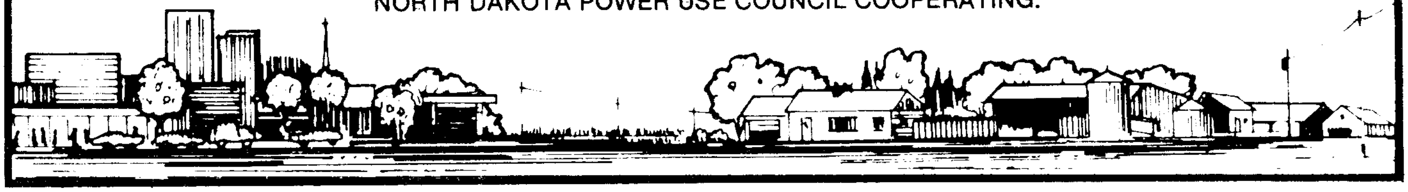
SAFE AND EFFICIENT USE OF ELECTRICITY

ELECTRIC POWER

PREPARED BY NDSU AGRICULTURAL ENGINEERING DEPARTMENT, COOPERATIVE EXTENSION SERVICE AND NORTH DAKOTA POWER USE COUNCIL COOPERATING.



INDOOR AIR QUALITY AND AIR-TO-AIR HEAT EXCHANGERS

Harvey Hirning
Extension Agricultural Engineer

Lambert Vogel
Energy Specialist

Because of the price of energy, most homeowners have implemented a program to improve the energy efficiency of their homes. An economical and simple technique to achieve this goal is by reducing the air leakage of homes. The estimated averaged energy loss from homes due to infiltration is about 30 percent. Homeowners have responded to this fact by tightening up their homes. They experienced favorable results almost immediately and were encouraged by these results to make their homes even tighter.

Contractors and home builders have also recognized the energy savings inherent in tight houses and have adopted techniques and materials to significantly reduce air leakage.

The commonly used term for air leakiness of homes is rate of infiltration, expressed as air changes per hour. If a home has an infiltration rate of one air change per hour (ACH), this means that all of the air or an equivalent amount that was in the home at 8:00 a.m. has leaked to the outside and has been replaced by outside air by 9:00 a.m. One air change per hour is a good average for homes built ten years ago. Weatherstripping and caulking along with air and moisture barriers in new construction, have resulted in infiltration rates of less than 0.2 ACH. Some of the new superinsulated homes have infiltration rates below 0.1 ACH.

The problems associated with the airtight house, unless provisions are made to provide ventilation, is that the levels of moisture and odor are increased.

High levels of pollutants have been found in some of these homes–carbon dioxide from gas appliances, radon gas from soil surrounding the basements and foundations, and formaldehyde from building materials, furnishings and some types of insulation. Table 1 lists some major sources of indoor and outdoor pollutants.

Generally, the major problem with air quality in our area is excess moisture. In tightly sealed homes, humidity can rise to levels where moisture generated indoors from occupants, cooking, bathing, and basement groundwater can cause condensation on windows and, if vapor barriers are inadequate, within wall and attic spaces.

To reduce these indoor air quality problems, some type of positive ventilation must be provided.

The simplest technique would be to simply open and close windows at opposite ends of the home.

A ventilating fan can be installed and operated manually or with a time clock or humidistat. Again, the air quality will essentially be controlled by the occupant. With any of these systems, you will be losing the energy exhausted with the ventilation air.

Another technique that can be used to ease your air quality problem, without sacrificing all of the gains or energy conserving measures, is to install a mechanical ventilation system incorporating an air-to-air heat exchanger.

An air-to-air heat exchanger is a device which uses the heat in exhaust air to warm the fresh air coming into the house (Figure 1).

This information is prepared as an activity of the North Dakota Power Use Council, an organization of the Rural Electric Cooperatives, Investor Owned Utilities, Generating and Transmission Cooperatives, North Dakota State University of Agriculture and Applied Science and the Rural Electrification Administration in North Dakota.

