

# HEATING AND COOLING SYSTEMS

## EVALUATING HEATING SYSTEMS

Combustion heating systems consume natural gas, propane, or oil to heat homes. Heat pumps utilize the same principles as air conditioners, but include a reversible cycle that allows them to provide both heating and cooling.

Both combustion furnaces and heat pumps include a large fan mounted in a metal box, called an air handler, to move air through duct and out of registers. Supply ducts carry air from the air handler to living space, and return ducts bring room air back to the air handler.

### Furnace Service

Gas furnaces should be serviced periodically to ensure that they operate safely and efficiently. Customers can perform some of the most important maintenance tasks themselves.

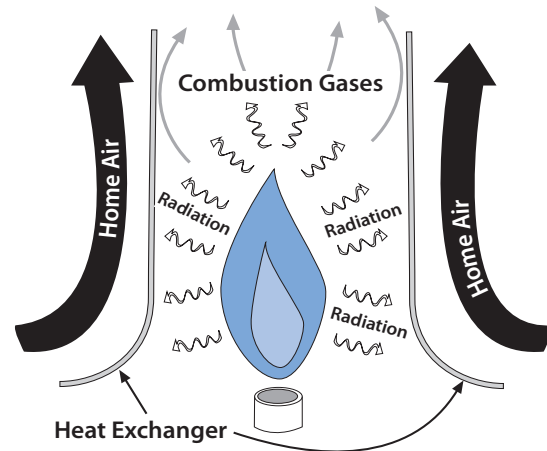
Furnaces and water heaters that burn oil or gas release combustion gases such as carbon dioxide, water vapor, and carbon monoxide. When the system operates properly, these gases are carried out of the home through a chimney.

Furnace safety and furnace efficiency are closely related to one another. Professional heating technicians perform the essential service tasks such as cleaning the combustion chamber and blower, testing combustion efficiency, and assessing chimney draft. Gas furnaces should be professionally serviced every two to three years.

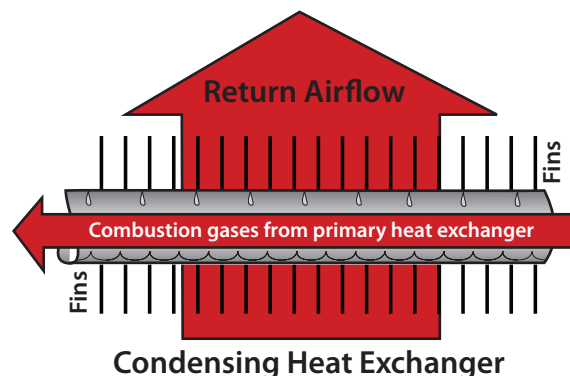
Furnace efficiency suffers when too little air flows through the ducts. Dirty filters, a dirty blower, damaged ducts, or blocked registers can cause reduced airflow. Another very common cause of low airflow is inadequately sized return air ducts.

## Building Science Combustion Heat Transfer

A conventional furnace heat exchanger absorbs heat from the flame's radiation and convection of combustion gases. Home air, moved by the blower, removes the heat from the heat exchanger and delivers it to the home.



High efficiency furnaces have condensing heat exchangers, in addition to conventional heat exchanger, which pre-heat return air from the home. The incoming return air cools the combustion gases to around 100°F forcing the water vapor in the gases to condense and to liberate significant additional heat.



Condensate from the combustion gases is drained into a floor drain or sewer.

Duct blockage has two major effects. The first is to reduce airflow through the ducts, which reduces heating efficiency. The second is increased air leakage through the building shell due to house pressures that are created by the blockage. Both of these waste energy. A heating technician should evaluate the airflow through ducts to confirm that it is balanced among all the rooms in the house. Some furnaces are so starved for return air that the customer may need to add an additional return grill and ducts to get adequate airflow.

