**[](http://en.wikipedia.org/wiki/File:Moody_Sunburst.jpg)Sustainable energy**

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[Concentrating solar power systems](http://en.wikipedia.org/wiki/Concentrating_solar_power) are a fast growing source of sustainable energy.

**Sustainable energy** is the provision of [energy](http://en.wikipedia.org/wiki/Energy) that meets the needs of the present without compromising the ability of future generations to meet their needs. [Sustainable](http://en.wikipedia.org/wiki/Sustainability) energy sources are most often regarded as including all [renewable energy](http://en.wikipedia.org/wiki/Renewable_energy) sources, such as [solar energy](http://en.wikipedia.org/wiki/Solar_energy), [wind power](http://en.wikipedia.org/wiki/Wind_power), [wave power](http://en.wikipedia.org/wiki/Wave_power), [geothermal power](http://en.wikipedia.org/wiki/Geothermal_power) [plant matter](http://en.wikipedia.org/wiki/Biomass), and [tidal power](http://en.wikipedia.org/wiki/Tidal_power). It usually also includes technologies that improve [energy efficiency](http://en.wikipedia.org/wiki/Efficient_energy_use). Conventional [fission power](http://en.wikipedia.org/wiki/Fission_power) is sometimes referred to as sustainable, but this is controversial politically due to concerns about [peak uranium](http://en.wikipedia.org/wiki/Peak_uranium), [radioactive waste disposal](http://en.wikipedia.org/wiki/High-level_radioactive_waste_management) and the risks of disaster due to accident, terrorism, or [natural disaster](http://en.wikipedia.org/wiki/Natural_disaster).

**Definitions**

Energy efficiency and renewable energy are said to be the *twin pillars* of sustainable energy.[[1]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-0) Some ways in which *sustainable energy* has been defined are:

* "Effectively, the provision of energy such that it meets the needs of the future without compromising the ability of future generations to meet their own needs. ...Sustainable Energy has two key components: renewable energy and energy efficiency." – *Renewable Energy and Efficiency Partnership* (British)[[2]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-1)
* "Dynamic harmony between equitable availability of energy-intensive goods and services to all people and the preservation of the earth for future generations." And, "the solution will lie in finding sustainable energy sources and more efficient means of converting and utilizing energy." – *Sustainable energy* by J. W. Tester, et al, from MIT Press.
* "Any energy generation, efficiency & conservation source where: Resources are available to enable massive scaling to become a significant portion of energy generation, long term, preferably 100 years.." – *Invest,* a green technology non-profit organization.[[3]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-2)
* "Energy which is replenishable within a human lifetime and causes no long-term damage to the environment." – *Jamaica Sustainable Development Network*[[4]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-3)

This sets *sustainable energy* apart from other [renewable energy](http://en.wikipedia.org/wiki/Renewable_energy) terminology such as [*alternative energy*](http://en.wikipedia.org/wiki/Alternative_energy) and [*green energy*](http://en.wikipedia.org/wiki/Green_energy), by focusing on the ability of an energy source to continue providing energy. Sustainable energy can produce some pollution of the environment, as long as it is not sufficient to prohibit heavy use of the source for an indefinite amount of time. Sustainable energy is also distinct from [Low-carbon energy](http://en.wikipedia.org/wiki/Low-carbon_economy), which is sustainable only in the sense that it does not add to the CO2 in the atmosphere.

[Green Energy](http://truebioelectric.com/green-energy.php) is energy that can be extracted, generated, and/or consumed without any significant negative impact to the environment. The planet has a natural capability to recover which means pollution that does not go beyond that capability can still be termed green.

Green power is a subset of renewable energy and represents those [renewable energy resources](http://en.wikipedia.org/wiki/Renewable_energy_resource) and technologies that provide the highest environmental benefit. The [U.S. Environmental Protection Agency](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) defines green power as electricity produced from solar, wind, geothermal, biogas, biomass, and low-impact small hydroelectric sources. Customers often buy green power for avoided environmental impacts and its [greenhouse gas](http://en.wikipedia.org/wiki/Greenhouse_gas) reduction benefits.[[5]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-4)

**Renewable energy technologies**

Main articles: [Renewable energy](http://en.wikipedia.org/wiki/Renewable_energy) and [Renewable energy commercialization](http://en.wikipedia.org/wiki/Renewable_energy_commercialization)

[Renewable energy](http://en.wikipedia.org/wiki/Renewable_energy) technologies are essential contributors to sustainable energy as they generally contribute to world [energy security](http://en.wikipedia.org/wiki/Energy_security), reducing dependence on [fossil fuel](http://en.wikipedia.org/wiki/Fossil_fuel) resources,[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] and providing opportunities for mitigating [greenhouse gases](http://en.wikipedia.org/wiki/Greenhouse_gases).[[6]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-IEA-5) The [International Energy Agency](http://en.wikipedia.org/wiki/International_Energy_Agency) states that:

Conceptually, one can define three generations of renewables technologies, reaching back more than 100 years .

