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**Heat transfer** is a discipline of [thermal engineering](http://en.wikipedia.org/wiki/Thermal_engineering) that concerns the generation, use, conversion, and exchange of [thermal energy](http://en.wikipedia.org/wiki/Thermal_energy) and [heat](http://en.wikipedia.org/wiki/Heat) between physical systems. Heat transfer is classified into various mechanisms, such as [thermal conduction](http://en.wikipedia.org/wiki/Thermal_conduction), [thermal convection](http://en.wikipedia.org/wiki/Convective_heat_transfer), [thermal radiation](http://en.wikipedia.org/wiki/Thermal_radiation), and transfer of energy by [phase changes](http://en.wikipedia.org/wiki/Phase_changes). Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system.

Heat conduction, also called diffusion, is the direct microscopic exchange of kinetic energy of particles through the boundary between two systems. When an object is at a different [temperature](http://en.wikipedia.org/wiki/Temperature) from another body or its surroundings, [heat](http://en.wikipedia.org/wiki/Heat) flows so that the body and the surroundings reach the same temperature, at which point they are in [thermal equilibrium](http://en.wikipedia.org/wiki/Thermal_equilibrium). Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature, as described by the [second law of thermodynamics](http://en.wikipedia.org/wiki/Second_law_of_thermodynamics).

Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter in the fluid. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". All convective processes also move heat partly by diffusion, as well. Another form of convection is forced convection. In this case the fluid is forced to flow by use of a pump, fan or other mechanical means.

Thermal radiation occurs through a [vacuum](http://en.wikipedia.org/wiki/Vacuum) or any [transparent](http://en.wikipedia.org/wiki/Transparency_%28optics%29) [medium](http://en.wikipedia.org/wiki/Optical_medium) ([solid](http://en.wikipedia.org/wiki/Solid) or [fluid](http://en.wikipedia.org/wiki/Fluid)). It is the transfer of energy by means of [photons](http://en.wikipedia.org/wiki/Photons) in[electromagnetic waves](http://en.wikipedia.org/wiki/Electromagnetic_waves) governed by the same laws.[[1]](http://en.wikipedia.org/wiki/Heat_transfer#cite_note-Geankoplis-1)

The most common units for heat are

* *BTU (Btu) - British Thermal Unit*
* *Calorie*
* *Joule*

**BTU - British Thermal Unit**

The unit of heat in the imperial system - the *BTU* - is

* the amount of heat required to raise the temperature of one pound of water through *1oF (58.5oF - 59.5oF)*at sea level *(30 inches of mercury).*
* *1 Btu (British thermal unit) = 1055.06 J = 107.6 kpm = 2.931 10-4 kWh = 0.252 kcal = 778.16 ft.lbf = 1.0551010 ergs = 252 cal = 0.293 watt-hours*

An item using one kilowatt-hour of electricity generates *3412 Btu*.

**Calorie**

A calorie is commonly defined as

* the amount of heat required to raise the temperature of one gram of water *1oC*
* the kilogram calorie, large calorie, food calorie, Calorie (capital C) or just calorie (lowercase c) is the amount of energy required to raise the temperature of one kilogram of water by one degree Celsius
* *1 kcal = 4186.8 J = 426.9 kp.m = 1.163 10-3 kWh = 3.088 ft.lbf = 3.9683 Btu = 1000 cal*

Be aware that alternative definitions exists - in short:

* Thermochemical calorie
* 4 °C calorie
* 15 °C calorie
* 20 °C calorie
* Mean calorie
* International Steam Table calorie (1929)
* International Steam Table calorie (1956)
* IUNS calorie (Committee on Nomenclature of the International Union of Nutritional Sciences)

The calorie is outdated and commonly replaced by the SI-unit Joule.

**Joule**

The unit of heat in the SI-system the Joule is

* a unit of energy equal to the work done when a force of one newton acts through a distance of one meter
* 4.184 joule of heat energy (or one calorie) is required to raise the temperature of a unit weight *(1 g)*of water from *0oC* to*1oC*, or from*32oF to 33.8oF*
* *1 J (Joule) = 0.1020 kpm = 2.778 10-7 kWh = 2.389 10-4 kcal = 0.7376 ft.lbf = 1 kg.m2/s2 = 1 watt second = 1 Nm = 9.478 10-4 Btu*

**Fuels** are any materials that store [potential energy](http://en.wikipedia.org/wiki/Potential_energy) in forms that can be practicably released and used as [heat energy](http://en.wikipedia.org/wiki/Heat_energy). The concept originally applied solely to those materials storing energy in the form of [chemical energy](http://en.wikipedia.org/wiki/Chemical_energy) that could be released through [combustion](http://en.wikipedia.org/wiki/Combustion),[[1]](http://en.wikipedia.org/wiki/Fuel#cite_note-1) but the concept has since been also applied to other sources of heat energy such as [nuclear energy](http://en.wikipedia.org/wiki/Nuclear_energy) (via [nuclear fission](http://en.wikipedia.org/wiki/Nuclear_fission) or [nuclear fusion](http://en.wikipedia.org/wiki/Nuclear_fusion)), as well as releases of chemical energy released through non-combustion [oxidation](http://en.wikipedia.org/wiki/Oxidation) (such as in cellular biology or in [fuel cells](http://en.wikipedia.org/wiki/Fuel_cell)).

The heat energy released by many fuels is harnessed into mechanical energy via an [engine](http://en.wikipedia.org/wiki/Engine). Other times the heat itself is valued for warmth, cooking, or industrial processes, as well as the illumination that comes with combustion. Fuels are also used in the [cells](http://en.wikipedia.org/wiki/Cell_%28biology%29) of [organisms](http://en.wikipedia.org/wiki/Organisms) in a process known as[cellular respiration](http://en.wikipedia.org/wiki/Cellular_respiration), where organic molecules are oxidized to release un-usable energy. [Hydrocarbons](http://en.wikipedia.org/wiki/Hydrocarbons) are by far the most common source of fuel used by humans, but other substances, including radioactive metals, are also utilized.

Fuels are contrasted with other methods of storing potential energy, such as those that directly release [electrical energy](http://en.wikipedia.org/wiki/Electrical_energy) (such as [batteries](http://en.wikipedia.org/wiki/Battery_%28electricity%29) and[capacitors](http://en.wikipedia.org/wiki/Capacitor)) or [mechanical energy](http://en.wikipedia.org/wiki/Mechanical_energy) (such as [flywheels](http://en.wikipedia.org/wiki/Flywheel), springs, compressed air, or water in a reservoir).

## History

The first known use of fuel was the combustion of wood or sticks by [*Homo erectus*](http://en.wikipedia.org/wiki/Homo_erectus) near 2000000 (two million) years ago. Throughout most of human history fuels derived from plants or animal fat were the only ones humans used. [Charcoal](http://en.wikipedia.org/wiki/Charcoal), a wood derivative, has been used since at least 6,000 BCE for melting metals. It was only supplanted by [coke](http://en.wikipedia.org/wiki/Coke_%28fuel%29), derived from coal, as European forests started to become depleted around the 18th century. Charcoal briquettes are now commonly used as a fuel for [barbecue](http://en.wikipedia.org/wiki/Barbecue) cooking.[[3]](http://en.wikipedia.org/wiki/Fuel#cite_note-3)

Coal was first used as a fuel around 1000 BCE in China. With the development of the [steam engine](http://en.wikipedia.org/wiki/Steam_engine) in 1769, coal came into more common use as a power source. Coal was later used to drive ships and locomotives. By the 19 th century, gas extracted from coal was being used for street lighting in [London](http://en.wikipedia.org/wiki/London). In the 20th century, the primary use of coal is to generate [electricity](http://en.wikipedia.org/wiki/Electricity), providing 40% of the world's electrical power supply in 2005.[[4]](http://en.wikipedia.org/wiki/Fuel#cite_note-4)

Fossil fuels were rapidly adopted during the industrial revolution, because they were more concentrated and flexible than traditional energy sources, such as water power.

