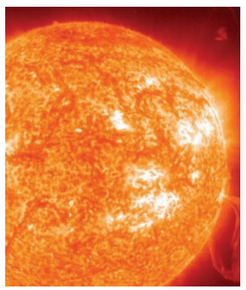
FACT FILE

Heat Heat is the process of energy transfer from one object or area to another because of temperature differences. Molecular vibrations, or the excitation of an electron's energy level, produce internal changes that affect temperature.

Fire Burning is the result of a complex chain of chemical reactions when fuel is combined with oxygen, or oxidized, and heat and/or light is set free.

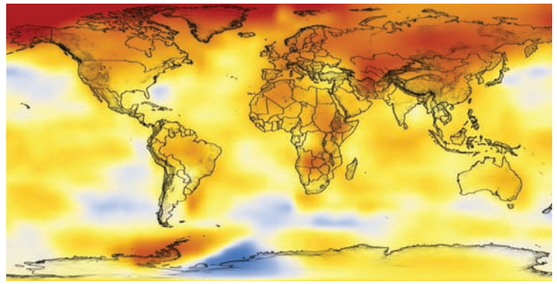


Nuclear reaction In the Sun's core, energy is created by fusion of hydrogen into helium. The star's temperature rises as its gases absorb surplus energy.

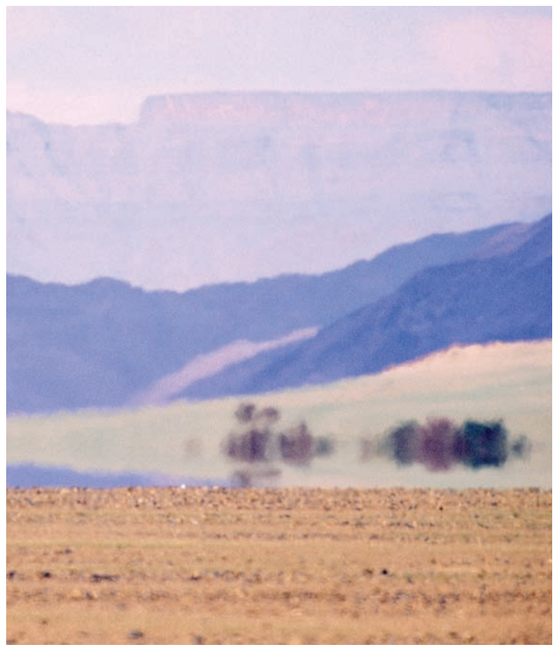
Currents Electrical energy is converted into heat energy when a current flows through a resistor. This principle is used by electric stoves and lightbulbs.