First-generation technologies emerged from the [industrial revolution](http://en.wikipedia.org/wiki/Industrial_revolution) at the end of the 19th century and include [hydropower](http://en.wikipedia.org/wiki/Hydropower), [biomass](http://en.wikipedia.org/wiki/Biomass) combustion, and [geothermal power](http://en.wikipedia.org/wiki/Geothermal_power) and heat. Some of these technologies are still in widespread use.

Second-generation technologies include [solar heating](http://en.wikipedia.org/wiki/Solar_heating) and cooling, [wind power](http://en.wikipedia.org/wiki/Wind_power), modern forms of [bioenergy](http://en.wikipedia.org/wiki/Bioenergy), and [solar photovoltaics](http://en.wikipedia.org/wiki/Solar_photovoltaics). These are now entering markets as a result of research, development and demonstration (RD&D) investments since the 1980s. The initial investment was prompted by [energy security](http://en.wikipedia.org/wiki/Energy_security) concerns linked to the oil crises ([1973](http://en.wikipedia.org/wiki/1973_oil_crisis) and [1979](http://en.wikipedia.org/wiki/1979_energy_crisis)) of the 1970s but the continuing appeal of these renewables is due, at least in part, to environmental benefits. Many of the technologies reflect significant advancements in materials.

Third-generation technologies are still under development and include advanced [biomass gasification](http://en.wikipedia.org/wiki/Biomass_gasification), [biorefinery](http://en.wikipedia.org/wiki/Biorefinery) technologies, concentrating [solar thermal](http://en.wikipedia.org/wiki/Solar_thermal) power, [hot dry rock geothermal energy](http://en.wikipedia.org/wiki/Hot_dry_rock_geothermal_energy), and [ocean energy](http://en.wikipedia.org/wiki/Ocean_energy). Advances in [nanotechnology](http://en.wikipedia.org/wiki/Nanotechnology) may also play a major role.

—[International Energy Agency](http://en.wikipedia.org/wiki/International_Energy_Agency), *RENEWABLES IN GLOBAL ENERGY SUPPLY, An IEA Fact Sheet[[6]](http://en.wikipedia.org/wiki/Sustainable_energy" \l "cite_note-IEA-5)*

First- and second-generation technologies have entered the markets, and third-generation technologies heavily depend on long term research and development commitments, where the public sector has a role to play.[[6]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-IEA-5)

A 2008 comprehensive [cost-benefit analysis](http://en.wikipedia.org/wiki/Cost-benefit_analysis) review of energy solutions in the context of global warming and other issues ranked [wind power](http://en.wikipedia.org/wiki/Wind_power) combined with [battery electric vehicles](http://en.wikipedia.org/wiki/Battery_electric_vehicle) (BEV) as the most efficient, followed by [concentrated solar power](http://en.wikipedia.org/wiki/Concentrated_solar_power), [geothermal power](http://en.wikipedia.org/wiki/Geothermal_power), [tidal power](http://en.wikipedia.org/wiki/Tidal_power), [photovoltaic](http://en.wikipedia.org/wiki/Photovoltaic), [wave power](http://en.wikipedia.org/wiki/Wave_power), [coal capture and storage](http://en.wikipedia.org/wiki/Clean_coal_technology), [nuclear energy](http://en.wikipedia.org/wiki/Nuclear_power), and finally [biofuels](http://en.wikipedia.org/wiki/Biofuel).[[7]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-jacobson2009-6)

**First-generation technologies**

[](http://en.wikipedia.org/wiki/File:West_Ford_Flat_Geothermal_Cooling_Tower.JPG)One of many power plants at [The Geysers](http://en.wikipedia.org/wiki/The_Geysers), a geothermal power field in northern California, with a total output of over 750 MW.

First-generation technologies are most competitive in locations with abundant resources. Their future use depends on the exploration of the available resource potential, particularly in developing countries, and on overcoming challenges related to the environment and social acceptance.

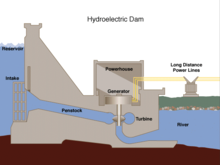
—[International Energy Agency](http://en.wikipedia.org/wiki/International_Energy_Agency), *RENEWABLES IN GLOBAL ENERGY SUPPLY, An IEA Fact Sheet[[6]](http://en.wikipedia.org/wiki/Sustainable_energy" \l "cite_note-IEA-5)*

Among sources of renewable energy, hydroelectric plants have the advantages of being long-lived—many existing plants have operated for more than 100 years. Also, hydroelectric plants are clean and have few emissions. Criticisms directed at large-scale hydroelectric plants include: dislocation of people living where the reservoirs are planned, and release of significant amounts of carbon dioxide during construction and flooding of the reservoir.[[8]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-7)

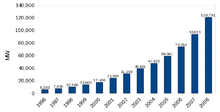
[](http://en.wikipedia.org/wiki/File:Nishidaira_Dam.jpg)[Hydroelectric dams](http://en.wikipedia.org/wiki/Hydroelectricity) are one of the most widely deployed sources of sustainable energy.

