HOME RETROFITTING
FOR
ENERGY CONSERVATION
AND
SOLAR CONSIDERATIONS

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PREFACE

These days, most anybody can tell you how to insulate your attic. You've probably also met people who can tell you more about energy than you'd ever want to know. Most books and pamphlets on energy seem to square off in the same way; they either give you a simplified version of how to weatherize your home, or delve into the far reaches of energy policy and engineering.

This manual has a unique approach. It presents both a review of key concepts behind energy use and a nuts-and-bolts explanation of how to improve the energy efficiency of your home. You want to know how heat escapes from your home? It's covered in a special chapter on "Heat Transfer Between Houses and Humans." You want to know what to do about it? Read the full section on "Energy Conservation Actions."

Throughout the manual, the interaction between people, houses, and energy use is emphasized. After all, you have to live with your house, and with your fuel bills as well. By gaining a better grasp on how you, your house, and your energy systems all work together, you'll be able to significantly reduce your fuel bills and improve your comfort. You'll also improve the comfort of the environment by reducing the strain on our resources, and improve the comfort of all of us by reducing our dependence on foreign energy supplies. Read on to begin improving the quality of your energy use.

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ABSTRACT

This manual, Home Retrofitting for Energy Conservation and Solar Considerations, displays a unique approach to energy education. It explains both the key concepts behind our need for and our impact on energy usage, as well as a nuts-and-bolts explanation of how to improve the energy efficiency of your home. In this sense, it fills the gap between "how-to-do-it" manuals and sophisticated energy texts. By reviewing both the concepts and practices of energy conservation, the manual presents a comprehensive picture of how home energy use is effected by the inhabitants and by the structure itself.

The manual begins with an explanation of why we are looking at energy, then proceeds to explain how the heat transfer occurs between houses and humans. Next is a chapter on energy audits and how to use them, followed by a comprehensive section on energy conservation actions to do now to reduce energy use.

Conservation actions include low cost/no cost measures, schemes to reduce infiltration, how to increase insulation, and what to do with windows and doors, heating and heat distribution systems, and water heaters. Solar energy options are then briefly explained, as well as the all important issues of financing and tax credits. The manual concludes with a bibliography to direct the reader to more sources of information. Using the information presented here as a starting point, the reader can go a long way towards saving money on fuel bills while increasing the comfort of the living space at the same time.

1.0 A PLANNED APPROACH TO ENERGY CONSERVATION ACTIONS

Many of us are looking at energy because energy has been looking so hard at us: fuel bills, supply shortages, environmental problems...the list goes on. Oftentimes, the bottom line for the consumer is cost--how much of your paycheck is going to have to go towards heating your home? The utilities, on the other hand, find their main problem to be supply. An increasing number of people on both sides of the fence are also concerned about the environment. How much coal can be burned before all of the freshwater fish are killed by acid rain? What are the risks in nuclear power, strip mining, or high voltage transmission lines? Environmental questions are especially difficult because the issues are so new and the global implications so large. There are no easy answers, but the questions are becoming clear. We are looking at energy because of economics, supply, and the environment.

As consumers, we can best deal with the energy questions by planning our approach to energy use. Ideally, we would plan to meet our energy needs at the least cost, while at the same time creating as little drain on supply, or pressure on the environment as possible. The easiest and most effective way to do this is to start using energy as efficiently as possible. Using energy efficiently doesn't mean that you'll have to compromise on comfort. The energy we'll be trying to cut is energy that you never needed in the first place. It's the energy that slides out cracks, goes down the drain, or up the chimney before you ever notice it. In fact, if you follow through with a conservation plan for your home, you will be **more comfortable** afterwards than before. You will understand this better after we discuss the means of heat transfer by and between humans and houses.

The first step in reducing our energy needs is to become aware of our **energy use patterns**. Many of these patterns are unconscious--we

simply don't think about the way we do small tasks. Changing some patterns, such as the way in which we wash dishes, may even seem ridiculous at first. Add the savings up over a year, however, and they may pay for several nice dinners at fine restaurants. Using energy efficiently is a matter of making a lot of small changes. The best place to begin is by changing your patterns to get the same work done with less energy. In some cases, these small changes have meant as much as a 50% savings in a home's total energy costs. We will give you a listing of ideas for looking at your energy use patterns to save energy.

After your own energy use patterns, think of your house. Most houses are ripe with opportunity to economize on energy. Sealing up leaks and insulating can truly save you a bundle. The question, though, is what saves the most energy, while at the same time, yields the best return on your investment in energy conservation? The answer depends upon the characteristics of your own particular house. Most houses gain the best savings through caulking and weatherstripping. If your house is already tight, however, then insulation may be the wisest first investment. So before you begin weatherizing, it is best to do an energy audit on your house to find out which conservation projects offer the best value for you. Energy audits, and how to use the information they give you, are explained in this workbook.

With the information from an energy audit, you can begin to improve the efficiency of your home. Here, you enter the world of a thousand **conservation products**. Some work well, some work better, and others can be either ineffective or dangerous. The workbook section on Energy Conservation Actions provides an overview of energy conservation products and methods of installation. This section won't turn you into an insulation contractor, but it will make you an educated shopper. It will tell you what kinds of products are best suited for your home, and how they should be installed for effectiveness and safety.

It is nice to know that you will be saving money by investing in energy conservation, but you may be wondering where that initial money for the investment is going to come from. In the "Where To Go From Here" section, we list a number of sources for loans for energy conservation projects. We also explain the State and Federal tax credits you will receive on your investment in conservation or renewable energy.

Finally, we provide a bibliography to inform you of other sources of information on energy. We include listings of information services, books, and pamphlets.

2.0 HEAT TRANSFER BETWEEN HOUSES AND HUMANS

2.1 PRINCIPLES OF HEAT TRANSFER

Heat is constantly being transferred between people and their environment. The nature of heat is to flow from warmer to cooler bodies. ("Bodies" is a general term to refer to people and material objects.) The actual rate of heat transfer depends upon a large number of things, including the temperature difference between the bodies, their thicknesses, and their resistances to heat flow. This section will explain five different kinds of heat transfer and how they effect your comfort and the energy efficiency of your house. We'll discuss the three primary modes of heat transfer: **conduction**, **convection**, and **radiation**, as well as the special cases of **evaporation** and **condensation**.

Conduction is the transfer of heat from one warmer part of a body to a cooler part of the same body or from one body to a different body in physical contact with it. The quantity of heat transferred through a substance over a specific period of time will increase as the area increases through which the heat transfer occurs. Heat transfer will also increase as the temperature difference across the substance increases. Heat transfer will decrease as the thickness increases through which the heat is transferred. Additionally, the rate of heat transfer is regulated by the ability of the body to allow heat to flow through it. This ability is a property of the body and is given the name of thermal conductivity. A higher thermal conductivity means a greater rate of heat transfer.

A property which is determined from the thermal conductivity and is more generally used in referring to heat loss from houses is the property known as the thermal resistance of a body. Whereas the thermal conductivity indicates the ability of a body to conduct heat

flow, the thermal resistance (or simply resistance) indicates the ability of the body to resist heat flow through it

What this means for your house is that as the area of wall increases, or as the temperature outside decreases or the temperature inside increases (either one of which causes the temperature difference to increase), or if the thermal conductivity of the wall increases then the rate of heat transfer through the wall will also increase. For example, since an air space in a wall will have a higher thermal conductivity than insulation would have in the same space, the wall with the air space will transfer more heat to the outside than the wall would transfer with the wall cavity filled with insulation.

Convection is the transfer of heat by fluid movement. This may occur, for example, by blowing across a hot muffin before eating it. The fluid movement of one's breath cools the muffin. Again the heat is transferred from the hotter muffin to the cooler air of the breath. As the surface of the muffin is cooled by convection, heat is transferred through the muffin by conduction from the hotter interior portion of the muffin to the cooler surface of the muffin.

The rate of heat transfer by convection from the muffin to the air is dependent on such effects as the temperature difference between the surface of the muffin and the air, the velocity of the air across the muffin, and the resistance to heat flow between the surface of the muffin and the air. An increasing temperature difference, an increasing velocity, or a decrease in the resistance will cause an increase in the rate of heat transfer.

Convection heat transfer can be either forced or natural. **Forced convection** is what happens when you're cooling the muffin--an outside source of power is used to speed up the transfer. **Natural convection** occurs when there is a difference in the density of the fluid. Hotter fluids are less dense than cooler fluids. This is

why the warmed air from the heating system in the house will rise to the ceiling of the room and the colder air such as that near the window will fall to the floor.

Another example of natural convection is the manner in which convection air currents aid in the removal of heat through outer, uninsulated walls of the house. Convection currents occur in the wall cavities where 1) the air film on the cavity side of the wall surface adjacent to the room is heated by contact with the warm surface; 2) this warmed air rises; 3) at the same time the warmed air causes the film of air on the cavity side surface of the outer wall, which has been cooled by transferring its heat to the cold wall, to flow around the bottom of the wall cavity, and rise along the warmer surface of the room side part of the wall; 4) the previously warmed air which rose to the top of the wall cavity is pulled down along the cavity side of the surface of the outer wall and is cooled by contact with this cold surface. Thus a naturally induced circular air flow pattern within the wall cavity is established by means of the varying density of the alternately warmed and cooled air. By filling the wall cavity with insulation, you eliminate this cycle.

Radiation is the transfer of heat from a body due to electromagnetic radiation. Thermal radiation, the radiation which we sense as heat, is emitted, or given off, by a solid body or fluid due to its temperature. The higher the temperature, the greater the thermal radiation emitted. Different surfaces and colors of surfaces emit radiation at different rates. Any body will emit radiation at a certain rate dependent on such factors as the specific material of the body, the surface roughness, and the color. The rate at which a body emits radiation is known as the emissivity of that body. Radiant heat transfer is dependent upon the surface temperature, the emissivity, and the area of the body.

The most familiar example to all of us of radiant heat transfer is

the sun. The sun gives life to the Earth and its inhabitants by radiating its heat through the vacuum of the space and the atmosphere of the Earth to the Earth's surface. The energy of the sun heats the air and the land and water masses of the Earth.

Within your own house, if you are standing in front of a window, radiant heat transfer occurs from your body to each glass surface of the window, from your body through the window to the outside surfaces, from each glass surface to your body, and from the outside surfaces to your body.

Evaporation and **condensation** involve heat transfer which occurs when a substance goes through a phase change while maintaining a constant temperature. A phase change occurs as ice melts into water, or water freezes into ice; water evaporates into water vapor, or water vapor condenses into liquid water. In other words, ice, liquid water, and water vapor represent the three common phases of a substance: solid, liquid, and gas, respectively.

Air which has a relative humidity greater than 0%, which is usually the case in most parts of the world, is called **moist air** because it has water vapor contained in it. Relative humidity is a percentage which reflects the ratio between the amount of water vapor which the air contains compared to the maximum amount that the air can hold before condensation occurs. The warmer the air, the more water vapor it can hold; the cooler the air, the less. The temperature at which water vapor condenses into liquid is known as the dew point temperature. The dew point temperature of moist air depends on the temperature of the air itself and the relative humidity of the air. The significance of the dew point is that the moist air will condense on any surface that has a temperature at or below the dew point temperature.

For example, if the air in a house is at 68 F and 50% relative humidity, the dew point temperature is about 48.5 degrees. A double

glazed window will have a surface temperature on the room side of the glass of 45 degrees when it is 68 F in the room and 0 degrees outside. Condensation will occur on the glass under this condition. If the room air was 68 F and 40% relative humidity, the dew point temperature would be about 43 degrees and condensation would not occur.

It requires the expenditure of energy to evaporate water but energy is released when water vapor condenses back into liquid. So when condensation does occur on windows much of the heat energy in the water vapor will be conducted through the window and lost to the outside. Therefore it will require an extra expenditure of energy from your house to once again evaporate the moisture from the windows back into the house air. Also, the condensation on the windows may drip onto the window sash and sill and cause rotting of the wood.

2.2 HEAT TRANSFER FROM HOUSES

Heat enters a house from a variety of sources such as heating systems, appliances, lights, solar radiation, and people. Heat is lost from the house by conduction through outside surfaces, radiation through windows, and by infiltration and exfiltration through cracks, holes, and porous materials. By balancing the heat input against the heat loss, it is possible to determine where heat is being lost in the house, and how much is being lost from different areas. With this information, you can begin to weatherize your house to reduce your energy consumption and costs.

One way in which heat leaves the house is by conduction. Conduction occurs through solid materials, including the walls, ceilings, floors, rim joists, foundations, windows, and doors of a residence. The rate at which heat passes through these various components depends upon their respective resistances to heat flow. The thermal

resistance of a given material is referred to as the "R-value". Figuring out the resistance of a part of your house, such as a wall, involves taking into account the resistances of all the different materials that make up the total component, such as the layers of the room-side surface of the wall, the wood studs in the wall, the air space or insulation between the studs, and the outdoor facing part of the wall.

For example, the plaster on the inside of the wall would have a different R-value than the lath underneath the plaster; the two-by-four studs framing the walls would be different than either the plaster or lath, and insulation piled between the studs would be different than all three. Siding on the outside of the wall would again have a unique value. To determine the overall resistance of such a component, it is necessary to first determine all of the unique R-values of the materials and air films which occur on the surface of any solid body, then add these all together and take the inverse of the resulting number. This factor is known as the "U-value," and represents the total rate of heat loss by conduction from a given building component.

Heat transfer by conduction is also dependent upon the "**design temperature difference**" between the inside of the house and the outdoors. This temperature difference is based on the "lowest" outdoor temperature (unusual conditions excepted), and the desired indoor temperature (currently, 65 to 68 F). The design temperature difference is used in predicting the total rate of heat loss through the various components of the house under the "most severe condition." This information is used for sizing a heating system to the energy needs of the residence and for evaluating the effect of energy conservation improvements on the house.

Convection air patterns can work in three ways to remove heat from your home. 1) The first way is by the air loop cycles set up within the walls, as described in the first part of this section. 2) In

the same way that the air loops function within the wall cavities, they can also circulate in the living space itself. Air in the room contacts the cold walls and windows, loses heat, and falls. Warmer air from the room is then pushed over towards the cold surfaces, and the cycle continues. 3) A third form of convection, called **infiltration**, occurs by air moving through the structure. Here, cold air seeps into the structure through cracks, holes, and porous material, pushing out the warm, conditioned air.