Temperature

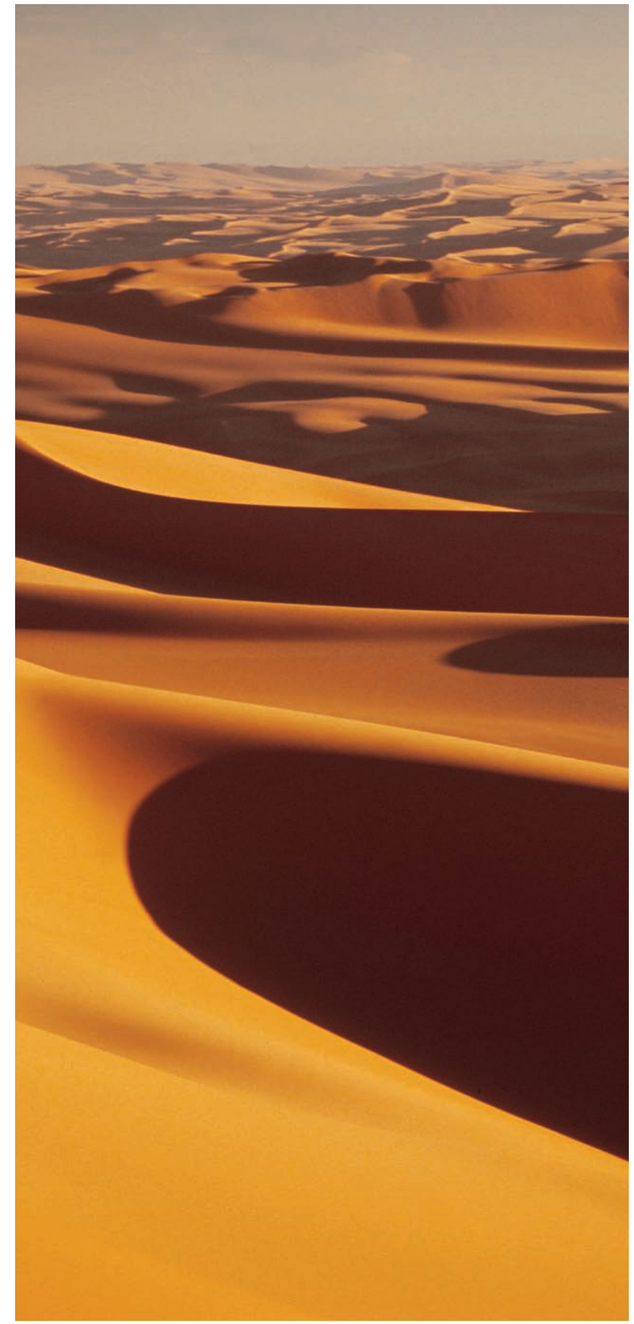
Temperature is a measure of the heat content, or average kinetic energy, of molecules in a substance. It is one of the most important weather and climate parameters and determines the heat flow between two different areas or objects. Temperature controls biological activity, the phase state of water (ice, liquid, or water vapor), and many other physical processes.



Anomalies (above) This image depicts temperature anomalies for 2002–2006 and shows that global atmospheric temperatures are inhomogeneously distributed. Strongest positive anomalies (red) are observed over the Arctic and Asia, while colder temperatures (blue) are found scattered over the oceans and parts of Antarctica.

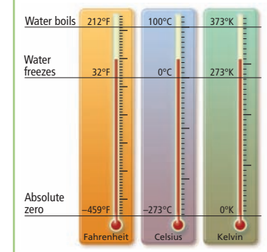


Optical illusion This photo taken in the Namibian Desert shows a mirage, a natural phenomenon where distant light rays are refracted at the interface between hot surface air and the colder air above it.



FACT FILE

Scales Temperature is measured with thermometers that can be calibrated to a variety of scales. While most countries use the Celsius scale, a few still use Fahrenheit. Kelvin is the basic thermodynamic scale in the International System of Units (SI).



Conversion In Celsius, water freezes at 0°C (32°F) and water boils at 100°C (212°F) at sea level. Kelvin is offset from Celsius by 273.15°. To convert between the Celsius and Fahrenheit scales, use the following equations.

From Celsius to Fahrenheit:
°F = (1.8 x °C) + 32

From Fahrenheit to Celsius:
°C = 0.56 x (°F – 32)

COMPARISON	°F	°C
Absolute zero (0°K)	–459.67	–273.15
Lowest recorded temperature on Earth	–128.2	–89
Fahrenheit and Celsius are equal	–40	–40
Water freezes (at sea level)	32	0
Mean surface temperature on Earth	57	13.9
Average human body temperature	98.2	36.8
Highest recorded temperature on Earth	136.4	58
Water boils (at sea level)	212	100

Over the Poles (far left) Very dry air, which reduces the greenhouse effect, combined with diminished sunlight and high snow albedo, leads to cold weather. Temperatures rarely rise above 32°F (0°C) in most of the Arctic and Antarctic.

In deserts (left) Dry, virtually cloud-free, desert air allows solar radiation to heat Earth's surface at full strength, resulting in extremely high daytime temperatures. At night, the same conditions permit warmth to escape, causing quick cooling.

