EFFICIENCY CONSERVATION

Energy Consumption:
Residential & Commercial Sectors

The residential and commercial sectors—homes and buildings—consume 36 percent of the energy used in the United States today. We use that energy to heat and cool our homes and buildings, to light them, and to operate appliances and office machines.

In the last 25 years, Americans have significantly reduced the amount of energy we use to perform these tasks, mostly through technological improvements in the systems we use, as well as in the manufacturing processes to make those systems.

Heating & Cooling

The ability to maintain desired temperatures is one of the most important accomplishments of modern technology. Our ovens, freezers, and homes can be kept at any temperature we choose, a luxury that wasn't possible 100 years ago.

Keeping our living and working spaces at comfortable temperatures provides a healthier environment, and uses a lot of energy. Half of the average home's energy consumption is for heating and cooling rooms.

The three fuels used most often for heating are natural gas, electricity, and heating oil. Today, more than half of the nation's homes are heated by natural gas, a trend that will continue, at least in the near future. **Natural gas** is the heating fuel of choice for most consumers in the United States. It is a clean-burning, inexpensive fuel.

Most natural gas furnaces in the 1970s and 1980s were about 60 percent efficient—they converted 60 percent of the energy in the natural gas into usable heat. Many of these furnaces are still in use today, since they can last 20 or more years with proper maintenance.

New furnaces manufactured today can reach efficiency ratings of 98 percent, since they are designed to capture heat that used to be lost up the chimney. These furnaces are more complex and costly, but they save significant amounts of energy.

The payback period for a new high-efficiency furnace is between four and five years, resulting in considerable savings over the life of the furnace.

Electricity is the second leading source of energy for home heating and provides almost all of the energy used for air conditioning. The efficiency of air conditioners and heat pumps has increased more than 50 percent in the last 25 years.

In 1973, air conditioners and heat pumps had an average Seasonal Energy Efficiency Rating, or SEER, of 7.0. Today, the average unit has a SEER of 10.7, and high-efficiency units are available with SEER ratings as high as 18.

These high-rated units are more expensive to buy, but their payback period is only three to five years. **Payback period** is the amount of time a consumer must use a system before beginning to benefit from the energy savings, because of the higher initial investment cost.

Heating oil is the third leading fuel for home heating, and is widely used in northeastern states. In 1973, the average home used 1,294 gallons of oil a year. Today, that figure is 833 gallons, a 35 percent decrease.

This decrease in consumption is a result of improvements in oil furnaces. Not only do today's burners operate more efficiently, they also burn more cleanly. According to the Environmental Protection Agency, new oil furnaces operate as cleanly as natural gas and propane burners.

A new technology under development would use PV cells to convert the bright, white oil burner flame into electricity.

The three most important things a consumer can do to reduce heating and cooling costs are:

Proper Maintenance

Maintaining equipment in good working order is essential to reducing energy costs. Systems should be serviced annually by a certified technician, and filters should be cleaned or replaced on a regular schedule by the homeowner.

Programmable Thermostats

Programmable thermostats raise and lower the temperature automatically, adjusting for time of day and season. They can lower energy usage appreciably.

Caulking & Weatherstripping

Preventing the exchange of inside air with outside air is very important. Weatherstripping and caulking around doors and windows can significantly reduce air leakage. Keeping windows and doors closed when systems are operating is also a necessity.

TO SAVE*energy*

Maintain Heating & Cooling Systems Properly

Use Programmable Thermostats to Control Indoor Temperature

Use Weatherstripping & Caulking to Reduce Leaks

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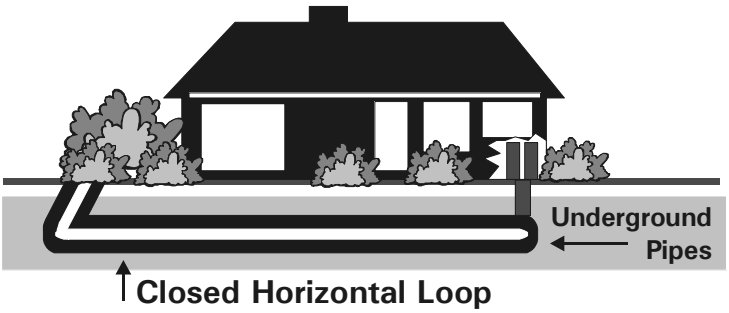
Residential GeoExchange Unit



District Energy Systems

Where there are many buildings close together, like on a college campus, it is sometimes more efficient to have a central heating and cooling facility, which is called a **district energy system**. A district system can reduce equipment and maintenance costs, as well as produce energy savings.

