ENERGY

In physics, energy (Ancient Greek: ἐνέργεια energēia "activity, operation") is a quantity that is often understood as the ability a physical system has to do work on other physical systems. Since work is defined as a force acting through a distance (a length of space), energy is always equivalent to the ability to exert pulls or pushes against the basic forces of nature, along a path of a certain length.

The total energy contained in an object is identified with its mass, and energy (like mass), cannot be created or destroyed. When matter (ordinary material particles) is changed into energy (such as energy of motion, or into radiation), the mass of the system does not change through the transformation process. However, there may be mechanistic limits as to how much of the matter in an object may be changed into other types of energy and thus into work, on other systems. Energy, like mass, is a scalar physical quantity. In the International System of Units (SI), energy is measured in joules, but in many fields other units, such as kilowatt-hours and kilocalories, are customary. All of these units translate to units of work, which is always defined in terms of forces and the distances that the forces act through.

Energy may be stored in systems without being present as matter, or as kinetic or electromagnetic energy. Stored energy is created whenever a particle has been moved through a field it interacts with (requiring a force to do so), but the energy to accomplish this is stored as a new position of the particles in the field—a configuration that must be "held" or fixed by a different type of force (otherwise, the new configuration would resolve itself by the field pushing or pulling the particle back toward its previous position). This type of energy "stored" by force-fields and particles that have been forced into a new physical configuration in the field by doing work on them by another system, is referred to as potential energy. A simple example of potential energy is the work needed to lift an object in a gravity field, up to a support. Each of the basic forces of nature is associated with a different type of potential energy, and all types of potential energy (like all other types of energy) appears as system mass, whenever present. For example, a compressed spring will be slightly more massive than before it was compressed. Likewise, whenever energy is transferred between systems by any mechanism, an associated mass is transferred with it.

Any form of energy may be transformed into another form. For example, all types of potential energy are converted into kinetic energy when the objects are given freedom to move to different position (as for example, when an object falls off a support). When energy is in a form other than thermal energy, it may be transformed with good or even perfect efficiency, to any other type of energy, including electricity or production of new particles of matter. With thermal energy, however, there are often limits to the efficiency of the conversion to other forms of energy, as described by the second law of thermodynamics.

In all such energy transformation processes, the total energy remains the same, and a transfer of energy from one system to another, results in a loss to compensate for any gain. This principle, the conservation of energy, was first postulated in the early 19th century, and applies to any
isolated system. According to Noether's theorem, the conservation of energy is a consequence of the fact that the laws of physics do not change over time.

Although the total energy of a system does not change with time, its value may depend on the frame of reference. For example, a seated passenger in a moving airplane has zero kinetic energy relative to the airplane, but non-zero kinetic energy (and higher total energy) relative to the Earth.

**Forms of energy**

In the context of physical sciences, several forms of energy have been defined. These include:

- **Thermal energy**, thermal energy in transit is called heat
- **Chemical energy**
- **Electrical energy**
- **Radiant energy**, the energy of electromagnetic radiation
- **Nuclear energy**
- **Magnetic energy**
- **Elastic energy**
- **Sound energy**
- **Mechanical energy**
- **Luminous energy**

These energies may be divided into two main groups; kinetic energy and potential energy. Other familiar types of energy are a varying mix of both potential and kinetic energy. Energy may be transformed between these forms.

The above list of the known possible forms of energy is not necessarily complete. Whenever physical scientists discover that a certain phenomenon appears to violate the law of energy conservation, new forms may be added, as is the case with dark energy, a hypothetical form of energy that permeates all of space and tends to increase the rate of expansion of the universe.

Classical mechanics distinguishes between potential energy, which is a function of the position of an object, and kinetic energy, which is a function of its movement. Both position and movement are relative to a frame of reference, which must be specified: this is often (and originally) an arbitrary fixed point on the surface of the Earth, the terrestrial frame of reference. It has been attempted to categorize all forms of energy as either kinetic or potential: this is not incorrect, but neither is it clear that it is a real simplification, as Feynman points out:
**Energy Scenario in India**

In India and all over the world, a variety of sources of energy are in use. Like firewood, agricultural waste, animal dung and human power are the traditional sources of energy which are still continue to meet the bulk of energy requirements in rural India. These traditional fuels are gradually getting replaced by commercial fuels such as coal, petroleum, natural gas and electricity.

It has been estimated that 60% of total energy requirement in India is derived from commercial fuels and non-commercial fuels contributes the rest 40%. Total energy produced in the form of electricity, is 60% from coal, 25% from hydel power, 4% from diesel and gas, 2% from nuclear power and less than 1% from non-conventional sources like solar, wind, ocean, biomass, etc.

In developing country like India—greater the availability of energy, more is the shortage. There is phenomenal increase in power generating capacity, still there is no electricity in many rural areas and even cities, electricity available is 30% less than the requirement.

Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly. India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. The country, though rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy has very small hydrocarbon reserves (0.4% of the world’s reserve). India, like many other developing countries, is a net importer of energy, more than 25 percent of primary energy needs being met through imports mainly in the form of crude oil and natural gas. The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn hampers economic growth.

If we look at the pattern of energy production, coal and oil account for 54 percent and 34 percent respectively with natural gas, hydro and nuclear contributing to the balance. In the power generation front, nearly 62 percent of power generation is from coal fired thermal power plants and 70 percent of the coal produced every year in India has been used for thermal generation.

The distribution of primary commercial energy resources in India is quite skewed. 70 percent of the total hydro potential is located in the Northern and Northeastern regions, whereas the Eastern region accounts for nearly 70 percent of the total coal reserves in the country. The Southern
region, which has only 6 percent of the total coal reserves and 10 percent of the total hydro potential, has most of the lignite deposits occurring in the country.