FACT FILE

Iceberg classification There are two basic types of iceberg: tabular and non-tabular. Tabular icebergs have sheer sides and a flat top like a table-top. There are five sub-types of non-tabular icebergs.

Tabular A solid mass of ice with vertical sides and a flat top. These originally formed part of an extensive ice sheet.

Dome These icebergs have rounded tops, usually with a smooth surface.

Pinnacle A few spires of ice protrude from the bulk of the submerged ice.

Wedge Like a wedge of cheese, these icebergs have a steep flat face on one side and a smooth gentle slope on the top side.

Drydock These icebergs have two or more tall columns of ice, with a deep U-shaped slot in between that reaches down to near water level.

Blocky Like tabular icebergs, blocky icebergs have steep, vertical sides and a flat top, but are proportionally taller and resemble huge ice-cubes.

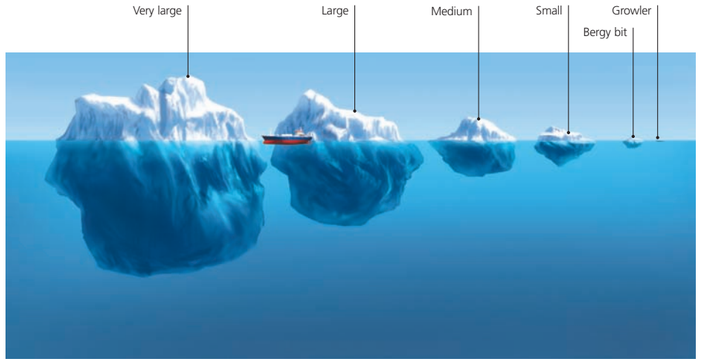
Icebergs

Icebergs are created when ice breaks away from glaciers that extend to the sea or from the breakup of floating ice sheets and ice shelves. They are composed of pure water that fell as snow thousands of years previously. Winds and tides cause icebergs to drift great distances and hundreds of them enter shipping lanes every year.

Penguins on ice Penguins use small icebergs and ice floes as temporary bases. They provide safety from predators but eventually the penguins must return to the sea to feed.

Iceberg size classification
The International Ice Patrol classifies icebergs by their observed dimensions above water. Typically, nine-tenths of the volume of an iceberg is below the surface.

ICEBERG SIZE CLASSIFICATION		
Size category	**Height**	**Length**
Growler	less than 3 feet (<1 m)	less than 16 feet (<5 m)
Bergy bit	3–13 feet (1–4 m)	15–46 feet (5–14 m)
Small	14–50 feet (5–15 m)	47–200 feet (15–60 m)
Medium	51–150 feet (16–45 m)	201–400 feet (61–122 m)
Large	151–240 feet (46–75 m)	401–670 feet (123–213)
Very large	over 240 feet (>75 m)	over 670 feet (>213)



An iceberg is born (right) Upon reaching the ocean, a glacier breaks apart when melting of its lower layers overcomes the structural integrity of the ice mass. Floating icebergs break up into smaller pieces under the stresses of ocean waves and subsurface currents and tides.

Melting iceberg (below) An iceberg in water only a few degrees above freezing can take months to melt completely. It may also lose mass when eroded by heavy waves.

FACT FILE

Glacier meets ocean The Drygalski Ice Tongue is a floating mass of ice that reaches more than 50 miles (80 km) into the Southern Ocean. It is an extension of Antarctica's David Glacier which is fed by ice from over 180 miles (300 km) inland.

Drygalski Ice Tongue David Glacier is so strong and thick that, unlike most glaciers, it does not quickly break up on reaching the ocean.

Ice strike In March 2006 an eight by seven mile (13 × 11 km) section of the Drygalski Ice Tongue was broken off when it was struck by a giant iceberg.