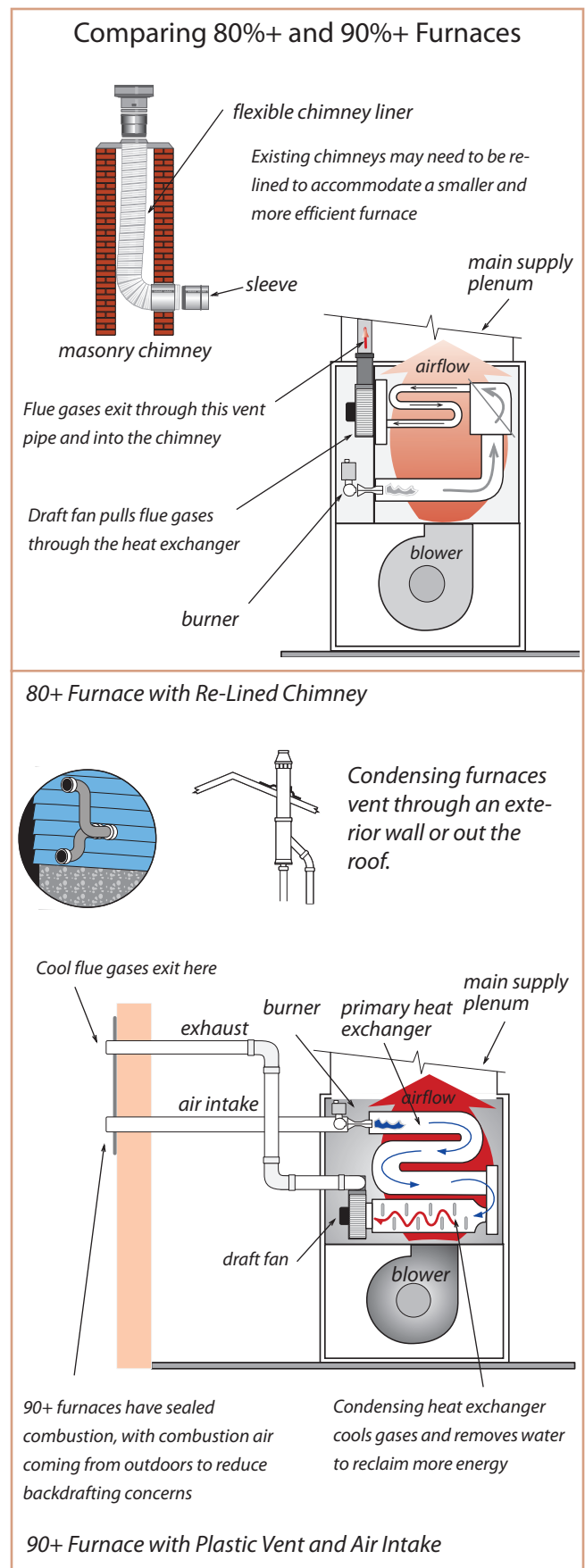
## Furnace Replacement

Furnace efficiency is rated by Annual Fuel Utilization Efficiency (AFUE), which must be posted on a furnace's Energy Guide Label. The Energy Guide Label is a federal requirement for many types of energy-using appliances. See "ENERGY STAR® and Energy Guide Labels" on page 9.

If a furnace has no draft fan and an old-fashioned pilot light, the customer should consider replacing it. This type of open-combustion furnace usually operates at an AFUE of 65 to 75 percent. Customers have two efficiency choices when shopping for a new gas furnace.

1. An improved version of older existing furnaces that has an AFUE of up to 82 percent. This furnace is equipped with electronic ignition and a draft fan. We call this choice the 80+ furnace.
2. A condensing furnace that has an AFUE greater than 90 percent. This condensing furnace recovers extra heat from combustion gases by extracting water from the combustion gases with a special corrosion-resistant heat exchanger. We call this choice the 90+ furnace.

An 80+ furnace saves between 10 and 15 percent compared to an older furnace, and a 90+ furnace saves between 20 and 25 percent. When estimating how much a new furnace can reduce a customer's heating bills, look at the portion of their calculated winter heating cost. See "Analyzing Energy Consumption" on page 4.



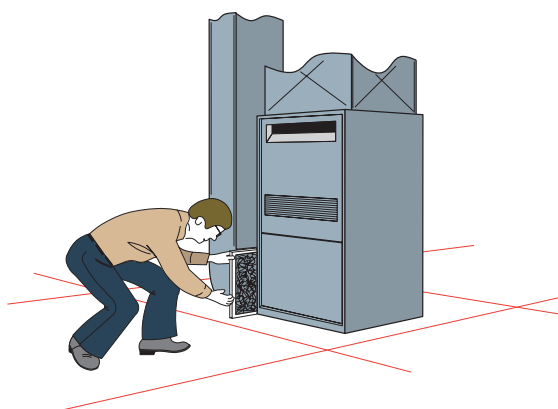
Considering the cost difference between the two furnace options, the 90+ furnace is by far the better option. These more advanced furnaces are safer in addition to being more efficient than the 80+ option.