Currently the trend has been towards renewable fuels, such as [biofuels](http://en.wikipedia.org/wiki/Renewable_energy#Biofuel) like alcohols.

## Chemical

[*Solid fuel*](http://en.wikipedia.org/wiki/Solid_fuel)*,*[*Liquid fuel*](http://en.wikipedia.org/wiki/Liquid_fuel)*, and*[*Gaseous fuel*](http://en.wikipedia.org/wiki/Gaseous_fuel)

Chemical fuels are substances that release energy by reacting with substances around them, most notably by the process of [oxidation](http://en.wikipedia.org/wiki/Oxidation).

Chemical fuels are divided in two ways. First, by their physical properties, as a solid, liquid or gas. Secondly, on the basis of their occurrence: *primary (natural fuel)* and *secondary (artificial fuel)*. Thus, a general classification of chemical fuels is:

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| **General types of chemical fuels** |
|  | **Primary (natural)** | **Secondary (artificial)** |
| [**Solid fuels**](http://en.wikipedia.org/wiki/Solid_fuel) | [wood](http://en.wikipedia.org/wiki/Wood), [coal](http://en.wikipedia.org/wiki/Coal), [peat](http://en.wikipedia.org/wiki/Peat), [dung](http://en.wikipedia.org/wiki/Feces), etc. | [coke](http://en.wikipedia.org/wiki/Coke_%28fuel%29), [charcoal](http://en.wikipedia.org/wiki/Charcoal) |
| [**Liquid fuels**](http://en.wikipedia.org/wiki/Liquid_fuel) | [petroleum](http://en.wikipedia.org/wiki/Petroleum) | [diesel](http://en.wikipedia.org/wiki/Diesel_fuel), [gasoline](http://en.wikipedia.org/wiki/Gasoline), [kerosene](http://en.wikipedia.org/wiki/Kerosene), [LPG](http://en.wikipedia.org/wiki/Liquefied_petroleum_gas), [coal tar](http://en.wikipedia.org/wiki/Coal_tar), [naptha](http://en.wikipedia.org/wiki/Naptha), [ethanol](http://en.wikipedia.org/wiki/Ethanol) |
| [**Gaseous fuels**](http://en.wikipedia.org/wiki/Gaseous_fuel) | [natural gas](http://en.wikipedia.org/wiki/Natural_gas) | [hydrogen](http://en.wikipedia.org/wiki/Hydrogen), [propane](http://en.wikipedia.org/wiki/Propane), [coal gas](http://en.wikipedia.org/wiki/Coal_gas), [water gas](http://en.wikipedia.org/wiki/Water_gas), [blast furnace](http://en.wikipedia.org/wiki/Blast_furnace) gas, [coke](http://en.wikipedia.org/wiki/Coke_%28fuel%29) oven gas, [CNG](http://en.wikipedia.org/wiki/CNG) |

### Solid fuel



Coal is an important solid fuel.

Solid fuel refers to various types of [solid](http://en.wikipedia.org/wiki/Solid) material that are used as fuel to produce [energy](http://en.wikipedia.org/wiki/Energy) and provide [heating](http://en.wikipedia.org/wiki/Heating), usually released through [combustion](http://en.wikipedia.org/wiki/Combustion). Solid fuels include [wood](http://en.wikipedia.org/wiki/Wood) (see [wood fuel](http://en.wikipedia.org/wiki/Wood_fuel)), [charcoal](http://en.wikipedia.org/wiki/Charcoal), [peat](http://en.wikipedia.org/wiki/Peat), [coal](http://en.wikipedia.org/wiki/Coal), [Hexamine fuel tablets](http://en.wikipedia.org/wiki/Hexamine_fuel_tablet), and pellets made from wood (see [wood pellets](http://en.wikipedia.org/wiki/Wood_pellets)), [corn](http://en.wikipedia.org/wiki/Maize), [wheat](http://en.wikipedia.org/wiki/Wheat), [rye](http://en.wikipedia.org/wiki/Rye)and other [grains](http://en.wikipedia.org/wiki/Cereal). [Solid-fuel rocket](http://en.wikipedia.org/wiki/Solid-fuel_rocket) technology also uses solid fuel (see [solid propellants](http://en.wikipedia.org/wiki/Rocket_fuel#Solid_propellants)). Solid fuels have been used by humanity for many years to[create fire](http://en.wikipedia.org/wiki/Making_fire). Coal was the fuel source which enabled the [industrial revolution](http://en.wikipedia.org/wiki/Industrial_revolution), from firing [furnaces](http://en.wikipedia.org/wiki/Furnace), to running [steam engines](http://en.wikipedia.org/wiki/Steam_engine). Wood was also extensively used to run [steam locomotives](http://en.wikipedia.org/wiki/Steam_locomotive). Both peat and coal are still used in [electricity generation](http://en.wikipedia.org/wiki/Electricity_generation) today. The use of some solid fuels (e.g. coal) is restricted or prohibited in some urban areas, due to unsafe levels of toxic emissions. The use of other solid fuels such as wood is increasing as heating technology and the availability of good quality fuel improves. In some areas, [smokeless coal](http://en.wikipedia.org/wiki/Anthracite) is often the only solid fuel used. In Ireland, peat [briquettes](http://en.wikipedia.org/wiki/Briquette) are used as smokeless fuel. They are also used to start a coal fire.

### Liquid fuel





A [gasoline station](http://en.wikipedia.org/wiki/Gasoline_station).

Liquid fuels are combustible or energy-generating molecules that can be harnessed to create [mechanical energy](http://en.wikipedia.org/wiki/Mechanical_energy), usually producing [kinetic energy](http://en.wikipedia.org/wiki/Kinetic_energy); they also must take the shape of their container. It is the fumes of liquid fuels that are flammable instead of the fluid. Most liquid fuels in widespread use are derived from [fossil fuels](http://en.wikipedia.org/wiki/Fossil_fuels); however, there are several types, such as hydrogen fuel (for [automotive](http://en.wikipedia.org/wiki/Automotive) uses), ethanol, and biodiesel, which are also categorized as a liquid fuel. Many liquid fuels play a primary role in transportation and the economy.

Some common properties of liquid fuels are that they are easy to transport, and can be handled with relative ease. Also they are relatively easy to use for all engineering applications, and home use. (Fuels like Kerosene are rationed and available in government subsidized shops in India for home use.) Liquid fuels are also used most popularly in [Internal combustion engines](http://en.wikipedia.org/wiki/Internal_combustion_engines). Most liquid fuels used currently are produced from petroleum. The most notable of these is [gasoline](http://en.wikipedia.org/wiki/Gasoline). Scientists generally accept that petroleum formed from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.

Conventional diesel is similar to gasoline in that it is a mixture of aliphatic hydrocarbons extracted from petroleum. Kerosene is used in [kerosene lamps](http://en.wikipedia.org/wiki/Kerosene_lamp)and as a fuel for cooking, heating, and small engines. [Natural gas](http://en.wikipedia.org/wiki/Natural_gas), composed chiefly of [methane](http://en.wikipedia.org/wiki/Methane), can be compressed to a liquid and used as a substitute for other traditional liquid fuels. [LP gas](http://en.wikipedia.org/wiki/LP_gas) is a mixture of [propane](http://en.wikipedia.org/wiki/Propane) and [butane](http://en.wikipedia.org/wiki/Butane), both of which are easily-compressible gases under standard atmospheric conditions. It offers many of the advantages of [compressed natural gas](http://en.wikipedia.org/wiki/Compressed_natural_gas) (CNG), but is denser than air, does not burn as cleanly, and is much more easily compressed. Commonly used for cooking and space heating, LP gas and compressed propane are seeing increased use in motorized vehicles; propane is the third most commonly used motor fuel globally.