HIDDEN DANGER

Approximately 80–90 percent of an iceberg lies beneath the surface of the water. The more dense an iceberg is, or the less air trapped inside it, the greater the amount of iceberg found underwater.

HURRICANES

A tornado may produce the strongest winds on Earth, but for destructive power nothing matches a hurricane. These spiraling storm systems can measure up to 500 miles (800 km) in diameter and can produce torrential rain, winds of up to 190 miles per hour (300km/h), and an enormous high tide called a storm surge. "Tropical cyclone" is the generic meteorological name and also the name by which they are known in and Australia and around the Indian Ocean. They are called hurricanes in the Atlantic, Caribbean, and Eastern Pacific, apparently in reference to a god of the indigenous Caribbeans named "Huracan." In the Western Pacific they are called typhoons, from the Cantonese word *tai fung,* meaning "big wind."

SUPER STORMS

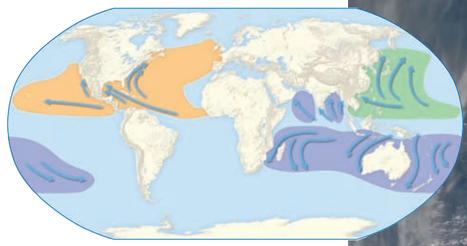
All mature hurricanes have certain features in common. In the center is an eye—a clear, almost calm area bordered by a ring of extremely vigorous convection, known as the eye wall. The extreme updrafts within the ring are fed by lines of converging winds that, in turn, form bands of thunderclouds and heavy rain.

The clusters of storms that produce hurricanes occur only where sea temperatures are at least 79°F (26°C). This means that they usually originate in the tropics. To develop its distinctive rotation, a system must be at least five degrees from the Equator, because this is where the Coriolis effect begins to have an influence (see page 39).

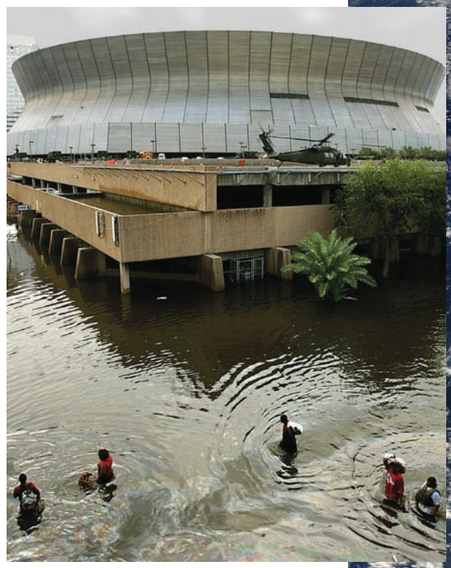
The warm ocean powers the hurricane via a process of energy exchange and release. First, the warm ocean heats the air above it, thus increasing the amount of vapor needed before the air reaches saturation. The ocean is essentially an unlimited source of water, so a huge amount of water is evaporated into the air (much more than is possible over land). The heat that caused the water to evaporate is released when the moisture condenses into clouds, particularly rain clouds. If the clouds are in a group, that heat especially warms an area in the center of the group, causing the air to expand and the pressure to drop. The lower the pressure, the faster the wind blows around the group which becomes a hurricane. The stronger the wind blows over the ocean surface, the greater the rate of evaporation, so, as the hurricane spins faster, it grows stronger. This positive feedback process continues for as long as conditions are favorable for hurricane development.

Once spinning, a hurricane tends to move erratically because its wind speeds greatly exceed the weak "steering winds" of its surrounding environment. Most storms move first towards the west, driven by the trade winds. Then they move poleward, driven by winds around a subtropical high. Farther from the Equator the cyclone encounters westerly flow and tends to move to the east.

