House as a System

This module will help you see how the house functions as a system and introduce you to to the critical role of air movement in a home. Make sure to thoroughly understand the points in this module or later information will be difficult. Think of this module as introducing you to the later *Keep It Ventilated* module.

The focus of this discussion is a typical home. One of the three types of homes is probably relevant to where you live.

1. Two-story home with a furnace and water heater in the basement and a crawlspace
2. Two-story row house
3. Two-story home with an open crawlspace and air handler in the attic

What's a House?

Houses can look drastically different, but they all share a common purpose. Think about the differences and the types of housing in your community.

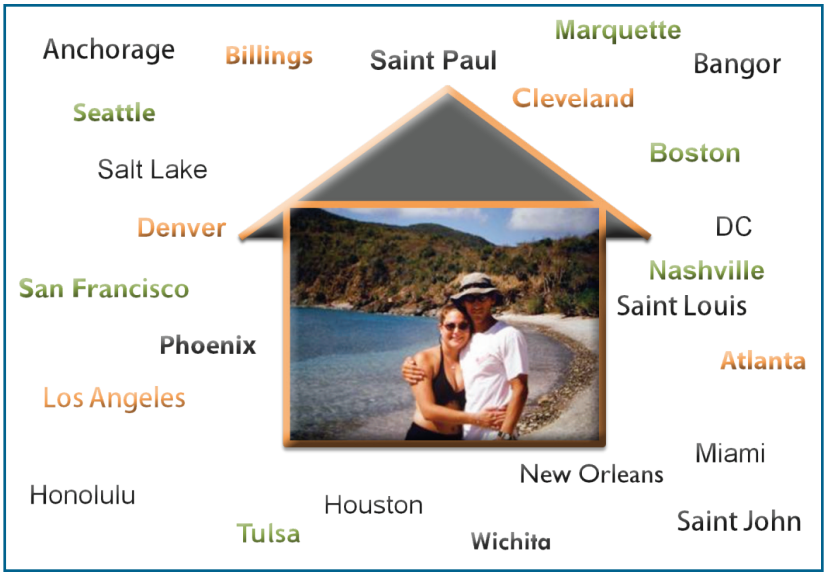
Learning Objective for this Module

- Identify three important housing systems that contribute to a comfortable living space.

Homes Shelter Us From:

- Animals and Insects
- Wind
- Sun
- Rain (sleet, snow)
- Cold or hot air
- Dust

Houses are a way of transporting a dry Mediterranean climate to every place on Earth. Residences may look a little different, but they must all do the same thing—create a comfortable inside space regardless of what's happening outdoors.



We enclose space with walls, windows, roofs, ceilings, floors and foundations that provide us with shelter from sun, wind and rain and make it possible to heat the space when it is cold out and cool the space when it is hot out. The enclosure is a climatic transition zone whenever outdoor conditions are different than indoor conditions.

Think about the climate in the community where you live and how it may impact a home.

Most of Us Are Comfortable:

Most of us are comfortable with the following conditions:

- Air temperature: 65°F (active) – 80°F (bathing)
- Air relative humidity: 30% –70%
- Air motion: 20– 40 feet per minute
- Surrounding surface temperatures: within 10–15°F of room air.

Most people are comfortable in the ranges of temperature, humidity, air speed and surface temperatures noted above. There are of course times when we are not: we are overdressed or underdressed; we are doing heavy work and generating two or three times more heat than when we are sitting; we have just come in from a cold or hot outdoors and have not acclimated to the new conditions; we are simply bored with paradise conditions (hence steam rooms, saunas, cold dips).

We Have Systems to:

- Add heat
- Remove heat
- Ventilate
- Maybe add or remove humidity

The enclosure of a building provides shelter. The mechanical systems do these things to make it more like a Mediterranean climate. They add or remove heat to balance heat loss or gain from outdoors (sometimes humidity loss or gain as well). Things we do in houses generate heat and water vapor – e.g. a person at rest releases around 240 British Thermal Unit (BTU) of heat and 0.1 pounds water vapor per hour. At higher activity levels this increases. For moderate activity it is more like 800 BTU and 0.2 pounds of water vapor are released per hour. During heavy work these rates may double or triple. In addition to people, any piece of operating equipment releases heat, including lights, refrigerators, freezers, motors, televisions, and computers.