### Gaseous fuels





A 20 pound (9.1 kg) propane cylinder.

Fuel gas is any one of a number of fuels that under ordinary conditions are [gaseous](http://en.wikipedia.org/wiki/Gas). Many fuel gases are composed of [hydrocarbons](http://en.wikipedia.org/wiki/Hydrocarbons) (such as [methane](http://en.wikipedia.org/wiki/Methane) or[propane](http://en.wikipedia.org/wiki/Propane)), [hydrogen](http://en.wikipedia.org/wiki/Hydrogen), [carbon monoxide](http://en.wikipedia.org/wiki/Carbon_monoxide), or mixtures thereof. Such gases are sources of potential [heat energy](http://en.wikipedia.org/wiki/Heat_energy) or [light energy](http://en.wikipedia.org/wiki/Light_energy) that can be readily transmitted and distributed through pipes from the point of origin directly to the place of consumption. Fuel gas is contrasted with [liquid fuels](http://en.wikipedia.org/wiki/Liquid_fuels) and from [solid fuels](http://en.wikipedia.org/wiki/Solid_fuel), though some fuel gases are [liquefied](http://en.wikipedia.org/wiki/Liquefaction_of_gases) for storage or transport. While their gaseous nature has advantageous, avoiding the difficulty of transporting solid fuel and the dangers of spillage inherent in liquid fuels, it also has limitation. It is possible for a fuel gas to be undetected and collect in certain areas, leading to the risk of a [gas explosion](http://en.wikipedia.org/wiki/Gas_explosion). For this reason, [odorizers](http://en.wikipedia.org/wiki/Odorizer) are added to most fuel gases so that they may be detected by a distinct smell. The most common type of fuel gas in current use is [natural gas](http://en.wikipedia.org/wiki/Natural_gas).

### Biofuels

[*Biofuel*](http://en.wikipedia.org/wiki/Biofuel)

[Biofuel](http://en.wikipedia.org/wiki/Biofuel) can be broadly defined as solid, liquid, or gas fuel consisting of, or derived from [biomass](http://en.wikipedia.org/wiki/Biomass). Biomass can also be used directly for heating or power—known as *biomass fuel*. Biofuel can be produced from any carbon source that can be replenished rapidly e.g. plants. Many different plants and plant-derived materials are used for biofuel manufacture.

Perhaps the earliest fuel employed by humans is wood. Evidence shows controlled fire was used up to 1.5 million years ago at [Swartkrans](http://en.wikipedia.org/wiki/Swartkrans), South Africa. It is unknown which hominid species first used fire, as both [*Australopithecus*](http://en.wikipedia.org/wiki/Australopithecus) and an early species of [*Homo*](http://en.wikipedia.org/wiki/Homo_%28genus%29) were present at the sites.[[5]](http://en.wikipedia.org/wiki/Fuel#cite_note-5) As a fuel, wood has remained in use up until the present day, although it has been superseded for many purposes by other sources. Wood has an [energy density](http://en.wikipedia.org/wiki/Energy_density) of 10–20 [MJ](http://en.wikipedia.org/wiki/Joule)/[kg](http://en.wikipedia.org/wiki/Kilogram).[[6]](http://en.wikipedia.org/wiki/Fuel#cite_note-6)

Recently biofuels have been developed for use in automotive transport (for example [Bioethanol](http://en.wikipedia.org/wiki/Bioethanol) and [Biodiesel](http://en.wikipedia.org/wiki/Biodiesel)), but there is widespread public debate about how carbon efficient these fuels are.

### Fossil fuels

[*Fossil fuel*](http://en.wikipedia.org/wiki/Fossil_fuel)

Fossil fuels are [hydrocarbons](http://en.wikipedia.org/wiki/Hydrocarbon), primarily [coal](http://en.wikipedia.org/wiki/Coal) and [petroleum](http://en.wikipedia.org/wiki/Petroleum) ([liquid petroleum](http://en.wikipedia.org/wiki/Liquid_petroleum) or [natural gas](http://en.wikipedia.org/wiki/Natural_gas)), formed from the [fossilized remains](http://en.wikipedia.org/wiki/Fossil) of ancient plants and animals[[7]](http://en.wikipedia.org/wiki/Fuel#cite_note-7) by exposure to high heat and pressure in the absence of oxygen in the [Earth](http://en.wikipedia.org/wiki/Earth)'s [crust](http://en.wikipedia.org/wiki/Crust_%28geology%29) over hundreds of millions of years.[[8]](http://en.wikipedia.org/wiki/Fuel#cite_note-8) Commonly, the term fossil fuel also includes hydrocarbon-containing [natural resources](http://en.wikipedia.org/wiki/Natural_resource) that are not derived entirely from biological sources, such as [tar sands](http://en.wikipedia.org/wiki/Tar_sands). These latter sources are properly known as *mineral fuels*.

Fossil fuels contain high percentages of [carbon](http://en.wikipedia.org/wiki/Carbon) and include [coal](http://en.wikipedia.org/wiki/Coal), [petroleum](http://en.wikipedia.org/wiki/Petroleum), and [natural gas](http://en.wikipedia.org/wiki/Natural_gas).[[9]](http://en.wikipedia.org/wiki/Fuel#cite_note-9) They range from [volatile](http://en.wikipedia.org/wiki/Volatility_%28chemistry%29) materials with low [carbon](http://en.wikipedia.org/wiki/Carbon):[hydrogen](http://en.wikipedia.org/wiki/Hydrogen) ratios like [methane](http://en.wikipedia.org/wiki/Methane), to liquid petroleum to nonvolatile materials composed of almost pure carbon, like [anthracite](http://en.wikipedia.org/wiki/Anthracite) coal. Methane can be found in [hydrocarbon](http://en.wikipedia.org/wiki/Hydrocarbon) fields, alone, associated with oil, or in the form of [methane clathrates](http://en.wikipedia.org/wiki/Methane_clathrates). Fossil fuels formed from the [fossilized remains](http://en.wikipedia.org/wiki/Fossil) of dead plants[[10]](http://en.wikipedia.org/wiki/Fuel#cite_note-10) by exposure to heat and pressure in the Earth's crust over millions of years.[[11]](http://en.wikipedia.org/wiki/Fuel#cite_note-11) This [biogenic theory](http://en.wikipedia.org/wiki/Petroleum#Biogenic_theory) was first introduced by [Georg Agricola](http://en.wikipedia.org/wiki/Georg_Agricola) in 1556 and later by [Mikhail Lomonosov](http://en.wikipedia.org/wiki/Mikhail_Lomonosov) in the 18th century.

It was estimated by the [Energy Information Administration](http://en.wikipedia.org/wiki/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.[[12]](http://en.wikipedia.org/wiki/Fuel#cite_note-12) Non-fossil sources in 2006 included [hydroelectric](http://en.wikipedia.org/wiki/Hydroelectricity) 6.3%, [nuclear](http://en.wikipedia.org/wiki/Nuclear_power) 8.5%, and others ([geothermal](http://en.wikipedia.org/wiki/Geothermal_power), [solar](http://en.wikipedia.org/wiki/Solar_energy), [tidal](http://en.wikipedia.org/wiki/Tidal_power), [wind](http://en.wikipedia.org/wiki/Wind_power), [wood](http://en.wikipedia.org/wiki/Wood_fuel), [waste](http://en.wikipedia.org/wiki/Waste-to-energy)) amounting to 0.9%.[[13]](http://en.wikipedia.org/wiki/Fuel#cite_note-13) World energy consumption was growing about 2.3% per year.