Infiltration is one of the easiest forms of heat transfer to reduce through conservation efforts. The rate of infiltration heat transfer is effected by: 1) the pressure difference between the inside of the house and the outdoors resulting from a) the wind speed against the house and b) the density differences resulting from the temperature differences between the temperature inside the house and the temperature of the outdoors, 2) cracks, holes, and porous materials in your house, and 3) the location of openings in the structure.

As houses age and settle, their various components tend to stretch and pull. Cracks start to open between pieces, and holes appear where two pieces have stretched in different ways. Materials that were porous to begin with, such as softwood siding, become more porous with age, and increase their transmittance of air. As the house thus becomes "looser," the pressure differences can have an even greater effect in sucking warm air out of the living space. Pressure differences between the inside of the house and the outdoors can be altered by the effects of the landscaping and geography around the structure on reducing the wind speed against the house. The pressure difference is also affected by vacuums created within the house, such as by exhaust fans and fireplaces. Reducing the magnitude of the infiltration heat loss can be accomplished by sealing up your house as tight as a boat. See the section on "The Structure" for information on how to do it.

Measuring the area of all of the unwanted openings through which infiltration can occur through the structure is more of an educated guess than a science. There are two methods which may be used to accomplish this: 1) the **crack length method**, and 2) the **air change per hour method**. With the crack length method, the evaluator measures all visible cracks in the structure and tallies them up. From this, one can gauge the amount of open space between the inside and the outside of the structure. Due to its detail and lack of high accuracy anyway, the crack length method is seldom used for residences.

The second method, the air change per hour approach, is most often used for measuring residential infiltration. In this case, one determines one value to use for estimating infiltration for the entire structure. The value is determined by an "educated guess" in allowing for the condition of the house and "looseness" or "tightness" of construction details of walls, windows, doors, etc.

It is not uncommon to find that a great majority of homes have cracks and holes and loose-fitting components that all totaled would equal having a two or three foot square hole in the wall. This gives a great motivation to be concerned about saving energy.

Temperature extremes within a particular climate or geographical location have a major influence on determining how much energy and conservation measures are appropriate for a specific house. The effect of the climate in regard to temperatures is measured in terms of "degree days." Degree days refer to the number arrived at by subtracting the average mean temperature for the day from 65 F. For example, a day in January where the temperature averaged 12 F would have a "degree day" rating of 53 ($65-12=53$). In central Minnesota, we average 8,200 degree days per year. During the winter of 1980-81, an unusually mild season, we only accumulated about 7,500 degree days. The degree day concept makes it possible to compare

winters from different years and from different locations. The degree days factor is useful in determining the annual heat loss of the structure. However it does not take into account climatological variables such as wind (see convection) and solar radiation.

The **home energy index** is like a miles-per-gallon rating for your house. It works as a simplified method to measure the efficiency of your heating system, the ability of your house to hold in heat, and your energy habits. The index is based on the amount of fuel and electricity used by your house during the six month period from November 1 to April 30. A copy of the worksheet for completing your home energy index is included in this workbook, along with a scale marked with several examples. You can compare your index number with those on the scale to find out how your home ranks in comparison to other houses in the Twin Cities.

2.3 HEAT TRANSFER FROM HUMANS

Humans lose heat in much the same way as houses. We perspire, and the **evaporation** of moisture from our skin cools us. We **breathe**; and as we inhale the cooler air of the room it mixes with the warm air from our lungs so that when we exhale some of our internal heat and moisture is transferred to our environment. We **insulate** ourselves with clothing. In the winter, we "caulk and weatherstrip" with gloves and scarves to insulate and seal against wind infiltrating through and around the seams of our clothing. Just as with houses, the amount of heat flow between us and the environment depends upon the differences in temperature between humans, the surrounding air, and the surrounding surfaces.

The human body produces heat through the **oxidation process**; that is, the chemical processes by which food is changed into usable energy. The measure of energy produced by oxidation is called the metabolic rate. How much heat we give off varies greatly depending upon our

level of activity. For an average male, this can range from 246 Btu per hour while sleeping, to over 2500 Btu per hour when engaged in strenuous exercise.

Heat is lost from the skin by **evaporation**. As water vapor diffuses through the skin and also as sweat is secreted from the surface of the skin, the heat of the body is used to evaporate this moisture into the air. In using the body's heat, the body is cooled. This same process accounts for the cooling effect surrounding large bodies of water. The evaporation of the water occurs by drawing the heat from the water and the surrounding land masses causing them to cool. Evaporative cooling also accounts for the removal of heat by spraying cool water onto a hot roof.

Respiration also facilitates heat loss from the body. The difference in the temperature of the air we inhale and exhale cools the body, along with an evaporative heat loss arising from the loss of moisture which is given off through the respiratory tract to the inhaled air as the air is exhaled.

To reduce a house's heat loss by conduction, you insulate. To reduce your own heat loss by conduction, you wear clothes. Although this may be a fairly primitive concept to fashion designers of today, it was probably once one of the main reasons for wearing clothes at all. The thermal resistance of clothing is more dependent upon thickness than upon the weave or fiber content of the material for ordinary textile materials (wool, cotton, silk, rayon, nylon, glass). The fit of clothing is also important in determining warmth. Layers of air between garments aid the insulation value to a certain extent. Too much air space, and heat can escape up between the layers of your clothes, due to both forced and natural convection, in just the same way that it can snake its way out of a house through cracks around pipes and wires in the attic.

2.4 INTERACTIONS BETWEEN HOUSES AND HUMANS

Humans react to house temperatures in two basic ways: by twirling the thermostat and by putting on or taking off clothes. In situations such as an office, where a large number of people are in the same, controlled environment, there are always individuals who are either too hot or too cold. Uncontrolled thermostats in settings like this would need high-speed bearings on the dial to be able to endure the constant changing. This personal variance is in part due to the different skin temperatures and sweat secretion levels of the individuals.

Since environmental variables in a house are more easily described than personality variables, we will discuss four elements which affect the inside climate: 1) relative humidity, 2) air velocity, 3) mean radiant temperature, and 4) ambient temperature.

Relative humidity generally runs between 20% and 50% in the home. A higher level of humidity has a small, but noticeable effect in making you feel warmer. Too high a level of relative humidity, and water will begin condensing on the windows and walls, potentially causing surface deterioration or structural problems. In order to avoid condensation the relative humidity in the house may have to be kept lower as the outdoor temperatures get colder.

In the same way that high humidity can make you feel warmer at cool temperatures (i.e., by decreasing evaporative cooling from the body), it can make you feel miserable when it is hot (when one needs the evaporative cooling effect). Therefore, reducing the humidity level in the summer is also a way to increase comfort.

Air velocity creates a "wind chill effect" on people. You have certainly noticed this outside during Minnesota winters, and have probably also felt it at certain restaurants and movie theaters in the summertime when the air conditioning first comes on. Since air

movement across our bodies has a cooling effect on us, the higher the air velocity, the more surrounding heat you need to feel comfortable, to make up for the extra heat loss due to the air movement.

To reduce air velocity through your home, make sure it is caulked and weatherstripped. You can also reduce the air velocity within the house by controlling air convection patterns within the rooms through such measures as wall insulation, thermal shades on the windows, and careful placement of furniture away from radiators, registers, or other heat sources.

Mean radiant temperature refers to the "average" surface temperature of all the walls, ceilings, floors, doors, and windows of a room. These surfaces will tend to be colder than the ambient air temperature in the room, due to heat loss through the various building components. By adding conservation measures, such as insulation, storm windows and doors, and window quilts, you can reduce heat loss through these surfaces. By reducing heat loss, the difference between the radiant surface temperature and the air temperature will also be reduced since the mean radiant temperature will then increase. This adds to your feeling of comfort and reduces the amount of heat required from the furnace to maintain a thermally comfortable warmth in the room.

3.0 WHERE IS YOUR ENERGY GOING TO NOW? - THE ENERGY AUDIT

The first step in improving your use of energy is to check on where you are using or losing energy in the house, and estimate how much energy is being used or lost in each area. Collecting your utility bills for a recent 12 month period is an appropriate, if sobering way to begin. From the bills, you can see how much you spend on different types of fuel--gas, oil, electricity, and wood--over the year. Now, look at the figures for the total amount of fuel consumed. Due to the ever-changing price per unit of energy, the actual energy use figures, not the cost of the energy, will allow you to be able to truly evaluate your conservation efforts.

As an example, in 1975, Mr. Untel caulked and weatherstripped his home. He monitored his fuel bills that winter, and discovered that he had saved \$5.00 over his bills for the winter of 1974. Mr. Untel was not impressed. He remembered then, that his utility rates had risen sharply during the same period. By comparing the gallons of oil his furnace burned in 1974 to the gallons it burned in 1975, he discovered that he had actually burned 50 gallons less fuel in 1975. He did some more figuring, and realized that by multiplying the 50 gallons times the current price of oil, he had saved enough to pay for nearly all of his caulking and weatherstripping project within the first year. Since then, Mr. Untel has insulated and added storm doors and windows. His utility bill today still isn't much lower than it was in 1974, but considering the current prices, that's nothing to complain about.

As the above example shows, we must begin by measuring fuel savings as opposed to dollar savings, simply because the spiralling cost of energy makes year-to-year cost comparisons irrelevant--unless you account for the changing cost of the fuel in your calculations.

Measuring energy use in a house and prescribing conservation

measures to trim energy waste is known as energy auditing. An energy audit can take many forms. The most common audit procedure is an inspection of the property by someone specifically trained in measuring residential heat loss. The auditor will check such things as insulation levels, areas that need caulking or weatherstripping, and mechanical systems such as the furnace and hot water heater. Depending upon the orientation and surrounding environment of your home, an audit may also include information on the feasibility of using solar or other renewable energy sources in your home.

After the auditor has made suggestions and recommendations on how you can improve the energy efficiency of your home, you must then decide which recommendations to act upon and how to go about completing those recommendations in your home. Remember, a home energy audit does not save you energy and money all by itself. Only by adopting some of the audit recommendations will you save energy and money.

The first conservation measures you should act upon are those with little or no cost. These might include turning down the thermostats on your furnace and water heater, or caulking any cracks in the foundation. After taking care of these low cost/no cost measures, you can proceed to the other recommendations made by your auditor. Other measures will involve some expense, but will save you substantially more in energy savings.

A range of energy conservation and renewable resource measures might be appropriate for your home, yet you may choose to start with one or two, and add the others later. One way to compare the different conservation measures is in terms of payback. Payback is the amount of time required for an energy conservation measure to pay for itself through fuel savings. For example, if you caulk and weatherstrip your house for \$120, and find that you start saving \$80 a year in fuel costs, the payback would be one-and-one-half years ($120/80=1.5$).

By performing conservation measures in the order from the shortest payback to the longest, you can start receiving a return on your conservation investment almost immediately, and use those savings to help offset the cost of more expensive measures.

Calculating energy savings is not an exact science. An energy auditor cannot predict precise costs and savings for your particular home and living patterns. The actual costs you incur and savings you realize from making the suggested improvements may differ from the actual audit estimates. Each measure will save you a certain amount of your energy costs, but because some of these measures act together and not individually, don't expect to add up all the estimated savings to a figure greater than your fuel bill.

In comparing the different estimated costs for conservation measures, keep in mind that prices will vary with the quality and the performance of the weatherization products. Make sure you are comparing products and systems of a similar type, quality, and performance.

If fuel prices continue to increase in your area, you will probably realize even greater savings than those estimated. An auditor's calculations are based on recent utility costs and may not take into account any rapid increases or other changes.

The best way to arrange for an audit of your home right now is through the Minnesota Energy Conservation Service (MECS). The MECS audit provides a truly comprehensive energy evaluation of your home. It is available through your local utilities for a cost of \$15. You can also have an audit performed by an independent auditor, but here, the cost will be substantially higher, often over \$75. In addition to a low price and a thorough service, the MECS audit can provide you with lists of contractors and suppliers of energy conservation materials. All contractors whose names appear on the

"Master List of Contractors" have agreed to provide the following consumer protections for any energy home improvement work done through the MECS program:

- Provide the customer with a 1 year written warranty on materials and installation work.
- Comply with Department of Energy standards for installing energy conservation devices.
- Provide the customer with a written contract detailing the job to be performed.
- Correct improper installations at no additional cost to the customer.

Through the MECS program, you can become eligible to have any contractor's work inspected by qualified inspectors to determine if the installation meets program standards. Any complaints concerning a contractor's work will be mediated by the Minnesota Office of Consumer Services. Your participating utility will assist you in obtaining contractors' bids on work to be done. Information describing the recommended energy conservation improvements is available from your participating utility upon request. Also, the Minnesota Energy Agency Information Center is available to answer your questions. Phone 296-5175 in the Twin Cities, or dial 800/652-9747 toll free.

If you decide not to take advantage of the MECS audit, you can either hire a private auditing firm, or better yet, perform the audit yourself. A number of good audit manuals are available which will guide you, step-by-step, through evaluating your energy use. By auditing your home yourself, you will get a better feel for how all of the energy supply systems work together. You will also discover the multitude of ways in which energy can seep out of your

house. Refer to the bibliography at the end of this workbook for a listing of audit manuals.

After you have either audited the house yourself, or hired an auditor, you will need to decide whether to do the weatherization work yourself or to contract for that as well. This decision depends upon your amount of free time and ambition, as compared to the balance in your checkbook. Many conservation measures are not complicated--anyone with some basic tools and know-how can do a nice job. Read through the "Structure" section of this workbook and think about the amount of work involved with each measure for your house. To find out more about how to do each particular job, refer to one of the conservation manuals listed in the bibliography.

If you decide to go with a contractor, shop around and compare price, materials, and reputation. Here are some tips for choosing a good contractor:

1. Experience and reputation: Choose a contractor with experience and a good reputation. Ratings are available from the Better Business Bureau and your local utility. You can also ask the contractor for a list of past customers and call several to verify the firm's reputation.
2. Guarantees: A contractor should offer sound, meaningful guarantees on materials and workmanship. Ask about the specifications of the materials. What will the contractor do if problems arise? What will be put in writing?
3. Multiple Bids: Price is not the only factor you should consider. Get at least three bids, but do not buy on price alone.
4. R-value: As with other kinds of insulation, you should compare products and prices by R-value. In some cases, there may be a significantly higher price for a product with a slightly higher R-value. Make sure that the installed R-value is in the

contract.