On the consumption front, the **industrial sector** in India is a major energy user accounting for about 52 percent of commercial energy consumption. **Per capita energy consumption** in India is one of the lowest in the world as shown in Fig. 1. But, **energy intensity**, which is energy consumption per unit of GDP, is one of the highest in comparison to other developed and developing countries. For example, it is 3.7 times that of Japan, 1.55 times that of the United States, 1.47 times that of Asia and 1.5 times that of the world average. Thus, there is a huge scope for energy conservation in the country.

![Per Capita Energy Consumption](image)

During the pre-reform period, the commercial energy sector was totally regulated by the government. The economic reform and liberalization, in the post 90s, has gradually welcomed private sector participation in the coal, oil, gas and electricity sectors in India. Energy prices in India have been under an administrated regime with subsidies provided to meet certain socio-economic needs of the public. This has led to distortion and inefficiency in the use of different sources of energy. The government has taken serious steps to deregulate the energy price from an Administered Price Mechanism (APM) regime. The prices of all grades of coal and petroleum products have already been deregulated. In the electricity sector, most of the State Electricity Boards (SEBs) have started taking reform measures and regulatory commissions have been set up to determine tariffs based on economic rational.
Solar Energy

Solar energy is an alternative energy source that involves harnessing the radiant light energy emitted by the sun and converting it into electrical current. Since the middle of the 20th century, the ability to harness and utilize solar energy has greatly increased, making it possible for homes and businesses to make use of the renewal energy source rather than rely on more conventional means of generating power. Research into the applications of solar energy continue, along with the development of more cost-effective ways to capture and store the energy for future use.

At present, the most common means of harnessing solar power is the utilization of a system involving a series of solar panels and storage batteries. The panels collect the radiant light and store the captured energy in the batteries. While energy is stored, it can also be used real time to operate various types of machinery and home appliances. The excess is stored for use at night or in other situations where radiant light is not readily available for some reason.

In a home powered by solar energy, batteries are now capable or maintaining a power supply that will maintain the operation of appliances such as stoves, refrigerators, computers and entertainment devices such as television sets. At the same time, the solar powered home can also use the stored energy to heat and cool the home or operate a hot water heater. Some homes today use a hybrid power system that integrates the use of solar energy along with power supplied by a traditional power grid. While the home is not completely dependent on solar power, this type of system can minimize utility bills and provide an excellent backup system in the event that a section of the local power grid should fail.

Along with homes, health care facilities are becoming increasingly open to the idea of solar energy as a source of power in an emergency situation. This would allow a hospital to continue functioning even if the power failed for some reason and a backup generator system was unable to meet the current demand for power.

Energy from the Sun
About half the incoming solar energy reaches the Earth's surface.

The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet.

Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti-cyclones. Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14 °C. By photosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived.

**Yearly Solar fluxes & Human Energy Consumption**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>3,850,000 EJ</td>
</tr>
<tr>
<td>Wind</td>
<td>2,250 EJ</td>
</tr>
<tr>
<td>Biomass</td>
<td>3,000 EJ</td>
</tr>
<tr>
<td>Primary energy use (2005)</td>
<td>487 EJ</td>
</tr>
<tr>
<td>Electricity (2005)</td>
<td>56.7 EJ</td>
</tr>
</tbody>
</table>

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

From the table of resources it would appear that solar, wind or biomass would be sufficient to supply all of our energy needs, however, the increased use of biomass has had a negative effect on global warming and dramatically increased food prices by diverting forests and crops into biofuel production. As intermittent resources, solar and wind raise other issues.

Solar energy can be harnessed in different levels around the world. Depending on a geographical location the closer to the equator the more "potential" solar energy is available.
Applications of solar technology

Average insolation showing land area (small black dots) required to replace the world primary energy supply with solar electricity. 18 TW is 568 Exajoule (EJ) per year. Insolation for most people is from 150 to 300 W/m² or 3.5 to 7.0 kWh/m²/day.

Solar energy refers primarily to the use of solar radiation for practical ends. However, all renewable energies, other than geothermal and tidal, derive their energy from the sun.

Solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

**SOLAR COOKER**

A solar oven or solar cooker is a device which uses sunlight as its energy source. Because they use no fuel and they cost nothing to run, humanitarian organizations are promoting their use worldwide to help slow deforestation and desertification, caused by using wood as fuel for cooking. Solar cookers are a form of outdoor cooking and are often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high.
There are a variety of types of solar cookers: over 65 major designs and hundreds of variations of them. The basic principles of all solar cookers are:

- **Concentrating sunlight**: Some device, usually a mirror or some type of reflective metal, is used to concentrate light and heat from the sun into a small cooking area, making the energy more concentrated and therefore more potent.
- **Converting light to heat**: Any black on the inside of a solar cooker, as well as certain materials for pots, will improve the effectiveness of turning light into heat. A black pan will absorb almost all of the sun's light and turn it into heat, substantially improving the effectiveness of the cooker. Also, the better a pan conducts heat, the faster the oven will work.
- **Trapping heat**: Isolating the air inside the cooker from the air outside the cooker makes an important difference. Using a clear solid, like a plastic bag or a glass cover, will allow light to enter, but once the light is absorbed and converted to heat, a plastic bag or glass cover will trap the heat inside. This makes it possible to reach similar temperatures on cold and windy days as on hot days.

**Box cookers**

Global Sun Oven
Insulator for the solar box cooker has to be able to withstand temperatures up to 150°C (300 °F) without melting or off-gassing. Crumpled newspapers, wool, rags, dry grass, sheets of cardboard, etc. can be used to insulate the walls of the cooker, but since most of the heat escapes through the top glass or plastic, very little insulation in the walls is necessary. The transparent top is either glass, which is durable but hard to work with, or an oven cooking bag, which is lighter, cheaper, and easier to work with, but less durable. If dark pots and/or bottom trays cannot be located, these can be darkened either with flat-black spray paint (one that is non-toxic when warmed), black tempera paint, or soot from a fire.