If the system relies on a fossil fuel cogeneration plant for heat, the overall efficiency of the plant can increase from 30 to 90 percent. Cogeneration can also reduce emissions per unit of energy produced by 50 to 60 percent. *(See the Electricity Infosheet on page 60 for more information on cogeneration.)*

If the district energy system uses a renewable energy source, such as geothermal energy or waste heat, emission levels can be reduced even more.

A major benefit of district heating is its ability to use materials as fuel that would otherwise be waste products. These fuels may include biomass, such as waste from the forest product industry, straw, garbage, industrial waste heat, and treated sewage.

In the next 25 years, district energy systems will double their current output, using natural gas, as well as cogeneration from biomass and geothermal sources.

GeoExchange Systems

There are only a few areas in the country that have high temperature geothermal reservoirs, but low temperature geothermal resources are everywhere. Geothermal heat pumps, or **geoexchange units** as they are often called, can use low temperature geothermal energy to heat and cool buildings. Geothermal systems cost more to install than conventional systems, but over the life of the system, they can save a significant amount of money and energy. They can reduce heating costs by 50-70 percent and cooling costs by 20-40 percent. It is estimated that the average homeowner can save $20,000 over the life of the system.

Today, there are about 300,000 geothermal systems in homes and buildings. By the year 2023, the geothermal industry estimates that more than 10 million homes and businesses will be equipped with this new technology.

Building Design

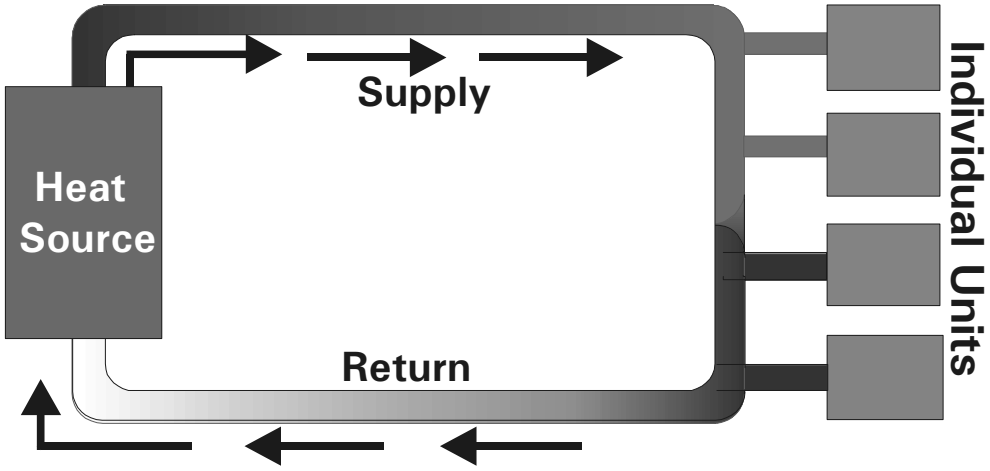
The placement, design, and construction materials used can affect the energy efficiency of homes and buildings. Making optimum use of the light and heat from the sun is becoming more prevalent, especially in commercial buildings.

Many new buildings are situated with maximum exposure to the sun, incorporating large, south-facing windows to capture the energy in winter, and overhangs to shade the windows from the sun in summer. Windows are also strategically placed around the buildings to make use of natural light, reducing the need for artificial lighting during the day. Using materials that can absorb and store heat can also contribute to the energy efficiency of buildings.

The Department of Energy's National Renewable Energy Lab has developed computer programs to design energy-efficient buildings for any area of the country, taking into account the local climate and availability of building materials.

For existing houses and buildings, there are many ways to increase efficiency. Adding insulation and replacing windows and doors with high efficiency models can significantly reduce energy costs. Adding insulated draperies and blinds, and using them wisely, can also result in savings. Even planting trees that provide shade in the summer and allow light in during the winter can make a big difference.

DISTRICT HEATING SYSTEM



Lighting

Lighting is essential to a modern society. Lights have revolutionized the way we live, work, and play. Today, about five percent of the energy used in the nation is for lighting our homes, buildings, and streets.

Lighting accounts for about 25 percent of the average home's electric bill but, for stores, schools, and businesses, the figure is much higher. On average, the commercial sector uses about 60 percent of its electricity for lighting.

Most homes still use the traditional incandescent bulbs invented by Thomas Edison. These bulbs only convert about ten percent of the electricity they use to produce light; the other 90 percent is converted into heat. With new technologies, such as better filament designs and gas mixtures, these bulbs are still more efficient than they used to be.