If a new 80+ furnace is vented into an existing masonry chimney, the chimney may need to be upgraded at the same time. Many existing furnaces are oversized, so the existing chimney is often too large for a new correctly-sized 80+ furnace. The upgrade usually involves re-lining the chimney with a new metal liner.

The 90+ furnace avoids the chimney issue since it usually employs new PVC plastic pipe for venting combustion gases. The plastic vent can exit the home either through a sidewall or the roof. Combustion air is drawn from outdoors through a second dedicated plastic pipe. This venting system provides superior health-and-safety benefits when compared to furnaces that vent into vertical chimneys and draw their combustion air from indoors.

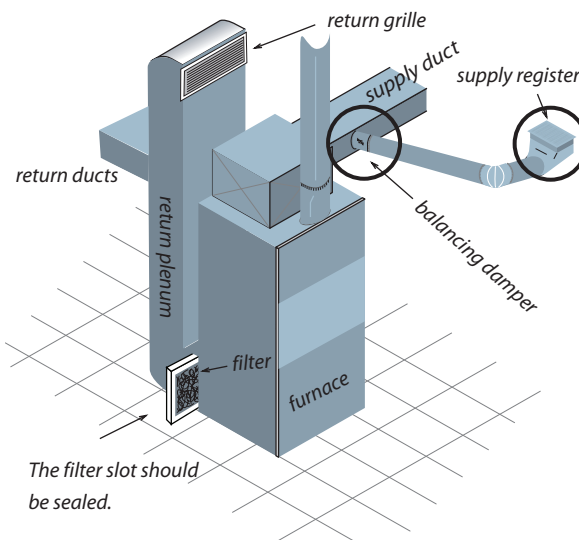
Installing a new plastic-piped vent for a 90+ furnace sometimes leaves a gas water heater venting into an existing chimney that was originally sized to accommodate both a furnace and a water heater. The old chimney may be too large for the “orphaned” water heater, resulting in poor chimney draft, condensation, and mortar deterioration. The usual solution is to install a smaller chimney liner or an entirely new chimney that is sized for the water heater alone.

### Replacing Furnace Filters



Learn where your furnace filter or filters are located, and clean or replace them when they get dirty. The filter shown here is located in the furnace's return plenum. Some filters are located behind a return air grille in the living space.

### Balancing a Furnace's Airflow



A furnace should move equal amounts of air to and from of home's living spaces. A heating contractor can adjust the supply air by using either the balancing dampers in the ducts or the adjustable dampers in the supply registers.

## Recommendations to Customers Improving Heating System

### Customer Tasks

- ✓ Inspect the filter in your furnace or heat pump. Clean or change it if it's dirty.
- ✓ Install a carbon monoxide detector.

### Professional Service

- ✓ Clean the furnace's combustion chamber and blower compartment.
- ✓ Perform a carbon monoxide test, and confirm that the chimney removes combustion gases from the home under all conditions.
- ✓ Test the combustion efficiency, and adjust as needed.
- ✓ Confirm that the furnace filter completely fills the opening where it is installed. Install a sealed cover over the filter slot to prevent air leakage.
- ✓ Verify the airflow by measurement with a duct blower or other method, and upgrade the duct system as needed.
- ✓ Measure the duct leakage with a duct blower or other method, and seal the duct leaks as needed.
- ✓ Balance the airflow to the supply registers using balancing dampers.

### Heating System Replacement

- ✓ Select a furnace with an ENERGY STAR label. This new furnace should have an efficiency rating (AFUE) of greater than 90 percent, and it should have a sealed combustion chamber.
- ✓ Be sure the furnace is sized correctly to the house heating load. This sizing should account for any improvements made to the building shell, which may mean that it has a smaller capacity than the old one.
- ✓ Confirm that the chimney is sized correctly for the new system. Upgrade the chimney if needed.

## EVALUATING COOLING SYSTEMS

Cooling systems include central air conditioners, room air conditioners, and evaporative coolers.