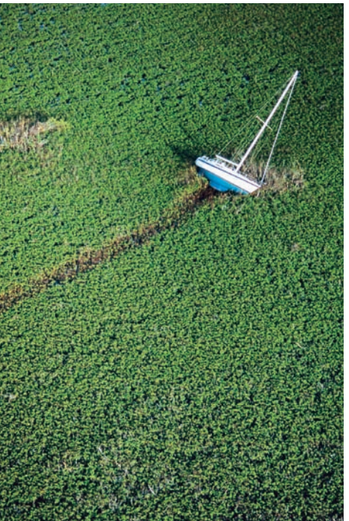
If a hurricane strikes land, its storm surge and rains may flood large areas and its winds create a wide path of devastation. But when a hurricane leaves the ocean, it also leaves behind its supply of moisture. As it moves inland, it weakens rapidly and soon dies out.



Hurricane Rita (right) Hurricane Rita churns across the Gulf of Mexico on September 21, 2005. Rita was one of four rare Category 5 hurricanes to roar across the gulf during the most active hurricane season ever in the Atlantic.



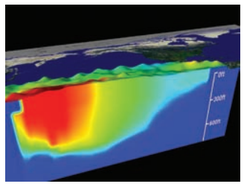
New Orleans after Katrina (right) The flooding in the wake of a hurricane is usually more destructive than the high winds. For days after Hurricane Katrina people were stranded in flooded neighborhoods. Houses were ruined by floodwater and the growth of mold.



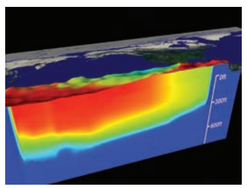
Dumped ashore (left) This yacht was swept several miles across a section of the Florida Everglades during Hurricane Andrew in 1992.

FACT FILE

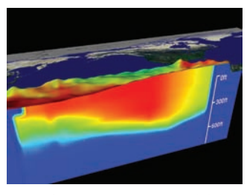
Water temperature Strong El Niño weather conditions occurred from 1997 to 1998. These images show the evolution of the depth of ocean temperature during the event, with temperatures ranging from 46.4°F (8°C), in blue, to 86°F (30°C), in red.



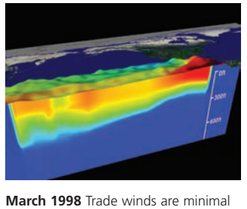
January 1997 During the normal conditions that precede El Niño, the ocean is warmest throughout its depth in the western Pacific Ocean.



June 1997 Trade winds slacken with the onset of El Niño, reducing cold upwelling in the eastern Pacific and allowing warm water to spread east.



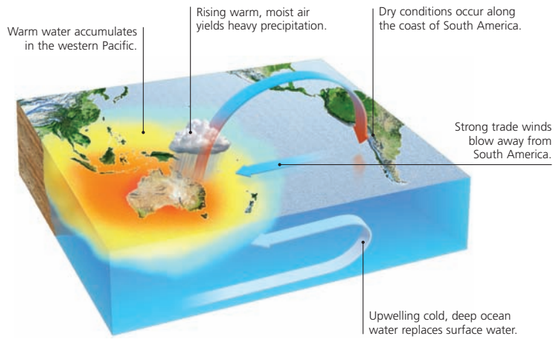
November 1997 Warm water sinks deeper and reaches South America as El Niño develops fully. The water near Australia's east coast begins to cool.



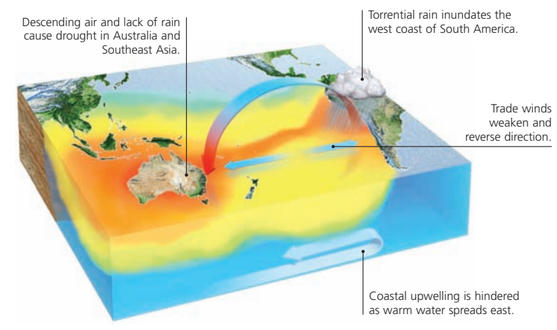
March 1998 Trade winds are minimal when El Niño peaks. Warm water off the coast of South America causes localized heavy rainfall and flooding.