Fossil fuels are [non-renewable resources](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Renewable_energy) is therefore under way to help meet increased energy needs. The burning of fossil fuels produces around 21.3 billion [tonnes](http://en.wikipedia.org/wiki/Tonnes) (21.3 [gigatonnes](http://en.wikipedia.org/wiki/Gigatonne)) of [carbon dioxide](http://en.wikipedia.org/wiki/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).[[14]](http://en.wikipedia.org/wiki/Fuel#cite_note-14) Carbon dioxide is one of the [greenhouse gases](http://en.wikipedia.org/wiki/Greenhouse_gas) that enhances [radiative forcing](http://en.wikipedia.org/wiki/Radiative_forcing) and contributes to [global warming](http://en.wikipedia.org/wiki/Global_warming), causing the [average surface temperature](http://en.wikipedia.org/wiki/Instrumental_temperature_record) of the Earth to rise in response, which [the vast majority of climate scientists](http://en.wikipedia.org/wiki/Scientific_opinion_on_climate_change)agree will cause major [adverse effects](http://en.wikipedia.org/wiki/Effects_of_global_warming).

## Nuclear

[*Nuclear fuel*](http://en.wikipedia.org/wiki/Nuclear_fuel)



**CANDU fuel bundles** Two [CANDU](http://en.wikipedia.org/wiki/CANDU) ("CANada Deuterium Uranium") fuel bundles, each about 50 cm long, 10 cm in diameter. Photo courtesy of Atomic Energy of Canada Ltd.

Nuclear fuel is any material that is consumed to derive [nuclear energy](http://en.wikipedia.org/wiki/Nuclear_power). Technically speaking this definition includes all matter because any element will under the right conditions release nuclear energy, the only materials that are commonly referred to as nuclear fuels though are those that will produce energy without being placed under extreme duress. Nuclear fuel is a material that can be 'burned' by [nuclear fission](http://en.wikipedia.org/wiki/Nuclear_fission) or [fusion](http://en.wikipedia.org/wiki/Nuclear_fusion) to derive [nuclear energy](http://en.wikipedia.org/wiki/Nuclear_power). *Nuclear fuel* can refer to the fuel itself, or to physical objects (for example bundles composed of **fuel rods**) composed of the fuel material, mixed with structural, [neutron moderating](http://en.wikipedia.org/wiki/Neutron_moderator), or neutron reflecting materials.

Most nuclear fuels contain heavy [fissile](http://en.wikipedia.org/wiki/Fissile) elements that are capable of nuclear fission. When these fuels are struck by neutrons, they are in turn capable of emitting neutrons when they break apart. This makes possible a self-sustaining [chain reaction](http://en.wikipedia.org/wiki/Chain_reaction) that releases energy with a controlled rate in a [nuclear reactor](http://en.wikipedia.org/wiki/Nuclear_reactor) or with a very rapid uncontrolled rate in a [nuclear weapon](http://en.wikipedia.org/wiki/Nuclear_weapon).

The most common fissile nuclear fuels are [uranium-235](http://en.wikipedia.org/wiki/Uranium-235) (235U) and [plutonium-239](http://en.wikipedia.org/wiki/Pu-239) (239Pu). The actions of mining, refining, purifying, using, and ultimately disposing of nuclear fuel together make up the [nuclear fuel cycle](http://en.wikipedia.org/wiki/Nuclear_fuel_cycle). Not all types of nuclear fuels create power from nuclear fission.[Plutonium-238](http://en.wikipedia.org/wiki/Plutonium-238) and some other elements are used to produce small amounts of nuclear power by [radioactive decay](http://en.wikipedia.org/wiki/Radioactive_decay) in [radioisotope thermoelectric generators](http://en.wikipedia.org/wiki/Radioisotope_thermoelectric_generator) and other types of [atomic batteries](http://en.wikipedia.org/wiki/Atomic_battery). Also, light [nuclides](http://en.wikipedia.org/wiki/Nuclide) such as [tritium](http://en.wikipedia.org/wiki/Tritium) (3H) can be used as fuel for [nuclear fusion](http://en.wikipedia.org/wiki/Nuclear_fusion). Nuclear fuel has the highest [energy density](http://en.wikipedia.org/wiki/Energy_density) of all practical fuel sources.

### Fission



[Nuclear fuel](http://en.wikipedia.org/wiki/Nuclear_fuel) pellets are used to create nuclear energy.

The most common type of nuclear fuel used by humans is heavy [fissile](http://en.wikipedia.org/wiki/Fissile) elements that can be made to undergo [nuclear fission](http://en.wikipedia.org/wiki/Nuclear_fission) [chain reactions](http://en.wikipedia.org/wiki/Chain_reaction) in a[nuclear fission reactor](http://en.wikipedia.org/wiki/Nuclear_reactor); *nuclear fuel* can refer to the material or to physical objects (for example fuel bundles composed of [fuel rods](http://en.wikipedia.org/wiki/Fuel_rod)) composed of the fuel material, perhaps mixed with structural, [neutron moderating](http://en.wikipedia.org/wiki/Neutron_moderator), or neutron reflecting materials. The most common fissile nuclear fuels are [235U](http://en.wikipedia.org/wiki/Uranium-235) and[239Pu](http://en.wikipedia.org/wiki/Pu-239), and the actions of mining, refining, purifying, using, and ultimately disposing of these elements together make up the [nuclear fuel cycle](http://en.wikipedia.org/wiki/Nuclear_fuel_cycle), which is important for its relevance to [nuclear power](http://en.wikipedia.org/wiki/Nuclear_power) generation and [nuclear weapons](http://en.wikipedia.org/wiki/Nuclear_weapon).

### Fusion

Fuels that produce energy by the process of [nuclear fusion](http://en.wikipedia.org/wiki/Nuclear_fusion) are currently not utilized by man but are the main source of fuel for [stars](http://en.wikipedia.org/wiki/Star). Fusion fuels tend to be light elements such as [hydrogen](http://en.wikipedia.org/wiki/Hydrogen) which will combine easily. Energy is required to start fusion by raising temperature so high all materials would turn into plasma, and allow nuclei to collide and stick together with each other before repelling due to electric charge. This process is called fusion and it can give out energy.