### Central Air Conditioning

Central air conditioners are the largest electrical appliance in many homes. Without regular service, air conditioner's efficiency can fall by as much as 50 percent. Proper maintenance and repair saves energy and money, while extending the life of air conditioning equipment.

Customers can perform a few simple maintenance tasks. However for the majority of maintenance tasks, the customer should hire an air-conditioning professional who has specialized tools and training.

The filter in a furnace or air conditioner protects the blower, heat exchanger, and cooling coils from dirt. If these components get dirty, they are difficult and expensive to clean. Changing or cleaning filters helps protect the fans and heat-exchange surfaces.

Filters should be changed or cleaned every few months. The most common filters are made of a fiberglass mat mounted in a cardboard frame. These are disposable, and customers can buy them from home improvement stores. Other filters are made of washable plastic fibers.

## Building Science Latent Heat and Cooling

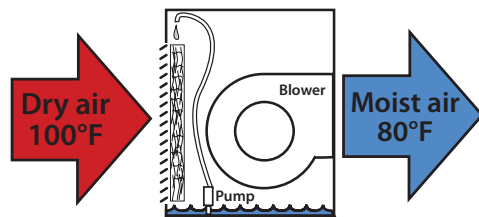
Latent heat is the heat released when a vapor condenses to a liquid or the heat absorbed when a liquid boils into a vapor.

Sweating, air conditioning and evaporative cooling all use the principle of latent heat.

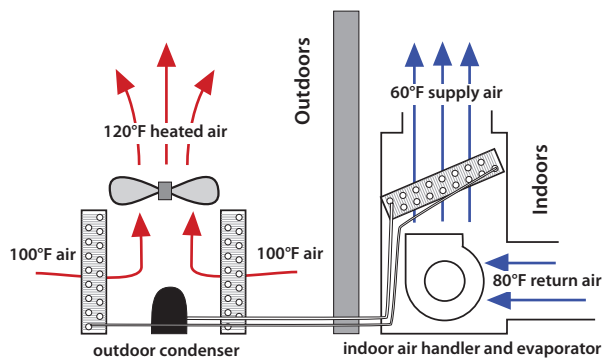


*Sweat evaporating from the skin carries a lot of heat away from the body. Sweat evaporates rapidly in dry air and slowly in humid air.*

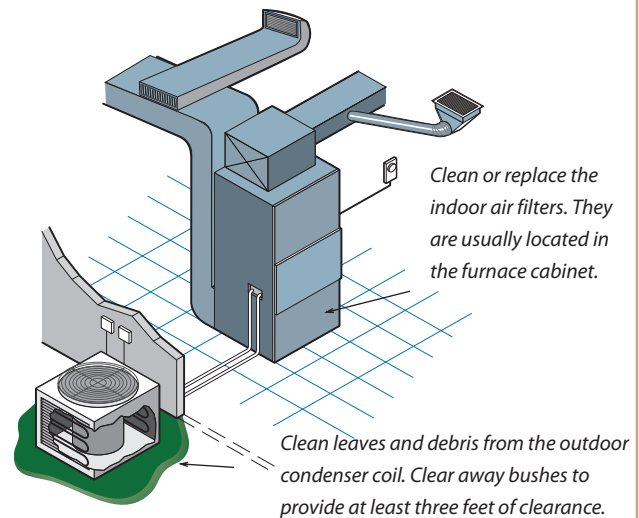
Evaporative coolers reduce the temperature of dry outdoor air by making that air evaporate water. Evaporative coolers only work in dry climates, because adding moisture to already humid air would be uncomfortable. Humid air suppresses the evaporation of sweat.



Air conditioners use a refrigerant to move heat from the home to the outdoors. When the refrigerant evaporates in the evaporator, heat is removed from the air by the evaporation. When the refrigerant condenses again in the condenser, the heat is absorbed by the outdoor air flowing through the condenser.



## Simple Service for Central Air Conditioners



*Many central air conditioners employ a "split system" design, with a condenser coil and compressor installed outdoors and an evaporator coil installed indoors.*

## Duct Efficiency

Poor performance of both cooling and heating systems is often the result of poor duct design and installation. These performance and energy problems result from the following conditions.

- Air leakage through holes in ducts.
- Heat loss through the walls of ducts.
- Inadequate airflow through ducts.