Table 1. Indoor Air Pollution in Residential Buildings

Outdoor Sources	Pollutant Types
Ambient Air	SO_2, NO, NO_2, O_3 Hydrocarbons, CO, Particulates and Lead Compounds
Motor Vehicles	CO
Indoor Sources	
Building Construction Materials	
Concrete, Stone, Gravel Soil	Radon
Particle Board	Formaldehyde
Insulation	Formaldehyde, Fiberglass
Fire Retardant	Asbestos
Adhesives	Organics
Paint	Mercury, Organics
Building Contents	
Heating and Cooking Combustion Appliances	CO, SO_2, NO, NO_2, Particulates
Furnishings	Organics, Odors
Water Service, Natural Gas	Radon
Human Occupants	
Metabolic Activity	CO_2, NH_3, Organics, Odors
Human Activities	
Tobacco Smoke	CO, NO_2, HCN, Organics, Odors
Aerosol Spray Devices	Fluorocarbons, Vinyl Chloride
Cleaning & Cooking Products	Hydrocarbons, Odors, NH_3
Hobbies and Crafts	Organics

Chemical Names: SO_2-Sulphur Dioxide; NO-Nitrous Oxide; NO_2-Nitrogen Dioxide; O_3-Ozone; CO-Carbon Monoxide; HCN-Hydrogen Cyanide; NH_3-Ammonia

Heat exchangers are generally classified by the way the air flows through the unit. In a counterflow exchanger, hot and cold airstreams flow parallel in opposite directions (Figure 2). In a crossflow unit, the airstreams flow perpendicular to each other (Figure 3). The counterflow heat exchanger is somewhat more efficient than the crossflow heat exchanger; however, the crossflow heat exchanger is used in the majority of the units available because of its compactness.

The air-to-air heat exchanger can be installed in a number of different ways. Figure 4 shows a unit installed in the basement. If extensive duct work is required, this may be one of the simpler installations. Attic installations have been used but are probably the most difficult system to install. Special care must be used to avoid losing heat to the attic space and to prevent condensation problems in the heat exchanger.

Figure 5 shows a unit installed in a utility room. This type of installation is often used in homes with slabs-on grade or crawlspaces.

With a central forced-air heating and cooling system, the existing duct system can be used. In homes using this system, the fresh air from the heat exchanger can be supplied to the furnace's return air duct for distribution. A small 1½ inch gap is left between the discharge from the air-to-air heat exchanger and the return air ducts to eliminate the influence of return air duct fan on the heat exchanger flow.

Moisture will condense on the heat exchanger surfaces. This water must be drained away from the system.

During periods of extremely cold weather, this condensation can freeze to heat exchanger surfaces. A means of defrosting the system is needed.

On most commercially available air-to-air heat exchangers, controls and heaters are incorporated in the design to prevent frost buildup on the heat transfer surfaces.

Installation costs can vary from $650 to $1,350 depending upon the size of the home and system required.