However, it has been found that high emissions are associated only with shallow reservoirs in warm (tropical) locales. Generally speaking, hydroelectric plants produce much lower life-cycle emissions than other types of generation. Hydroelectric power, which underwent extensive development during growth of electrification in the 19th and 20th centuries, is experiencing resurgence of development in the 21st century. The areas of greatest hydroelectric growth are the booming economies of Asia. China is the development leader; however, other Asian nations are installing hydropower at a rapid pace. This growth is driven by much increased energy costs—especially for imported energy—and widespread desires for more domestically produced, clean, renewable, and economical generation.

*Hydroelectric dam in cross section*

[](http://en.wikipedia.org/wiki/File:Hydroelectric_dam.png)[Geothermal power](http://en.wikipedia.org/wiki/Geothermal_power) plants can operate 24 hours per day, providing base-load capacity, and the world potential capacity for geothermal power generation is estimated at 85 GW over the next 30 years. However, geothermal power is accessible only in limited areas of the world, including the United States, Central America, Indonesia, East Africa and the Philippines. The costs of geothermal energy have dropped substantially from the systems built in the 1970s.[[6]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-IEA-5) [Geothermal heat](http://en.wikipedia.org/wiki/Geothermal_heat) generation can be competitive in many countries producing geothermal power, or in other regions where the resource is of a lower temperature. [Enhanced geothermal system](http://en.wikipedia.org/wiki/Enhanced_geothermal_system) (EGS) technology does not require natural convective hydrothermal resources, so it can be used in areas that were previously unsuitable for geothermal power, if the resource is very large. EGS is currently under research at the U.S. Department of Energy.

[Biomass briquettes](http://en.wikipedia.org/wiki/Biomass_briquettes) are increasingly being used in the developing world as an alternative to charcoal. The technique involves the conversion of almost any plant matter into compressed briquettes that typically have about 70% the calorific value of charcoal. There are relatively few examples of large scale briquette production. One exception is in North Kivu, in eastern [Democratic Republic of Congo](http://en.wikipedia.org/wiki/Democratic_Republic_of_Congo), where forest clearance for charcoal production is considered to be the biggest threat to Mountain Gorilla habitat. The staff of [Virunga National Park](http://en.wikipedia.org/wiki/Virunga_National_Park) have successfully trained and equipped over 3500 people to produce biomass briquettes, thereby replacing charcoal produced illegally inside the national park, and creating significant employment for people living in extreme poverty in conflict affected areas.[[9]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-8)

**[](http://en.wikipedia.org/wiki/File:WorldWindPower.png)Second-generation technologies**

Worldwide installed wind power capacity 1996-2008

Markets for second-generation technologies are strong and growing, but only in a few countries. The challenge is to broaden the market base for continued growth worldwide. Strategic deployment in one country not only reduces technology costs for users there, but also for those in other countries, contributing to overall cost reductions and performance improvement.

—[International Energy Agency](http://en.wikipedia.org/wiki/International_Energy_Agency), *RENEWABLES IN GLOBAL ENERGY SUPPLY, An IEA Fact Sheet[[6]](http://en.wikipedia.org/wiki/Sustainable_energy" \l "cite_note-IEA-5)*

[](http://en.wikipedia.org/wiki/File:SolarPowerPlantSerpa.jpg)[Solar heating](http://en.wikipedia.org/wiki/Solar_heating) systems are a well known second-generation technology and generally consist of solar thermal collectors, a fluid system to move the heat from the collector to its point of usage, and a reservoir or tank for heat storage and subsequent use. The systems may be used to heat domestic hot water, swimming pool water, or for space heating.[[10]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-9) The heat can also be used for industrial applications or as an energy input for other uses such as cooling equipment.[[11]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-10) In many climates, a solar heating system can provide a very high percentage (50 to 75%) of domestic hot water energy. Energy received from the sun by the earth is that of electromagnetic radiation. Light ranges of visible, infrared, ultraviolet, x-rays, and radio waves received by the earth through solar energy. The highest power of radiation comes from visible light. Solar power is complicated due to changes in seasons and from day to night. Cloud cover can also add to complications of solar energy, and not all radiation from the sun reaches earth because it is absorbed and dispersed due to clouds and gases within the earth's atmospheres.[[12]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-11)

11 MW solar power plant near Serpa, Portugal

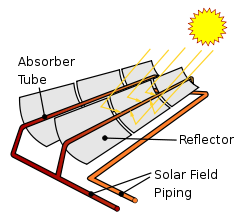
[38°1′51″N 7°37′22″W](http://toolserver.org/%7Egeohack/geohack.php?pagename=Sustainable_energy&params=38_1_51_N_7_37_22_W_)

[38.03083°N 7.62278°W](http://toolserver.org/%7Egeohack/geohack.php?pagename=Sustainable_energy&params=38_1_51_N_7_37_22_W_)

[38.03083; -7.62278](http://toolserver.org/%7Egeohack/geohack.php?pagename=Sustainable_energy&params=38_1_51_N_7_37_22_W_)