So you've audited your house, completed most of the conservation opportunities you discovered, and now, you're wondering how your house's energy use this winter will compare to its use last winter. By completing the "Energy Index," as mentioned in the section on heat transfer from houses, you can measure energy use to evaluate your home's energy use changes from year to year, to compare your house with others, or to use as a tool for marketing your now energy efficient home.

To calculate the energy index, you will need accurate fuel use data for all fuels used in the house from November through April. Following is an example of how the index is calculated.

First, list the meter readings on approximately November 1st and May 1st for each of your energy services. Subtract the November figure from the May figure to find the total amount of energy used for the period.

a) Gas meter reading: 10/23/80 -- 18,720 CCF

4/27/81 -- 20,220 CCF

Total amount of gas consumed for the period: 1,500 CCF.

b) Electric meter reading: 11/4/80 -- 4739 kWh

5/5/81 -- 5381 kWh

Total amount of electricity consumed for the period: 1642 kWh.

c) Kerosene for portable space heater: 11/15/80 to 4/15/81: 20 gallons.

Second, convert the meter readings to Btu's. Do this by multiplying the amount of energy used by the number of Btu's per unit of measure for each specific fuel. BTU heating values of fuels are shown in the

continuation of this example below.

a) Gas: $1,500 \text{ CCF} \times 100,000 \text{ Btu/CCF} = 150,000,000 \text{ Btu's.}$

b) Electricity: $1642 \text{ kWh} \times 3400 \text{ Btu/kWh} = 5,582,800 \text{ Btu's.}$

c) Kerosene: $20 \text{ gallons} \times 140,000 \text{ Btu/gallon} = 2,800,000 \text{ Btu's.}$

If oil or propane is used, they need to be included in the energy calculations. The heating values of these fuels are 140,000 Btu/gallon for oil and 92,000 Btu/gallon for propane.

Third, calculate the Weather Adjustment Factor for each specific billing period. This factor is represented by the following equation:

Weather Adjustment Factor =

$$\frac{\text{Heating Degree Days (HDD) Normal}}{\text{Current Year Heating Degree Days (CYHDD)}}$$

Both the Current Year Heating Degree Days and Heating Degree Days must be calculated for each specific billing period. Therefore, the normal example would require three separate equations for weather adjustment factor, one for each fuel.

$$\begin{array}{lcl} \text{a) Gas billing period:} & \frac{6122 \text{ (HDD)}}{5390 \text{ (CYHDD)}} & = 1.135 \end{array}$$

$$\begin{array}{lcl} \text{b) Electric billing period:} & \frac{5985 \text{ (HDD)}}{5140 \text{ (CYHDD)}} & = 1.164 \end{array}$$

$$\begin{array}{lcl} \text{c) Kerosene billing period:} & \frac{5553 \text{ (HDD)}}{4720 \text{ (CYHDD)}} & = 1.176 \end{array}$$

Fourth, multiply the total Btu figure for each fuel by the corresponding Weather Adjustment Factor:

a) Gas: $150,000,000 \text{ Btu} \times 1.135 = 170,250,000$

b) Electricity: $5,582,800 \text{ Btu} \times 1.164 = 6,498,379$

c) Kerosene: $2,800,000 \text{ Btu} \times 1.176 = 3,292,800$

The fifth and final step is to add the total figures in step four, then divide by 1,000,00 to find the Home Energy Index number.

$$\begin{array}{r}
 170,250,000 \\
 6,498,379 \\
 + \quad 3,292,800 \\
 \hline
 180,041,176 \text{ Btu Divided by } 1,000,000 = 180.
 \end{array}$$

Following is a scale marked with several index examples. You can compare your index number with those on the scale to find out how your home ranks in comparison to other houses in the Twin Cities area.

4.0 LIVING HABITS

Take three identical houses in terms of design, size, construction, condition, heating system, heating fuel, etc. Fill these houses with three different types of residents, and you will have three very different utility bills. As an example, we will look at three hypothetical houses located in a bedroom community of a major city. In the first house, there are two adults and three young children. Total fuel bill: \$1500. In the second house, there is one older woman with three pet schnauzers and one cat. Total fuel bill: \$1200. The third house lodges two adults and one older child. Total fuel bill: \$900. Why such a big difference? It all comes down to the energy use patterns of the residents.

The first house contains a traditional family where the father works at the office and the mother works at home. Two of the three children are also at home, and spend much of the day watching television or doing other things that require electricity. The house is well-equipped with appliances, and because of the children, the appliances see a lot of use. With all the people, a lot of cooking goes on, as well as cleaning up to match the cooking. The children usually prefer to be indoors when they are outdoors, and outdoors when they are inside, so the doors are used several dozen times a day. The family likes to wear light clothing around the house, so the thermostat stays in the mid-seventies all winter. The general attitude about energy is that it is there to be used. Total fuel bill: \$1500.

The second house, with the older woman, three pet shnauzers, and one cat, has a substantially lower fuel bill than the first, but higher than the third. This house seems like it should have the lowest fuel bill of all, but again, the energy use patterns make the difference. Because of her age, the older woman has problems

staying warm. She needs to keep her thermostat in the mid-seventies. She doesn't do nearly the cooking that the family does, but with all of her pets, the doors in her house open and shut nearly as often. She has fewer appliances, and uses them much less often. She is aware of the energy problem, but fears it may be a conspiracy on the part of the oil companies.

The third house, with the two adults and the one child, has the lowest bill of all. Both of the adults work, and the child spends the day at school. Because everybody is gone during the day, the thermostat is set back during the day as well as at night. This family also has a particular fondness for sweaters. Appliances are used less frequently, and the doors open and shut just a few times each day. They are aware of the spiraling energy costs, and do a number of simple things, such as turning off appliances that are not being used, to manage their energy budget. Total fuel bill: \$900.

From this example, we can see how people influence energy use in two fundamental ways: 1) the way they use and abuse the systems within the home, and 2) the way they clothe themselves and equip their homes. The residents' attitudes towards energy is also a factor in their respective fuel bills. The family in the first house prefers the ease of power appliances for nearly every task from washing dishes to pressing garlic. They are also unaware of home management practices such as opening and closing drapes, and turning down the thermostat. The older woman in the second house practices some home management, and the family in the third house serves as an example of the difference simple home management practices can make in their fuel bills.

4.1 HOME ENERGY MANAGEMENT: THE LOW COST/NO COST WAY TO ENERGY CONSERVATION

Like the family in the third house, you can substantially reduce

your fuel bills by simply adopting some new energy use patterns. There are also a number of things you can do for a reasonable cost that will produce substantial savings. These practices will be most effective when they focus on the structure, the heating and cooling systems, and hot water use. Remember, energy conservation is a combination of a number of small actions, all working together. Following is a list of practices that will give you a good start.

4.2 HEATING AND COOLING SYSTEM ADJUSTMENTS

Keep your heating system tuned up, just like you would your car, for peak operating efficiency. Before the beginning of each heating season for oil furnaces/boilers or every three to five years for natural gas furnaces/boilers, have a service representative check your furnace to make sure that it is working properly. The service representative can start by cleaning and adjusting your burner. Be sure the service person performs a flue gas analysis and calculates the steady state efficiency of your furnace or boiler as well. Clean or change air conditioner and furnace filters regularly. You can do this simple job yourself.

If you heat with a forced air system, have the service representative check the internal temperature setting of your furnace fan--the fan that forces warm air up through the duct system into the house. To conserve fuel, the furnace's internal fan-off temperature should be set at 80 F. Heated air is circulated longer at this temperature. Find out how to do this yourself. In the design of some systems the air from the registers may feel to cool at this temperature. Therefore, after a trial period, you may need to adjust it up to 85 - 90 F for your particular case. But the lower it can be set, the more energy you will save.

Turn off the pilot light on your gas furnace during the summer. DON'T BLOW IT OUT! Improperly shutting off or blowing out a pilot

light can create a significant safety hazard. Even though the pilot light uses a relatively small amount of gas, shutting it off will cut down on your total fuel bill. Read instructions on your furnace carefully before relighting.

The best energy-saving adjustment for your furnace is still a simple **daily adjustment of your thermostat**. Each 1 F you reduce the house temperature for 24 hours a day will reduce your heat bill by about 3%. A house at 50 F will use less than half as much heat per year as it would at 70 F. During the winter, lower the thermostat setting at night to 55 F. Add more quilts or an electric blanket and you will be as comfortable as you were with higher house temperatures. During the day, set the thermostat at 68 F or lower, if you prefer. In the summer, set the air conditioning control at 78 F or higher.

If you have pipes in uninsulated exterior walls they could freeze if the house temperature drops too low. When these pipes run behind kitchen cabinets, open the cabinet doors to keep them warmer.

CAUTION: Some older people may require higher indoor temperatures--above 65 F at all times--to avoid accidental hypothermia, a possible fatal drop in body temperature.

People with circulatory problems or those taking certain types of drugs (such as phenothiazines, commonly used to treat anxiety and nausea) may also be vulnerable. In such instances, follow a physician's advice on both winter and summer thermostat settings in your home.

4.3 HOT WATER ADJUSTMENTS

Heating water for your family's showers, baths, laundry, and dishwashing accounts for a large part of your energy use. By

reducing the amount of hot water you use each month, you can save considerable amounts of energy. To save energy and money you should:

Install flow restrictors in shower heads and faucets. These small devices limit the water flow to a maximum of 2-3 gallons per minute (the lower the better) and, in most cases, have no effect on the look and feel of the water. You can enjoy a comfortable shower and at the same time save from 1 to 3 gallons of hot water per minute. Some shower heads do not work well with a flow restrictor installed--the water just dribbles out. New low-flow shower heads are available that give a good shower while using much less water.

Set the thermostat on your water heater at 110-120 F (the lower the better). At this temperature, the water will be hot enough to meet your needs. If it does not clean the dishes in your dishwasher at this temperature, raise the water temperature a few degrees until you are satisfied.

Set your washing machine for a "warm" wash and a "cold" rinse. A typical washing cycle takes a total of about 35 gallons of water to do one wash and rinse. If a hot wash and warm rinse combination is used, this would consume about 25 gallons of hot water. Therefore, by changing the wash setting from hot to warm, 8 gallons of hot water can be saved. In addition, if the rinse water is also changed from warm to cold, which does not affect the results of the wash, another 8 gallons of hot water may be saved. The results may pleasantly surprise you.

Tighten or plug leaking joints in hot water pipes.

Replace washers in leaking faucets. A single leaking faucet can cause from 1 to 10 gallons of hot water a day to go down the drain needlessly.

4.4 HOW TO RESET YOUR WATER HEATER THERMOSTAT

Anybody with 10 minutes to spare can reset the water heater thermostat.

For gas water heaters, you will find a temperature control knob near the bottom of the tank with "high", "medium", and "low" settings or numerical settings. Turn the knob to 110-120 F or to the lowest marking. NOTE: Do not use a screwdriver or open any plates on your gas water heater.

If you have an electric water heater, you will need a screwdriver to reset its thermostat. At the front of most water heaters there are 1 or 2 metal plates held on by screws. CAUTION: TURN OFF THE CIRCUIT BREAKER. Then remove the plates. Push back the insulation and you will see the thermostat. It will either have numerical settings or simply the designations "high", "medium", and "low." Reset the thermostat to 110-120 F or the lowest setting. After replacing the insulation and the plates, turn on the circuit breaker.

NOTE: If your electric water heater is a "quick recovery" model, check for a second thermostat and turn it down, too.

4.5 PLUGGING OR SEALING LEAKS

A house is like a ship surrounded by a sea of air. In the winter, cold air tries to force its way in, like water, through every crack, while heated air tries to leak out. In the summer, hot air comes in and cooled air leaks out. Here are practices for keeping heated and cold air where they belong.

Step into your attic some winter night. Even if it is insulated, you may be surprised to find that the attic is much warmer than the

outside air. That means that some of the expensive heat you need downstairs has escaped to an area where it won't do you any good. It is common to find large openings cut where pipes, ducts, wiring, or exhaust fans pass up through the attic floor. **Caulk these holes.** If they are large, you can first stuff them tight with fiberglass insulation and then caulk.

Check the gap where the furnace stack or chimney meets the wood framing of the house. Fireproof insulation, such as fiberglass, can be stuffed tightly between the wood frame and the wall of the chimney. Do not use cellulose here, as it may burn.

When your fireplace is not being used, be sure the damper is closed so that heated air is not lost up your chimney.

It is not unusual to find a gap of an inch or more in a fireplace with a closed damper! Because the chimney itself encourages a strong flow of air, this can create a major air leak when the fireplace is not in use. **Stuff the gap** with fireproof insulation or cover it with a sheet of fireproof material. **Chimney caps** that can be opened and closed from the fireplace are very effective in reducing losses up the chimney. Sealing the front of your fireplace with metal or glass is also effective in stopping heat losses. Of course, you will have to remove these materials before lighting your next fire!

A great deal of heat is lost from a house by **infiltration** through joints in the baseboards, around windows, and around door frames; through holes where plumbing pipes and telephone wires enter the house; and through holes around exhaust fans, dryer vents, and sink and bathtub drains as they exit from the house. These gaps and holes should all be caulked or stuffed with insulation and then caulked.

A tremendous amount of heat can also be lost by infiltration through

wall outlets on exterior walls. Inexpensive electric outlet and wall switch gaskets can be installed behind the cover plate to prevent these leaks. Follow the manufacturer's instructions on installation carefully.

4.6 SHADES, CURTAINS, AND DRAPES

Every house is a solar collector. The trouble is, it may be collecting the sun's heat when you don't want it and releasing the heat when you do. Shades, curtains, or drapes can help with this problem.

Floor length drapes that block off heat registers or radiators will actually increase your heating bills in the winter. In this case they would not allow the heat to get to where you need it, and would force the heat to go straight out the cold wall and window. Avoid this by installing drapes to permit full flow of the heat to the room, or install shorter drapes.

In the winter, if it is sunny, raise shades and open drapes on the sunny side of the house. Keep shades or drapes closed when the sun is not shining through a window.

Shut windows, lower shades, and close drapes on the north, east, and west windows as much as possible during the winter.

