design of air conditioning units, both central and window, has changed substantially also. Units manufactured before 1975 usually had a Seasonal Energy Efficiency Ratio (SEER) of 6.0-6.5 Btu of cooling per watt of electricity used. Units are now available with a SEER of 10-14. As efficiency increases, so does the price. However, no new unit with a SEER of less than 9.0 should be considered, as that will be the minimum efficiency required after the 1991 deadline. Units with a SEER of more than 11 may not provide adequate dehumidification in very humid climates. In areas with high summer electrical rates, replacement of an older unit that is still operating may be economically justified, since savings in operating costs of 30-40% are possible.

ENERGY CONSERVATION THROUGH DESIGN AND CONSTRUCTION

In winter, the dwelling must shield the occupants from outdoor cold, precipitation, and wind. In summer, it protects against outdoor heat, humidity, and sun.

Insulation and multiple glazing are effective in all regions, not only to save heating energy in winter but also to save cooling energy in summer. Increased winter comfort is also provided by the warmer surface temperatures resulting from insulation and multiple glazing. In each of the following items, the numbers in Btu per hour (Btuh) indicate the heat loss from a particular component of the house. The total heat loss is the sum of the losses from the ceiling, walls, windows, doors, and foundation, plus the loss from air infiltration. The total heat loss is used to size the heating equipment and is proportional to the annual heating energy costs. The pre-calculated values given are for standard frame construction, exposed to an outdoor temperature of -7°F and a 15 mile per hour wind, while maintaining an indoor temperature of 68°F. The attic temperature is assumed to be 3°F. Each 1000 Btuh of design heat loss represents 2 to 3 gallons of oil, or 3 to 4 therms of gas, or 55 to 80 kWh of electricity per year for each 1000 heating degree-days. Use your local weather data.
42. Ceiling insulation. The values at the right show the heat loss of each 1000 square feet of ceiling area with an attic space above. For a 30 ft. by 50 ft. ceiling (1500 square feet), the heat loss will be 1.5 x 4000, or 6000 Btuh for a 4-inch thickness of mineral wool insulation (or equivalent) in the ceiling joist spaces. The same ceiling with 9-inch-thick insulation would lose 1.5 x 1860, or 2790 Btuh. When the insulation exceeds 12 inches, the heat loss through the ceiling becomes almost negligible. For comparison, four occupants give off about 1800 Btuh.

The temperatures at the far right are the surface temperatures of the ceiling facing the occupant. A person loses less heat to warmer surfaces (such as ceilings, walls, windows, and floors) and is more comfortable as surface temperatures approach the room temperature of 68°F.

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>Btuh</th>
</tr>
</thead>
<tbody>
<tr>
<td>0&quot;</td>
<td>7200</td>
</tr>
<tr>
<td>2&quot;</td>
<td>4000</td>
</tr>
<tr>
<td>4&quot;</td>
<td>2900</td>
</tr>
<tr>
<td>6&quot;</td>
<td>1860</td>
</tr>
<tr>
<td>9&quot;</td>
<td>1410</td>
</tr>
<tr>
<td>12&quot;</td>
<td>1140</td>
</tr>
<tr>
<td>15&quot;</td>
<td>960</td>
</tr>
<tr>
<td>18&quot;</td>
<td>1000 sq. ft. area</td>
</tr>
</tbody>
</table>

43. Wall insulation. For typical frame construction, each 1000 square feet of wall surface, excluding windows and doors, will show the heat loss indicated. For example, a house having 1300 square feet of net wall surface will lose 1.3 x 4725 or 6140 Btuh with 3½-inch mineral wool batts in the wall. The 5½-inch insulation is based upon 2x6 wall framing, and the 8½-inch and 10½-inch thicknesses on double-framed walls. This construction requires deep window and door frames, available at extra cost. Foam plastic sheathing is about equivalent to twice its thickness in mineral wool.

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>Btuh</th>
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<tbody>
<tr>
<td>0&quot;</td>
<td>18750</td>
</tr>
<tr>
<td>1&quot;</td>
<td>9750</td>
</tr>
<tr>
<td>2&quot;</td>
<td>6600</td>
</tr>
<tr>
<td>3 1/2&quot;</td>
<td>4725</td>
</tr>
<tr>
<td>5 1/2&quot;</td>
<td>3225</td>
</tr>
<tr>
<td>8 1/2&quot;</td>
<td>2175</td>
</tr>
<tr>
<td>10 1/2&quot;</td>
<td>1800</td>
</tr>
<tr>
<td>Values are for</td>
<td>1000 sq. ft. area</td>
</tr>
</tbody>
</table>

44. Windows, operable. The heat loss through windows is the combined loss through the glass and the loss of heated air through the cracks around the window unit. If a house has 150 square feet of single-glazed windows without storm sash, the heat loss may be as much as 15 x 1050, or 15,750 Btuh. High-performance glazing units, combining low-emissivity coatings and inert gas fill, are becoming popular.

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>Btuh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>1050</td>
</tr>
<tr>
<td>Double</td>
<td>510</td>
</tr>
<tr>
<td>Triple</td>
<td>330</td>
</tr>
<tr>
<td>High-Perf. 4.5R</td>
<td>270</td>
</tr>
<tr>
<td>Values are for</td>
<td>10 sq. ft. area</td>
</tr>
</tbody>
</table>

45. Windows, fixed. Tightly sealed fixed windows will lose heat through the glass, but have no air leakage. The values shown are for each 10 square feet of window area. For example, a picture window that is 4 ft. high and 6 ft. wide (24 square feet) will have a heat loss of 2.4 times the number shown.