In the 1980s and early 1990s, most photovoltaic modules provided [remote-area power supply](http://en.wikipedia.org/wiki/Remote-area_power_supply), but from around 1995, industry efforts have focused increasingly on developing [building integrated photovoltaics](http://en.wikipedia.org/wiki/Building_integrated_photovoltaics) and power plants for grid connected applications (see [photovoltaic power stations](http://en.wikipedia.org/wiki/Photovoltaic_power_stations) article for details). Currently the largest photovoltaic power plant in North America is the [Nellis Solar Power Plant](http://en.wikipedia.org/wiki/Nellis_Solar_Power_Plant) (15 MW).[[13]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-prn1-12)[[14]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-13) There is a proposal to build a [Solar power station in Victoria](http://en.wikipedia.org/wiki/Solar_power_station_in_Victoria), Australia, which would be the world's largest PV power station, at 154 MW.[[15]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-14)[[16]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-15) Other large photovoltaic power stations include the [Girassol solar power plant](http://en.wikipedia.org/wiki/Girassol_solar_power_plant) (62 MW),[[17]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-16) and the [Waldpolenz Solar Park](http://en.wikipedia.org/wiki/Waldpolenz_Solar_Park) (40 MW).[[18]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-17)

*Sketch of a Parabolic Trough Collector*

[](http://en.wikipedia.org/wiki/File:Solarpipe-scheme.svg)Some of the second-generation renewables, such as wind power, have high potential and have already realised relatively low production costs. At the end of 2008, worldwide [wind farm](http://en.wikipedia.org/wiki/Wind_farm) capacity was 120,791 [megawatts](http://en.wikipedia.org/wiki/Megawatts) (MW), representing an increase of 28.8 percent during the year,[[19]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-18) and [wind power](http://en.wikipedia.org/wiki/Wind_power) produced some 1.3% of global electricity consumption.[[20]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-19) Wind power accounts for approximately 20% of electricity use in [Denmark](http://en.wikipedia.org/wiki/Wind_power_in_Denmark), 9% in [Spain](http://en.wikipedia.org/wiki/Wind_power_in_Spain), and 7% in [Germany](http://en.wikipedia.org/wiki/Wind_power_in_Germany).[[21]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-20)[[22]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-21) However, it may be difficult to site wind turbines in some areas for aesthetic or environmental reasons, and it may be difficult to integrate wind power into electricity grids in some cases.[[6]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-IEA-5)

Solar thermal power stations have been successfully operating in [California](http://en.wikipedia.org/wiki/California) commercially since the late 1980s, including the largest solar power plant of any kind, the 350 MW [Solar Energy Generating Systems](http://en.wikipedia.org/wiki/Solar_Energy_Generating_Systems). [Nevada Solar One](http://en.wikipedia.org/wiki/Nevada_Solar_One) is another 64MW plant which has recently opened.[[23]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-22) Other parabolic trough power plants being proposed are two 50MW plants in [Spain](http://en.wikipedia.org/wiki/Spain), and a 100MW plant in [Israel](http://en.wikipedia.org/wiki/Israel).[[24]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-23)

*[](http://en.wikipedia.org/wiki/File:EthanolPetrol.jpg)Information on pump, California*

[Brazil](http://en.wikipedia.org/wiki/Brazil) has one of the largest renewable energy programs in the world, involving production of [ethanol fuel](http://en.wikipedia.org/wiki/Ethanol_fuel) from [sugar cane](http://en.wikipedia.org/wiki/Sugar_cane), and [ethanol](http://en.wikipedia.org/wiki/Ethanol) now provides 18 percent of the country's automotive fuel. As a result of this, together with the exploitation of domestic deep water oil sources, Brazil, which years ago had to import a large share of the petroleum needed for domestic consumption, recently reached complete self-sufficiency in oil.[[25]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-24)[[26]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-25)[[27]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-26)

Most cars on the road today in the U.S. can run on blends of up to 10% ethanol, and motor vehicle manufacturers already produce vehicles designed to run on much higher ethanol blends. [Ford](http://en.wikipedia.org/wiki/Ford_Motor_Company), [DaimlerChrysler](http://en.wikipedia.org/wiki/DaimlerChrysler), and [GM](http://en.wikipedia.org/wiki/General_Motors_Corporation) are among the automobile companies that sell “flexible-fuel” cars, trucks, and minivans that can use gasoline and ethanol blends ranging from pure gasoline up to 85% ethanol (E85). By mid-2006, there were approximately six million E85-compatible vehicles on U.S. roads.[[28]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-world-27)

**Third-generation technologies**

[](http://en.wikipedia.org/wiki/File:Flipped_MIT_Solar_One_house.png)Third-generation technologies are not yet widely demonstrated or commercialised. They are on the horizon and may have potential comparable to other renewable energy technologies, but still depend on attracting sufficient attention and RD&D funding. These newest technologies include advanced [biomass gasification](http://en.wikipedia.org/wiki/Biomass_gasification), [biorefinery](http://en.wikipedia.org/wiki/Biorefinery) technologies, [solar thermal](http://en.wikipedia.org/wiki/Solar_thermal) power stations, [hot dry rock geothermal energy](http://en.wikipedia.org/wiki/Hot_dry_rock_geothermal_energy), and [ocean energy](http://en.wikipedia.org/wiki/Ocean_energy).