For the windows in bedrooms and other areas, cut foam insulation board to fit the window frame. Place the board in the window at night to reduce heat loss.

For windows in basements and other unused rooms, stuff a batt of insulation between the panes of glass to greatly reduce the heat loss.

When you use air conditioning in the summer, keep the windows tightly covered during the day, especially on the sunny side of your home. Open shades and windows to use natural ventilation during summer evening and night hours to cool your home when there are fresh breezes and you can turn off your air conditioner.

4.7 REDUCING ENERGY USE WHEN YOUR HOME IS UNOCCUPIED

You can take advantage of several opportunities to conserve energy when your home is unoccupied. Many people believe that you do not save energy by turning off heating or cooling equipment when you are away. **THIS IS NOT TRUE. Turning equipment off always saves more energy than is used after you return to the house:**

If your home will be empty for four hours or more, you can set the thermostat at 55 F. Again, remember to keep kitchen cabinet doors open where pipes run through uninsulated exterior walls behind the cabinets.

Turn off your air conditioner when no one is home.

Turn off your water heater when you leave the house for a weekend or longer.

5.0 ENERGY CONSERVATION ACTIONS RELATED TO THE STRUCTURE

When you start investing in energy conservation for your home, the best place to begin is with the structure itself. In this section, we'll cover the most effective means of weatherizing your home: **caulking and weatherstripping, insulation, and treatments for windows and doors.** In addition, we'll describe the special considerations to be aware of when you begin to modify your house.

5.1 REDUCING INFILTRATION AND EXFILTRATION

There are three main ways to reduce air flow through the house: by caulking and weatherstripping, sealing bypasses between the living space and the attic as well as the living space and the basement, and by insulating the exterior walls. The air flow through a house is measured in terms of air changes per hour. The fewer air changes per hour, the less heat that is lost from the house due to cold outside air leaking into the house and warm inside air leaking out of the house.

Caulking and weatherstripping the structure and sealing infiltration bypasses will pay for themselves in energy savings within the first year or two. These measures also reduce the drafts through the house so the thermal comfort (refer to section 2.0) of the home will noticeably increase.

5.2 CAULKING AND WEATHERSTRIPPING

Caulking or weatherstripping should be applied to all cracks, seams, or leaks between the living space and the outside. Caulk is used for sealing all stationary seams, while weatherstripping is installed on all moving parts, such as around windows and doors.

Openings in the structure often result from poor design, construction, or ageing. Foundation movement, wood rot, and wood warping create cracks and holes in homes. In examining your home, look for cracks in the following areas:

- around storm windows
- between siding and masonry
- around electrical fixture openings
- around electrical wires
- around plumbing fixture openings
- along cracks in the foundation
- loose window glazing
- around dryer vents
- around exhaust vents
- at the corners of the house
- near floor by-passes:
 - trap doors
 - basement stairwells
 - plumbing fixtures
- around window air conditioners
- around central air conditioning, and the wiring, piping and venting of central air conditioning
- at floor/wall interfaces
- near interior wall by-passes, such as utility outlets
- around ductwork
- around foundation walls, windows, and doors.

A wide variety of caulking products are available on the market. Following are brief descriptions of the more common products.

Oil Resin Base--This is often lowest in cost. It is not particularly durable, and tends to shrink and harden. It can be painted. This caulking material is found in most stores. It should not be used for long-term applications.

Latex Base--This will bond to most surfaces. It is more durable than resin based material, and also paintable. Some shrinkage will occur. It is adequate, but not the best material available.

Butyl Rubber--This material will bond to most surfaces. It is still more durable than the others, also paintable, and shrinks. This is often the best choice for use on masonry surfaces, but not on moving joints or places where two different materials join.

Polyvinyl Acetate--This will bond to most surfaces, is more durable, but it too shrinks and hardens. This sealant is surpassed by other compounds.

Nitrile Rubber--This bonds well to metal and masonry but not to painted materials. It is both durable and paintable, but large amounts of shrinkage are reported. Its primary use is for high moisture areas.

Neoprene Rubber--This will bond to most surfaces, is expensive, but durable and paintable. Moderate shrinkage is reported. This is especially good for use in concrete walls and foundations.

Silicone Seal--This will bond to most surfaces except concrete. It is very expensive and very durable, but not paintable. Little shrinkage is reported. It remains very flexible. This is an excellent caulk for most jobs.

Acrylic-Silicone--This is less expensive than silicone, has good adhesion, is paintable, and has little shrinkage

Polysulfide--This needs a primer to bond to surfaces. It is expensive, very durable, and no shrinkage is reported. This is difficult to work with, however, and is toxic until cured. It can dry out in arid climates.

Polyurethane--This will bond to most surfaces. It, too, is expensive, very durable and paintable. Little shrinkage is reported. An excellent caulk, but not readily available.

Hypalon--This requires priming for use on porous materials. It is expensive, very durable, and paintable. Little shrinkage is reported. An excellent caulk, easy to work with, but not readily available.

Polymeric Foam Insulating Sealant--These are single component, low-expansion spray foams of the polyurethane/polyisocyanurate type. They are available in pressurized cylinders. These are especially good for sealing sill plates, rough openings for doors and windows, and other openings too large for caulking. They should not be used in enclosed cavities. They need to have an open area to expand into.

Before caulking, you should first make any necessary repairs to the areas that you will be working with. Clean all surfaces, and where necessary, scrape off loose paint or caulk. Allow the surface to dry before caulking. If you have any cracks wider than 1/4 of an inch, it is best to first pack them with pieces of insulation or a foam type of "roping" that is sold for this purpose.

When caulking, hold the gun at a 45 degree angle and slowly push the cartridge tip along the crack, causing the caulk to penetrate the crack, while squeezing the trigger with a steady pressure. To ensure a good seal, and to smooth the surface for painting, some types of caulk may require you to smooth the bead of caulk with your finger or a putty knife. When you are finished, close off the end of the cartridge with a large nail and cover with aluminum foil.

Weatherstripping is installed on windows, doors, and cracks around surfaces which move in relation to one another. Weatherstripping should be installed so that when the windows or doors are closed,

they compress the material, rather than rub against it. As with caulk, a variety of weatherstripping products are available on the market:

Adhesive backed foam--This is very easy to install, but not a very durable material. It is inexpensive and provides a fair seal.

Felt--Felt is stapled into place. It is not very durable, but is inexpensive and provides a fair to poor seal.

Rolled vinyl gasket with metal backing--This is fairly easy to install, more durable, and moderately expensive. It provides a fair to good seal.

Foam rubber with wood backing--This material is easy to install, but not very durable. It is inexpensive and provides a good seal.

Spring metal--This is more difficult to install, but extremely durable. It is somewhat expensive, but provides an excellent seal.

V-Strip--This comes in metal or plastic. The metal is much less expensive than the plastic type but takes a little longer to install. The metal must be nailed in place while the plastic has an adhesive backing for simple installation. They both hold up very well, are very durable, and provide an excellent seal.

Any of the materials listed above can be used for weatherstripping windows. The better the material you use, the longer the job will last. The common "double-hung" window should be weatherstripped on the sides, bottom, and "meeting rail" of the bottom window. If there are drafts around the top window, it should be weatherstripped as well.

The spring metal and v-strip types of weatherstripping can be installed by opening the window and slipping the material up the

crack between the window and the frame. The weatherstripping need only extend to a height one inch above the top of the closed window. Tack the strip in place. They can also be installed by removing the side trim on one side of the window and taking out the window.

Other types of weatherstripping should be nailed or sealed to the frame so as to fit tightly against the window. For the sake of apperance, this is best done on the outside surface.

If, after weatherstripping, you consistently get condensation between the inside window and its storm, then try to tighten up the inside window even further.

When weatherstripping doors, apply the material to the frame around the door, as opposed to the door itself. Make sure the material contacts the edge of the door, and provides a tight seal.

The bottom of the door may require a different type of weatherstripping than the sides and top. A "sweep" is attached to the face of the door at the bottom.

"Gasket thresholds" can be used to replace existing thresholds, or provide a threshold where there is none. A "two-piece door shoe" fits on both the door and the threshold to seal out the cold. Special strips are also available for sealing garage doors.

5.3 INFILTRATION BYPASSES

Infiltration bypasses are leaks around pipes, wires, interior wall cavities, vents, chimneys, appliances, and other breaks in the attic floor or between floors of your house. Very little material is required to seal these leaks, but the effect is significant.

The following steps explain how to seal up the attic bypasses, i.e.

those infiltration bypasses that connect up with the attic:

Place a board over the top of the joists to form a walkway. Do not step between the joists. The ceiling will not support you.

Pull back the insulation where necessary to locate cracks formed along the interior walls. If the attic is insulated with loose fill, sweep the insulation aside. Seal the cracks with caulking compound.

Caulk any holes for electrical wiring and seal around electrical boxes. Make sure that insulation is kept three inches away from any heat-producing electrical fixtures such as recessed lights or fans.

Use caulking compound to seal around plumbing vents. For any large gaps, stuff the void with insulation or foam void filler or "roping" before caulking.

Pack insulation tightly around openings for soil stacks and caulk.

Accurately cut two pieces of sheet metal or gypsum board to fit snugly around the chimney; or pack tightly with fiberglass insulation only.

Insulate the attic hatch door, and weatherstrip around its edges.

Infiltration bypasses between floors such as around radiator pipes coming up from the basement to the first floor and from the first floor to the second floor should also be caulked up.

5.4 R-VALUE

The R-value is a measure of a material's resistance to the flow of heat. The higher the R-value of a material, the greater its resistance to heat flow, and the better its quality as insulation. You should buy insulation on the basis of R-value, not thickness or weight. The type of insulation you buy will depend upon where its going to be used--one type may be best for attics, while another works better in walls. Since every type of insulation has a different R-value per inch of thickness, different thicknesses of different materials can have the same total R-value. You may be able to save money by installing more inches of a less expensive insulation.

5.5 INSULATION

In order to get the most benefit from **insulation**, you should first make your home as energy efficient as possible. Insulation should be one part of a total weatherization plan, because effects such as air infiltration and an inefficient furnace can rob your home of the warmth that insulation conserves.

Before adding insulation:

1. Limit the amount of cold air entering your home through windows, doors, the chimney, and cracks in the wall. Do this by **caulking** and **weatherstripping**, installing storm windows, and reducing unnecessary traffic through doors. In winter, air infiltration can result in an average 33% of the total heat loss, and reach over 60% when the wind velocity exceeds 60 miles per hour.
2. **Maintain your furnace** to keep it operating at peak efficiency. Check the filters at least once a month, and change them when dirty.
3. **Turn down your thermostat.** You'll save about 3% of your home's

heating energy for every degree you reduce the thermostat setting over a 24 hour period. Adjusting the temperature from 72 F to 65 F can save as much as 21% of your energy consumption.

The following several sections describe some of the most commonly used types of insulation.

5.6 LOOSE FILL AND FIBROUS OR GRANULAR INSULATION

This includes cellulose, mineral fiber (glass fiber and rock wool), perlite, and vermiculite. All of these materials may be poured in, but only mineral fiber and cellulose can be blown in. Cellulose has about thirty percent more insulating value than glass fiber for the same installed thickness, which may be important when you are insulating a tight space. Vermiculite is more expensive than the other materials, but can be poured into a smaller space.

The poured-in method is used almost exclusively for unfinished attic floors, and is well suited for irregular joist spacing and insulating around obstructions. You can install blown-in cellulose and mineral fiber in unfinished attic floors, finished attic floors, finished frame walls, and the underside of floors. Blown insulation requires a machine to fluff it up. You may be able to rent a machine wherever you buy the insulation. Mineral wool and glass fiber are more difficult to install than cellulose, and are usually blown-in by a contractor. Vapor barriers for these products are bought and installed separately.

All loose fill materials must meet standards for combustion resistance, proper adhesion to chemicals, dust and health hazards, settled density, thermal performance, moisture absorption, odor, vermin, and fungi resistance.

These products should be kept dry and free of extraneous materials.

During and upon completion of the installation, the material should be inspected to ensure that the coverage and density requirements have been met. Insulation should not be blown into electrical devices, sockets, or other equipment. After the job is finished, turn off the house electricity and inspect these devices to make sure they remained free of insulation.

5.7 SPRAY-ON CELLULOSE INSULATION

Spray-on cellulose insulation is primarily used in commercial buildings such as warehouses, and has few applications for the home. It is usually installed by a contractor.

The material is applied with pneumatic equipment. Cellulose fiber is mixed with water and/or adhesive, and sprayed onto the walls and ceiling of a structure. Sprayed-on cellulose is often used for sound as well as thermal insulation.

As with the loose fill materials, spray-on cellulose must meet standards for combustion resistance, proper adhesion to chemicals, dust and health hazards, settled density, thermal performance, moisture absorption, odor, vermin, and fungi resistance.

5.8 MINERAL FIBER BATT AND BLANKET INSULATION

Batts and blankets are made of either glass fiber or rock wool. They're used to insulate unfinished attic floors, unfinished attic rafters, and the underside of floors. Since batts and blankets are manufactured in standard widths, they're best suited for areas with evenly spaced joists, relatively free of obstructions. To install, simply cut the product to the right length and fasten between the joists, making sure that the vapor barrier is on the side toward the living area.

These products are made from rock, slag, or glass processed into fibers from a molten state. Facings or membranes attached to serve as vapor barriers have a vapor permeability no greater than one perm. Batts and blankets must resist combustion, flame, and smoldering, meet minimum standards for moisture absorption, odor emission, fungi resistance and not produce corrosion. All tears, punctures, or flaws in the vapor barriers should be patched before installation.

When installing batts or blankets between floor joists, fit them in tightly, and hold them in place with wire fasteners or screens stapled or nailed to the joists. If the insulation is provided with a reverse flange, this may be attached directly to the joists.

NOTE: A vapor barrier should not be used on top of existing insulation.

5.9 CELLULAR PLASTIC RIGID BOARD INSULATION

Rigid board insulation is most commonly used on foundation walls, such as in basements. Because of its relatively high cost, it's seldom used to insulate other areas of the house, except where the highest possible R-value is required in a narrow space.

Boards are generally made from polystyrene or urethane. Extruded polystyrene and urethane boards are their own vapor barriers, whereas expanded polystyrene boards, bead boards, and other types are not. The material comes in 24 or 48 inch widths, and thicknesses from 3/4" to 4".