In 1879, the average bulb produced only 1.4 lumens per watt, compared to about 17 lumens per watt today. By adding halogen gases, this efficiency can be increased to 20 lumens per watt.

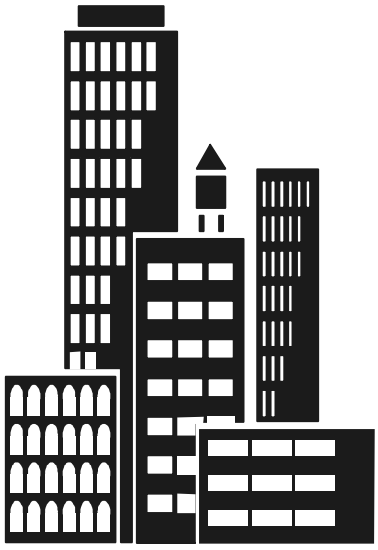
Most commercial buildings have converted to fluorescent lighting, which costs more to install, but uses much less energy to produce the same amount of light. Buildings can lower their long-term lighting costs by as much as 50 percent with fluorescent systems.

Compact fluorescent bulbs have made inroads into home lighting systems in the last few years. These bulbs are more expensive to purchase, but last much longer and use much less energy, producing significant savings over the life of the bulb. Many consumers, however, are reluctant to spend the $10–$20 initial cost to buy these bulbs. *(For more information on incandescent vs. fluorescent bulbs, see page the Electricity Infosheet on page 63.)*

New fluorescent bulb technology has made more dramatic advances in lighting efficiency. Some of the new fluorescent systems have increased the efficiency of these bulbs to as high as 100 lumens per watt.

Most light bulbs are used in some kind of fixture. The design of fixtures can have a major impact on the amount of light required in buildings. Good fixture designs that capture all of the light produced and direct it to where it is needed can reduce energy costs significantly.

Outdoor lighting consumes a lot of energy, too. Most of our major highways and residential streets have street lights, as well as many parking lots. In the 1970s, most street lights were inefficient incandescent and mercury vapor lights.

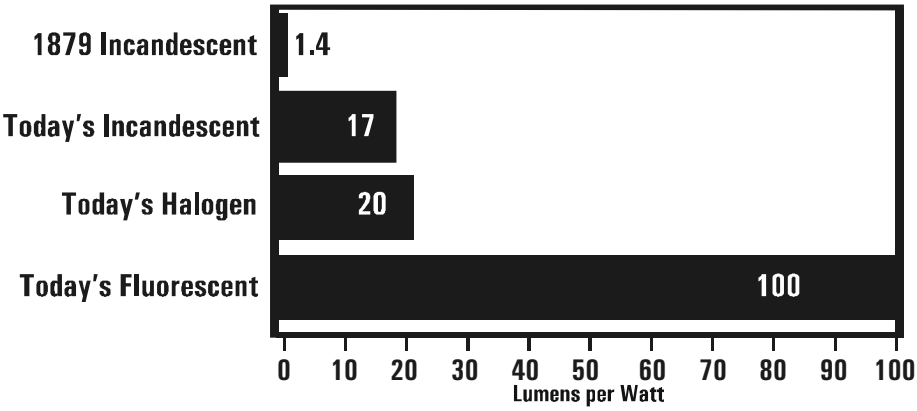


It was at this time that the Federal government began replacing these lights with high pressure sodium lights, which produce four to five times as much light per watt. Automatic sensors also were installed to reduce energy use.

Consumers should make use of new fluorescent bulbs wherever feasible and use only the amount of light they need for the task at hand. Most people use higher wattage bulbs than are necessary in most fixtures in their homes. Automatic turn-off and dimmer switches can also contribute to energy savings. Keeping light bulbs free of dust is an energy-saver, too.

One of the most important actions consumers can take is to turn off lights they aren't using, buy lamps that are suited to their needs in different rooms, and make energy conservation a priority in their daily lives.

LIGHTING EFFICIENCY



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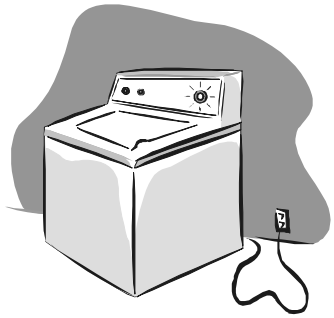


Appliances

In the last 100 years, appliances have revolutionized the way we spend our time at home. Tasks that used to take hours are now accomplished in minutes, using electricity most of the time, instead of human energy.

In 1990, Congress passed the National Appliance Energy Conservation Act, which requires appliances to meet strict energy efficiency standards.