MIT's Solar House #1 built in 1939 used

[seasonal thermal storage](http://en.wikipedia.org/wiki/Seasonal_thermal_storage) for year round heating.

—[International Energy Agency](http://en.wikipedia.org/wiki/International_Energy_Agency), *RENEWABLES IN GLOBAL ENERGY SUPPLY, An IEA Fact Sheet[[6]](http://en.wikipedia.org/wiki/Sustainable_energy" \l "cite_note-IEA-5)*

[](http://en.wikipedia.org/wiki/File:SeaGen_installed.jpg)According to the International Energy Agency, new bioenergy (biofuel) technologies being developed today, notably cellulosic ethanol biorefineries, could allow biofuels to play a much bigger role in the future than previously thought.[[29]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-28) Cellulosic ethanol can be made from plant matter composed primarily of inedible cellulose fibers that form the stems and branches of most plants. Crop residues (such as corn stalks, wheat straw and rice straw), wood waste, and municipal solid waste are potential sources of cellulosic biomass. Dedicated energy crops, such as switchgrass, are also promising cellulose sources that can be [sustainably produced](http://en.wikipedia.org/wiki/Sustainability) in many regions of the United States.[[30]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-29)

*The world's first commercial* [*[31]*](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-30) *tidal stream generator — SeaGen — in* [*Strangford Lough*](http://en.wikipedia.org/wiki/Strangford_Lough)*. The strong* [*wake*](http://en.wikipedia.org/wiki/Wake) *shows the power in the tidal current.*

In terms of [Ocean energy](http://en.wikipedia.org/wiki/Ocean_energy), another third-generation technology, [Portugal](http://en.wikipedia.org/wiki/Portugal) has the world's first commercial [wave farm](http://en.wikipedia.org/wiki/Wave_farm), the [Aguçadora Wave Park](http://en.wikipedia.org/wiki/Agu%C3%A7adora_Wave_Park), under construction in 2007. The farm will initially use three [Pelamis P-750](http://en.wikipedia.org/wiki/Pelamis_Wave_Energy_Converter) machines generating 2.25 MW.[[32]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-31)[[33]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-32) and costs are put at 8.5 million [euro](http://en.wikipedia.org/wiki/Euro). Subject to successful operation, a further 70 million euro is likely to be invested before 2009 on a further 28 machines to generate 525 MW.[[34]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-33) Funding for a wave farm in [Scotland](http://en.wikipedia.org/wiki/Scotland) was announced in February, 2007 by the [Scottish Executive](http://en.wikipedia.org/wiki/Scottish_Executive), at a cost of over 4 million [pounds](http://en.wikipedia.org/wiki/Pound_sterling), as part of a £13 million funding packages for [ocean power in Scotland](http://en.wikipedia.org/wiki/Renewable_energy_in_Scotland#Wave_power). The farm will be the world's largest with a capacity of 3 MW generated by four Pelamis machines.[[35]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-34) (see also [Wave farm](http://en.wikipedia.org/wiki/Wave_farm)).

In 2007, the world's first turbine to create commercial amounts of energy using [tidal power](http://en.wikipedia.org/wiki/Tidal_power) was installed in the narrows of [Strangford Lough](http://en.wikipedia.org/wiki/Strangford_Lough) in Ireland. The 1.2 MW underwater tidal electricity generator takes advantage of the fast tidal flow in the lough which can be up to 4[m/s](http://en.wikipedia.org/wiki/M/s). Although the generator is powerful enough to power up to a thousand homes, the [turbine](http://en.wikipedia.org/wiki/Turbine) has a minimal [environmental impact](http://en.wikipedia.org/wiki/Environmental_degradation), as it is almost entirely submerged, and the rotors turn slowly enough that they pose no danger to [wildlife](http://en.wikipedia.org/wiki/Wildlife).[[36]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-35)[[37]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-36)

Solar power panels that use [nanotechnology](http://en.wikipedia.org/wiki/Nanotechnology), which can create circuits out of individual silicon molecules, may cost half as much as traditional photovoltaic cells, according to executives and investors involved in developing the products. [Nanosolar](http://en.wikipedia.org/wiki/Nanosolar) has secured more than $100 million from investors to build a factory for nanotechnology thin-film solar panels. The company's plant has a planned production capacity of 430 megawatts peak power of solar cells per year. Commercial production started and first panels have been shipped[[38]](http://en.wikipedia.org/wiki/Sustainable_energy" \l "cite_note-37) to customers in late 2007.[[39]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-38)

Most current solar power plants are made from an array of similar units where each unit is continuously adjusted, e.g., with some step motors, so that the light converter stays in focus of the sun light. The cost of focusing light on converters such as high-power solar panels, [Stirling engine](http://en.wikipedia.org/wiki/Stirling_engine), etc. can be dramatically decreased with a simple and efficient rope mechanics.[[40]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-39) In this technique many units are connected with a network of ropes so that pulling two or three ropes is sufficient to keep all light converters simultaneously in focus as the direction of the sun changes.