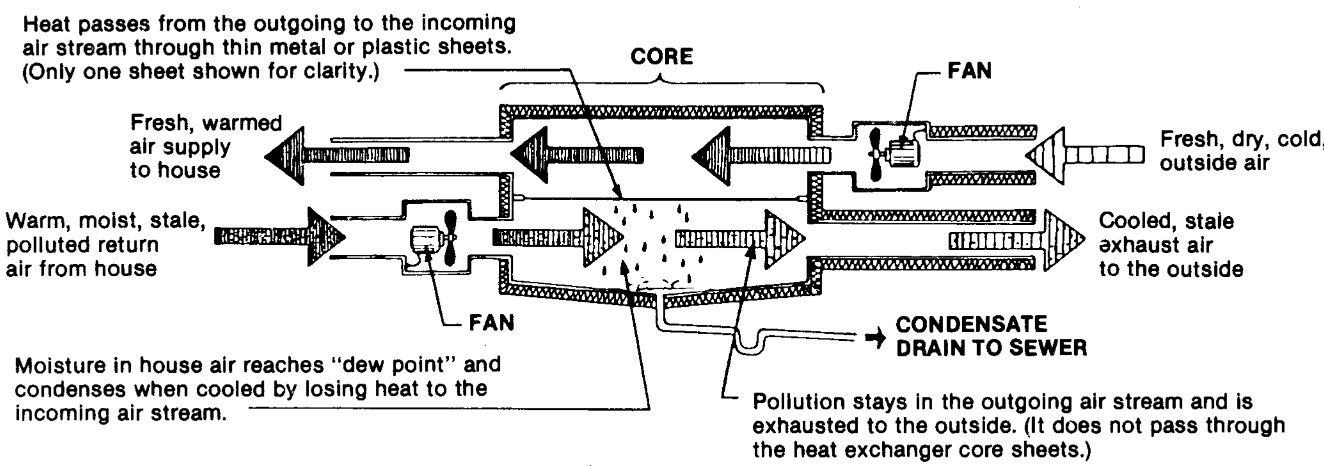


Figure 1. This simplified schematic diagram shows the essential components of an air-to-air heat exchanger.

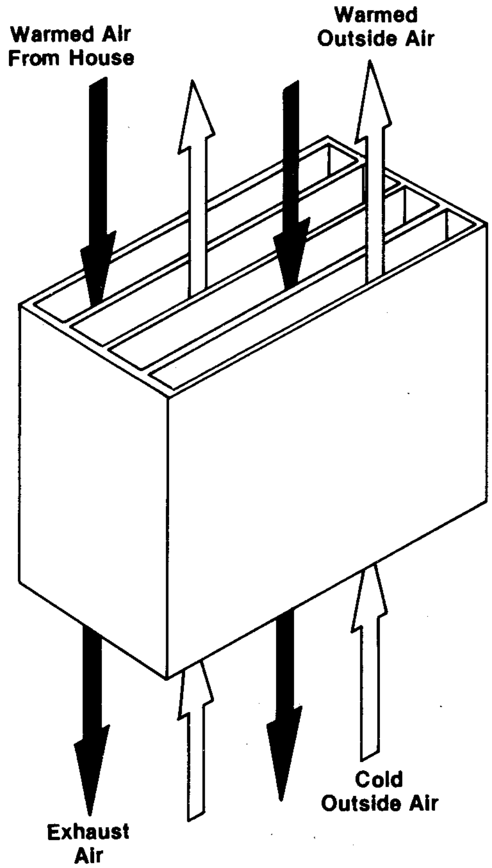


Figure 2. Schematic diagram of a counterflow heat exchanger. In this type of unit, hot and cold air streams flow parallel in opposite directions.

To determine whether the air-to-air heat exchanger is an economical expenditure for you, you will have to calculate the costs and savings involved and make a comparison. In new homes some type of positive ventilation system will be required and there will be an expense for this system. Currently, the recommended ventilation rate for homes is 0.5 air changes per hour. You can assume an average cost of $200 for installing an exhaust fan. You can eliminate the kitchen and bathroom fans if you install an air-to-air heat exchanger.

You can use the following set of calculations as a guide for calculating the cost effectiveness of an air-to-air heat exchanger.

The air-to-air heat exchanger can be operated manually to suit the homeowner's comfort, with a humidistat set to a predetermined value, with a timer set to run the unit during times of high moisture or odor production, or continuously at about 50 percent of rated capacity. The majority of the systems now in use are operated continuously at about 50 percent capacity. Most air-to-air heat exchangers are sold with one or all of these options. These controls can be built into the system and are easy to use.

If you are building a new home or you have substantially improved the infiltration rate of an existing home, consideration of an air-to-air heat exchanger is paramount.