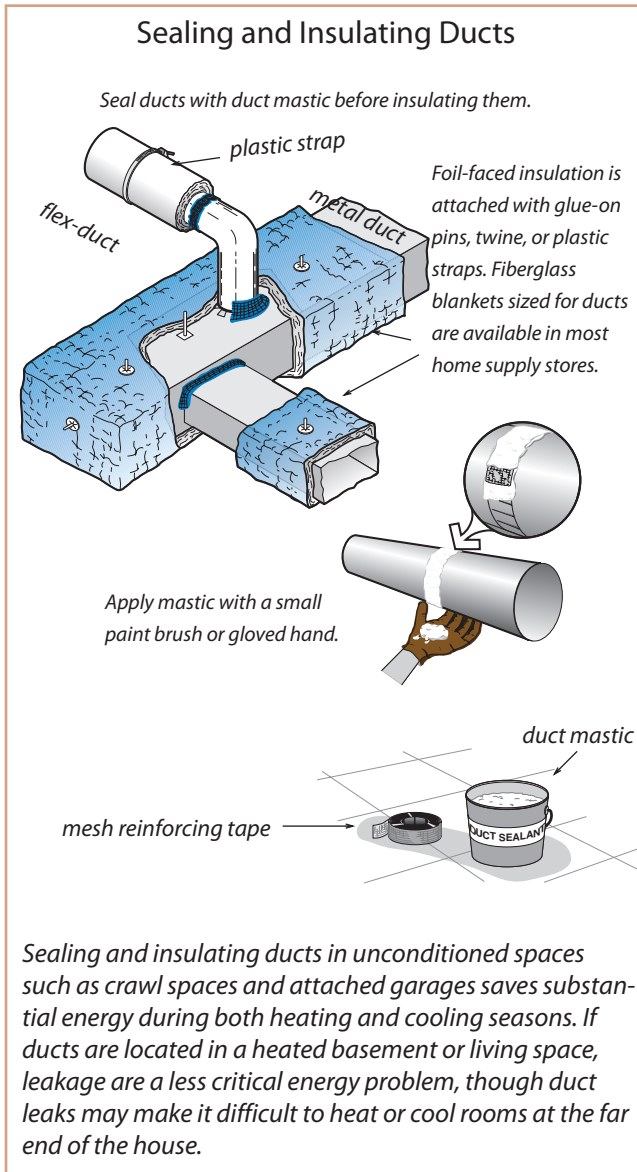
In many homes, duct leakage wastes 15 to 25 percent of the energy consumed by the heating and cooling systems. Contractors can perform a duct air-tightness test that measures and locates duct leakage.

Duct leaks near the air handler are the most important to seal because the air pressure is greatest in ducts nearest to the blower. It's particularly important for a contractor or homeowner to seal all air leaks in the return air ducts near the furnace. These draw air in from their surroundings, and can cause a furnace or water heater to backdraft and spill combustion gases into the living space.



This potential backdraft problem is one good reason to have ducts sealed by a professional, who has measuring equipment to test for possible safety problems.

If a customer chooses to seal their duct systems, they should not use standard gray fabric duct tape, since its adhesive tends to fail quickly. Duct mastic, available in buckets and painted over duct seams, is the preferred sealant.



## Recommendations for Customers Servicing Cooling System

### Customer Tasks

- ✓ Before doing any service work, shut the unit off at its main switch.
- ✓ Clean or replace the filter located inside the metal air handler cabinet or behind a return air register. This may be the same filter that serves the furnace.
- ✓ Remove plants and other debris from within 3 feet of the outdoor unit. Make sure the upward path of air leaving the unit is unrestricted for at least 5 feet.

### Professional Service

- ✓ Clean the blower so that it moves air more efficiently.
- ✓ Balance airflow to each room to provide consistent comfort.
- ✓ Verify the airflow by measurement with a duct blower or other method, and upgrade the duct system as needed.
- ✓ Measure the duct leakage with a duct blower or other method, and seal the duct leaks as needed.
- ✓ Clean the indoor evaporator and outdoor condenser coil. If there is no access panel, install one.
- ✓ Check the refrigerant charge and adjust if needed.
- ✓ Straighten any bent fins on the condenser and evaporator coils.