Heating Systems

Heating systems can be can be divided by their fuel source, how they distribute heat to the building, how they vent the combustion by-products, and how they are controlled.

Fuel: gas, oil, wood, electric

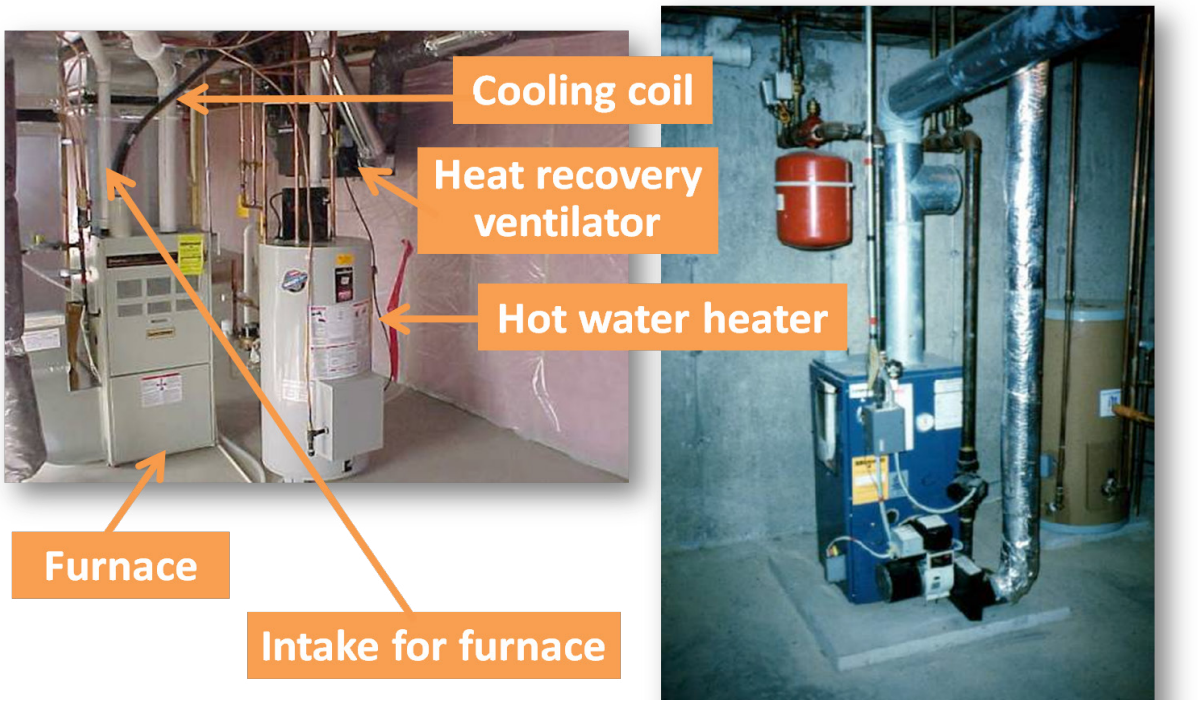
Distribution: hot water, steam, warm air, space heaters; radiators, baseboards, ducts; radiant floors and ceilings

Ventilation: chimneys; sealed combustion; fan powered

Temperature controls

Heat must be added to a building when the outdoor air cools down and the wind blows. How much heat must be added depends on how well the building has been insulated and air-sealed. The heat released by activities in the building helps to heat it when it gets cold out. An ordinary building has to begin adding heat when the outdoor temperature drops to five degrees below the thermostat setpoint. The heating system in a well-insulated and sealed building may not turn on until the outdoor temperature drops by ten or fifteen degrees.

The pictures at the top of the next page show several typical heating and cooling systems and a hot water heater. Pictures of older, less common systems follow.