The solar box cooker typically reaches a temperature of 150 °C (300 °F). This is not as hot as a standard oven, but still hot enough to cook food over a somewhat longer period of time. Food containing a lot of moisture cannot get much hotter than 100 °C (212 °F) in any case, so it is not always necessary to cook at the high temperatures indicated in standard cookbooks. Because the food does not reach too high a temperature, it can be safely left in the cooker all day without burning. It is best to start cooking before noon, though. Depending on the latitude and weather, food can be cooked either early or later in the day. The cooker can be used to warm food and drinks and can also be used to pasteurize water or milk. If you use an indoor stove for your actual cooking, you can save significant fuel by using the solar cooker to preheat the water to be used for cooking grains, soups, etc., to nearly boiling.

Solar box cookers can be made of locally available materials or be manufactured in a factory for sale. They range from small cardboard devices, suitable for cooking a single meal when the sun is shining, to wood and glass boxes built into the sunny side of a house. Although invented by Horace de Saussure, a Swiss naturalist, as early as 1767, solar box cookers have only gained popularity since the 1970s. These surprisingly simple and useful appliances are seen in growing numbers in almost every country of the world. An index of detailed wiki pages for each country can be found here.

**Panel cookers**

Panel solar cookers are very inexpensive solar cookers that use reflective panels to direct sunlight to a cooking pot that is enclosed in a clear plastic bag. A common model is the CooKit. Developed in 1994 by Solar Cookers International, it is often produced locally by pasting a reflective material, such as aluminum foil, onto a cut and folded backing, usually corrugated cardboard. It is lightweight and folds for storage. When completely unfolded, it measures about three feet by four feet (1 m by 1.3 m). Using materials purchased in bulk, the typical cost is about US$5. However, CooKits can also be made entirely from reclaimed materials, including used cardboard boxes and foil from the inside of cigarette boxes.

The CooKit is considered a low-to-moderate temperature solar cooker, easily reaching temperatures high enough to pasteurize water or cook grains such as rice. On a sunny day, one
CooKit can collect enough solar energy to cook rice, meat or vegetables to feed a family with up to three or four children. Larger families use two or more cookers.

The HotPot cooking vessel consists of a dark pot suspended inside a clear pot with a lid.

To use a panel cooker, it is folded into a bowl shape. Food is placed in a dark-colored pot, covered with a tightly fitted lid. The pot is placed in a clear plastic bag and tied, clipped, or folded shut. The panel cooker is placed in direct sunlight until the food is cooked, which usually requires several hours for a full family-sized meal. For faster cooking, the pot can be raised on sticks or wires to allow the heated air to circulate underneath it.

A recent development is the HotPot developed by US NGO Solar Household Energy, Inc. The cooking vessel in this cooker is a large clear pot with a clear lid into which a dark pot is suspended. This design has the advantage of very even heating since the sun is able to shine onto the sides and the bottom of the pot during cooking. An added advantage is that the clear lid allows the food to be observed while it is cooking without removing the lid. The HotPot provides an alternative to using plastic bags in a panel cooker.

Solar kettles

Solar kettles are solar thermal devices that can heat water to boiling point through the reliance on solar energy alone. Some of them use evacuated solar glass tube technology to capture, accumulate and store solar energy needed to power the kettle. Besides heating liquids, since the stagnating temperature of solar vacuum glass tubes is a high 220 °C (425 °F), solar kettles can also deliver dry heat and function as ovens and autoclaves. Moreover, since solar vacuum glass tubes work on accumulated rather than concentrated solar thermal energy, solar kettles only need diffused sunlight to work and needs no sun tracking at all. If solar kettles use solar vacuum tubes
technologies, the vacuum insulating properties will keep previously heated water hot throughout the night e.g. the SK-TF.

**SOLAR WATER HEATER**

**Solar water heating** (SWH) systems comprise several innovations and many mature renewable energy (or SHW Solar Hot Water) technologies which have been accepted in most countries for many years. SWH has been widely used in Greece, Turkey, Israel, Australia, Japan, Austria and China.

In a "close-coupled" SWH system the storage tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank through thermosiphon flow. In a "pump-circulated" system the storage tank is ground or floor mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collectors.

SWH systems are designed to deliver the optimum amount of hot water for most of the year. However, in winter there sometimes may not be sufficient solar heat gain to deliver sufficient hot water. In this case a gas or electric booster is normally used to heat the water.

**Overview**

Hot water heated by the sun is used in many ways. While perhaps best known in a residential setting to provide hot domestic water, solar hot water also has industrial applications, e.g. to generate electricity [1]. Designs suitable for hot climates can be much simpler and cheaper, and can be considered an appropriate technology for these places. The global solar thermal market is dominated by China, Europe, Japan and India.

![Solar Water Heater](image)

A solar hot water heater installed on a house in Belgium
In order to heat water using solar energy, a collector, often fastened to a roof or a wall facing the sun, heats **working fluid** that is either pumped (active system) or driven by **natural convection** (passive system) through it. The collector could be made of a simple glass topped insulated box with a flat solar absorber made of sheet metal attached to copper pipes and painted black, or a set of metal tubes surrounded by an evacuated (near vacuum) glass cylinder. In industrial cases a parabolic mirror can concentrate sunlight on the tube. Heat is stored in a hot water storage tank. The volume of this tank needs to be larger with solar heating systems in order to allow for bad weather, and because the optimum final temperature for the solar collector is lower than a typical immersion or combustion heater. The heat transfer fluid (HTF) for the absorber may be the hot water from the tank, but more commonly (at least in active systems) is a separate loop of fluid containing **anti-freeze** and a **corrosion inhibitor** which delivers heat to the tank through a **heat exchanger** (commonly a coil of copper tubing within the tank). Another lower-maintenance concept is the 'drain-back': no anti-freeze is required; instead all the piping is sloped to cause water to drain back to the tank. The tank is not pressurized and is open to atmospheric pressure. As soon as the pump shuts off, flow reverses and the pipes are empty before freezing could occur.

**Types of Solar Water Heating (SWH) systems**

The type and complexity of a solar water heating system is mostly determined by:

- The changes in ambient temperature during the day-night cycle.
- Changes in ambient temperature and solar radiation between summer and winter.
- The temperature of the water required from the system.