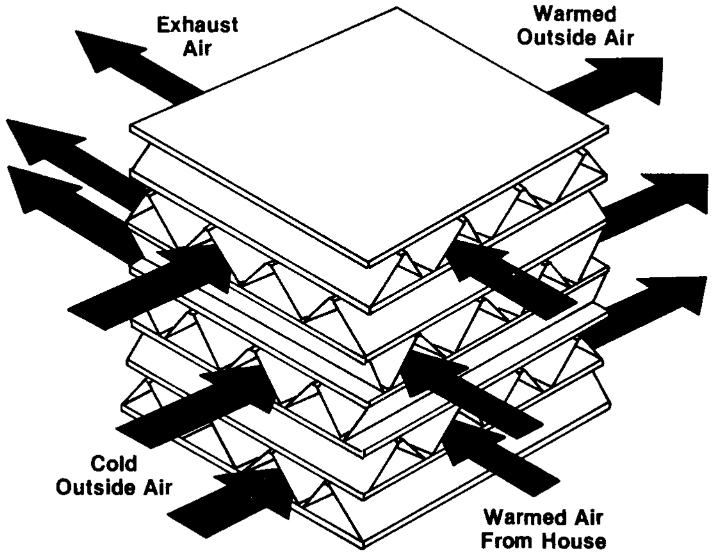


Figure 3. Schematic diagram of a crossflow heat exchanger. In this type of unit, hot and cold air streams flow perpendicular to each other.

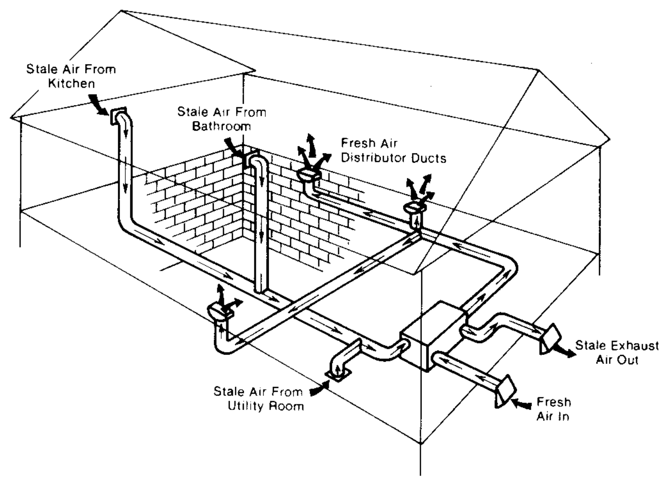


Figure 4

HOME LOCATED IN FARGO, NORTH DAKOTA

Floor Area	1500 ft.^{2}
Ceiling Height	8 ft.
Air Infiltration Rate	0.1 Air Changes/hr.
Air Change Required	0.5 Air Changes/hr.

Heating Degree Days (HDD) Normals
for Fargo, North Dakota

Month	HDD
January	1832
February	1520
March	1265
April	681
October	558
November	1092
December	1612
	8560

Volume of Air = 1500(8) = 12,000 $ft.^3$

Net Air Changes Per Hour = 0.5 – 0.1 = 0.4

Volume of air moved from house per minute =

$\frac{(0.4)(12{,}000)}{60} = 80\ ft.^3/minute$

Air-to-air heat exchanger efficiency = 65 percent
Power consumption = 90 watts

Heat saved per year = (specific heat of air)
(specific weight of air)(CFM)(DD)(24)(60)(efficiency)

Specific heat of air = $\frac{.24\ BTU}{\#\ degree\ Fahrenheit}$

Specific weight of air = .075 $\#/ft.^3$
Heat exchanger efficiency = 0.65

Hours operated per year = 5088

Heating season DDs per year heat exchanger will be operating = 8560

Heat saved per year = (.24)(.075)(80)(8560)(24)(60)(.65)
= 11,537,510

If fuel oil is your heating source,
fuel oil = 140,000 BTU/gallon
annual furnace efficiency = 65 percent