**Energy efficiency**

Moving towards energy sustainability will require changes not only in the way energy is supplied, but in the way it is used, and reducing the amount of energy required to deliver various goods or services is essential. Opportunities for improvement on the demand side of the energy equation are as rich and diverse as those on the supply side, and often offer significant economic benefits.[[41]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-40)

Renewable energy and [energy efficiency](http://en.wikipedia.org/wiki/Efficient_energy_use) are sometimes said to be the “twin pillars” of sustainable energy policy. Both resources must be developed in order to stabilize and reduce carbon dioxide emissions. Efficiency slows down energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too fast, renewable energy development will chase a receding target. Likewise, unless clean energy supplies come online rapidly, slowing demand growth will only begin to reduce total emissions; reducing the carbon content of energy sources is also needed. Any serious vision of a sustainable energy economy thus requires commitments to both renewables and efficiency.[[42]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-41)

Renewable energy (and energy efficiency) are no longer niche sectors that are promoted only by governments and environmentalists. The increased levels of investment and the fact that much of the capital is coming from more conventional financial actors suggest that sustainable energy options are now becoming mainstream.[[43]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-42)

[Climate change](http://en.wikipedia.org/wiki/Climate_change) concerns coupled with [high oil prices](http://en.wikipedia.org/wiki/Oil_price_increases_since_2003) and increasing government support are driving increasing rates of investment in the sustainable energy industries, according to a trend analysis from the [United Nations Environment Programme](http://en.wikipedia.org/wiki/United_Nations_Environment_Programme). According to [UNEP](http://en.wikipedia.org/wiki/UNEP), global investment in sustainable energy in 2007 was higher than previous levels, with $148 billion of new money raised in 2007, an increase of 60% over 2006. Total financial transactions in sustainable energy, including acquisition activity, was $204 billion.[[44]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-invest-43)

Investment flows in 2007 broadened and diversified, making the overall picture one of greater breadth and depth of sustainable energy use. The mainstream capital markets are "now fully receptive to sustainable energy companies, supported by a surge in funds destined for clean energy investment".[[44]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-invest-43)

**Green energy**

[](http://en.wikipedia.org/wiki/File:Solar_Array.jpg)

*A* [*solar trough*](http://en.wikipedia.org/wiki/Solar_trough) *array is an example of green energy*

Green energy includes natural energetic processes that can be harnessed with little pollution. [Anaerobic digestion](http://en.wikipedia.org/wiki/Anaerobic_digestion), [geothermal power](http://en.wikipedia.org/wiki/Geothermal_power), [wind power](http://en.wikipedia.org/wiki/Wind_power), small-scale [hydropower](http://en.wikipedia.org/wiki/Hydropower), [solar energy](http://en.wikipedia.org/wiki/Solar_energy), [biomass power](http://en.wikipedia.org/wiki/Biomass_power), [tidal power](http://en.wikipedia.org/wiki/Tidal_power), and [wave power](http://en.wikipedia.org/wiki/Wave_power) fall under such a category. Some definitions may also include power derived from the [incineration](http://en.wikipedia.org/wiki/Incineration) of waste.

Some people, including [George Monbiot](http://en.wikipedia.org/wiki/George_Monbiot)[[45]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-44) and [James Lovelock](http://en.wikipedia.org/wiki/James_Lovelock)[[46]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-45) have specifically classified [nuclear power](http://en.wikipedia.org/wiki/Nuclear_power) as green energy. Others, including [Greenpeace](http://en.wikipedia.org/wiki/Greenpeace)[[47]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-46)[[48]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-47) disagree, claiming that the problems associated with [radioactive waste](http://en.wikipedia.org/wiki/Radioactive_waste) and the risk of nuclear accidents (such as the [Chernobyl disaster](http://en.wikipedia.org/wiki/Chernobyl_disaster)) pose an unacceptable risk to the environment and to humanity.

No power source is entirely impact-free. All energy sources require energy and give rise to some degree of pollution from manufacture of the technology.

In several [countries](http://en.wikipedia.org/wiki/Nation) with [common carrier](http://en.wikipedia.org/wiki/Common_carrier) arrangements, [electricity retailing](http://en.wikipedia.org/wiki/Electricity_retailing) arrangements make it possible for consumers to purchase green electricity ([renewable electricity](http://en.wikipedia.org/wiki/Renewable_electricity)) from either their utility or a green power provider.