The minimum efficiency of the system is determined by the amount or temperature of hot water required during winter (when the largest amount of hot water is often required). The maximum efficiency of the system is determined by the need to prevent the water in the system from becoming too hot (to boil, in an extreme case). There are two main categories of solar water heating systems. Passive systems rely on convection or heat pipes to circulate water or heating fluid in the system, while active systems use a pump. In addition, there are a number of other system characteristics that distinguish different designs:

- The type of collector used (see below)
- The location of the collector - roof mount, ground mount, wall mount
- The location of the storage tank in relation to the collector
- The method of **heat transfer** - open-loop or closed-loop (via heat exchanger)
- **Photovoltaic thermal hybrid solar collectors** can be designed to produce both hot water and electricity.
Passive systems

An integrated collector storage (ICS) system

A special type of passive system is the **Integrated Collector Storage** (ICS or Batch Heater) where the tank acts as both storage and solar collector. Batch heaters are basically thin rectilinear tanks with glass in front of it generally in or on house wall or roof. They are seldom pressurised and usually depend on gravity flow to deliver their water. They are simple, efficient and less costly than plate and tube collectors but are only suitable in moderate climates with good sunshine.

A step up from the ICS is the **Convection Heat Storage unit** (CHS or thermosiphon). These are often plate type or evacuated tube collectors with built-in insulated tanks. The unit uses convection (movement of hot water upward) to move the water from collector to tank. Neither pumps nor electricity are used to enforce circulation. It is more efficient than an ICS as the collector heats a small(er) amount of water that constantly rises back to the tank. It can be used in areas with less sunshine than the ICS. An CHS also known as a compact system or monobloc has a tank for the heated water and a solar collector mounted on the same chassis. Typically these systems will function by natural convection or heat pipes to transfer the heat energy from the collector to the tank.
Direct systems: (A) Passive CHS system with tank above collector. (B) Active system with pump and controller driven by a photovoltaic panel

Direct ('open loop') passive systems use water from the main household water supply to circulate between the collector and the storage tank. When the water in the collector becomes warm, convection causes it to rise and flow towards the water storage tank. They are often not suitable for cold climates since, at night, the water in the collector can freeze and damage the panels.

Indirect ('closed loop') passive systems use a non-toxic antifreeze heat transfer fluid (HTF) in the collector. When this fluid is heated, convection causes it to flow to the tank where a passive heat exchanger transfers the heat of the HTF to the water in the tank.

The attraction of passive solar water heating systems lies in their simplicity. There are no mechanical or electrical parts that can break or that require regular supervision or maintenance. Consequently the maintenance of a passive system is simple and cheap. The efficiency of a passive system is often somewhat lower than that of an active system and overheating is largely avoided by the inherent design of a passive system.

Active systems

Indirect active systems: (C) Indirect system with heat exchanger in tank; (D) Drainback system with drainback reservoir. In these schematics the controller and pump are driven by mains electricity
Active solar hot water systems employ a pump to circulate water or HTF between the collector and the storage tank. Like their passive counterparts, active solar water heating systems come as two types: direct active systems pump water directly to the collector and back to the storage tank (direct collectors can contain conventional freeze-vulnerable metal pipes or low pressure freeze-tolerant silicone rubber pipes), indirect active systems which are usually made of metals pump heat transfer fluid (HTF), the heat of which is transferred to the water in the storage tank. Because the pump should only operate when the fluid in the collector is hotter than the water in the storage tank, a controller is required to turn the pump on and off. The use of an electronically controlled pump has several advantages:

- The storage tank can be situated lower than the collectors. In passive systems the storage tank must be located above the collector so that the thermosiphon effect can transport water or HTF from collector to tank. The use of a pump allows the storage tank to be located lower than the collector since the circulation of water or HTF is enforced by the pump. A pumped system allows the storage tank to be located out of sight.

- Because of the fact that active systems allow freedom in the location of the storage tank, the tank can be located where heat loss from the tank is reduced, e.g. inside the roof of a house. This increases the efficiency of the solar water heating system.

- New active solar water heating systems can make use of an existing warm water storage tanks ("geysers"), thus avoiding duplication of equipment.

- Reducing the risk of overheating. If no water from the solar hot water system is used (e.g. when water users are away), the water in the storage tank is likely to overheat. Several pump controllers avoid overheating by activating the pump during the day at during times of low sunlight, or at night. This pumps hot water or HTF from the storage tank through the collector (which can be cool in low light levels), thus cooling the water in the storage tank.

- Reducing the risk of freezing. For direct active systems in cold weather, where freeze tolerant collectors or drain down approaches are not used, the pump controller can pump hot water from the water storage tank through the collector in order to prevent the water in the collector from freezing, thus avoiding damage to the metal parts of the system.

**Geothermal energy**

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is energy that determines the temperature of matter. Earth's geothermal energy originates from the
original formation of the planet, from radioactive decay of minerals, from volcanic activity, and from solar energy absorbed at the surface. The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.

From hot springs, geothermal energy has been used for bathing since Paleolithic times and for space heating since ancient Roman times, but it is now better known for electricity generation. Worldwide, about 10,715 megawatts (MW) of geothermal power is online in 24 countries. An additional 28 gigawatts of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications.

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels.

The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, and interest rates.

The Earth's internal thermal energy flows to the surface by conduction at a rate of 44.2 terawatts (TW), and is replenished by radioactive decay of minerals at a rate of 30 TW. These power rates are more than double humanity's current energy consumption from all primary sources, but most of this energy flow is not recoverable. In addition to the internal heat flows, the top layer of the surface to a depth of 10 meters (33 ft) is heated by solar energy during the summer, and releases that energy and cools during the winter.

Outside of the seasonal variations, the geothermal gradient of temperatures through the crust is 25–30 °C (45–54 °F) per kilometer of depth in most of the world. The conductive heat flux averages 0.1 MW/km². These values are much higher near tectonic plate boundaries where the crust is thinner. They may be further augmented by fluid circulation, either through magma conduits, hot springs, hydrothermal circulation or a combination of these.