Heating Water

Heating water uses more energy than any other task, except for home heating and cooling. Most water heaters use natural gas or electricity as fuel. New water heaters are much more energy efficient than earlier models. Many now have timers that can be set to the times when hot water is needed, so that energy is not being used 24 hours a day.

New systems on the market combine high efficiency water heaters and furnaces into one unit to share heating responsibilities. Combination systems can produce a 90 percent efficiency rating.

In the future, expect to see water heaters that utilize heat from inside the house that is usually pumped outside as waste heat. Systems will collect the waste heat and direct it into the water heater, resulting in efficiency ratings three times those of conventional water heaters.

Most consumers set the temperature on their water heaters much too high. Lowering the temperature setting can result in significant energy savings. Limiting the amount of hot water usage with low-flow shower heads and conservation behaviors also contributes to lower energy bills.

Refrigerators

Refrigerators have changed the way we live and brought health benefits to our lives. With these appliances, we can safely store foods for long periods of time. Since refrigerators involve heat exchange, they also consume a significant amount of electricity each year.

New refrigerators are many times more efficient than early models. Manufacturers have improved the insulation and the seals, or gaskets, to hold in the cold air better. The industry has also made technological advances in defrost systems, as well as in more energy-efficient compressors and motors.

The appliance industry has worked with the chemical industry to develop refrigerants that are not harmful to the ozone layer, as the early CFCs were.

As with all appliances, the most efficient models are more expensive to purchase but produce energy savings over the life of the refrigerator.

Laundry Machines

Before washers and dryers, doing the laundry meant hard physical work all day, no matter what the weather. Today, the most difficult thing about laundry is deciding which cycle to use.

Today's machines have many innovations that save energy. Dryers with automatic sensors can tell when clothes are dry.

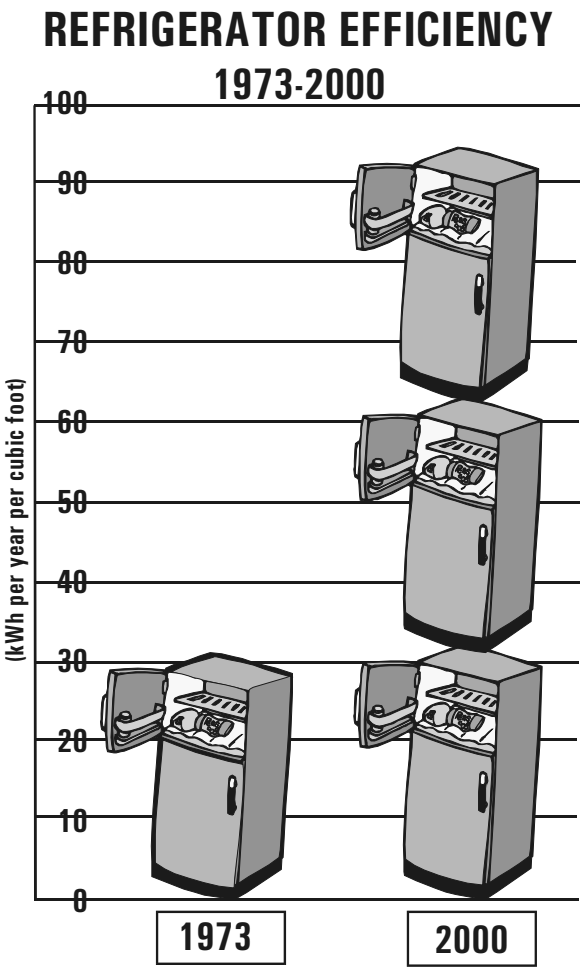
New washing machines are being designed with a horizontal axis, rather than the traditional top-load design. These machines use 40 percent less water and 60 percent less energy than the top-loading models. They also have higher capacity; they can wash large items such as comforters and sleeping bags.

Appliance Efficiency Ratings

We use many other appliances every day. Some use less than 10 cents worth of electricity a year, while others use much more. Have you noticed that those appliances that produce or remove heat require the most energy?

When purchasing any appliance, consumers should define their needs and pay attention to the Energy Efficiency Rating (EER) included on the yellow label of every appliance. The EER allows consumers to compare not just purchase price, but operating cost as well, to determine which appliance is the best investment. Usually, more energy efficient appliances cost more to buy, but result in significant energy savings over the life of the appliance. Buying the cheapest appliance is rarely a bargain in the long run.

In the next few years, consumers will have the choice of many *smart* appliances that incorporate computer chip technology to operate more efficiently, accurately, and effectively.