46. Doors, outside. Doors have considerable leakage around the frame even when closed, and this has been included in these calculations. An insulated steel door with magnetic weatherstrip may be the best combination. The losses are given for a standard door 3 ft. by 6 ft. 8 in. (20 square feet) and 1½ in. thick.
47. **Basement foundation.** A warm basement space provides warmer floors in the rooms above, and improved comfort conditions. Most basements are primarily heated by vagrant heat from the furnace casing and ductwork. Heat lost from the basement is just as expensive as heat lost from an upstairs room. To reduce heat loss from the basement, install storm windows, caulk the sill joint, and insulate the band joist and basement walls. For example, an uninsulated basement of 1500 square feet (30 ft. by 50 ft.) will lose 1.5 x 14,320 or 21,480 Btuh when the outdoor temperature is -7°F. When properly insulated, the same basement will lose only 1.5 x 6160 or 9,240 Btuh.

48. **Crawl-space foundation.** A warm crawl space reduces the heat loss through the floor above. In winter, vents in the crawl space should be closed. (If there are moisture and dampness problems, they must be corrected first.) The vents can remain closed during the summer if there are no moisture problems. This will reduce the problem of condensation on the cooling ductwork. The indicated temperatures and heat losses are based on a tight space and an outdoor temperature of -7°F. For example, a 30 ft. by 24 ft. floor over an uninsulated crawl space would have a heat loss of 0.72 x 6100 or 4390 Btuh. By insulating the crawl space walls as indicated, the loss can be reduced to about half that amount.

49. **Slab floor foundation.** The heat loss from a slab floor occurs mainly at the edge of the floor exposed to outdoors. An uninsulated 30 ft. by 50 ft. slab floor would have a heat loss of 1.5 x 7800 or 11,700 Btuh, if heating ducts or cables are not imbedded in the floor. In an existing house, edge insulation can be installed vertically on the outside of the foundation and up to the lower edge of the siding. Extruded polystyrene or impregnated fiberglass boards will best resist moisture and temperature change. The insulation should be protected from damage.
Winter

50. **Building shape and size.** A larger building usually has less heat loss per square foot, and a square building has less wall area per square foot.

51. **Roof overhang.** A properly designed roof overhang on the *south wall* protects the wall from summer sun and exposes it to winter sun. Any overhang protects the wall surface against weather.

52. **Vestibule.** A vestibule with an inner door reduces the flow of outdoor air into the living area, especially in homes with heavier traffic (children and pets).

53. **Window areas.** For a given area, windows and doors lose more heat than walls. A double-glazed window will lose seven times as much heat as a well-insulated wall.

54. **Earth protection.** Caves served early man not only as protection against animals, but also as a constant temperature haven. Basement rooms or earth-bermed houses provide additional protection against weather. Homes fully underground present waterproofing problems and may lack fire exits from rear rooms.

55. **Inside chimney.** A chimney inside the house gives off heat to the house. A chimney on an outside wall loses most of its heat to the outdoors and provides a poorer draft.

56. **Window treatments.** Closing a tightly fitting shade or drapery (perhaps insulated) over a window will reduce heat loss but may cause condensation on the sash.

57. **Room over garage.** The floor of a room over a garage should have 6 to 9 inches of insulation in the floor, and a vapor barrier. The ceiling should have fire protection, such as Type X gypsum drywall.

58. **Sill sealer.** A compressible filler placed on the foundation before the sill plate is fastened will reduce air infiltration. On older houses, the joint between the sill and the foundation should be caulked.

59. **Ventilation.** Some air exchange (at least one-half air change per hour) is needed to control odors, moisture, and other forms of indoor air pollution. An air-to-air heat exchanger will permit this ventilation while minimizing heat loss.

Summer

60. **Building orientation.** For a given building design, an East-West orientation will result in less solar heat gain in the summer and more solar heat gain in the winter, particularly if there is a properly designed overhang.

61. **Roof surface.** A light-colored roof surface reflects more solar heat than a dark-colored roof. This is not important if the attic is properly insulated and ventilated. A flat roof can be sprayed with a reflective paint or covered with white stone chips.

62. **Attic ventilation.** The attic should be properly ventilated to remove solar heat gain. A proper combination of continuous overhang and ridge vents eliminates the need for power venting.

63. **Porches.** A wide porch serves as an outside living space and shades the walls and windows against solar heat gain.

64. **East- and West-facing glass.** Solar heat gain through unshaded East and West windows is twice as great as through equal-sized south windows.

65. **Shading effectiveness.** Window shading devices reduce solar heat gain. Each shading method below can be compared. The priority of window treatment is East, West, and then South.

<table>
<thead>
<tr>
<th>Shading Method</th>
<th>Btu/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glass, unshaded</td>
<td>1000</td>
</tr>
<tr>
<td>Double glass, unshaded</td>
<td>2000</td>
</tr>
<tr>
<td>Triple glass, unshaded</td>
<td>3000</td>
</tr>
<tr>
<td>Single, heat absorbing</td>
<td></td>
</tr>
<tr>
<td>Single, full length drapery</td>
<td></td>
</tr>
<tr>
<td>Single, venetian blinds</td>
<td></td>
</tr>
<tr>
<td>Single, roller shades</td>
<td></td>
</tr>
<tr>
<td>Single, louvered screens</td>
<td></td>
</tr>
<tr>
<td>Tree shade</td>
<td></td>
</tr>
<tr>
<td>External shutter, closed</td>
<td></td>
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</tbody>
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