A geothermal heat pump can extract enough heat from shallow ground anywhere in the world to provide home heating, but industrial applications need the higher temperatures of deep resources. The thermal efficiency and profitability of electricity generation is particularly sensitive to temperature. The more demanding applications receive the greatest benefit from a high natural
heat flux, ideally from using a hot spring. The next best option is to drill a well into a hot aquifer. If no adequate aquifer is available, an artificial one may be built by injecting water to hydraulically fracture the bedrock. This last approach is called hot dry rock geothermal energy in Europe, or enhanced geothermal systems in North America. Much greater potential may be available from this approach than from conventional tapping of natural aquifers.

Estimates of the potential for electricity generation from geothermal energy vary sixfold, from .035 to 2 TW depending on the scale of investments. Upper estimates of geothermal resources assume enhanced geothermal wells as deep as 10 kilometres (6 mi), whereas existing geothermal wells are rarely more than 3 kilometres (2 mi) deep. Wells of this depth are now common in the petroleum industry. The deepest research well in the world, the Kola superdeep borehole, is 12 kilometres (7 mi) deep. This record has recently been imitated by commercial oil wells, such as Exxon's Z-12 well in the Chayvo field, Sakhalin.

**Difference between a Renewable & Nonrenewable Resource**

There are two types of sources of energy in the world: renewable energy sources and non-renewable energy sources. Renewable energy sources include solar energy, biomass energy, wind energy, tidal energy, hydro energy, and geothermal energy. Non-renewable energy sources include oil, coal, natural gas, and nuclear energy.

Renewable energy sources are generated directly from nature, like the sun, rain, wind, tides, and it is possible to generate it over and over whenever it is needed. Renewable energy sources are abundant and are definitely the cleanest energy sources in Earth. For instance, it is possible to utilize the energy we get from the sun in order to generate electricity. Geothermal, wind, tides, and biomass energy from plants can also be used in different forms.

Most energy that is used in the world today is generated from non-renewable energy sources. These energy sources can be re-generated over a short period of time. Natural gas and oil are derived from ancient plant or animal remains or fossils. These remains are what we have been left with after millions of years of fluctuation in pressure and temperature.

There are pros and cons to using both renewable energy sources and non-renewable energy sources. First let’s look at renewable energy. The obvious advantages of it is that wind, sun, ocean, and geothermal energy is in abundance and completely free of charge. Secondly, renewable energy sources have very low or zero carbon emissions, so they are environmentally friendly. Thirdly, it isn’t necessary to rely on any country to supply renewable energy sources, unlike its non-renewable counterparts.
However, things are not all so rosy with renewable energy sources. First of all, it is quite difficult set-up to get any of these sources to generate energy, and the starting costs can be astronomical. As in the case of solar energy, it can only be generated during the day, which completely excludes night-time and the rainy season. And to utilize wind energy, you have to depend on strong winds, so choosing the right place for the set-up can be challenging.

Renewable resources

Renewable resources are resources that can be continually reproduced in a short amount of time, while nonrenewable resources cannot. In the mid-1800s, wood supplied up to 90 percent of the United States' energy needs, but as of 2009, most American energy is produced from nonrenewable resources like fossil fuels.

Basics of Renewable Resources

  o The most commonly used renewable resources in the United States as of 2008, according to the U.S. Energy Information Administration, are biomass, hydro power and energy generated from geothermal, wind and solar sources. Biomass is organic material from plants and animals that contains the stored energy of the sun; wood, manure and certain types of garbage are examples of biomass fuels. Hydro power comes from harnessing the energy of water; geothermal power stems from heat sources deep within the Earth, and solar power uses the sun's energy.

Use of Renewable vs. Nonrenewable Resources

  o Only 7 percent of the United States' energy came from renewable energy resources in 2008. That means 93 percent of the energy used in the U.S. was from nonrenewable sources. Half of renewable energy resources go to producing electricity, though they have the capability of being used for a wide variety of purposes--such as fueling vehicles with biodiesel. Nonrenewable resources produce over 90 percent of electricity and fuel most vehicles on the roads as of 2010.

Barriers to Using Renewable Energy Resources

  o The sun alone provides enough energy for the world in just 40 minutes--if the appropriate technologies were produced. However, before the early 21st century price increases on nonrenewable resources--like oil, nonrenewable resources were generally less expensive to use. That is becoming less true as of 2010. Other barriers to using renewable energy resources before 2010 included mass production of technology that could compensate for
environmental factors--such as cloudy days when using solar panels or non-windy days when using wind turbines. The U.S. Energy Information Administration expects use of renewable resources to increase in the 21st century.

Controversy Surrounding the Term "Renewable"

- There is some controversy surrounding the use of the term "renewable." Wood, for instance, is considered renewable, as the trees used to produce wood fuel can be regrown--some in a few years. However, this depends on refraining from using certain practices that are still employed today--such as clear-cutting, which destroys a forest's ecosystem.

**Nonrenewable Resources**

- Nonrenewable resources originate beneath the surface of the Earth and are liquids, solids or gases in their raw forms. The most commonly used nonrenewable resources as of 2008, according to the U.S. Energy Information Administration, are oil and petroleum products--like gasoline, diesel fuel and propane--natural gas, coal and uranium, the last of which supplies nuclear power plants. Fossil fuels are types of nonrenewable resources formed from plant and animal remains buried millions of years ago and turned into products like petroleum (oil). Other fossil fuels include coal, natural gas and propane.

2. The obvious advantage of non-renewable energy sources is that they are ready, cheap, and easy to use. It is also cheap to convert one non-renewable energy type to another. However, a major disadvantage of non-renewable energy sources is that they are finite and will expire some time in the future. This will make the prices of these energy sources increase dramatically. They also cause severe environmental changes and are in a large way responsible for climate change and global warming. Non-renewable energy sources can have a serious impact on human health, as they are certainly not environmentally friendly.