The boards should be of a uniform texture and reasonably free of foreign matter. They should not have unexpanded material, broken edges or corners, holes, voids, or depressions. Boards may have

laminated facings to serve as vapor barriers, which should also be free of slits or voids. All types of boards must meet restrictions for combustion resistance, water absorption, water vapor transmission, and dimensional stability (expansion and shrinkage).

When installing insulation boards, make sure they're protected from sources of heat and open flame. If you install boards inside a building, you must cover them with half-inch thick gypsum wallboard, or a similar fire barrier which will withstand a fire for at least 15 minutes. Boards may be attached either mechanically or with adhesives, according to the manufacturer's recommendations. A vapor barrier must be installed when boards are used on the inside of a structure, unless the material itself has a good vapor permeability rating.

5.10 LOOSE FILL CELLULAR PLASTIC INSULATION

This material is most often used to fill concrete blocks in new construction. It may also be blown into walls in the same manner as other loose fill insulation, but should not be used in attics or ceilings. Cellular plastic insulation isn't affected by moisture, and won't catch or snag on blocks or structural members during installation. It's light in weight, but tends to be flammable.

The material is made by grinding or chipping board stock and scrap material, or by the direct expansion of beads. It should be reasonably free of unexpanded beads and foreign matter.

When the material is installed in an enclosed cavity or block wall, the available space should be completely filled. The material may be blown in, or poured if there is enough access to ensure that the entire cavity or block wall is filled.

5.11 UREA-BASED FOAM INSULATION (UREA-FORMALDAHYDE)

Urea-based foam has mainly been used to insulate finished frame walls. It consists of a two part resin which is mixed through an applicator gun to form a solid foam. Urea-based foam has a higher R-value than blown-in insulation, as well as a higher price. The product is always installed by a contractor. To date, the quality of installation has been very inconsistent. This material is subject to shrinkage after installation. It also can give off harmful fumes. It has been banned in some states. (Refer to section 5.15 for further warnings about this insulation.)

5.12 WHERE TO BEGIN INSULATING

Insulate the attic first. The attic can usually be insulated at a lower cost than the walls, and provides a better return per dollar invested. Fortunately, the attic is also the easiest place to add insulation. Before you start spreading batts or loose fill over the joists, however, make sure the structure is ready.

Infiltration bypasses-- Seal them up tight.

Heat sources--Inspect the attic for all flush and recessed light fixtures, as well as other heat-producing equipment. You should keep insulation at least three inches away from recessed light fixtures, unless the fixture is approved for coverage with insulation in accordance with the National Electric Code. Most fixtures are labelled in respect to this. Insulation should also be kept three inches away from other heat-producing equipment; some manufacturers may recommend more than three inches for their equipment. Install wood or aluminum rigid blocking to keep insulation away from these heat sources.

The structure itself--Moisture in your attic can turn some kinds of

insulation into a mushy pulp. To prevent this, and protect your structure, you should inspect the siding, roof, walls, ceilings, and floors in the installation area before adding insulation. Look for peeling paint, warpage, stain, rotting, or structural damage. If you find leakage, make repairs before you insulate.

Ventilation--You need ventilation to allow moisture to escape in the winter, and to reduce heat build-up in the summer. When installing vents, arrange them to provide a good flow of air through the attic. A combination of soffit vents with ridge vents works best; although soffit vents with gable vents may also work well. If there is not a vapor barrier in the attic, install at least one square foot of free ventilation area per 150 square feet of attic floor space. If there is an adequate vapor barrier, install one square foot of free ventilation area per 300 square feet of attic floor space.

Vapor barriers--Vapor barriers reduce the flow of moisture from an area of higher humidity to an area of lower humidity. Therefore if a vapor barrier is applied in an attic over the ceiling below, it will help prevent moisture from getting into the attic and condensing in the insulation or on the underside of the rafters. Vapor barriers should be installed on the attic floor, or, if this is not practical, they may be painted on to the ceilings beneath the attic.

Do not install a vapor barrier over existing insulation. If you plan to install loose fill, staple sheets of heavy polyethylene on the floor between the joists. If you plan to install batts or blankets, buy the type with paper, plastic, or foil vapor barriers already attached to the backside of the insulation.

You may want to install a vapor barrier on the ceilings of rooms beneath the attic if there is already some insulation in the attic. These types of vapor barriers are available as paints, wallpapers, and wall sealants. If you decide to apply paint, choose a brand

with a "vapor permeability rating" of one perm or less. These are not as effective as a separate vapor barrier may they are better than nothing.

Vapor barriers should always face the living space--they should never face the cold side of existing insulation. If you add new insulation to old, buy insulation without an attached vapor barrier, or remove or slash the vapor barrier at intervals to allow the moisture to escape.

5.13 HOW MUCH INSULATION FOR THE ATTIC?

Standards for new buildings in Minnesota require an R-value of 30 in the attic. Over the long run, however, an R-value of 45-60 in the attic is a good investment. To figure out how much additional insulation is best for your particular house, refer to the energy audit form. Remember to specify R-value and not inches of insulation.

5.14 DOING THE JOB

If you have a conventional one or two story house, it is a fairly easy job to spread or blow loose fill insulation evenly over the attic floor, or to press batts or blankets between the joists. If you use several layers of batt or blanket insulation, remember to alternate the pattern of how they are laid down for each layer, so no seams are on top of each other between the different layers. Also, be sure the batts or blankets are butted together on their sides as close as possible.

If you have a 1-1/2 or 2-1/2 story house the process becomes more difficult. Here, you will need to insulate five separate areas: 1) the outer attic floor, 2) the knee wall, 3) the short section of

rafters between the space to the side of the room and the ceiling, 4) the attic ceiling, and 5) the end walls of the attic room. For a description of how to insulate these kinds of houses, refer to one of the "how-to-do-it" books listed in the bibliography.

For houses with attics too small to be worked in, or houses with no attics at all, there are still ways to insulate. In some cases, insulation can be blown in from openings drilled around the top edge of the walls. In other cases, insulation can be applied on top of the existing roof. Both of these methods require the services of an experienced contractor. For houses with high ceilings, it may also be possible to insulate on the inside by securing batts or blankets against the existing ceiling, and adding a suspended ceiling beneath the insulation.

5.14 INSULATING THE WALLS

Insulating the sidewalls of your house not only provides a much greater resistance to heat transfer; but also offers increased resistance to infiltration (although infiltration should be stopped by caulking and weatherstripping); and increases the surface temperature of the room side of the wall to add to a greater feeling of thermal comfort (refer to section 2.0 on Heat Transfer for further explanation of this concept).

Sidewalls are more difficult and expensive to insulate than the attic. It is still a worthwhile project, however, if other, more cost-effective measures have been done first. In most cases, this is a job better left to an experienced contractor.

If your house has wood frame walls (most houses do), there are four options open to you for adding insulation: 1) blowing in loose-fill insulation, 2) injecting urea-formaldehyde foam, 3) rebuilding the walls, or 4) insulating the outside of the walls. If your house has

masonry walls, the first three options are open to you only if there is a continuous air space between the layers of masonry. If there is no continuous air space, your only option would be to rebuild the interior walls.

Blowing in loose-fill insulation is the most common way of insulating an existing wall. Holes are drilled in the exterior of the house, and the loose-fill insulation is pneumatically packed into the wall cavities. To ensure a well-insulated wall, it may be necessary to drill at least two holes per stud space, per floor for some types of insulation and blowing techniques.

An experienced contractor will be well versed in removing and replacing your siding, drilling and patching your stucco, or chipping out and replacing your bricks so that the finished house will look as if the walls had never been touched.

Injecting urea-formaldehyde foam into walls has become a controversial practice. Tests by the U.S. Consumer Products Safety Commission have indicated that this type of foam, and all other building products containing formaldehyde, constitute a health hazard for some people. The CPSC warning reads as follows:

Warning. This product contains the chemical formaldehyde. For some people formaldehyde may cause health problems such as irritation of the eyes, nose and throat, sneezing, coughing, headaches, shortness of breath, or chest or stomach pains. Children under the age of 2, elderly people, people with breathing problems or people with allergies may have more serious difficulties. If you have questions about problems you may have with formaldehyde, consult your doctor."

In addition to the potential health risk, urea-formaldehyde foam has had a reputation for shrinking after it is injected into the wall

cavity. Because of this shrinkage, the U.S. Department of Energy stipulated that the R-value of foam should be reduced by 28% from its initial level. The Canadian government, making similar tests on foam, concluded that the product should be derated by 40%.

Rebuilding the walls to add insulation is only a good option if you have other reasons for rebuilding the walls in the first place, such as in constructing an addition to your house, or doing some major renovating in an older residence. If you already have the wall cavities open, it will add little in cost to the project to stuff the cavities with batts or blankets. Be sure to use the kind with the attached vapor barrier, and place the vapor barrier towards the room.

Insulating the outside of the walls is a good option if you are planning on re-siding. In this case, you can add insulation sheathing under the new sheathing, and double the original R-value of the wall, as well as stopping wall infiltration at the same time. Generally, this is economically worthwhile only if you plan to be re-siding in the first place.

5.16 INSULATING THE RIM JOIST

Insulating the rim joist can be a weekend project with little cost and a good return on your investment. To find the rim joist, walk down into the basement and look at the top edge of the basement wall. On the top of the wall is one plate of wood laying flat, and another fastened on edge. The member fastened on edge runs around the perimeter of the foundation, supporting the house. This is the rim joist. To insulate this area, take 6" R-19 fiberglass batts, cut them into lengths, and stuff them between the top of the foundation wall and the floor.

5.17 INSULATING THE FOUNDATION

Up until recently, few homes were built with foundation insulation. Yet with today's rising energy costs, it may be economical to insulate the foundation. Whether it is economical or not will depend on your house's particular requirements and whether you do the work yourself or have someone else do it.

There are four common types of foundations: full basements, crawl spaces, open foundations, and concrete slabs. Depending upon the type of foundation, there are several ways to insulate. If you have a full basement, you can insulate either around the exterior perimeter of the house, or along the inside basement walls. If you have crawl spaces, you can either insulate the walls to make heated storage space, or insulate the ceiling of the crawl space (i.e. the underneath side of the floor) and keep the area cold. If you have an open foundation, you can cover either the floor or the walls with insulation. And for a slab-on-grade, you can best stop heat loss by insulating around the perimeter of the concrete.

How you end up insulating your foundation will depend upon the unique features of your house. Although it is generally best to insulate on the outside of the foundation, you may have porches, sidewalks, or gardens that prevent you from doing so. In such cases, you can either insulate on the inside or opt for a combination of inside and outside insulation.

The most important part of your foundation to insulate is the exposed stone, concrete block, or poured concrete between the earth and the siding. By itself, a stone, concrete block, or poured concrete foundation will lose heat at a rate between that of a single pane and a double pane window. So the more area of your house that is made up of exposed block or poured concrete, the more you can reduce heat loss by adding insulation to this part of your foundation. If your house already has foundation wall insulation, it

will generally not be worth your money to add more insulation.

As with all insulation projects, make any structural repairs to the house before beginning the insulation work. Correct any water leakage problems, and seal cracks and air leaks with good quality caulk. The type of insulation you use for the job will depend upon whether you are insulating on the inside or the outside. On the inside, fiberglass batts usually work best. On the outside, the only product which will hold up to the elements is extruded polystyrene.

To insulate on the room side of foundation walls, build a stud wall along the area to be insulated. Place batts in the stud wall next to the existing wall, with the vapor barrier facing the room. Finish off the wall by fastening gypsum board over the new wall.

Insulating on the exterior requires more labor, but is no more difficult. The process involves setting two pieces of extruded polystyrene (2" thickness) next to the foundation. The first piece is installed flush to the foundation wall, extending from the top of masonry to approximately 12" below ground level. The top of this piece must be covered with a drip cap to prevent water from running between the insulation and the foundation. The second piece of insulation is installed horizontal to the first, twelve inches below the ground. This requires considerable excavating. For areas which can't be excavated, such as driveways, porches, and plantings, the inside of the foundation can be insulated instead. For detailed information on this procedure, refer to the "how-to-do-it" books listed in the bibliography.

5.18 WINDOWS

Weatherizing your windows and doors can increase their insulating value and reduce their infiltration depending on which measures are

applied. A single pane of glass has an R-value of about one, so it loses about 14-17 times as much heat as the same area of properly insulated wall.

There are four ways to reduce the heat loss of existing windows: 1) weatherstrip the window, 2) add additional glazing, 3) install thermal window coverings, and 4) cover the glass with heat absorbing or reflecting film.

Weatherstripping the windows, as has been previously mentioned, is one of the first measures that should be accomplished.

Additional glazing may be added to a window in a number of ways. The cheapest method is to fasten sheets of six mil (i.e. 0.006 inches) plastic sheeting to the outside and/or the inside of the windows. The edges of the plastic should be securely and continuously fastened to the window frame to control any air leakage through the window, as well as to increase the thermal resistance. Plastic is efficient, easy to install, and very cheap. Unfortunately, it lasts only one season and has a tendency to fade, scratch, and rip.

A more permanent solution is to install single pane storm windows. These are the type which must be put on in the fall and removed each spring. To ensure a good fit, the edges of this type of storm window should be weatherstripped. Single pane storms are very efficient, but some people may not be physically able to install and remove them with the change of seasons.

The best, and also most expensive type of additional glazing, is the combination screen and glass storm window. These are permanently mounted to the window frame, providing a tight seal against infiltration.

Windows can be coated with a heat absorptive or reflective film.

These films are often sold to reduce summer heat gain but are also effective in reducing winter heat loss. They can be either applied directly to the window, or to the outdoor-facing side of a window shade. They work by controlling the amount of radiant energy entering into or escaping from the room. Subsequently, this controls heat gain or loss.

5.19 DOORS

Conventional doors are about twice as effective as a single pane of glass in preventing heat loss, but are still losers when compared to the walls. You only have two options when it comes to weatherizing doors: either add a storm door or replace the existing door.

The most important consideration in reducing heat loss, of course, is to make sure that the door is tightly weatherstripped. After you have stopped any air leakage, you can improve the thermal quality of the door itself. Storm doors are available as either single pane or combination units. The combination units are nicer, but more expensive. Both are effective in reducing heat loss.