In stars that undergo nuclear fusion, fuel consists of [atomic nuclei](http://en.wikipedia.org/wiki/Atomic_nuclei) that can release energy by the absorption of a [proton](http://en.wikipedia.org/wiki/Proton) or [neutron](http://en.wikipedia.org/wiki/Neutron). In most stars the fuel is provided by hydrogen, which can combine together to form [helium](http://en.wikipedia.org/wiki/Helium) through the [proton-proton chain reaction](http://en.wikipedia.org/wiki/Proton-proton_chain_reaction) or by the [CNO cycle](http://en.wikipedia.org/wiki/CNO_cycle). When the hydrogen fuel is exhausted, nuclear fusion can continue with progressively heavier elements, although the net energy released is lower because of the smaller difference in nuclear binding energy. Once [iron-56](http://en.wikipedia.org/wiki/Iron-56) or [nickel-56](http://en.wikipedia.org/wiki/Isotopes_of_nickel) nuclei are produced, no further energy can be obtained by nuclear fusion as these have the highest nuclear binding energies. The elements then on use up energy instead of giving out when fused, and therefore fusion stops and the stars die. In attempts by human, fusion are only carried out with hydrogen (isotope of 2 and 3) to form helium-4 as this reaction gives out the most net energy. Electric confinement ([ITER](http://en.wikipedia.org/wiki/ITER)), [inertial confinement](http://en.wikipedia.org/wiki/Inertial_confinement)(heating by laser) and heating by strong electric currents are the popular methods used. The power given out is enormonus as each kilogram of hydrogen can give out 0.41PJ. This means that burning 0.7 tonne of hydrogen per second can power the world, replacing the millions of tonnes of fossil fuels burnt and emission made by us each second. Unfortunately this clean energy whose product would dissipate harmlessly as helium if leak happens, and also does not emit any radiation or pollution, is not expected to contribute electricity to electricity networks until 2040.[[15]](http://en.wikipedia.org/wiki/Fuel#cite_note-15)

# Ground (electricity)

Grounding or earthing is among canons of safety. If the body of any electrical equipment or machinery is grounded it will pass the current to ground in case of short circuit. If a person accidentally touch the body of that machinery which is connected to live wire he will not get electric shock because current is passing through grounding conductor and it has much lower resistance then human body. So resistance of grounding conductor is also a major factor in electric safety. It is important to keep a relation to the earth.
Imagine a 3-phase supply of 380V phase-to-phase but it is NOT earthed. When something has gone wrong and a live (or HOT) wire is connected to the earth because of an earth fault, no circuit breakers will trip and the system works as if nothing has gone wrong. But the voltage of the other 2 live wires become 380V to the earth (and anything else). It is very dangerous.

In [electrical engineering](http://en.wikipedia.org/wiki/Electrical_engineering), **ground** or **earth** (symbol ⏚) can refer to the reference point in an [electrical circuit](http://en.wikipedia.org/wiki/Electrical_circuit) from which voltages are measured, a common return path for [electric current](http://en.wikipedia.org/wiki/Electric_current), or a direct physical connection to the [Earth](http://en.wikipedia.org/wiki/Earth).





A typical earthing electrode *(left)*, consisting of a conductive rod driven into the ground, at a home in [Australia](http://en.wikipedia.org/wiki/Australia). [Electrical codes](http://en.wikipedia.org/wiki/Electrical_code) specify that earthing wires must be a certain color, to prevent wiring errors.

Electrical circuits may be connected to ground (earth) for several reasons. In [mains](http://en.wikipedia.org/wiki/Mains_%28electric_power%29) powered equipment, exposed metal parts are connected to ground to prevent user contact with dangerous voltage if [electrical insulation](http://en.wikipedia.org/wiki/Electrical_insulation) fails. Connections to ground limit the build-up of [static electricity](http://en.wikipedia.org/wiki/Static_electricity) when handling flammable products or [electrostatic-sensitive devices](http://en.wikipedia.org/wiki/Electrostatic-sensitive_device).

In some [telegraph](http://en.wikipedia.org/wiki/Telegraph) and [power transmission](http://en.wikipedia.org/wiki/Power_transmission) circuits, the earth itself can be used as one [conductor](http://en.wikipedia.org/wiki/Electrical_conductor) of the circuit, saving the cost of installing a separate return conductor (see [single-wire earth return](http://en.wikipedia.org/wiki/Single-wire_earth_return)).

For measurement purposes, the Earth serves as a (reasonably) constant potential reference against which other potentials can be measured. An electrical ground system should have an appropriate current-carrying capability to serve as an [adequate zero-voltage reference level](http://en.wikipedia.org/wiki/Ground_and_neutral). In [electronic circuit](http://en.wikipedia.org/wiki/Electronic_circuit)theory, a "ground" is usually idealized as an infinite [source or sink](http://en.wikipedia.org/wiki/Current_sources_and_sinks) for charge, which can absorb an unlimited amount of current without changing its potential. Where a real ground connection has a significant resistance, the approximation of zero potential is no longer valid. [Stray voltages](http://en.wikipedia.org/wiki/Stray_voltage) or [earth potential rise](http://en.wikipedia.org/wiki/Earth_potential_rise) effects will occur, which may create noise in signals or if large enough will produce an electric shock hazard.

The use of the term ground (or earth) is so common in electrical and electronics applications that circuits in [portable electronic devices](http://en.wikipedia.org/wiki/Portable_electronics) such as [cell phones](http://en.wikipedia.org/wiki/Cell_phone) and [media players](http://en.wikipedia.org/wiki/Portable_media_player) as well as circuits in [vehicles](http://en.wikipedia.org/wiki/Vehicles) may be spoken of as having a "ground" connection without any actual connection to the Earth. This is usually a large conductor attached to one side of the [power supply](http://en.wikipedia.org/wiki/Power_supply) (such as the "[ground plane](http://en.wikipedia.org/wiki/Ground_plane)" on a [printed circuit board](http://en.wikipedia.org/wiki/Printed_circuit_board)) which serves as the common return path for current from many different components in the circuit.

Below are the basic needs of Earthing.

To protect human lives as well as provide safety to electrical devices and appliances from leakage current.To keep voltage as constant in the healthy phase (If fault occurs on any one phase).To Protect Electric system and buildings form lighting.To serve as a return conductor in electric traction system and communication.To avoid the risk of fire in electrical installation systems.

# Electrical safety devices

When buying electrical fittings and appliances, always ask for products that have an enhanced level of safety, such as a built-in RCD or recessed sockets.

* [Residual current devices](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Residual_Current_Devices)
* [Testing your RCD](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Testing_your_RCD)
* [Isolating transformers](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Isolating_Transformers)
* [Shuttered sockets](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Shuttered_Sockets)
* [Recessed sockets and shrouded plugs](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Recessed_Sockets_and_Shrouded_Plugs)
* [Insulated metal pins](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Insulated_Metal_Pins)
* [Transparent sockets and plugs](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Transparent_Sockets_and_Plugs)
* [Four-way switched socket outlets](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices#Four-way_Switched_Socket_Outlets)

## Residual current devices

**![[image] Residual current devices. ]()**An RCD constantly monitors the current flowing along a circuit.  If it senses any loss of current, where electricity is diverting to the ground rather than through the circuit, is will immediately shut off.

If your body is providing the path for the electricity to divert to the ground, you could be seriously injured, burned, severely shocked or electrocuted.

* An RCD will prevent the shock being fatal by shutting the system down instantly.
* RCDs should be installed in damp areas of your home where there are electric fittings, such as bathrooms, laundries, kitchens, garages, pools and external electric outlets.

Different types of RCD’s include fixed RCDs, which can be installed in standard socket outlets and wired in a way that protects other outlets downstream, circuit RCDs, which are wired into your switchboard, and portable RCDs.

It is a legal requirement for all new circuits originating at the switchboard and supplying lighting or socket outlets (power points) in domestic buildings to have RCD protection.  These RCD’s will normally be located at the switchboard. They will provide protection for all electrical wiring and appliances plugged into new circuits.

## Testing your RCD

You can test your socket outlet and portable RCDs by plugging in a small electrical appliance (such as a night-light):

* Press the “test” button.
* If the appliance turns off, the RCD is working.
* Make sure you press “reset” once the test is complete.
* You should test these RCDs regularly e.g. every three months.

It’s a good idea to test switchboard RCDs every six months by checking that it trips when the “test” button in pushed.  However, be aware that tripping circuits will turn off the power to any appliances on that circuit.  So appliances with electronic clocks will have to be reset.  For this reason, it’s a good idea to test your switchboard RCDs when changing to and from daylight saving – when clocks will have to be reset anyway and it will be about six months since the RCDs where last tested.