**What are the conventional and non-conventional sources of renewable energy?**

**Conventional**: Energy that has been used from ancient times is known as conventional energy. Coal, natural gas, oil, and firewood are examples of conventional energy sources. (or usual) sources of energy (electricity) are coal, oil, wood, peat, uranium.

**Non-conventional** (or unusual) sources of energy include:
- Solar power
- Hydro-electric power (dams in rivers)
- Wind power
• Tidal power
• Ocean wave power
• Geothermal power (heat from deep under the ground)
• Ocean thermal power (the difference in heat between shallow and deep water)
• Biomass (burning of vegetation to stop it producing methane)
• Biofuel (producing ethanol (petroleum) from plants)

We hope that all the conventional sources will become rare, endangered and extinct, as they produce lots of carbon dioxide that adds to the greenhouse effect in the atmosphere (uranium leaves different dangerous byproducts).

And we similarly hope that all the non-conventional sources will become conventional, common, and every day, as they are all free, green and emit no carbon dioxide (well, biomass does, but it prevents the production of methane which is a greenhouse gas 21 times more dangerous that CO2).

Brief description of non-conventional energy resources:

**Solar Energy:**

Most of the renewable energy is ultimately “Solar energy” that is directly collected from sunlight. Energy is released by the Sun as electromagnetic waves. The energy reaching earth’s atmosphere consists of about:
• 8% UV radiation
• 46% visible light
• 46% infrared radiations

Solar energy storage is as per figure below:

![Solar Energy Storage Diagram](image)

Solar Energy can be used in two ways:
• Solar heating
• Solar electricity
Solar Heating is to capture/concentrate sun’s energy for heating buildings and for cooking/heating foodstuffs etc. solar electricity is mainly produced by using photovoltaic solar cells which is made of semi conducting materials that directly converts sunlight into electricity. Obviously the Sun doesn’t provide constant energy at any spot on the Earth, so it’s use is limited. Therefore often Solar cells are used to charge batteries which are used either as secondary energy source or for other applications of intermittent use such as night lightening or water pumping etc. A solar power plant offers good option for electrification of disadvantageous locations such as hilly regions, forests, deserts and islands where other resources are neither available nor exploitable in techno economically viable manner.

Wind Energy:

The origin for Wind Energy is Sun. When sun ray falls on the earth, it’s surface gets heated up and as a consequence unevenly winds are formed. Kinetic energy in the wind can be used to run wind turbines but the output power depends upon the wind speed. Turbines generally require a wind in the range of 20km/hr. In practice relatively few land areas have significantly prevailing winds. Otherwise wind power is one of the most cost competitive renewable energy today and this has been the most rapidly-growing means of electricity generation at the turn of 21st century and provides a complement to a large scale base load power stations. Its long term technical potential is believed to be 5 times current global energy consumption or 40 times current electricity demand.

Water Power

Energy in the water can be harnessed and used in the form of motive energy or temperature difference. Since water is about 1000 times heavier than air, even a slow flowing stream of water can yield great amount of energy.

There are many forms:

- Hydroelectric energy, a term usually reserved for hydroelectric dam
- Tidal power, which captures energy from the tides in horizontal direction. Tides come in, raise water levels in a basin, and tides roll out. The water is made to pass through turbine to get out of the basin. Power generation through this method has a varying degree of success.
- Wave power, which uses energy in waves. The waves will usually make large pontoons go up and down in the water. The wave power is also hard to tap.

Biomass

Solid biomass

Plants use photosynthesis to store solar energy in the form of chemical energy. The easiest way to release this energy is by burning the dried up plants. Solid biomass such as firewood or combustible field crops including dried manure is usually burnt to heat water and to drive turbines. Field crops may be grown specifically for combustion or may be for other purposes and the processed plant waste then used for combustion. Most sort of biomass including sugarcane residue, wheat chaff, corn cobs and other plant matter can be, and is, burnt quiet successfully. Currently biomass contributes 15% of total energy supply world wide.
A drawback is that all these biomass needs to go through some of these steps: It needs to be grown, collected, dried and fermented and burned. All of these steps require resources and an infrastructure.

**Bio-fuel**

Bio-fuel is any fuel that derives from biomass—recently living organisms or their metabolic byproducts, such as manure from cows. Typically bio-fuel is burnt to release its stored chemical energy. Biomass, can be directly used as fuel or to produce liquid biofuel. Agriculturally produced biomass fuels, such as biodiesel, ethanol and bagasse (often byproduct of sugarcane cultivation) can be burnt in internal combustion engines or boilers.

**Biogas**

Biogas can easily be produced from current waste streams, such as paper production, sugarcane production, sewage, animal waste and so forth. The various waste streams have to be slurried together and allowed to naturally ferment, producing 55% to 70% inflammable methane gas. Biogas production has the capacity to provide us with about half of our energy needs, either burned for electrical productions or piped into current gas line for use. This has to be done and made a priority. The payback period of biogas is around 2-3 years, rather in case of community and institutional Biogas plant is even less. Therefore biogas electrification at community level is required to be implemented.

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**WIND ENERGY**

Wind energy is the kinetic energy associated with the movement of atmospheric air. It has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert this kinetic energy to more useful forms of power. Wind energy systems for irrigation and milling have been in use since ancient times and since the beginning of the 20th century it is being used to generate electric power. Windmills for water pumping have been installed in many countries particularly in the rural areas.

Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding etc. or further converting to electric power to generate electricity. Wind turbines can be used singly or in clusters called ‘wind farms’. Small wind turbines called aero-generators can be used to charge large batteries.

Five nations – Germany, USA, Denmark, Spain and India – account for 80% of the world’s installed wind energy capacity. Wind energy continues to be the fastest growing renewable energy source with worldwide wind power installed capacity reaching 14,000 MW.
Realizing the growing importance of wind energy, manufacturers have steadily been increasing the unit size of the wind electric generators since the late 1980s. Another important development has been the offshore (i.e. in the sea) wind farms in some regions of Europe, which have several advantages over the on-shore ones. The third major development has been the use of new techniques to assess the wind resource for techno-commercial viability.