Another solution to reducing heat loss through the door is to replace the existing door with an insulated door. A good one should be at least two inches thick.

5.20 SPECIAL CONSIDERATIONS

Combustion Air--Combustion air is the air needed by all of your fuel-burning appliances. If your home is very tightly sealed, you may want to ensure that these appliances can still receive enough air to burn effectively. This is best accomplished by installing a duct to directly supply outside air to your furnace and water heater. The supply duct can either be directly connected to the furnace, or can be set to spill outside air into the area of the

appliances.

Perhaps the best solution to supplying outside air can be achieved when the furnace and water heater are located in the same, small room. Here, an air supply duct can be run into the room, and the room itself sealed off and insulated from the rest of the house. A ready supply of combustion air will then be available for the appliances, with no excess air spilling into the rest of the home.

Indoor Air Quality--In rare cases, it is possible to seal a house up so tight that the rate of indoor air changes falls below a healthy level. It should be emphasized that this is extremely difficult to achieve with an older home, due to the large number of cracks and hairline openings that have developed over the years as the house has settled. It is, however, possible. If you have caulked, weatherstripped, and insulated everything in sight, and feel that your air is becoming too stagnant, it might be wise to look into purchasing an air-to-air heat exchanger. These units mount in the wall and trade stale inside air for fresh (you hope) outside air without a substantial loss of heat.

6.0 HEATING EQUIPMENT AND DELIVERY SYSTEMS

Conventional home heating systems operate on natural gas, oil, or electricity. Natural gas and oil units can be maintained and modified to improve their energy efficiency, but electric units are virtually 100% efficient at the outset. Considering current technologies and fuel prices, natural gas furnaces are the least expensive systems for heating your home.

6.1 NATURAL GAS FURNACES AND BOILERS

Furnaces and boilers use gas to heat either air or water, which is then circulated through ducts or pipes to heat the living space. Furnaces are equipped with a blower to circulate the air through the furnace enclosure, over the heat exchanger, and through the ductwork distribution system. Boilers use a pump to distribute heated water through the heat exchanger and around the piping distribution system.

If either a furnace or boiler system does not have a blower or pump, respectively, then it is called a "gravity" or "thermosyphon" system. In this situation the density difference created by a temperature difference in heating the air or water causes the fluid to circulate through the system.

The advantages of a forced air furnace are as follows:

1. Circulation of air is easily controlled, and in a properly designed system, can be controlled in such a way as to give a comfortable, uniform temperature distribution.
2. Humidity control is readily attained.
3. The air may be cleaned by filters or other means such as

electrostatic precipitators.

4. If properly designed or suitably adapted, the same air distribution system can be used for summer cooling as well as winter heating. Although summer cooling can be achieved with the use of whole house and/or window fans and reflective shades at much less expense.
5. The use of the fan permits flexibility in the location of supply and return grills as required to obtain proper distribution of air for comfort and to reduce indoor air stratification by the use of high level air returns.
6. Controlled quantities of ventilation air may be drawn into the system and conditioned before being introduced into occupied portions of the structure. A means for supplying combustion air is also allowed.
7. Recirculated air can be treated as necessary to obtain the desired quality.

The advantages of a boiler are as follows:

1. Lower electrical energy needs for operation.
2. Less room is needed for the distribution system.
3. Resetting of system supply water temperatures with respect to outdoor air temperature or load, i.e., by use of an outdoor temperature compensator.

6.2 MAINTAINING THE SYSTEM

One of the best all-around conservation measures is to have an

annual **check-up** of your heating equipment for oil-fired systems and a check-up every three to five years for natural gas systems. The service person will clean and adjust the furnace, and should perform a flue gas analysis and calculate the steady state efficiency of the unit as well.

Cleaning the filters on forced-air furnaces is easy to do yourself. Most filters sold today are the disposable type, made from fiberglass. These can sometimes be cleaned with a vacuum cleaner, but because of their low cost, replacing them is usually better. Some furnaces are equipped with permanent filters which can be taken out and washed. Clean or change your filters several times a year.

On hot water systems, it is important to keep the radiators clean and free of dust. The radiators should be "bled" at the beginning of every heating season. This should also be done as necessary during the season if you can hear the water circulating through the radiators or the radiators do not feel warm over a significant portion of their surface. Since the water in the radiator will cool off as it gives its heat to the room, the top of the radiator will feel warmer than the bottom part of the radiator. Also, one end may feel warmer than the other end, depending on the layout of the piping into and out of the radiator.

"Bleeding" the radiator refers to the process of getting air out of the system so the water can circulate freely. This is done with a small "key wrench" made to fit the valve at the top of one end of the radiator.

Ideally, radiators should be covered with as little paint as possible. Most flat paints will not impede the heat flow very much due to their color. The exception is the reflective or metallic type paints like a gold or aluminum bronze finish. These paints should be avoided as they will reduce the heat flow from the radiators.

It is also important not to use enclosures over or around the radiators. Enclosures will prevent the circulation of air around the radiators. The air circulation allows convection heat transfer to occur. Enclosures will r the also prevent the "visual" contact of the radiator with the surrounding surfaces and objects. The "visual" contact allows radiation heat transfer to occur.

"Zone control" refers to balancing the distribution system to provide the right amount of heat to the right part of the house. An example of this is shutting the register or turning off the radiator in an unused room or basement. Enough warmth will still seep into the area from the rest of the house to prevent freezing. In many northern European homes, for example, the bedrooms are sealed off (by weatherstripping and insulation) from the rest of the living space. The bedrooms are kept cool during the day, then warmed at night to a comfortable sleeping temperature. The savings are substantial. You can use the same principle in your home by closing registers or turning down radiators in bedrooms during the day and keeping the doors shut. In the evening, open the registers or radiators, and open the doors to allow the rooms to warm up.

6.3 MODIFYING THE SYSTEM

Following are descriptions of a number of modifications which you can make to your heating system to improve its efficiency.

Thermostat Setback--In Minnesota, a rule of thumb for energy savings due to setting back the thermostat is that 3% of the annual heating energy consumption is saved for each 1 degree that the thermostat is turned down for a 24 hour period.

Therefore, if the thermostat were turned down permanently from 70 F to 65 F, an energy savings of about 15% would be realized. If a

setback were used for part of the time, then the savings calculated on the 3% rule would have to be reduced by multiplying by the fraction of time that the setback was used. For example, if the thermostat was turned back by 5 F for 8 hours a day, then the savings would be - $3\% \times 5 \times (8/24) = 5\%$. That is, the savings would be 5% in this case instead of the 15%.

Turning Off The Pilot Light--In Minnesota, the pilot light on the furnace can be turned off for three to five months per year, depending upon the weather, the design and construction of the house, and the needs of the occupants. If the furnace was turned off during the months of June, July, and August, for example, 25% of the annual pilot light consumption could be saved each year.

If you are able to turn off the furnace in the spring, and relight it in the fall, the savings you will realize are immediate, and cost nothing. (Furnaces usually have shutdown and fireup directions on them.) If a service person must be called in, energy is still saved, but it is unlikely that you will save money.

Lowering The Temperature Setting On The Fan Switch Inside The Furnace--Furnaces have a thermostat which senses the temperature of the heated air entering the ductwork. This thermostat controls the on and off operation of the fan which drives the air through the ducts. By adjusting this thermostat, the temperature at which the fan comes on and turns off can be controlled. For most furnaces, the most efficient settings for the fan are 30 F above room temperature for the "fan on" setting, and 15 F above room temperature for the "fan off" setting. For example, if you had your room thermostat set at 65 F, the ideal "fan on" setting would be 95 F, and the "fan off" temperature would be set at 80 F. Again, this can be a "no cost" measure if a service call is not required to make the adjustment.

Vent Dampers--A vent damper is a device that automatically closes

off the vent pipe between the chimney and the draft hood to prevent the escape of room air up the chimney while the burner is off. Damper systems are available which are activated either electrically (by solenoids or electric motors), mechanically (by gas pressure), or thermally (by heat in the flue products). Electrically operated damper systems are generally used in a new furnace installation, while thermally operated damper systems are used in retrofit situations. For retrofit, thermal dampers are safer and less expensive than electrically operated dampers.

The effectiveness of vent dampers can vary greatly depending upon the condition of the heating system and the design of the damper itself. In general, vent dampers are most effective if your house has one or more of the following conditions: 1) an oversized furnace or boiler; 2) an oversized or high chimney; 3) a furnace or boiler located in heated space; 4) two or more fuel-burning units sharing the same chimney.

Vent dampers will probably not be as effective, however, if your home has the following conditions:

1. All combustion and ventilation air is supplied from outdoors to direct vent appliances or to appliances which are located in a separate unheated room.
2. The appliance is in an unheated basement which is insulated from the heated space.
3. You have a one story, flat roof house with a short, individual vent. This would be unlikely to carry away excessive amounts of heated air.
4. A side wall discharge is used on a newer furnace that is designed for it.

All vent dampers must pass American National Standards Institute safety standards before installation is permitted by the Minnesota State Building Codes. These units are fail-safe if properly installed according to the ANSI safety standards. If improperly installed, at worst they can be fatal, and at best, they can cause the furnace to be inoperable. No vent damper should be installed by a person not specifically trained and certified for installation.

Vent Restrictors--A vent restrictor reduces energy loss in the same way, but not to the same degree as a vent damper. While a vent damper nearly eliminates the heat lost up the chimney when the furnace is off, a vent restrictor will only reduce this heat loss. A vent restrictor is of use only when the chimney is oversized. Using one in a properly sized chimney can create a potentially dangerous situation.

Power Vents--A power vent is a fan, ejector, or blower used to assist in the flow of furnace exhaust up the chimney when the furnace is on, and to minimize the escape of warm room air when the furnace is off. The average potential energy savings for power vents are generally 2% more than vent dampers. Power vents are like vent dampers in that both require similar conditions to be effective. And as with vent dampers, only a qualified service person should install them.

Flue Gas Heat Exchangers--Small accessory heat exchangers, designed to fit between the furnace and the chimney, can recover a portion of the heat which would otherwise be lost. Installing one of these devices may create other problems, however, so if you are interested in this option, you should have your system checked by a qualified contractor first.

Derating--If an oversized furnace has been installed in your house, or if you have weatherized your home and substantially reduced its heating requirements, then you may want to "derate" your furnace.

Derating is a mechanical modification which requires an experienced furnace service person.

Electronic Ignition--Electronic ignition devices ignite the main burner of an appliance by producing a hot spark. You save energy because the device draws current only for the second it takes to ignite the appliance. Electronic ignition devices are required on all new home appliances sold in Minnesota. They may not be a good investment for your old appliances, however, as with their initial cost and installation fee it may take a very long time to return your investment in energy savings.

Sealing And Insulating The Ducting In Unheated Spaces--Anytime you have air supply ducts running through cold areas, such as crawl spaces, all seams in the ducts should be sealed with heat-resistant tape and the ducts themselves insulated with R-7 fiberglass batts. In a similar manner, heating pipes running through cold spaces should be wrapped with insulation as well. This is an easy, low-cost project with a nice return on your investment.

6.4 OIL FIRED FURNACES AND BOILERS

Oil fired furnaces and boilers are very similar to gas fired equipment, with the main difference being in the type of burner which actually fires the fuel. Burners on oil fired units will foul up more readily than those on gas fired units, and so should be carefully maintained. Modifications that can be made to oil fired equipment to improve its efficiency are as follows: 1) vent dampers, 2) derating, 3) flue gas heat exchangers, 4) lowering fan switch setting, 5) sealing and insulating ductwork or pipes in unheated spaces, 6) burner modifications, and 7) burner replacement.

6.5 REPLACING THE WHOLE FURNACE

In cases where the existing furnace is old and the steady-state efficiency cannot be adjusted to the manufacturer's specification, you may do well to replace the furnace. New systems are available which can attain up to 93% steady state and 90% seasonal efficiency--a marked improvement over an old system which may only be operating at 50% seasonal efficiency.

If you plan to replace your furnace, it is a good investment to first caulk, weatherstrip, and insulate your house. With an efficient structure, you will be able to purchase a replacement furnace substantially smaller than the original unit. This saves you money in purchasing the furnace, and of course, in paying for fuel.

7.0 DOMESTIC HOT WATER

Next to your furnace, your hot water heater is the second biggest energy user in the house. So the more that you can **reduce hot water use**, the more you can save on your utility bill. Conserving hot water does not have to be difficult: **washing clothes in warm water and rinsing in cold water, washing full loads at a time, adjusting the water level on the washer for the minimum necessary, and using flow restrictors on your faucets and showers can make a noticeable difference.**

The first thing to do is to check the **temperature of the thermostat** on the hot water heater. Many hot water heaters have been set at 140 F, which is hotter than is necessary for your household needs. By lowering the thermostat to 110-120 F, you can save money without sacrificing service. The only problem you might have with this lower setting would be with a dishwasher without a supplementary heater.

In a dishwasher, the first cycle of water is a mixture of cold water from the pipes between the dishwasher and the water heater, and the hot water from the heater itself. With a lower thermostat setting, this first mixture of water may not be hot enough for effective cleaning. You can prevent this problem from ever happening by simply turning on a hot water faucet in the sink before starting the dishwasher. This will clean all the cold water out of the pipes. When you turn off the faucet and start the dishwasher, your first cycle will then be hot enough to do the job.

Flow restrictors reduce the volume of water running out of faucets and shower heads. They are very inexpensive, simple to install, and effective. Chances are that you won't even notice the reduced volume of water.

For the water heater itself, you can install an insulation jacket

around the tank. Insulation jackets are designed for specific types of water heaters and are readily available from plumbing supply houses and many hardware stores. Follow the instructions that come with the jacket to ensure a safe installation.

You can also wrap the hot water pipes with insulation. Wrap all of the hot water piping that you can get to with fiberglass pipe wrap insulation or preformed pipe insulation made for this purpose. Also, be sure to wrap both the hot and cold water pipes coming out of the heater for a distance of two to three feet. This reduces the amount of heat conducted out into the room by the copper pipes.

8.0 SOLAR ENERGY

The term "solar energy" has come to include all forms of energy either directly supplied by or renewed by the sun. This includes four main groups: 1) solar collectors, 2) wind, 3) biomass, and 4) hydro power. In this section, we'll look at only those applications of solar which can be used directly in your home. Specifically, this will include active and passive solar space heating systems, solar domestic hot water systems, and wood burning appliances. We'll also briefly mention wind generators. For sources of information on the many aspects of solar, refer to the bibliography at the end of the workbook.