El Niño and La Niña

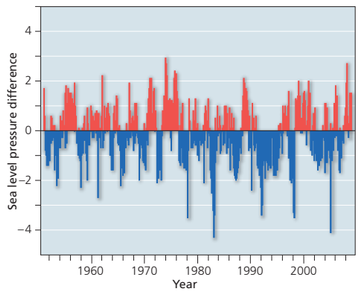
El Niño and La Niña designate weather conditions experienced at either extreme of the Southern Oscillation, a massive coupling of oceanic and atmospheric heat transfer across the Pacific Ocean near the Equator. These conditions cycle irregularly: every two to seven years for El Niño, which rarely lasts longer than a year and alternates with opposing La Niña events.



Normal (above) Trade winds push warm surface water westward, resulting in the upwelling of cold water along the eastern boundary of the Pacific Ocean. Evaporation causes heavy rainfall over Australia.



El Niño (above) Diminished surface winds allow warm water to spread across the Pacific, preventing the normal cold, deep ocean water upwelling. Heavy precipitation falls in South America.



Southern Oscillation Index Readings taken in Tahiti and Darwin, Australia, measure the strength of trade winds, which flow from high to low pressure. El Niño events are characterized by negative (blue) values and La Niña by positive (red). In 2008, La Niña conditions prevailed.

FACT FILE

1. Drought in Australia Parts of Australia experience extreme drought during El Niño events. Strong El Niño events in 2003–04 and 2006–07 led to severe and extended droughts, with 2004 the worst year on record for eastern Australia. New policies, such as gray water recycling, have been introduced to lessen the demand for water.

Australia

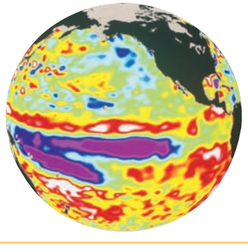
2. Drought in Southeast Asia Dry conditions in Southeast Asia also accompany El Niño events. The most severe drought on record occurred in late 2004 and early 2005, after the 2004 wet season ended early. Thailand suffered the greatest crop losses, primarily sugar, but agriculture declined throughout the region, leading to food shortages.

Southeast Asia

Floodwater Villagers attempt to slow a mudslide with stones outside Lima, Peru. Strong El Niño conditions result in severe flooding in Peru and Ecuador. Scientists speculate that a warming climate will intensify El Niño events, increasing the threat to these coastal regions.

LA NIÑA

La Niña often follows El Niño, especially a strong El Niño event, and has basically the opposite effect. It is characterized by unusually cold ocean temperatures, shown in purple, extending further west across the Pacific than usual.



FACT FILE

1. Washington, D.C. The U.S. capital is not a major industrial or manufacturing center. However, many industry advocacy firms are headquartered in Washington to influence government. Recently, the U.S. government decided to regulate CO_2, signaling a change in climate policy that will affect many industries.

Washington, D.C., U.S.A.

2. London England's capital saw rapid growth during the industrial revolution in the late 18th and early 19th centuries as the steam engine enabled dramatic modernization. From about 1830 to 1920, London was the world's largest city and is still a major business center.

London, England

3. New Delhi The capital of India is one of northern India's largest commercial and financial centers, with an expanding service sector in banking, information technology, media, telecommunications, and tourism. With an English-speaking workforce, India has attracted many multinational corporations.

New Delhi, India

4. Beijing China's capital is a megacity of over 10 million inhabitants. Since the economic reforms of the 1990s, the country has seen rapid expansion and urbanization, creating air pollution problems arising from the coal-powered manufacturing of electricity.

Beijing, China

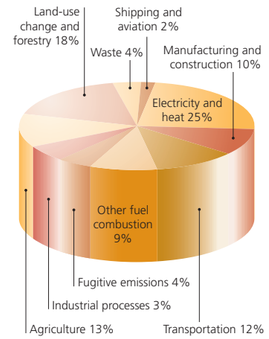
5. Tokyo The world's most populous metropolitan area is Japan's capital, with 35 million residents. Tokyo is a major international financial center and the headquarters of several large companies. Japan's economic boom in the 1980s and 1990s came mainly from high-technology industries.