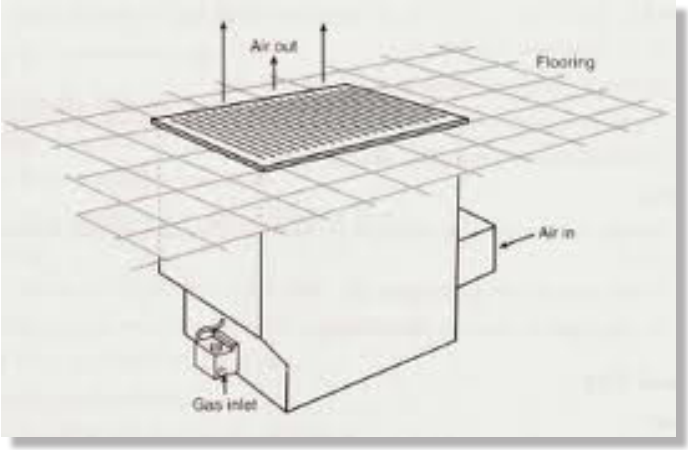
Left picture: A photo of a gas fired sealed combustion warm air furnace and a power vented hot water heater. A DX cooling coil has been installed in the supply side of the air handler so this is a heating and cooling system. There is no way of inspecting and cleaning this otherwise well designed system. Notice the heat recovery ventilator in the background behind the cylindrical water heater.

Right picture: An oil-fired boiler provides hot water to baseboard radiators. This boiler has a dedicated outdoor air supply ducted directly to the burner air intake.

To the right is a picture of an octopus heating system—also known as a "gravity feed" system. They were mostly used between the late 1800's through the mid 1900's.

This antiquated system consists of a natural gas or oil fired burner and heat exchanger with no blower. It looks like an octopus in the basement because with no blower it needs large ducts sloped upwards to allow the heated air to flow upwards to the perimeter of the rooms above, while a centrally located cold air return brings the cooling air back down into the furnace located in the middle of the basement. These systems typically have asbestos wrapped ducts. The older ones may have been coal fired, and the natural gas fired ones may have been retrofitted.

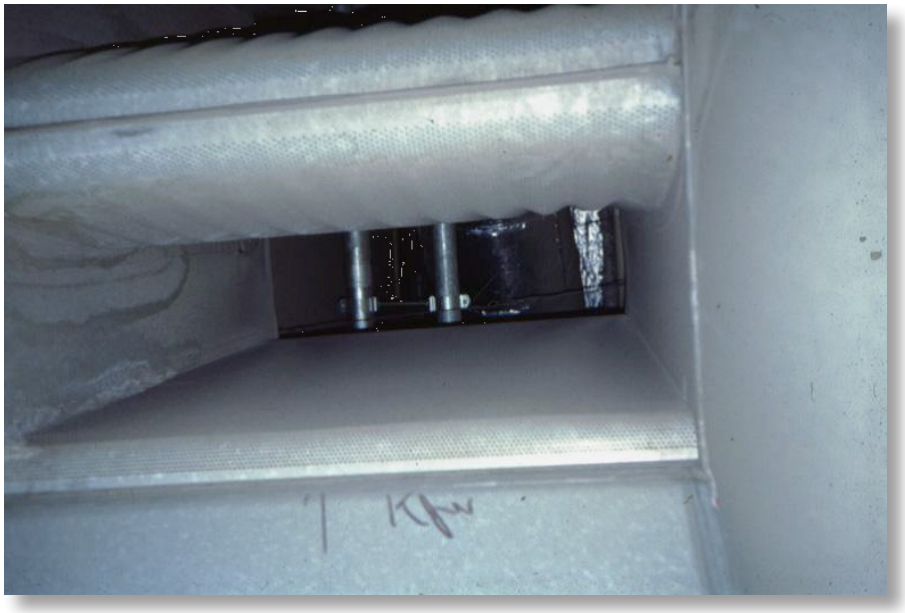
Below are pictures of a floor furnace. These furnaces are like an exposed heat exchanger that is mounted under the floor. Their advantages are that there are no ducts to leak, no fans to push or pull air from unconditioned sources, and they do fairly well if all doors inside the house are kept open. Since heat rises these furnaces can warm up a house with 8 foot walls very well. However, floor furnaces have hot grills and will burn if stepped upon with a bare foot. Carbon monoxide detectors along with smoke detectors are needed in case the units develop a crack in their heating chambers.