EFFICIENCY CONSERVATION

Energy Consumption:

Industrial Sector

The United States is a highly industrialized society. We use a lot of energy. Industry consumed 36.5 percent of the energy in 2000.

Since 1973, the industrial sector has grown by 60 percent, but it has only required 12 percent more energy to fuel that growth. New technology has allowed industry to do more with less energy.

Industry has been a leader in developing cogeneration technology. Cogenerators produce electricity and using the waste heat for manufacturing, increasing energy efficiency by 50 percent.

Every industry uses energy, but there are six energy-intensive industries that use the lion's share of the energy consumed by the industrial sector.

Petroleum Refining

Refineries need energy to convert crude oil into transportation fuels, heating fuels, chemicals, and other products. Enormous amounts of heat are required to separate crude oil into its components, such as gasoline, diesel and aviation fuel, and important gases. Heat is also needed to crack, or break, big hydrogen and carbon molecules into lighter, more valuable petroleum products.

On average, operating the refineries consumes about nine percent of the energy in the crude oil. On a per barrel basis, today's refineries use about 25 percent less energy than they did in 1973.

Steel Manufacturing

The steel industry consumes about three percent of total U.S. energy demand. The energy is used to convert iron ore and scrap metal into hundreds of products we use daily.

The cost of energy represents between 15-20 percent of the manufactuing cost of steel. Most of this energy (60 percent) comes directly from coal and electricity generated by coal–fired plants.

Since 1973, the steel industry has reduced its energy consumption by 45 percent per ton of steel. This increase in efficiency has been accomplished through advanced technologies, the closing of older plants, and the increased use of recycled steel.

New technology has also made steel stronger, reducing the amount of steel needed for many uses. With today's steel, a building like the Sears Tower in Chicago could be erected using 35 percent less steel. Today's cars are also lighter and more fuel-efficient because of this stronger steel.

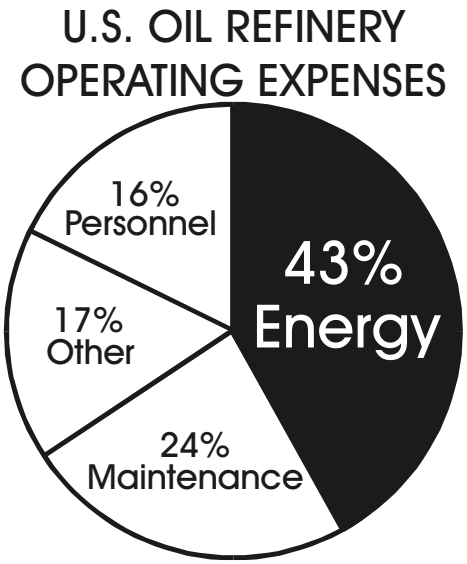
The increased use of recycled steel also saves energy. It requires 33 percent less energy to recycle steel than to make it from iron ore. Today, steel is the nation's leading recycled product, with 68 percent of new steel being manufactured from recycled scrap.

Aluminum Manufacturing

It takes huge amounts of electricity to make aluminum from **bauxite**, or aluminum ore. It requires six to seven kilowatt-hours of electricity to convert one pound of bauxite into aluminum. The cost of electricity accounts for 30 percent of the total manufacturing cost.

Today, it requires 23 percent less energy to produce a pound of aluminum than it did 25 years ago, mostly because of the growth of recycling. Aluminum recycling has almost doubled since the 1970s. Using recycled aluminum requires 95 percent less energy than converting bauxite into aluminum.

Aluminum is a very lightweight metal. The increased use of aluminum in vehicles during the last 25 years has decreased average vehicle weight. Lighter vehicles consume less fuel, saving energy. The decreased weight also allows vehicles to carry more cargo, so that energy is saved in transporting goods. Aluminum saves energy in many ways.



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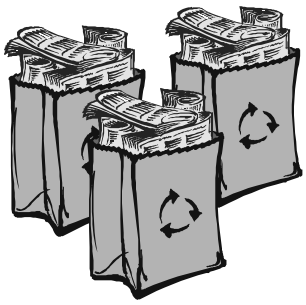


Paper Manufacturing

The United States uses enormous amounts of paper every day—newspaper, books, bags, boxes, all are made of paper.

Energy is required in every step of the paper-making process. Energy is used to chip, grind, and cook the wood into pulp, and more is needed to roll and dry the pulp into paper. To produce a ream (500 sheets) of copy paper requires 27,500 Btu's of energy, the equivalent of about two gallons of gasoline. In 1973, it required 47,500 Btu's, or the equivalent of 3.7 gallons of gasoline, to produce the same amount of paper.