Gallons of oil saved per year = $\frac{11{,}537{,}510}{(140{,}000)(.65)} = 126.79$

cost of fuel oil per gallon = 1.00
dollars saved (126.79)(1.00) = $127 per year

If air-to-air heat exchanger costs $1,000,
simple payback = $\frac{1000}{127}$ (approx. 8 years)

for electricity at $0.05/KWH

Electricity $\frac{3413\ BU}{KWH}$

Efficiency = 100 percent

KWH saved = $\frac{11{,}537{,}510}{3413}$ = 3380 KWH

Dollars saved = 3380 × .05 = $169

Simple payback = $\frac{\$1000}{169}$ = **6 years**

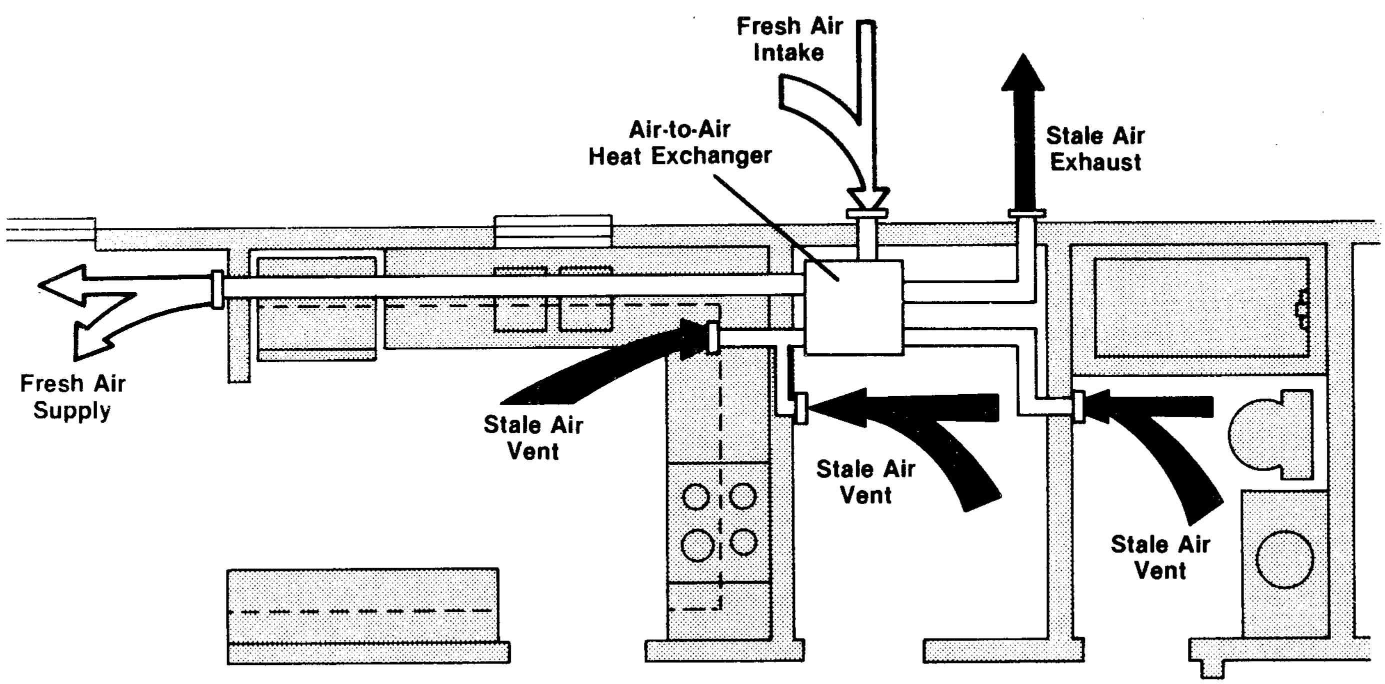


Figure 5