If your RCD trips at other times; note the appliances connected at the time, unplug all connected appliances and reset the RCD, plug in the appliances one at a time and switch on.  If the RCD trips when an appliance is switched on, the appliance should be repaired or replaced.  If the RCD does not trip when appliances are plugged in and switched on, one at a time, but trips when several appliances are used together, you should get your RCD checked by a licensed electrician.

[Top](http://www.med.govt.nz/energysafety/consumer/safe-living-with-electricity/electrical-safety-devices)

## Isolating transformers

An isolating transformer protects you from an electric shock by providing an electricity supply that is isolated from earth.  For maximum protection, the transformer should be placed as near as possible to the electrical outlet.

## [image] Shuttered sockets. Shuttered sockets

Socket outlets fitted with internal protective shutters make it more difficult for children to poke things into them.

## Recessed sockets and shrouded plugs

Recessed sockets and shrouded plugs on electrical fittings, extension cords and double adaptors help to prevent contact with the metal pins on a plug if they become partially exposed.

## Insulated metal pins

An additional safety feature is a plastic insulation sleeve on the metal pins on a plug.  Like recessed sockets, these prevent contact with the metal pins while connected to electricity supply.

## Transparent sockets and plugs

Clear-backed sockets and plugs expose any problems with the wiring.

## Four-way switched socket outlets

These can be installed as part of your home’s permanent fittings to give you four sockets at an outlet, eliminating the need for multi-boxes and extension cords.

# Lighting





Low-intensity lighting and haze in a concert hall allows laser effects to be visible





Daylight used at the train station [Gare de l'Est](http://en.wikipedia.org/wiki/Gare_de_l%27Est) Paris





Illuminated Cherry blossoms, light from the shop windows, and Japanese lantern at night in [Ise, Mie](http://en.wikipedia.org/wiki/Ise%2C_Mie), Japan





Composite image of the Earth at night

**Lighting** or **illumination** is the deliberate use of [light](http://en.wikipedia.org/wiki/Light) to achieve a practical or aesthetic effect. Lighting includes the use of both artificial[light sources](http://en.wikipedia.org/wiki/Light_source) like lamps and light fixtures, as well as natural illumination by capturing [daylight](http://en.wikipedia.org/wiki/Daylight). [Daylighting](http://en.wikipedia.org/wiki/Daylighting) (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants.

Indoor lighting is usually accomplished using [light fixtures](http://en.wikipedia.org/wiki/Light_fixture), and is a key part of [interior design](http://en.wikipedia.org/wiki/Interior_design). Lighting can also be an intrinsic component of [landscape projects](http://en.wikipedia.org/wiki/Landscaping).

## HistoryWith the discovery of [fire](http://en.wikipedia.org/wiki/Fire), the earliest form of artificial lighting used to illuminate an area were [campfires](http://en.wikipedia.org/wiki/Campfire) or [torches](http://en.wikipedia.org/wiki/Torch). As early as 400,000 [BCE](http://en.wikipedia.org/wiki/BCE), fire was kindled in the caves of [Peking Man](http://en.wikipedia.org/wiki/Peking_Man). Prehistoric people used primitive lamps to illuminate surroundings. These lamps were made from naturally occurring materials such as rocks, shells, horns and stones, were filled with [grease](http://en.wikipedia.org/wiki/Grease_%28lubricant%29), and had a [fiber](http://en.wikipedia.org/wiki/Fiber) [wick](http://en.wikipedia.org/wiki/Candle_wick). Lamps typically used animal or vegetable fats as fuel. Hundreds of these lamps (hollow worked stones) have been found in the [Lascaux](http://en.wikipedia.org/wiki/Lascaux) caves in modern day [France](http://en.wikipedia.org/wiki/France), dating to about 15,000 years ago. Oily animals (birds and fish) were also used as lamps after being threaded with a wick. [Fireflies](http://en.wikipedia.org/wiki/Firefly) have been used as lighting sources. [Candles](http://en.wikipedia.org/wiki/Candle) and glass and pottery lamps were also invented.[[1]](http://en.wikipedia.org/wiki/Lighting#cite_note-1) [Chandeliers](http://en.wikipedia.org/wiki/Chandelier) were an early form of "[light fixture](http://en.wikipedia.org/wiki/Light_fixture)". With the development of [electricity](http://en.wikipedia.org/wiki/Electricity) and the [incandescent light bulb](http://en.wikipedia.org/wiki/Incandescent_light_bulb), the luminosity of artificial lighting improved enough to be used indoors. They became widely used and extended the time that people could stay up, among other developments.

## Fixtures

Lighting fixtures come in a wide variety of styles for various functions. The most important functions are as a holder for the light source, to provide directed light and to avoid [visual glare](http://en.wikipedia.org/wiki/Visual_glare). Some are very plain and functional, while some are pieces of art in themselves. Nearly any material can be used, so long as it can tolerate the excess heat and is in keeping with safety codes.

An important property of light fixtures is the [luminous efficacy](http://en.wikipedia.org/wiki/Luminous_efficacy) or [wall-plug efficiency](http://en.wikipedia.org/wiki/Wall-plug_efficiency), meaning the amount of usable light emanating from the fixture per used energy, usually measured in [lumen](http://en.wikipedia.org/wiki/Lumen_%28unit%29)per [watt](http://en.wikipedia.org/wiki/Watt). A fixture using replaceable light sources can also have its efficiency quoted as the percentage of light passed from the "bulb" to the surroundings. The more [transparent](http://en.wikipedia.org/wiki/Transparency_and_translucency) the lighting fixture is, the higher efficacy. [Shading](http://en.wikipedia.org/wiki/Shadow) the light will normally decrease efficacy but increase the directionality and the [visual comfort probability](http://en.wikipedia.org/wiki/Visual_comfort_probability).

[Color temperature](http://en.wikipedia.org/wiki/Color_temperature) for white light sources also affects their use for certain applications. The color temperature of a white light source is the temperature in [Kelvin](http://en.wikipedia.org/wiki/Kelvin) of a theoretical [black body](http://en.wikipedia.org/wiki/Black_body) emitter that most closely matches the spectral characteristics of the lamp. An incandescent bulb has a color temperature around 2800 to 3000 Kelvin; daylight is around 6400 Kelvin. Lower color temperature lamps have relatively more energy in the yellow and red part of the visible spectrum, while high color temperatures correspond to lamps with more of a blue-white appearance. For critical inspection or color matching tasks, or for retail displays of food and clothing, the color temperature of the lamps will be selected for the best overall lighting effect.

### Types





A demonstration of the effects of different kinds of lighting

Lighting is classified by intended use as general, accent, or task lighting, depending largely on the distribution of the light produced by the fixture.

* [Task lighting](http://en.wikipedia.org/wiki/Task_lighting) is mainly functional and is usually the most concentrated, for purposes such as [reading](http://en.wikipedia.org/wiki/Reading_%28activity%29) or [inspection](http://en.wikipedia.org/wiki/Inspection) of materials. For example, reading poor-quality reproductions may require task lighting levels up to 1500 [lux](http://en.wikipedia.org/wiki/Lux) (150 [footcandles](http://en.wikipedia.org/wiki/Footcandle)), and some inspection tasks or [surgical](http://en.wikipedia.org/wiki/Surgical) procedures require even higher levels.
* [Accent lighting](http://en.wikipedia.org/w/index.php?title=Accent_lighting&action=edit&redlink=1) is mainly decorative, intended to highlight [pictures](http://en.wikipedia.org/wiki/Picture), [plants](http://en.wikipedia.org/wiki/Plant), or other elements of [interior design](http://en.wikipedia.org/wiki/Interior_design) or [landscaping](http://en.wikipedia.org/wiki/Landscaping).
* General lighting (sometimes referred to as ambient light) fills in between the two and is intended for general illumination of an area. Indoors, this would be a basic [lamp](http://en.wikipedia.org/wiki/Lamp_%28electrical_component%29) on a table or floor, or a fixture on the [ceiling](http://en.wikipedia.org/wiki/Ceiling). Outdoors, general lighting for a [parking lot](http://en.wikipedia.org/wiki/Parking_lot) may be as low as 10-20 lux (1-2 footcandles) since [pedestrians](http://en.wikipedia.org/wiki/Pedestrian) and [motorists](http://en.wikipedia.org/wiki/Motorist) already used to the dark will need little light for crossing the area.