The pulp and paper industry has reduced its energy consumption per ton of paper by about 42 percent in the last 25 years, mostly through the use of better technology and cogeneration systems. Almost 56 percent of the fuel the industry uses to power the cogeneration equipment comes from wood waste, a renewable energy source.

Paper recycling has increased from 23 percent in 1973 to 45 percent today. While other industries reap significant energy savings by using recycled material, the paper industry does not. The energy required to collect, sort, de-ink, and process waste paper is higher than producing paper from virgin wood.

Paper recycling mills may use less energy than those using virgin wood, but the added energy costs of collecting and transporting the waste paper results in no energy savings. In addition, recycling mills usually use fossil fuels instead of wood waste to power their facilities.

On the other hand, recycling paper reduces the amount of waste paper put into landfills, and reduces the amount of virgin timber cut to produce paper.

Chemical Manufacturing

Chemicals are essential to our way of life. We use chemicals in our medicines, cleaning products, fertilizers, and plastics, as well as in many of our foods. Chemical manufacturers convert molecules into other molecules, in much the same way as our bodies convert the food we eat into usable sugars and proteins.

The chemical industry uses natural gas, coal, and oil to power the equipment they use to manufacture chemicals. Chemical manufacturing also needs a hydrocarbon source of raw materials to process into chemical products. Petroleum is one of the major sources of hydrocarbons used by the chemical industry today.

New technology has made the chemical industry almost 60 percent more energy efficient today than it was in 1973. Technology has allowed the industry to use less energy, as well as produce more product from an equivalent amount of petroleum feedstock.

Cement Manufacturing

Some people think the United States is becoming a nation of concrete. New roads and buildings are being built everywhere, every day. We use a lot of concrete.

Concrete is made from cement, water, and crushed stone. Making cement is an energy-intensive industry, because of the extremely high temperatures required—up to 3,500 degrees Fahrenheit.

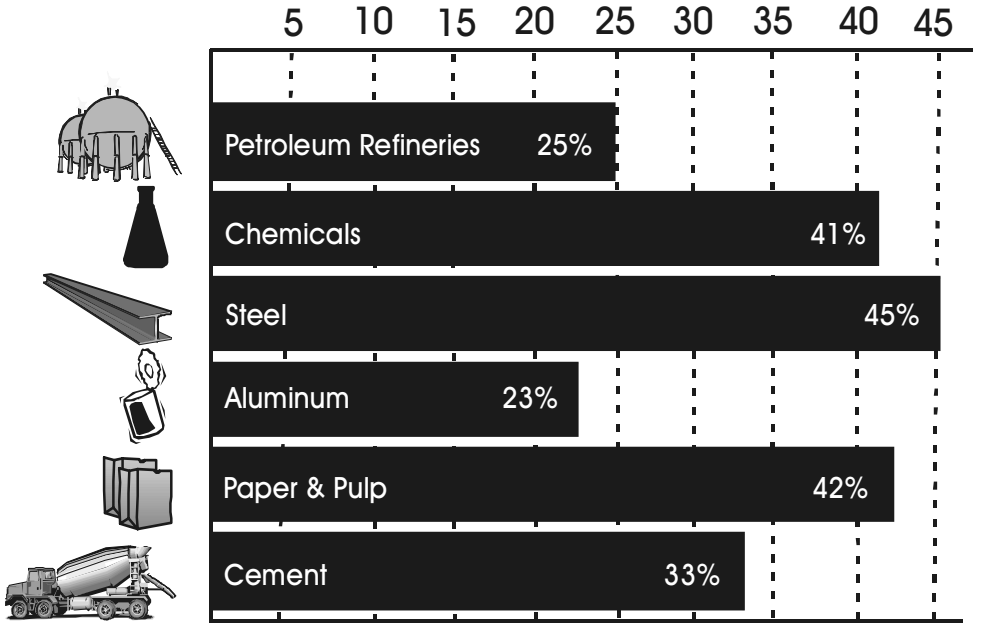
Twenty-five years ago, cement plants all burned fossil fuels to produce this heat. Today, the industry has reduced its energy consumption by one-third using innovative waste-to-energy programs.

More than half of the 118 cement plants in the U.S. now use some type of waste by-product for fuel, including used printing inks, dry cleaning fluids, and used tires—all of which have high energy content. The average used tire, for example, has the energy equivalent of two gallons of petroleum.

One cement kiln burning one million tires a year saves enough fossil fuel to heat 2,700 homes. It also recovers the energy in the tires, rather than throwing it into a landfill, to be buried and never recovered.