When energy is purchased from the electricity network, the power reaching the consumer will not necessarily be generated from green energy sources. The local [utility company](http://en.wikipedia.org/wiki/Public_utility), [electric company](http://en.wikipedia.org/wiki/Electric_company), or state power pool buys their electricity from [electricity producers](http://en.wikipedia.org/wiki/Electricity_generation) who may be generating from [fossil fuel](http://en.wikipedia.org/wiki/Fossil_fuel), [nuclear](http://en.wikipedia.org/wiki/Nuclear_power) or renewable energy sources. In many countries green energy currently provides a very small amount of electricity, generally contributing less than 2 to 5% to the overall pool. In some U.S. states, local governments have formed regional power purchasing pools using [Community Choice Aggregation](http://en.wikipedia.org/wiki/Community_Choice_Aggregation) and [Solar Bonds](http://en.wikipedia.org/w/index.php?title=Solar_Bonds&action=edit&redlink=1) to achieve a 51% renewable mix or higher, such as in the City of San Francisco.[[49]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-48)

By participating in a green energy program a consumer may be having an effect on the energy sources used and ultimately might be helping to promote and expand the use of green energy. They are also making a statement to policy makers that they are willing to pay a price premium to support renewable energy. Green energy consumers either obligate the utility companies to increase the amount of green energy that they purchase from the pool (so decreasing the amount of non-green energy they purchase), or directly fund the green energy through a green power provider. If insufficient green energy sources are available, the utility must develop new ones or [contract](http://en.wikipedia.org/wiki/Contract) with a third party energy supplier to provide green energy, causing more to be built. However, there is no way the consumer can check whether or not the electricity bought is "green" or otherwise.

In some countries such as the Netherlands, electricity companies guarantee to buy an equal amount of 'green power' as is being used by their green power customers. The [Dutch](http://en.wikipedia.org/wiki/Netherlands) government exempts green power from pollution taxes, which means green power is hardly any more expensive than other power.

In the United States, one of the main problems with purchasing green energy through the electrical grid is the current centralized infrastructure that supplies the consumer’s electricity. This infrastructure has led to increasingly frequent brown outs and black outs, high CO2 emissions, higher energy costs, and power quality issues.[[50]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-49) An additional $450 billion will be invested to expand this fledgling system over the next 20 years to meet increasing demand.[[51]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-50) In addition, this centralized system is now being further overtaxed with the incorporation of renewable energies such as wind, solar, and geothermal energies. Renewable resources, due to the amount of space they require, are often located in remote areas where there is a lower energy demand. The current infrastructure would make transporting this energy to high demand areas, such as urban centers, highly inefficient and in some cases impossible. In addition, despite the amount of renewable energy produced or the economic viability of such technologies only about 20 percent will be able to be incorporated into the grid. To have a more sustainable energy profile, the United States must move towards implementing changes to the electrical grid that will accommodate a mixed-fuel economy.[[52]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-51)

However, several initiatives are being proposed to mitigate these distribution problems. First and foremost, the most effective way to reduce USA’s CO2 emissions and slow global warming is through conservation efforts. Opponents of the current US electrical grid have also advocated for decentralizing the grid. This system would increase efficiency by reducing the amount of energy lost in transmission. It would also be economically viable as it would reduce the amount of power lines that will need to be constructed in the future to keep up with demand. Merging heat and power in this system would create added benefits and help to increase its efficiency by up to 80-90%. This is a significant increase from the current fossil fuel plants which only have an efficiency of 34%.[[53]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-52)

A more recent concept for improving our electrical grid is to beam microwaves from Earth-orbiting satellites or the moon to directly when and where there is demand. The power would be generated from solar energy captured on the lunar surface In this system, the receivers would be “broad, translucent tent-like structures that would receive microwaves and convert them to electricity”. NASA said in 2000 that the technology was worth pursuing but it is still too soon to say if the technology will be cost-effective.[[54]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-53)

The [World Wide Fund for Nature](http://en.wikipedia.org/wiki/World_Wide_Fund_for_Nature) and several green electricity labelling organizations have created the [Eugene Green Energy Standard](http://en.wikipedia.org/wiki/Eugene_Green_Energy_Standard) under which the national green electricity certification schemes can be accredited to ensure that the purchase of green energy leads to the provision of additional new green energy resources.[[55]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-54)

**Local green energy systems**

Main article: [Microgeneration](http://en.wikipedia.org/wiki/Microgeneration)

Those not satisfied with the third-party grid approach to green energy via the power grid can install their own locally based renewable energy system. Renewable energy electrical systems from solar to wind to even local hydro-power in some cases, are some of the many types of renewable energy systems available locally. Additionally, for those interested in heating and cooling their dwelling via renewable energy, [geothermal heat pump](http://en.wikipedia.org/wiki/Geothermal_exchange_heat_pump) systems that tap the constant [temperature](http://en.wikipedia.org/wiki/Temperature) of the earth, which is around 7 to 15 degrees [Celsius](http://en.wikipedia.org/wiki/Celsius) a few feet underground, are an option and save money over conventional [natural gas](http://en.wikipedia.org/wiki/Natural_gas) and [petroleum](http://en.wikipedia.org/wiki/Petroleum)-fueled heat approaches.