8.1 PRINCIPLES OF SOLAR COLLECTORS

The sun's energy comes to earth as radiation waves of different lengths. The shorter, invisible waves are known as ultraviolet radiation. Most of these are absorbed by the earth's atmosphere. The longer, invisible waves are known as infrared radiation, which can be felt as heat. Between ultraviolet and infrared radiation is visible light, as you might see displayed in a rainbow.

Solar radiation strikes the ground in three ways: as direct, diffuse, or reflected radiation. Direct radiation is made up of parallel rays coming straight from the sun. This radiation casts shadows on clear days. Diffuse radiation is scattered, nonparallel energy rays. This type of radiation makes the sky appear blue on clear days and grey on hazy days. Reflected radiation is solar energy bounced from adjacent surfaces of buildings or the ground. The amount of reflected radiation depends upon the shape and texture of the surroundings. For example, a snow-covered surface reflects a great deal more radiation than a dark surface.

When solar radiation contacts a surface, it must be either absorbed

by the surface, reflected away from the surface, or transmitted through the surface. Most surfaces at least partially absorb radiation and turn it into heat. Absorption is the process most solar energy devices use to change solar radiation to a useable form. The absorptance of a material is the ratio of the amount of energy it absorbs (not reflects or transmits) relative to the total energy striking its surface.

Reflection is solar radiation deflected away from a surface. An important factor with reflection is the angle at which light strikes the reflecting surface. The greater the angle deviates from being perpendicular to the surface, the more light is reflected and the less is absorbed or transmitted.

Transmittance refers to the amount of energy a material allows to pass through it, as opposed to the amount it absorbs or reflects. A perfectly transparent surface would allow energy to pass through it undisturbed. Glass, for example, transmits about 84% to 92% of the solar radiation striking its surface. The remainder of the radiation is either absorbed as heat or reflected away.

Capturing the sun's energy requires an absorbing surface. The ideal surface would convert all of the radiation to energy by converting the different wavelengths of light into heat. After the heat is collected, however, it must often be transported in order to be used. An exception to this is the passive heating system, where the structure itself serves as the collector.

After the energy is transmitted to the place of use, it must be stored in order to provide service when the sun isn't shining. Various means are available for storing the sun's energy. The best natural storage is in plants--the basis of energy from biomass, such as wood for fuel. Heat energy for use in a house, on the other hand, is most often stored in the mass of heavy materials, such as rock beds, masonry walls, and water.

In Minnesota, active and passive solar space heating systems are a good investment only if you've first completely weatherized your home. The payback on solar can be elusive to predict, but in general, it requires more time to pay for itself than conservation measures.

An "active" solar system is one which uses solar collectors to capture heat from the sun's radiation and transfers this heat, via a circulation system, to a storage mechanism.

A "passive" system is different in that the structure itself is the collector. An example of this is a house with a large, south-facing picture window. During the day, the sun radiates heat through the window. The heat warms the room, and is absorbed by the interior "mass" of the walls, floor, and furnishings. In the evenings, the heat that was stored in the mass during the day is radiated back into the room.

8.2 ACTIVE SOLAR SYSTEMS

Active solar systems work to capture, transmit, and store energy from the sun for use in either space heating or water heating. Solar collectors admit light through either a single or double pane of glazing. When the sun's shorter wavelength energy (ultraviolet and visible radiation) passes through the glazing and strikes the absorber plate, most of it is absorbed by the absorber plate while some of it is reflected from the plate. The reflected radiation is converted to longer wavelength energy (heat or infrared radiation).

Since glass is more transparent to shortwave radiation, but more opaque to longwave energy, heat becomes trapped between the glass and the absorber plate. The back and sides of the plate are well insulated to minimize loss of the collected heat. Once the plate

reaches a pre-set temperature, a heat transfer medium, such as water or air, is moved through the collector to pick up the heat and move it to a storage medium.

Systems for transporting heat generally work in a "loop" pattern. They remove heat from the collector, transfer it to storage, then return to the collector to be reheated. The most common transport fluids used today in active systems are air, water, and antifreeze solutions.

The main advantages of air are that it will not freeze, boil, or cause corrosion. The main drawback to air is that it is a relatively poor heat conductor, thus requiring more pumping power per unit of energy gathered. Water is a better heat conductor than air, and generally requires less pumping power. However, water can freeze in extreme weather conditions, thus damaging the system. The antifreeze solutions used to prevent this problem are toxic, and must be separated from a domestic water supply (such as a water heater) by a double-walled heat exchanger to ensure a safe water supply.

The **storage medium** serves the purpose of storing the heat, which is often needed at a time other than when it is collected. Air systems generally store heat in rock bins, while liquid systems use a large tank of water in which to store heat. A rock heat storage system will generally require about two and a half to three times the space of a water system to retain the same heat.

A set of **collector panels** must be placed to receive the maximum amount of sunlight available. Attention must be paid to obstructions such as trees, houses, and buildings, so that the collectors remain unshaded for most of the day. You should also try to keep the collectors close to the area where the heat will be stored. By minimizing the distance between the collectors, the storage, and the point of use for the heat, you can reduce both heat

loss and the amount of equipment needed for the system.

Ideally, collectors should be mounted so as to face within 15 degrees of true south (not magnetic south). But even mounted at a 30 degree angle, collectors will still receive 90% of the sun's energy. At a 45 degree deviation from due south, the amount of energy received drops to 72%.

Any smooth, south-facing surface can be used for mounting collectors. They can be set on the ground, the roof, vertical south walls, or other locations. The surface you mount the collectors on must be sturdy enough to bear their weight. If you are placing them on the roof, you may be limited by obstructions such as chimneys, gables, or antennas. A solar contractor will be able to determine the capacity of your roof and optimum location for mounting the collectors.

In the Twin Cities, collectors mounted on the roof will have to be installed so as to meet applicable building codes.

The angle at which collectors are mounted varies depending upon the application of the system and the latitude. In the Twin Cities, collectors used exclusively for domestic hot water heating should be mounted at a 45-50 degree angle. Collectors used for both hot water and space heating should be mounted at a 60 degree angle. Collectors used exclusively for space heating can be mounted at a 60 degree angle or at a 90 degree angle, i.e. on a vertical wall. If there is snow cover on the ground in front of the collector for most of the winter, then a vertical surface in the Twin Cities receives almost as much total radiation, due to the reflection from the snow, as a surface at the optimum 60 degree angle.

8.3 PASSIVE SYSTEMS

Passive systems use the house itself as a solar collector. In its simplest form, this is probably the easiest way to apply solar energy to any house. It simply involves letting the sun shine in through south-facing windows, thereby heating the space directly. Mechanically, passive systems are much less complicated than active systems. There is no heat transfer medium to be circulated, no pumps, no pipes, no danger of freeze-up, and no large storage bin to be installed in the residence.

Passive solar measures may be added to existing houses in a number of ways: 1) adding or enlarging windows, 2) installing reflectors, 3) constructing an addition to the house.

Adding or enlarging windows along the south side of the house is one way to make direct use of the sun. Here, the room functions as a solar collector, retaining the radiation as heat after it passes through the glass. The limitation to this is that the room itself offers little capacity for storing the heat. If you're planning on doing some major remodeling, you can increase the heat storage capacity of the structure by increasing the mass of the walls and floor directly behind the southern windows. Mass can be added in the form of quarry tile on the floor, or brick on the wall, among other things.

When installing or enlarging windows, pay close attention to how you cut through the framing. The wall structure must generally be reinforced to effectively transfer the load-bearing capacity to other framing members.

Reflectors may increase the amount of solar radiation passing through a window by as much as 35%. Any shiny material such as polished metal, mirrors, or plastics may be used. Insulated reflectors are also available which can be pulled over the windows at night to help reduce the loss of heat gained during the day.

If you're planning an addition to your house, you can make maximum use of south-facing window area to add heat to your home. Keep in mind, though, that plans for the addition should include a method for transferring heated air from the new space to the rest of the structure. In addition, constructing a solar-oriented addition gives you an opportunity to install thermal mass (i.e., brick, stone, tile, water containers) to increase the heat retaining ability of your home.

A number of state laws have been passed regarding solar energy. These laws were developed both to encourage solar through tax incentives, and to regulate the construction and installation of solar measures.

8.4 MINNESOTA SOLAR ENERGY STATUTES

1. Renewable Energy Tax Credit

Minnesota taxpayers are now eligible for a state income tax credit for renewable energy systems. A credit of 20 percent of the first \$10,000 spent on solar, wind, biomass conversion, and earth sheltered housing may be claimed. This claim is valid during taxable years 1979 through 1982. (1979 Laws, Ch. 303, art. V)

2. Property Tax Exemption

In addition to receiving a state income tax credit, residents who install renewable energy systems are exempted from paying property tax on the market value of their new equipment. This applies to heating, cooling, and electrical systems which are powered by solar, wind, or agriculturally-derived methane gas equipment. Installation of equipment must be completed prior to January 1, 1984. (MN Statutes, 1978, Section 273.11, subd. 6)

3. Solar Energy Standards of Performance

The statutes have set standards for solar equipment in order to help the prospective buyer judge the quality and effectiveness of different types of systems. These standards take into account the performance, durability, reliability, and maintenance of solar energy systems and subsystems. The law requires that the seller provide the buyer with specific information about the solar system being sold. Copies of the standards are available for \$1.50 from: Department of Administration, Building Code Division, 140 Centennial Office Building, St. Paul, MN 55102. (MN Statutes, 1978, Section 116H.127)

4. Sun Rights

A solar easement can be legally negotiated to ensure adequate sunlight for a solar energy system. Unlike a law, an easement does not grant an individual unlimited access to the sun's rays. Rather, it provides the opportunity to negotiate with another party for that access. All parties must agree to an easement. A solar easement is similar to an easement in real property. (MN Statutes, 1978, Section 500.30)

5. Zoning Ordinances

A municipality or county may establish zoning ordinances that ensure access to direct sunlight for solar energy systems. The ordinance may include restrictive contracts, limits on heights, side yard and setback requirements, and other permissible forms of land use control. County or municipal boards of adjustment shall consider the inability to use solar equipment as a reason to grant a variance from zoning requirements. (MN Statutes, 1978, Section 394.24, subd. 2; 394.27, subd. 7; 462.357, subd. 1,

6; 462.358, subd. 2, 6)

6. Planning

Regional development commissions are required to revise their comprehensive development plans to consider the impact of solar access on future development.

The Metropolitan Council has required all municipalities in the Twin Cities seven county area to submit land use plans. These plans must consider the protection and development of access to direct sunlight for solar energy systems. (MN Statutes, 1978, Section 264.39, subd. 3; 473.859, subd. 2)

7. State Buildings

Plans for all new state buildings or renovations of existing buildings must include designs for renewable energy systems, where feasible. (1979 Laws, Ex. Sess., Ch. 2, Sec. 9)

8. Housing Finance Agency Programs

The Minnesota Housing Finance Agency (MHFA) is authorized to establish programs to finance renewable energy equipment for low and moderate income Minnesotans. A clause in the MHFA charter allows revenue bonds to be issued to finance this program. (1979 Laws, Ex. Sess., Ch. 2, Sec. 44)

9.0 COOLING YOUR HOME

In Minnesota, the hot spells in the summer are like the cold spells in the winter--short and intense. The best way to stay comfortable during hot spells (and all through the summer) is to prevent heat from building up in the house.

Lights, stoves, and other household appliances all produce heat as they burn fuel. Minimize your use of appliances to keep the heat down. For cooking, you may be able to serve more salads, sandwiches, and cold cuts to avoid firing up the oven. Practice window shade management as you do in the winter, only now, reverse the process. Keep the shades drawn when the sun shines on the windows, and raise the shades at other times to allow for more open window space for ventilation.

Whereas higher humidity makes you feel warmer in the winter (but also causes more condensation problems in the winter), it can make you downright miserable in the summer. When it is hot outside, the lower the humidity, the more comfortable you will be. You can reduce humidity by using exhaust fans when you cook or shower. Since hot water is a major source of humidity and heat, controlling your use of hot water will also help.

And finally, open your windows and use window fans to help increase ventilation through the house. Increased ventilation will carry out moisture created from washing, cooking, bathing, and plants, and will also help cool your skin by evaporating perspiration. A whole house fan mounted in the ceiling of the highest story and drawing air in through the windows of the lower floors may offer as much cooling as you will ever need.

The same weatherization improvements that help retain heat in the winter, help keep it out in the summer. Attic and wall insulation are especially good for blocking the transmittance of heat into the

house. If you're using air conditioning, caulking and weatherstripping can also play an important role. Remember that dark colors absorb heat, while light colors reflect them. You may even consider planting shade trees along the east and west sides of your house to further reduce gain.

Many Minnesotans stay comfortable all summer without air conditioning. If you choose to install either room air-conditioners or a central air-conditioning unit, choose the most efficient unit to help keep your electrical bills from skyrocketing. Air-conditioners are labelled with an Energy Efficiency Ratio (EER) tag. The higher the number on the tag, the more efficient the unit. The tag also lists the EER range for all air conditioners of the same size. For example, if the range for 10,000 Btu/hour air-conditioners is 5.7 to 10.2, and the model you are looking at has a rating of 9.8, then you know you have found an efficient unit. It is recommended that you buy only those air-conditioners with an EER rating of 8.0 or higher.

Air-conditioners should be tuned up and inspected once a year. Several times during the heating season, you should clean the filters, vacuum dirt from the coils and cooling fins, and if recommended, oil moving parts. Window units should be located on the north or shady side of the house, and ideally, in the middle of the area to be cooled. Central air-conditioning units should also be installed in shady areas. If there is no shade, you can plant bushes or build a fence to help shelter the unit. With all air-conditioning equipment, you'll save money by turning them off when the outside temperature is below 78 F, or when no one is home.

10.0 WHERE TO GO FROM HERE

10.1 FINANCING

Even with the cost of financing, you'll still be ahead by weatherizing your house. Check the following sources for information:

- your bank
- Minnesota Housing Finance Agency
- your local Housing and Redevelopment Authority
- the "Who Has the Cash" brochure available from the Minnesota Energy Agency.