Floor furnaces are generally found in houses built in the 1920's up through the 1940's. New ones are still being produced for replacements. They may have been used as early as 1900 when this type of system was first being created. They do have good points, especially where a forced air system installation would destroy the integrity of an older house. They are good systems when properly maintained.[1]

This is an example of a gas-fired wall furnace. Wall furnaces are either installed on the wall as a free-standing unit or recessed within the wall. All currently manufactured models of wall furnaces are gravity-vented (without fan-assisted combustion). Heated air can be furnished either by gravity or fan circulation. Gravity units operate in the same manner as gravity room heaters. Like room heaters, gravity units can be shipped with optional counterflow fans. Fan wall furnaces are equipped with factory-installed air circulation fans. The efficiencies of fan wall units are relatively high, since they are designed to take full advantage of the counterflow air circulation. [2]

Below is a photo of a heat exchanger inside a furnace. This is the side where inside air moves. Inside the metal tube is the flame.



Cooling Systems

- Fuel - almost all are electric
- Windows, fans, and shades
- Distribution
  - Central air
  - Through the wall
  - Duct-less splits
- Dehumidification
  - Air conditioners/part-load
  - Dehumidifiers
- Control thermostat, humidity

Residential cooling systems are nearly all powered by electricity. There may be one or multiple cooling units. The cool air may be distributed using ductwork or cool air may be blown from the unit directly into the room (window air conditioners and ductless split air conditioners).

Although properly sized air conditioners can dehumidify, they are not efficient at it until they run around 20 minutes in each hour. The more oversized an air conditioner is the less it will dehumidify. When this happens people feel cold and clammy—the air cooled to the setpoint but it is humid. The first step is to size the unit correctly. Many ductless split systems have electric resistance reheat in them to improve humidity control and in fact can often be controlled by a humidistat as well as a thermostat.

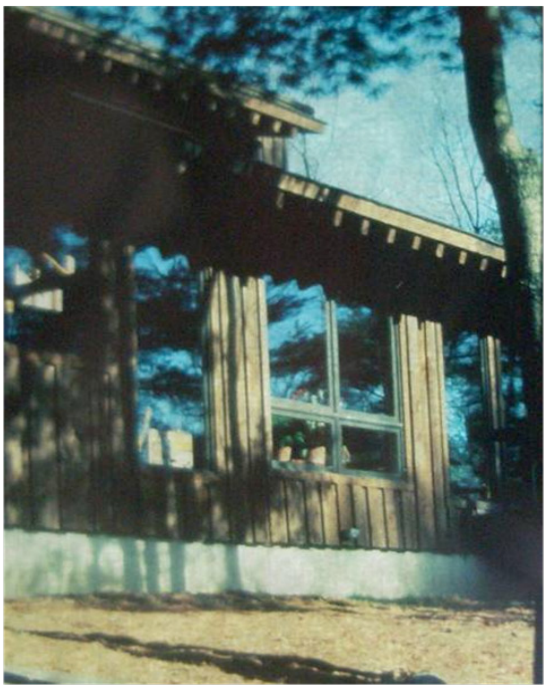
A dehumidifier is an air conditioner that uses the heat it removes from the air to reheat the cold air rather than dumping the heat to the outdoors. A small dehumidifier can be used in combination with an air conditioner to provide both temperature and humidity control.

Left: a picture of a warm air furnace with central air conditioning. There is no way to inspect or clean the coil without opening up the ductwork.

Bottom right: an electric heat pump in a multi-family building.

Upper right: an A-coil in a horizontal DX air conditioner.

A significant amount of cooling can be done by blocking the sun (trees, high performance windows, shades) and providing recirculating fans and venting equipment that produces heat.



Internal and Solar Gains:
Good when cold out; bad when hot out

Heat can come from people (100-150 watts/person), electric and gas appliances, and solar heat in through windows. In the average house in the United States, around 23% of heating is done by these gains and 59% of cooling needs are caused by these gains. Heat from occupants and activities and sunlight shining through the windows can help heat the house when it is cold out, but add to the cooling load when it is hot out.

Other Factors Related to Heating and Cooling

- Water (drinking, cooking, washing, toilets)
- Cooking and storing food
- Ventilation fans
- Lighting
- Computers, stereos, hair dryers, razors

Again the home and the real world are complex. There are other things that are going on in the house that affect temperature and moisture. Once people are in the building they need to cook, wash, groom, work, entertain, and use the bathroom. Somewhere water comes into the building does a number of jobs and leaves through a sewage pipe. How does that happen? Where does it happen? The same is true for electricity and air.

Learning Objectives

- Identify three important housing systems that contribute to a comfortable living space.