Today, a modern cement plant can meet between 20 and 70 percent of its energy needs by burning waste materials that otherwise would not be used for their energy value. They turn these wastes into a valuable resource.

Reduction in Energy Use 1975-2000



EFFICIENCY CONSERVATION

Energy Consumption: *Transportation*

America is a nation on the move. Twenty-six percent of the energy we use goes to transporting people and goods from one place to another.

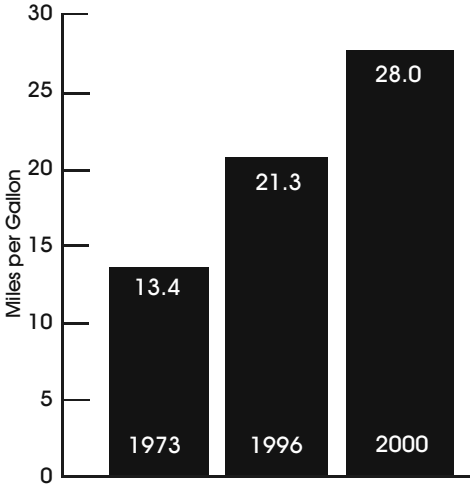
The Automobile

The people in the United States have always had a love affair with the automobile. Until the embargos of the 1970s, Americans drove without thought of fuel economy or environmental impacts.

In 1973, there were 102 million cars on the road, driving an average of 9,600 miles a year. In 2000, there were about 140 million cars, driving 11,800 miles a year. Even with the scares of the oil embargos, we are driving more cars, more miles. It's a good thing we're doing it more efficiently and cleanly.

Although the oil crises didn't alter Americans' driving habits much, they did bring about changes in vehicle design. Automakers downsized many large and mid-sized models and significantly reduced vehicle weight. Aerodynamic designs were incorporated and engine size reduced. More important, engines were improved to increase fuel efficiency with fuel injectors and electronic transmissions.

AVERAGE FUEL EFFICIENCY OF PASSENGER CARS



All of these improvements have resulted in a doubling of average mileage ratings for vehicles since 1973. If mileage had remained the same, we would be consuming 30 percent more fuel today.

The import of foreign cars has also increased. In 1973, foreign cars had a seven percent share of the market. Today, that figure is 30 percent and many foreign car companies have opened assembly plants in the United States.

Mileage Requirements

Most of the improvements in automobile efficiency have been the result of mandates by the Federal government. Today, passenger cars are required to achieve a combined city and highway mileage of 22.5 miles per gallon. For every mile per gallon below this standard, a tax of $1,000 is placed on the purchase price. Currently, only a few high-performance vehicles are subject to this tax. Furthermore, this standard does not apply to vans, pick-up trucks and sport utility vehicles.

Last year when gas prices were low, consumers made no great effort to buy fuel efficient vehicles. In 2000, for example, sales of the ten most efficient cars and ten most efficient trucks totalled less than one percent of total vehicle sales. On the other hand, sport utility vehicles and light pick-up trucks made up half of the total passenger vehicle sales.

Advocates of further increases in fuel efficiency think the mileage standard should be raised to 24.5 miles per gallon, and that vans, sport utility vehicles, and trucks should be required to meet the same standards as other vehicles.

Opponents think consumer choice would become limited and consumers would not be able to afford the vehicles of their choice. They also think vehicles might become smaller and not as safe.

To promote more fuel efficient vehicles, the federal government entered into a partnership with the Big Three automakers in 1993 to develop an environmentally friendly car by 2003. This vehicle, called the Supercar, is supposed to achieve a mileage rating of 80 miles per gallon without sacrificing safety, affordability, or performance.

Alternative Fuels

There is also a push to develop vehicles that run on fuels other than petroleum products, or on blended fuels. Today, there are vehicles that run on electricity, natural gas, propane, and ethanol. There are even solar-powered cars on the roads.

In 1973, there were only a few vehicles that ran on alternative fuels. Today, there are about 500,000 in the United States, and that figure is increasing by about eight percent a year. The largest barriers to widespread acceptance are:

Refueling Infrastructure

Manufacturers are now capable of producing a large volume of alternative fuel vehicles, but there needs to be a convenient infrastructure for obtaining the fuels. Not many people are willing to drive 15 miles or more to refuel.

Consumer Education

Most Americans know very little about alternative fuel vehicles. Consumers must be educated about environmental and other benefits of these vehicles before they will consider them a choice.

If these barriers can be removed, alternative fuel vehicles can develop a strong niche market in the United States. New technologies are being developed all the time to make these vehicles more practical and convenient for consumers.