10.2 TAX CREDITS

You can help offset the cost of your home energy improvements by taking advantage of the following Federal and State tax credits:

- 1) The Federal Conservation Tax Credit - covers 15% of the first \$2000 in expenditures for conservation measures such as insulation, caulking and weatherstripping, and furnace modifications.
- 2) The Federal Renewable Energy Tax Credit - covers 40% of the first \$10,000 in expenditures for alternative energy systems such as solar, wind and geothermal.
- 3) The Minnesota Renewable Energy Tax Credit - covers 20% of the first \$10,000 in expenditures for alternative energy systems such as solar (with specific limitations), earth sheltered homes, and biomass conversion equipment.

To qualify for the tax credits, you must first install the qualifying measure, then at the end of the tax year in which you made the improvements, apply for the tax credit, using Form 5695 with the Federal return and Form REC with the Minnesota State return. You will receive a credit against the taxes you owe, but you will not receive a rebate if the credit is greater than the amount owed. If the credit surpasses the amount you owe, you may file a portion of your tax credit in the next tax year.

For more information on tax credits, contact the Minnesota Energy Agency Information Center at 296-5175 in the Twin Cities, or 800/652-9747 toll free. Copies of the Minnesota Tax Credit Rules are available for \$.78 from the Documents Division, 117 University Avenue, St. Paul, MN 55155. Ask for the Income Tax Energy Credit Rule, 13 MCAR Section 1.6020.

11.0 BIBLIOGRAPHY

There is no shortage of information about energy. In the years since the oil embargo of 1973, a wealth of publications have appeared, many of them designed for the homeowner. Your public library is one source of energy information, as well as the Minnesota Energy Agency, which maintains an energy information center to help you with your questions (dial 296-5175 in the Twin Cities, or 800/652-9747 toll free). A number of other organizations and utilities, such as NSP, also maintain information services. We have listed a number of these in the bibliography, along with a list of books and other energy publications. Start here, and work your way towards a reduced need for energy in your home.

energy information center

minnesota energy agency • metro (612) 296-5175 • statewide toll-free 1-800-652-9747

BUILDING A NEW HOME - BIBLIOGRAPHY

Energy Efficient Single Family Dwelling Design and Construction

Note: We listed a large number of publications in this bibliography so that you can choose from a large selection. Since many of these materials contain the same basic concepts, you should have no problem finding enough items to use. Contact your local public library for publishers' addresses.

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Note: All NTIS items are available from your local Minnesota public library through MINITEX Interlibrary Loan System (all these NTIS reports will be in microfiche from the Minnesota Energy Agency Library).

PERIODICAL ARTICLES:

"Art of the Possible in Home Insulation," D. A. Robinson, Solar Age, V. 4, No. 10, October 1979, pp. 24-32.

"Building an Energy Saving House," H. Wicks, Popular Mechanics, V. 148, No. 5, November 1977, pp. 124-125, 161.

"Energy and Architecture," D. Watson, Journal of Architectural Education, February 1977

"Energy Conservation in New Housing Design," Science, June 26, 1976.

"Energy Conservation Through Rational Planning and Architecture," Building Systems Design, June/July 1976.

"Illinois Lo-Cal House," W. Shick and R. Jones, Small Homes Council-Building Research Council, University of Illinois, V. 1, No. 4, Spring 1976.

"Landscape Development and Natural Ventilation: Effect of Moving Air in Buildings and Adjacent Areas," Landscape Architect, V. 45, January 1955, pp. 72-81.

"New Wrinkles in Window Insulation," W. Langdon, Solar Age, V. 4, No. 8, August 1979, pp. 20-23.

"Passive Solar Home for Northern Climate," Alternative Sources of Energy, No. 25, April 1977, pp. 5-11.

AGRICULTURAL EXTENSION SERVICE UNIVERSITY OF MINNESOTA

Residential Energy Information Source List

ger A. Peterson,
Extension Specialist Residential Energy

SUBJECT/ QUESTION AREAS	SOURCE CODE NUMBERS (See next page)	SUBJECT/ QUESTION AREAS	SOURCE CODE NUMBERS (See next page)
● Appliances.....4, 6		● Insulation, Caulking, Weatherstrip3, 4, 16, 22	
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water heaters		● Loans and Grants13, 5, 3	
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● Construction Trades, Contractors.....14		● Solar Heating.....1, 7, 3, 8, 9, 16, 22	
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● Handyman or How-To-Do-It.....16, 22			

CODE NUMBER	NAME AND ADDRESS	PHONE NUMBER	SUBJECT AREAS/SERVICES
1	Mid-American Solar Energy Complex 1256 Trapp Road Eagan, MN 55121	(612) 452-5300	MASEC provides referrals to qualified solar engineers and architects, and will send literature and related energy conservation topics.
2	Department of Economic Security Weatherization Special Project 690 American Center Bldg. 150 E. Kellogg Blvd. St. Paul, MN 55101	(612) 297-2589	This agency coordinates the work of 26 local community action projects (CAP) to weatherize homes for low-income families throughout Minnesota. Call for location of weatherization project nearest you.
3	Minnesota Energy Agency 980 American Center Bldg. 150 East Kellogg Blvd. St. Paul, MN 55101	(612) 296-5175 or TOLL FREE 1-800-652-9028	The MEA is the State of Minnesota's major information source in energy conservation and alternatives. For loan and grant information, ask for a booklet titled "Who Has the Cash?"
4	"Ask NSP" Northern States Power G02 414 Nicollet Mall Minneapolis, MN 55401	(612) 330-6000	NSP will answer questions about residential energy and will send helpful energy conservation information.
5	Energy Services-Residential Northern States Power G02 414 Nicollet Mall Minneapolis, MN 55401	(612) 330-5760	NSP will refer consumers to insulation and weatherizing contractors who are approved by the Better Business Bureau. NSP can arrange financing for their customers.
6	Energy Information Department Minnegasco 733 Marquette Avenue Minneapolis, MN 55402	(612) 372-4670 or TOLL FREE 1-800-552-8717	Minnegasco's consumer answering service will cover all areas of residential consumer information including heating, cooling, and appliances. Printed materials are available upon request.
7	National Solar Heating and Cooling Information Center P.O. Box 1607 Rockville, MD 20850	1-800-523-2929 TOLL FREE	NSHCIC has a wide variety of written materials and consumer response services. For a list of the publications available free, call and ask for their "Solar Bulletin"
8	The Renewable Energy and Environment Collection Engineering Library 128 Lind Hall University of Minnesota Minneapolis, MN 55455	(612) 373-2957	The "TREE" library specializes in solar energy, wind, wood heat, biomass, and energy conservation, but is not a consumer answering service.
9	Alternative Sources of Energy Magazine 107 South Central Milaca, MN 56353	please write	ASE Magazine is published quarterly and contains up-to-date information on solar, wood, wind, greenhouses, methane, and energy conservation. ASE will respond to consumer requests made by letter.
10	Ouroboros Tours Continuing Education in the Arts 320 Wesbrook Hall University of Minnesota Minneapolis, MN 55455	(612) 373-5170	The University offers tours of an experimental solar house, "Ouroboros South," in Rosemount. This center in Wesbrook Hall also sends a bibliography on alternative energy.

CODE NUMBER	NAME AND ADDRESS	PHONE NUMBER	SUBJECT AREAS/SERVICES
11	American Underground Space Assoc. Dept. of Civil Engineering 221 Church Street S.E. University of Minnesota Minneapolis, MN 55455	(612) 376-5580	This source can provide a list of references and information on how to order a 1978 publication titled: "Earth-Sheltered Housing Design: Guidelines, Examples, and References."
12	Continuing Education and Extension 202 Wesbrook Hall 77 Pleasant Street S.E. University of Minnesota Minneapolis, MN 55455	(612) 373-5166	CEE offers two excellent classes in energy efficient housing.
13	Minnesota Housing Finance Agency First Floor Hanover Building 480 Cedar Street St. Paul, MN 55101	(612) 296-9807	MHFA offers low interest energy conservation improvement loans and grants for homeowners with qualifying incomes.
14	Minnesota State Building Trades Council 411 Main Street St. Paul, MN 55102	(612) 224-9445	Trades Council will refer consumers to a union local or council in the building trade that applies to their home improvement plans.
15	State Building Code Division Department of Administration Metro Square Building Seventh and Robert Street St. Paul, MN 55101	(612) 296-4639	The State has recently printed building codes in the area of thermal performance and performance standards for solar equipment.
16	ECOL Library Minneapolis Public Library 300 Nicollet Mall Minneapolis, MN 55401	(612) 372-6609	ECOL (Environment Conservation Library) has do-it-yourself information on insulation, wood stoves, wind and solar heating. Residents may request ECOL books through your local library or directly from ECOL.
17	Minnesota Society of Architects 314 Clifton Avenue Minneapolis, MN 55403	(612) 874-8771	MSA will refer consumers to qualified architects.
18	Housing and Urban Development ENERGY Dept. Washington, D.C. 20410		Write to HUD for a free information packet on heating and cooling the home.
19	Federal Information Center U.S. Courthouse and Federal Bldg. 110 S. 4th Street Minneapolis, MN 55401	(612) 725-2073	The U.S. Commerce Department has a bookstore at this address which carries several useful titles on energy conservation. A Consumer Information Catalog is also available.
20	Office of Consumer Services 5th Floor Metro Square Bldg. 7th and Robert St. Paul, MN 55101	(612) 296-2331	This agency will register your complaint or advise you on consumer's rights.
21	Urban Coalition Weatherization Program 3400 Nicollet Avenue Minneapolis, MN 55408	(612) 827-5465	Urban coalition will weatherize, at no cost, homes and rental units for low-income Minneapolis residents.
22	Center for Local Self Reliance 3302 Chicago Avenue South Minneapolis, MN 55407	(612) 824-6663	CLSR gives courses and workshops with an emphasis on weatherization and alternative energy sources, and will do energy audits in Minneapolis.

LOCAL INFORMATION SOURCES

Your own community may have local expertise and educational programs in residential energy. Hardware stores, lumber yards, contractors, community action programs, and municipal or county building officials may be able to advise you. Call your school district and ask for the adult vocational or community director to see if energy classes are offered locally. If you live near Rochester, Staples, or Red Wing, call one of these regional energy information centers:

Rochester Energy Center (507) 285-8498
Staples Energy Center (218) 894-2430, ext. 146
Red Wing Energy Center. (612) 388-3945

OTHER PUBLICATIONS

Other residential energy publications available from the Agricultural Extension Service, University of Minnesota.

Interested in Solar? Extension Folder 383. Roger A. Peterson. 15 cents

Residential Energy Information Source List. Extension Folder 385. Roger A. Peterson. 15 cents

First Things First, What to Do Before Investing in Home Insulation. Extension Folder 386. 15 cents

Hot Water and Your Home Energy Budget. Extension Folder 388. Roger A. Peterson and Wanda W. Olson. 15 cents

Understanding Heat Loss and Energy Conservation Codes. Extension Folder 389. Roger A. Peterson. 20 cents

Air Conditioner Efficiency. Extension Folder 394. Roger A. Peterson. 10 cents

NOW

CONSERVATION AND
RENEWABLE ENERGY
INQUIRY AND REFERRAL
SERVICE

SOLAR CENTER EXPANDS

THE CONSERVATION AND RENEWABLE ENERGY INQUIRY AND REFERRAL SERVICE (formerly the National Solar Heating and Cooling Information Center) is now a clearinghouse for information about:

energy conservation

active solar

bioconversion

wind energy

passive solar

alcohol fuels

photovoltaics

wood energy

solar thermal

ocean energy

In addition to answering questions about these technologies, CAREIRS maintains contact with a nationwide network of public and private organizations which specialize in highly technical or regionally-specific information. If necessary, callers can be referred to other sources, such as trade and professional organizations, researchers, state and local groups, federal agencies, consultants, and special interest groups.

For information on any of these technologies, or CAREIRS, call toll-free:

800-523-2929 U.S., including Virgin Islands and Puerto Rico

800-462-4983 Pennsylvania

800-523-4700 Alaska and Hawaii

Or write:

Renewable Energy Information

P.O. Box 8900

Silver Spring, MD 20907

The Conservation and Renewable Energy Inquiry and Referral Service is operated by the Franklin Research Center for the U.S. Department of Energy.

Solar Bibliography

LIST OF PUBLICATIONS

These publications may be obtained, free, from the National Solar Information Center by calling the toll-free number or by writing. Please specify the title and the code number of each publication.

BROCHURES

THE FIRST PASSIVE SOLAR HOME AWARDS, SD 33
HOT WATER FROM THE SUN (flyer), SD 46F
HUD INTERMEDIATE MINIMUM PROPERTY STANDARDS, SUPPLEMENT 1977 EDITION, SD 19
INSTALLATION GUIDELINES FOR SOLAR DHW SYSTEMS, SD 34
PASSIVE SOLAR HEATING, SD 29
PASSIVE SOLAR HEATING (bookmark), SD 18
PASSIVE SYSTEMS SOLAR COOLING (bookmark), SD 14
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COMPARISON OF AIR AND LIQUID SOLAR SYSTEMS, DC 163
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DC 136, 5th Edition, September 1980

The Center is operated by the Franklin Research Center for the U.S. Department of Housing and Urban Development and the U.S. Department of Energy. The listings contained herein are based on information known by the Center at the time of printing. Periodic updates are available. For more information, please contact us at P.O. Box 1607, Rockville, MD 20850 or call toll free (800) 523-2929. In Pennsylvania call (800) 482-4983. In Alaska and Hawaii call (800) 523-4700.

EMPLOYMENT IMPACT OF SOLAR ENERGY, DC 132
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SOLAR ENERGY EDUCATION DIRECTORY (by state), LE + state
SOURCES OF INFORMATION ON SOLAR (by state), LS + state

THE NATIONAL SOLAR HEATING AND COOLING INFORMATION CENTER ALSO HAS FEDERAL GRANT INFORMATION FACT SHEETS AND A VARIETY OF SPECIAL LISTS ON BUILDINGS, MANUFACTURERS, AND PROFESSIONALS.

NOTE: NOT ALL THESE PUBLICATIONS ARE AVAILABLE IN BULK QUANTITY. PLEASE CONTACT THE NATIONAL SOLAR HEATING AND COOLING INFORMATION CENTER FOR FURTHER INFORMATION.