**Form of Energy:** Kinetic energy

**This energy is used for:**
Sailing ships, Pumping water/Irrigation, Grinding Grains, Power generation

**Some of the gadgets and other devices:** Sails, Windmills, Wind turbines

In India the states of Tamilnadu and Gujarat lead in the field of wind energy. At the end of March 2000 India had 1080-MWs capacity wind farms, of which Tamilnadu contributed 770-MW capacity. Gujarat has 167MW followed by Andhra Pradesh, which has 88 MW installed wind farms. There are about a dozen wind pumps of various designs providing water for agriculture, afforestation, and domestic purposes, all scattered over the country.

The design of the Auroville multi-blade windmill has evolved from the practical experience gained in operating these mills over a period of 20 years or so. It has a high tripod tower and its double-action pump increases water output by about 60% compared to the conventional single-action pumps.

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**NUCLEAR ENERGY**

*The sun and stars are seemingly inexhaustible sources of energy. That energy is the result of nuclear reactions, in which matter is converted to energy. We have been able to harness that mechanism and regularly use it to generate power. Presently, nuclear energy provides for approximately 16% of the world's electricity. Unlike the stars, the nuclear reactors that we have today work on the principle of nuclear fission. Scientists are working like madmen to make fusion reactors which have the potential of providing more energy with fewer disadvantages than fission reactors.*

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**Production**

Changes can occur in the structure of the nuclei of atoms. These changes are called nuclear reactions. Energy created in a nuclear reaction is called nuclear energy, or atomic energy.
Nuclear energy is produced naturally and in man-made operations under human control.

**Naturally:** Some nuclear energy is produced naturally. For example, the Sun and other stars make heat and light by nuclear reactions.

**Man-Made:** Nuclear energy can be man-made too. Machines called nuclear reactors, parts of nuclear power plants, provide electricity for many cities. Man-made nuclear reactions also occur in the explosion of atomic and hydrogen bombs.

Nuclear energy is produced in two different ways, in one, large nuclei are split to release energy. In the other method, small nuclei are combined to release energy.

For a more detailed look at nuclear fission and nuclear fusion, consult the nuclear physics page.

**Nuclear Fission:** In nuclear fission, the nuclei of atoms are split, causing energy to be released. The atomic bomb and nuclear reactors work by fission. The element uranium is the main fuel used to undergo nuclear fission to produce energy since it has many favorable properties. Uranium nuclei can be easily split by shooting neutrons at them. Also, once a uranium nucleus is split, multiple neutrons are released which are used to split other uranium nuclei. This phenomenon is known as a chain reaction.

![Fission of uranium 235 nucleus](image)

**Fission of uranium 235 nucleus.** Adapted from *Nuclear Energy. Nuclear Waste*

**Nuclear Fusion:** In nuclear fusion, the nuclei of atoms are joined together, or fused. This happens only under very hot conditions. The Sun, like all other stars, creates heat and light through nuclear fusion. In the Sun, hydrogen nuclei fuse to make helium. The hydrogen bomb, humanity's most powerful and destructive weapon, also works by fusion. The heat required to start the fusion reaction is so great that an atomic bomb is used to provide it. Hydrogen nuclei fuse to form helium and in the process release huge amounts of energy thus producing a huge explosion.

**Milestones in the History of Nuclear Energy**

Amore in depth and detailed history of nuclear energy is on the nuclear past page.
December 2, 1942: The Nuclear Age began at the University of Chicago when Enrico Fermi made a chain reaction in a pile of uranium.

August 6, 1945: The United States dropped an atomic bomb on Hiroshima, Japan, killing over 100,000.

August 9, 1945: The United States dropped an atomic bomb on Nagasaki, Japan, killing over 40,000.

November 1, 1952: The first large version of the hydrogen bomb (thousands of times more powerful than the atomic bomb) was exploded by the United States for testing purposes.

February 21, 1956: The first major nuclear power plant opened in England.

**Advantages of Nuclear Energy**

The Earth has limited supplies of coal and oil. Nuclear power plants could still produce electricity after coal and oil become scarce.

Nuclear power plants need less fuel than ones which burn fossil fuels. One ton of uranium produces more energy than is produced by several million tons of coal or several million barrels of oil.

Coal and oil burning plants pollute the air. Well-operated nuclear power plants do not release contaminants into the environment.

**Disadvantages of Nuclear Energy**

The nations of the world now have more than enough nuclear bombs to kill every person on Earth. The two most powerful nations -- Russia and the United States -- have about 50,000 nuclear weapons between them. What if there were to be a nuclear war? What if terrorists got their hands on nuclear weapons? Or what if nuclear weapons were launched by accident?

Nuclear explosions produce radiation. The nuclear radiation harms the cells of the body which can make people sick or even kill them. Illness can strike people years after their exposure to nuclear radiation.

One possible type of reactor disaster is known as a meltdown. In such an accident, the fission reaction goes out of control, leading to a nuclear explosion and the emission of great amounts of radiation.

**The Future of Nuclear Energy**
Some people think that nuclear energy is here to stay and we must learn to live with it. Others say that we should get rid of all nuclear weapons and power plants. Both sides have their cases as there are advantages and disadvantages to nuclear energy. Still others have opinions that fall somewhere in between.

What do you think we should do? After reviewing the pros and cons, it is up to you to formulate your own opinion. Read more about the politics of the issues or go to the forum to share your own opinions and see what others think.

**DENDROTHERMAL ENERGY**

Dendrothermal energy is the conversion of wood (by burning) to electricity.

divided, well, we know that "thermal" is heat (like the thermal blankets, that hold in your body's heat to keep you so warm!)

"dendro" comes from the Greek word "dendron," meaning tree.

Below I listed some things I found in different websites about dendrothermal energy. I listed the sources numerically below.