### Methods

* [Downlighting](http://en.wikipedia.org/wiki/Downlight) is most common, with fixtures on or recessed in the ceiling casting light downward. This tends to be the most used method, used in both offices and homes. Although it is easy to design it has dramatic problems with glare and excess energy consumption due to large number of fittings.[[2]](http://en.wikipedia.org/wiki/Lighting#cite_note-ReferenceA-2) The introduction of LED lighting has greatly improved this by approx. 90% when compared to a halogen downlight or spotlight. LED lamps or bulbs are now available to retro fit in place of high energy consumption lamps.
* [Uplighting](http://en.wikipedia.org/w/index.php?title=Uplight&action=edit&redlink=1) is less common, often used to bounce indirect light off the ceiling and back down. It is commonly used in lighting applications that require minimal glare and uniform general illuminance levels. Uplighting (indirect) uses a diffuse surface to reflect light in a space and can minimize disabling glare on computer displays and other dark glossy surfaces. It gives a more uniform presentation of the light output in operation. However indirect lighting is completely reliant upon the reflectance value of the surface. While indirect lighting can create a diffused and shadow free light effect it can be regarded as an uneconomical lighting principle.[[3]](http://en.wikipedia.org/wiki/Lighting#cite_note-Kim_W_1023-3)[[4]](http://en.wikipedia.org/wiki/Lighting#cite_note-M._Velds_2002_pp._95-4)
* Front lighting is also quite common, but tends to make the subject look flat as its casts almost no visible shadows. Lighting from the side is the less common, as it tends to produce [glare](http://en.wikipedia.org/wiki/Glare_%28vision%29)near [eye](http://en.wikipedia.org/wiki/Human_eye) level. [Backlighting](http://en.wikipedia.org/wiki/Backlighting_%28lighting_design%29) either around or through an object is mainly for accent.





Wall-mounted light with shadows

### Forms of lighting

#### Indoor lighting





LED Lighting furniture by [Manfred Kielnhofer](http://en.wikipedia.org/wiki/Manfred_Kielnhofer)

Forms of lighting include [alcove](http://en.wikipedia.org/wiki/Alcove) lighting, which like most other uplighting is indirect. This is often done with [fluorescent lighting](http://en.wikipedia.org/wiki/Fluorescent_lighting) (first available at the [1939 World's Fair](http://en.wikipedia.org/wiki/1939_World%27s_Fair)) or [rope light](http://en.wikipedia.org/w/index.php?title=Rope_light&action=edit&redlink=1), or occasionally with [neon lighting](http://en.wikipedia.org/wiki/Neon_lighting). It is a form of backlighting.

[Soffit](http://en.wikipedia.org/wiki/Soffit) or close to wall lighting can be general or a decorative wall-wash, sometimes used to bring out texture (like [stucco](http://en.wikipedia.org/wiki/Stucco) or [plaster](http://en.wikipedia.org/wiki/Plaster)) on a wall, though this may also show its [defects](http://en.wiktionary.org/wiki/defect) as well. The effect depends heavily on the exact type of lighting source used.

[Recessed lighting](http://en.wikipedia.org/wiki/Recessed_lighting) (often called "pot lights" in [Canada](http://en.wikipedia.org/wiki/Canada), "can lights" or 'high hats" in the [US](http://en.wikipedia.org/wiki/United_States)) is popular, with fixtures mounted into the ceiling structure so as to appear flush with it. These downlights can use narrow beam spotlights, or wider-[angle](http://en.wikipedia.org/wiki/Angle) [floodlights](http://en.wikipedia.org/wiki/Stage_lighting_instrument#Floodlights), both of which are bulbs having their own[reflectors](http://en.wikipedia.org/wiki/Mirror). There are also downlights with internal reflectors designed to accept common 'A' lamps (light bulbs) which are generally less costly than reflector lamps. Downlights can be incandescent, fluorescent, [HID (high intensity discharge)](http://en.wikipedia.org/wiki/High-intensity_discharge_lamp) or [LED](http://en.wikipedia.org/wiki/LED).

[Track lighting](http://en.wikipedia.org/wiki/Track_lighting), invented by [Lightolier](http://en.wikipedia.org/wiki/Lightolier)  was popular at one period of time because it was much easier to install than recessed lighting, and individual fixtures are decorative and can be easily aimed at a [wall](http://en.wikipedia.org/wiki/Wall). It has regained some popularity recently in low-voltage tracks, which often look nothing like their predecessors because they do not have the safety issues that line-voltage systems have, and are therefore less bulky and more ornamental in themselves. A master [transformer](http://en.wikipedia.org/wiki/Transformer) feeds all of the fixtures on the track or rod with 12 or 24 volts, instead of each light fixture having its own line-to-low voltage transformer. There are traditional spots and floods, as well as other small hanging fixtures. A modified version of this is [cable lighting](http://en.wikipedia.org/wiki/Cable_lighting), where lights are hung from or clipped to bare [metal](http://en.wikipedia.org/wiki/Metal) [cables](http://en.wikipedia.org/wiki/Cable) under [tension](http://en.wikipedia.org/wiki/Tension_%28mechanics%29).

A [sconce](http://en.wikipedia.org/wiki/Sconce_%28light_fixture%29) is a wall-mounted fixture, particularly one that shines up and sometimes down as well. A [torchiere](http://en.wikipedia.org/wiki/Torchiere) is an uplight intended for ambient lighting. It is typically a floor lamp but may be wall-mounted like a sconce.

The portable or table lamp is probably the most common fixture, found in many homes and [offices](http://en.wikipedia.org/wiki/Office). The standard lamp and shade that sits on a table is general lighting, while the desk lamp is considered task lighting. [Magnifier](http://en.wikipedia.org/wiki/Magnification) lamps are also task lighting.





Animated fountain in [Moscow](http://en.wikipedia.org/wiki/Moscow)'s [Square of Europe](http://en.wikipedia.org/wiki/Square_of_Europe), lit at night.

The [illuminated ceiling](http://en.wikipedia.org/w/index.php?title=Illuminated_ceiling&action=edit&redlink=1) was once popular in the 1960s and 1970s but fell out of favor after the 1980s. This uses [diffuser](http://en.wikipedia.org/wiki/Diffuser_%28optics%29) panels hung like a [suspended ceiling](http://en.wikipedia.org/wiki/Suspended_ceiling) below fluorescent lights, and is considered general lighting. Other forms include neon, which is not usually intended to illuminate anything else, but to actually be an artwork in itself. This would probably fall under accent lighting, though in a dark [nightclub](http://en.wikipedia.org/wiki/Nightclub) it could be considered general lighting.

In a [movie theater](http://en.wikipedia.org/wiki/Movie_theater) each step in the aisles is usually marked with a row of small lights, for convenience and safety when the film has started, hence the other lights are off. Traditionally made up of small low wattage, low voltage lamps in a track or translucent tube, these are rapidly being replaced with LED based versions.