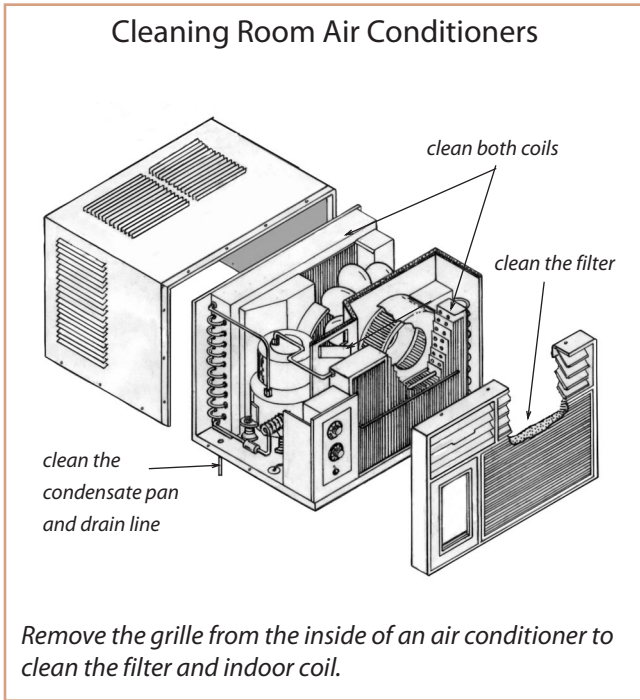
## Room Air Conditioners

Portable room air conditioners are typically located in a window and cool one room. Cleaning a portable air conditioner's filter and coils helps the portable unit perform well and minimize electricity use.

Room air conditioners contain filters that protect their indoor cooling coils from dust and debris. The filter is behind a removable louvered cover on

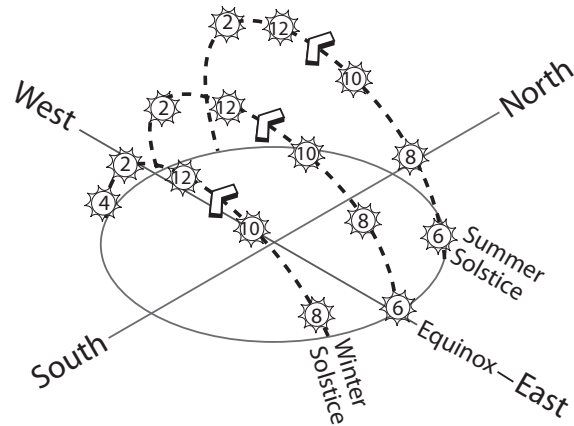
the room side of the unit. You or the customer can remove this cover and the foam filter and wash both in the kitchen sink with soap and water.

The condenser coil is accessible from the outdoor side of the room air conditioner. The outdoor coil is similar to the indoor coil, though more difficult to clean.

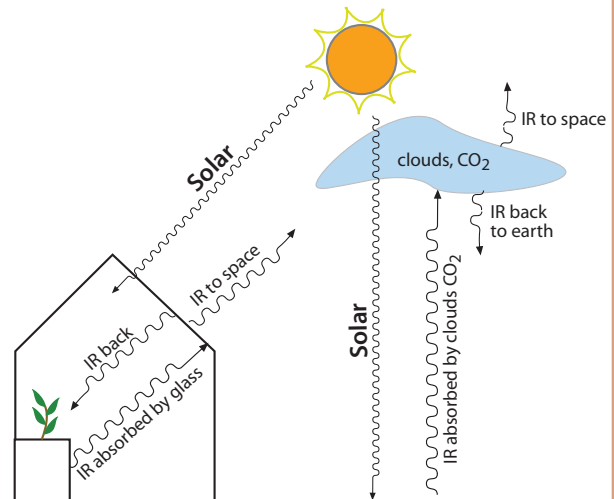


## Building Science Solar Radiation

The sun's arc through the sky changes with the season. In winter the sun scribes a low arc, staying in the southern sky all day. At the equinoxes, the sun rises higher, and the summer sun rises highest and stays in the sky for the longest of any season.



Glass in a greenhouse transmits solar radiation, which heats objects in the greenhouse. The warm objects emit infrared radiation (IR), which is absorbed by the glass. The glass then emits IR back to the greenhouse and out into space.



The earth's atmosphere transmits solar radiation, which heats the earth. The earth emits IR out towards space. Some of the IR escapes the atmosphere and some is trapped by clouds and CO<sub>2</sub>. The trapping of heat by materials in the atmosphere is called the "greenhouse effect".