1) “Dendrothermal systems” are an example of a direct combustion system using woodfuels, wherein power generation plants are integrated with dedicated fuelwood tree plantations. These have been shown to be technically feasible, but their economic and commercial viability remains in doubt.

2) Woodfuels could offer an alternative to power stations using fossil fuels in some areas. Advantages in terms of cost and environmental impacts certainly exist under some circumstances - especially where adequate and economic supplies of biomass are available. Within the region, the Philippines attempted a national-scale dendrothermal electricity programme in the 1980s. The programme was largely unsuccessful due to, among other things, to a lack of cost-effective wood supplies.

3) This one seems to be very well put, but I will just give you the reference page (listed below) Scroll down on this page for the section on "Electricity from wood"
BIOMASS ENERGY

Biomass, a renewable energy source, is biological material from living, or recently living organisms, such as wood, waste, (hydrogen) gas, and alcohol fuels. Biomass is commonly plant matter grown to generate electricity or produce heat. In this sense, living biomass can also be included, as plants can also generate electricity while still alive. The most conventional way in which biomass is used, however, still relies on direct incineration. Forest residues, for example (such as dead trees, branches and tree stumps), yard clippings, wood chips and garbage are often used for this. However, biomass also includes plant or animal matter used for production of fibers or chemicals. Biomass may also include biodegradable wastes that can be burnt as fuel. It excludes such organic materials as fossil fuels, which have been transformed by geological processes into substances such as coal or petroleum.

Industrial biomass can be grown from numerous types of plants, including miscanthus, switchgrass, hemp, corn, poplar, willow, sorghum, sugarcane, and a variety of tree species, ranging from eucalyptus to oil palm (palm oil). The particular plant used is usually not important to the end products, but it does affect the processing of the raw material.

Although fossil fuels have their origin in ancient biomass, they are not considered biomass by the generally accepted definition because they contain carbon that has been "out" of the carbon cycle for a very long time. Their combustion therefore disturbs the carbon dioxide content in the atmosphere.

Biomass sources

Biomass energy is derived from five distinct energy sources: garbage, wood, waste, landfill gases, and alcohol fuels. Wood energy is derived both from direct use of harvested wood as a fuel and from wood waste streams. The largest source of energy from wood is pulping liquor or "black liquor," a waste product from processes of the pulp, paper and paperboard industry. Waste energy is the second-largest source of biomass energy. The main contributors of waste
energy are municipal solid waste (MSW), manufacturing waste, and landfill gas. Biomass alcohol fuel, or ethanol, is derived primarily from sugarcane and corn. It can be used directly as a fuel or as an additive to gasoline.

Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotting garbage, and agricultural and human waste, release methane gas - also called "landfill gas" or "biogas." Crops like corn and sugar cane can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats. Also, Biomass to liquids (BTLs) and cellulosic ethanol are still under research.

**HYDROELECTRICITY**

**Hydroelectricity** is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide (CO₂) than fossil fuel powered energy plants. Worldwide, an installed capacity of 777 GWe supplied 2998 TWh of hydroelectricity in 2006. This was approximately 20% of the world's electricity,  

**Generating methods**

#### Conventional (dams)

Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. The power extracted from the water depends on the volume and on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is proportional to the head. A large pipe (the "penstock") delivers water to the turbine.

**Pumped-storage**

This method produces electricity to supply high peak demands by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine. Pumped-storage schemes currently provide the most commercially important means of large-scale grid energy storage and improve the daily capacity factor of the generation system.

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**Run-of-the-river**

Run-of-the-river hydroelectric stations are those with small or no reservoir capacity, so that the water coming from upstream must be used for generation at that moment, or must be allowed to bypass the dam.

**Tide**

A tidal power plant makes use of the daily rise and fall of ocean water due to tides; such sources are highly predictable, and if conditions permit construction of reservoirs, can also be dispatchable to generate power during high demand periods. Less common types of hydro schemes use water's kinetic energy or undammed sources such as undershot waterwheels.

**Underground**

An underground power station makes use of a large natural height difference between two waterways, such as a waterfall or mountain lake. An underground tunnel is constructed to take water from the high reservoir to the generating hall built in an underground cavern near the lowest point of the water tunnel and a horizontal tailrace taking water away to the lower outlet waterway.

**FOSSIL FUELS**

Fossil fuels are fuels formed by natural resources such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. The fossil fuels, which contain high percentages of carbon, include coal, petroleum, and natural gas. Fossil fuels range from volatile materials with low carbon:hydrogen ratios like methane, to liquid petroleum to nonvolatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields, alone, associated with oil, or in the form of methane clathrates. It is generally accepted that they formed from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust over millions of years. This biogenic theory was first introduced by Georg Agricola in 1556 and later by Mikhail Lomonosov in the 18th century.

It was estimated by the Energy Information Administration that in 2007 primary sources of energy consisted of petroleum 36.0%, coal 27.4%, natural gas 23.0%, amounting to an 86.4% share for fossil fuels in primary energy consumption in the world. Non-fossil sources in 2006 included hydroelectric 6.3%, nuclear 8.5%, and others (geothermal, solar, tide, wind, wood, waste) amounting to 0.9 percent. World energy consumption was growing about 2.3% per year.
Fossil fuels are **non-renewable resources** because they take millions of years to form, and reserves are being depleted much faster than new ones are being made. The production and use of fossil fuels raise environmental concerns. A global movement toward the generation of **renewable energy** is therefore under way to help meet increased energy needs.

The burning of fossil fuels produces around 21.3 billion **tonnes** (21.3 **gigatonnes**) of **carbon dioxide** (CO₂) per year, but it is estimated that natural processes can only absorb about half of that amount, so there is a net increase of 10.65 billion tonnes of atmospheric carbon dioxide per year (one tonne of atmospheric carbon is equivalent to 44/12 or 3.7 tonnes of carbon dioxide). Carbon dioxide is one of the **greenhouse gases** that enhances **radiative forcing** and contributes to **global warming**, causing the **average surface temperature** of the Earth to rise in response, which most climate scientists agree will cause major adverse **effects**.