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Commercial Transportation

The United States is a large country. We use a lot of energy moving goods and groups of people from one place to another.

Passenger vehicles consume about two-thirds of the transportation fuel and commercial vehicles consume the remaining third. The fuel efficiency of trains, trucks, buses, and planes has increased significantly in the last 25 years, and so has the number of miles traveled.

Trucks

Trucks use more transportation fuel than any other commercial vehicle. Almost all products are at some point transported by truck. In 1997, the average tractor-trailer traveled about 4.8 miles on a gallon of fuel.

New trucks manufactured today can travel about seven miles on a gallon of fuel. This increase in fuel efficiency is due mainly to improvements in engine design and computerized electronic controls.

New diesel engines can convert about 45 percent of the energy in the fuel into vehicle movement, while gasoline engines can convert only about 24 percent. Federal research is aimed at improving diesel efficiency to 55 percent, by redesigning engines, redesigning braking systems to use air flow to help slow down vehicles, and engineering tires to roll more easily.

Planes

Since 1973, the amount of cargo and the number of passengers on planes have more than doubled. Planes all use petroleum products for fuel, which is the largest cost item for air transport after labor. The airline industry has been a leader in efficiency. While consumer prices in general have more than doubled, airline prices have remained almost unchanged.

In 1970, the average number of passenger miles per gallon was 15. Today, that figure is almost 40 miles per gallon of fuel. Passenger and cargo miles have more than doubled in the same time period. In 2000, more than 600 million passengers flew on airplanes. That number is expected to reach one billion by the year 2010.

There is also research being done into the use of alternative fuels for airplanes. One advantage that airlines have is that refueling stations are more centralized; the airline industry doesn't need the vast infrastructure that ground vehicles do. Changing the engines of airplanes is a technical and difficult challenge, though, to ensure that all of the systems can work together.

Railroads

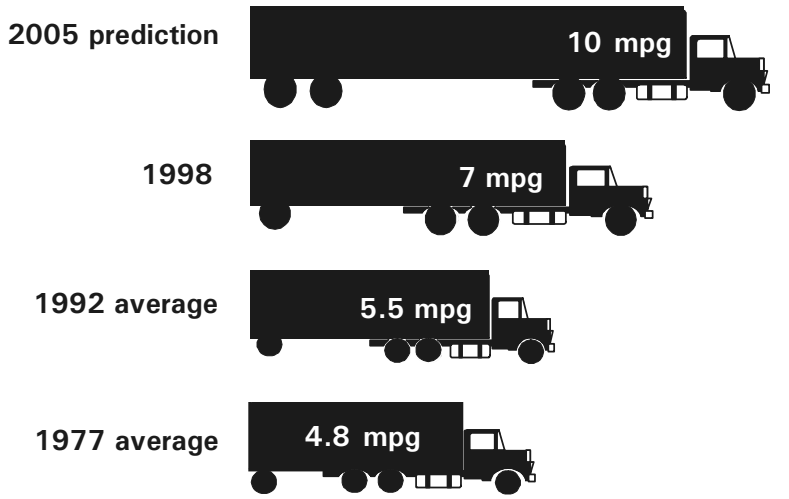
Railroads are the nation's leading carrier of freight between cities. Since 1973, the fuel efficiency of freight trains has increased by 61 percent. This reduction in energy use was accomplished by using longer trains with less handling and fewer changes and stops. The equipment is stronger and lighter to handle more cargo. There have also been major improvements in rail technology that have contributed to ease of movement.

The trucking and marine shipping industries work with the railroad industry to move cargo efficiently. More freight is being transported on trains directly in truck trailers and uniform containers, so that there is less handling. Today, containers often travel by ship, rail, and truck in one shipment.

In the future, there will be an increase in the use of AC motors on diesel electric engines on locomotives. With AC motors, there are fewer moving parts, so less heat is generated, resulting in more efficient use of fuel. A train that today requires six locomotives might require only four with this new technology.

Mass Transit

Mass transit is the system of public transportation for moving people on buses, trains, light rail, and subways. In 1998, about eight billion trips were taken on public transit systems, two-thirds on buses. This figure sounds huge, but it is less than the number of trips in 1970. Why this decrease? Americans love their cars; most families own more than one. And, as more people have moved from cities into suburbs, public transportation has has not been economically feasible for many dispersed locations.

This situation may change in the future. Congress recently passed legislation increasing the funding for public transit. There is growing awareness of the problems caused by increased traffic congestion. The number of hours that people are delayed in traffic has increased by 95 percent in the last ten years. Building more roads can't be the only answer, especially with environmental concerns over vehicle emissions.

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