#### Outdoor lighting





High mast lighting along [Highway 401](http://en.wikipedia.org/wiki/Highway_401_%28Ontario%29) in[Ontario](http://en.wikipedia.org/wiki/Ontario), [Canada](http://en.wikipedia.org/wiki/Canada).

[Street Lights](http://en.wikipedia.org/wiki/Street_light) are used to light roadways and walkways at night. Some manufacturers are designing LED and photovoltaic luminaires to provide an energy-efficient alternative to traditional street light fixtures.[[5]](http://en.wikipedia.org/wiki/Lighting#cite_note-5)[[6]](http://en.wikipedia.org/wiki/Lighting#cite_note-6)[[7]](http://en.wikipedia.org/wiki/Lighting#cite_note-7)





[Floodlights](http://en.wikipedia.org/wiki/Floodlights_%28sport%29) are used to illuminate outdoor playing fields or work zones during nighttime.

[Floodlights](http://en.wikipedia.org/wiki/Floodlights_%28sport%29) can be used to illuminate outdoor playing fields or work zones during nighttime hours. The most common type of floodlights are metal halide and high pressure sodium lights.

[Beacon lights](http://en.wikipedia.org/wiki/Street_light#Beacon_lights) are positioned at the intersection of two roads to aid in navigation.

Sometimes [security lighting](http://en.wikipedia.org/wiki/Security_lighting) can be used along roadways in urban areas, or behind homes or commercial facilities. These are extremely bright lights used to deter crime. Security lights may include floodlights.

Entry lights can be used outside to illuminate and signal the entrance to a property.[[8]](http://en.wikipedia.org/wiki/Lighting#cite_note-8) These lights are installed for safety, security, and for decoration.

Underwater accent lighting is also used for koi ponds, fountains, swimming pools and the like.

**Three-phase electric power** is a common method of [alternating-current](http://en.wikipedia.org/wiki/Alternating_current) [electric power](http://en.wikipedia.org/wiki/Electric_power) [generation](http://en.wikipedia.org/wiki/Electric_power_generation), [transmission](http://en.wikipedia.org/wiki/Electric_power_transmission), and[distribution](http://en.wikipedia.org/wiki/Electric_power_distribution).[[1]](http://en.wikipedia.org/wiki/Three-phase_electric_power#cite_note-1) It is a type of [polyphase system](http://en.wikipedia.org/wiki/Polyphase_system) and is the most common method used by [electrical grids](http://en.wikipedia.org/wiki/Electrical_grid) worldwide to transfer power. It is also used to power large [motors](http://en.wikipedia.org/wiki/Electric_motor) and other heavy loads. A [three-phase](http://en.wikipedia.org/wiki/Three-phase) system is usually more economical than an equivalent [single-phase](http://en.wikipedia.org/wiki/Single-phase_electric_power) or [two-phase](http://en.wikipedia.org/wiki/Two-phase_electric_power) system at the same [voltage](http://en.wikipedia.org/wiki/Voltage) because it uses less conductor material to transmit electrical power. In a three-phase system, three circuit conductors carry three [alternating currents](http://en.wikipedia.org/wiki/Alternating_current) (of the same frequency) which reach their instantaneous peak values at one third of a cycle from each other. Taking one current as the reference, the other two currents are delayed in time by one third and two thirds of one cycle of the electric current. This delay between phases has the effect of giving constant power transfer over each cycle of the current and also makes it possible to produce a rotating magnetic field in an[electric motor](http://en.wikipedia.org/wiki/Electric_motor).

Three-phase systems may have a [neutral](http://en.wikipedia.org/wiki/Ground_and_neutral) wire. A neutral wire allows the three-phase system to use a higher voltage while still supporting lower-voltage [single-phase](http://en.wikipedia.org/wiki/Single-phase_electric_power) loads. In high-voltage distribution situations, it is common not to have a neutral wire as the loads can simply be connected between phases (phase-phase connection).

## Single-phase loads

Single-phase loads may be connected to a three-phase system in two ways. Load may be connected across any two phases, or a load can be connected from phase to neutral, if neutral is available.[[10]](http://en.wikipedia.org/wiki/Three-phase_electric_power#cite_note-IAEI-10)

Single-phase loads should be distributed evenly between the phases of the three-phase system for efficient use of the supply transformer and supply conductors.

**Two-phase electrical power** was an early 20th-century [polyphase](http://en.wikipedia.org/wiki/Polyphase_system) [alternating current](http://en.wikipedia.org/wiki/Alternating_current) electric power distribution system. Two circuits were used, with voltage [phases](http://en.wikipedia.org/wiki/Phase_%28waves%29) differing by the [right angle](http://en.wikipedia.org/wiki/Right_angle) (90°). Usually circuits used four wires, two for each phase. Less frequently, three wires were used, with a common wire with a larger-diameter conductor. Some early two-phase [generators](http://en.wikipedia.org/wiki/Electric_generator) had two complete rotor and field assemblies, with [windings](http://en.wikipedia.org/wiki/Coil) physically offset by 90 degrees to provide two-phase power.

## Comparison with single-phase power

The advantage of two-phase electrical power over [single-phase one](http://en.wikipedia.org/wiki/Single-phase_electric_power) was that it allowed for simple, self-starting electric motors. In the early days of [electrical engineering](http://en.wikipedia.org/wiki/Electrical_engineering), it was easier to analyze and design two-phase systems where the phases were completely separated.[[2]](http://en.wikipedia.org/wiki/Two-phase_electric_power#cite_note-2) It was not until the invention of the method of [symmetrical components](http://en.wikipedia.org/wiki/Symmetrical_components) in 1918 that polyphase power systems had a convenient mathematical tool for describing unbalanced load cases. The revolving magnetic field produced with a two-phase system allowed electric motors to provide [torque](http://en.wikipedia.org/wiki/Torque) from zero motor speed, which was not possible with a single-phase [induction motor](http://en.wikipedia.org/wiki/Induction_motor) (without extra starting means). Induction motors designed for two-phase operation use the same winding configuration as[capacitor start](http://en.wikipedia.org/wiki/Electric_motor#Single-phase_AC_induction_motors) single-phase motors.

## Comparison with three-phase power

[Three-phase electric power](http://en.wikipedia.org/wiki/Three-phase_electric_power) requires less conductor mass for the same voltage and overall amount of power, compared with a two-phase four-wire circuit of the same carrying capacity.[[3]](http://en.wikipedia.org/wiki/Two-phase_electric_power#cite_note-3) It has replaced two-phase power for commercial distribution of electrical energy, but two-phase circuits are still found in certain control systems. These power pulsations tend to cause increased mechanical noise in transformer and motor laminations due to magnestriction and torsional vibration in generator and motor drive shafts.

Two-phase circuits typically use two separate pairs of current-carrying conductors. Alternatively, three wires may be used, but the common conductor carries the vector sum of the phase currents, which requires a larger conductor. Three-phase can share conductors so that the three phases can be carried on three conductors of the same size. In electrical power distribution, a requirement of only three conductors, rather than four, represented a considerable distribution-wire cost savings due to the expense of conductors and installation.

Two-phase power can be derived from a three-phase source using two [transformers](http://en.wikipedia.org/wiki/Transformer) in a [Scott connection](http://en.wikipedia.org/wiki/Scott_connection): One transformer primary is connected across two phases of the supply. The second transformer is connected to a center-tap of the first transformer, and is wound for 86.6% of the phase-to-phase voltage on the three-phase system. The secondaries of the transformers will have two phases 90 degrees apart in time, and a balanced two-phase load will be evenly balanced over the three supply phases.

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