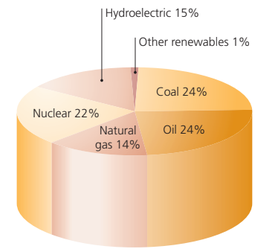
Tokyo, Japan

Industry

Global industry accounts for a large part of the human influence on climate change as many of the processes rely on fossil fuel combustion. Energy- and water-intensive industries, such as textiles and paper, are a major drain on resources. The climate impact of most industries can be mitigated by moving away from fossil fuels and toward renewable and carbon-free energy sources.

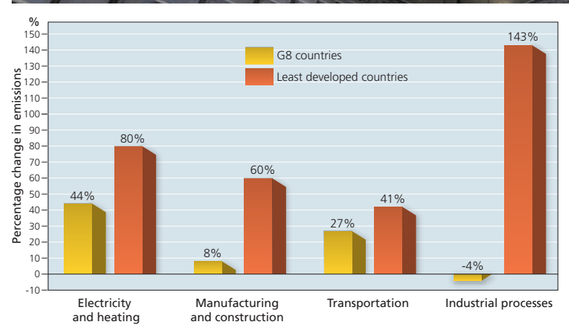
Steel production (below) Being very energy intensive, blast furnaces and steel mills release significant industrial carbon emissions in steel-producing countries and approximately four percent of global man-made greenhouse gas emissions.





Emissions by sector (far left) Industrial processes directly account for three percent of global carbon dioxide emissions. However, a large portion of the emissions produced by other sectors—manufacturing and construction, transportation, electricity and heat, shipping and aviation, and waste—are also attributable to industry.

Electricity production (left) This chart shows the proportion of energy sources used in global electricity production, which has a major impact on greenhouse gas emissions. Coal-sourced electricity has the highest carbon emissions per energy produced, oil is second, natural gas is third. Hydroelectric, nuclear, and renewable energy sources have lower CO_2 emissions.

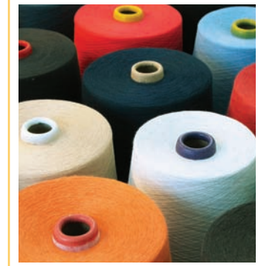


Auto industry (above) Transportation produces 12 percent of global greenhouse gas emissions. Therefore, innovations in this industry are important to reducing emissions, and the race is on to create more fuel-efficient vehicles. A car is retrieved from an automatic palette at the Volkswagen factory in Wolfsburg, Germany.

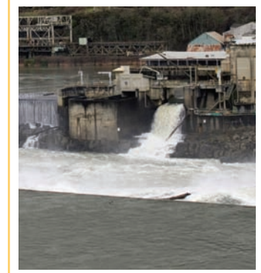
Emissions growth (left) Since 1990, the emissions of greenhouse gases from industrial processes have decreased in the industrialized G8 countries—Canada, Italy, France, Germany, Japan, Russia, the U.K., and the U.S.—but dramatically increased in developing countries.

FACT FILE

Industry impacts Some industries are particularly energy intensive and also major polluters. The use of cleaner fuel sources is being encouraged by governments, and industries are gradually developing more sustainable practices.



Textiles The textile industry is energy and water intensive. Many companies have developed guidelines to increase energy efficiency and to reduce pollution and their carbon footprint.



Paper Pulp mills emit large amounts of sulfur oxides into the air and water. Paper production is the world's fifth-largest energy consumer and North America's third-largest industrial polluter.

Coal The most carbon-intensive and least expensive fossil fuel is coal, a dangerous combination for minimizing emissions. The world's largest exporter—Australia—ships 75 percent of its coal overseas.