The advantage of this approach in the United States is that many states offer incentives to offset the cost of installation of a renewable energy system. In California, Massachusetts and several other U.S. states, a new approach to community energy supply called [Community Choice Aggregation](http://en.wikipedia.org/wiki/Community_Choice_Aggregation) has provided communities with the means to solicit a competitive electricity supplier and use municipal revenue bonds to finance development of local green energy resources. Individuals are usually assured that the electricity they are using is actually produced from a green energy source that they control. Once the system is paid for, the owner of a renewable energy system will be producing their own renewable electricity for essentially no cost and can sell the excess to the local utility at a profit.

**Using green energy**

Main articles: [Energy storage](http://en.wikipedia.org/wiki/Energy_storage) and [Grid energy storage](http://en.wikipedia.org/wiki/Grid_energy_storage)

Renewable energy, after its generation, needs to be stored in a medium for use with autonomous devices as well as vehicles. Also, to provide household electricity in remote areas (that is areas which are not connected to the [mains electricity grid](http://en.wikipedia.org/wiki/Mains_electricity)), energy storage is required for use with renewable energy. Energy generation and consumption systems used in the latter case are usually [stand-alone power systems](http://en.wikipedia.org/wiki/Stand-alone_power_system).

Some examples are:

* energy carriers as [hydrogen](http://en.wikipedia.org/wiki/Hydrogen), [liquid nitrogen](http://en.wikipedia.org/wiki/Liquid_nitrogen), [compressed air](http://en.wikipedia.org/wiki/Compressed_air), [oxyhydrogen](http://en.wikipedia.org/wiki/Oxyhydrogen), [batteries](http://en.wikipedia.org/wiki/Battery_%28electricity%29), to power vehicles.
* [flywheel energy storage](http://en.wikipedia.org/wiki/Flywheel_energy_storage), [pumped-storage hydroelectricity](http://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity) is more usable in stationary applications (eg to power homes and offices. In household power systems, conversion of energy can also be done to reduce smell. For example organic matter such as cow dung and spoilable organic matter can be converted to [biochar](http://en.wikipedia.org/wiki/Biochar). To eliminate emissions, [carbon capture and storage](http://en.wikipedia.org/wiki/Carbon_capture_and_storage) is then used.

Usually however, renewable energy is derived from the mains electricity grid. This means that energy storage is mostly not used, as the mains electricity grid is organised to produce the exact amount of energy being consumed at that particular moment. Energy production on the mains electricity grid is always set up as a combination of (large-scale) renewable energy plants, as well as other power plants as [fossil-fuel power plants](http://en.wikipedia.org/wiki/Fossil-fuel_power_plant) and [nuclear power](http://en.wikipedia.org/wiki/Nuclear_power). This combination however, which is essential for this type of energy supply (as eg wind turbines, solar power plants etc.) can only produce when the wind blows and the sun shines. This is also one of the main drawbacks of the system as fossil fuel powerplants are polluting and are a main cause of [global warming](http://en.wikipedia.org/wiki/Global_warming) (nuclear power being an exception). Although fossil fuel power plants too can made emissionless (through carbon capture and storage), as well as renewable (if the plants are converted to e.g. biomass) the best solution is still to phase out the latter power plants over time. Nuclear power plants too can be more or less eliminated from their problem of nuclear waste through the use of [nuclear reprocessing](http://en.wikipedia.org/wiki/Nuclear_reprocessing) and newer plants as [fast breeder](http://en.wikipedia.org/wiki/Fast_breeder_reactor) and [nuclear fusion](http://en.wikipedia.org/wiki/Nuclear_fusion) plants.

Renewable energy power plants do provide a steady flow of energy. For example hydropower plants, ocean thermal plants, osmotic power plants all provide power at a regulated pace, and are thus available power sources at any given moment (even at night, windstill moments etc.). At present however, the number of steady-flow renewable energy plants alone is still too small to meet energy demands at the times of the day when the irregular producing renewable energy plants cannot produce power.

Besides the greening of fossil fuel and nuclear power plants, another option is the distribution and immediate use of power from solely renewable sources. In this set-up energy storage is again not necessary. For example, [TREC](http://en.wikipedia.org/wiki/Trans-Mediterranean_Renewable_Energy_Cooperation) has proposed to distribute solar power from the Sahara to Europe. Europe can distribute wind and ocean power to the Sahara and other countries. In this way, power is produced at any given time as at any point of the planet as the sun or the wind is up or ocean waves and currents are stirring. This option however is probably not possible in the short-term, as fossil fuel and nuclear power are still the main sources of energy on the mains electricity net and replacing them will not be possible overnight.

Several [large-scale energy storage suggestions for the grid](http://en.wikipedia.org/wiki/Grid_energy_storage) have been done. This improves efficiency and decreases energy losses but a conversion to a energy storing mains electricity grid is a very costly solution. Some costs could potentially be reduced by making use of energy storage equipment the consumer buys and not the state. An example is [car batteries](http://en.wikipedia.org/wiki/Grid_energy_storage) in personal vehicles that would double as an energy buffer for the electricity grid. However besides the cost, setting-up such a system would still be a very complicated and difficult procedure. Also, energy storage apparatus' as car batteries are also built with materials that pose a threat to the environment (eg sulphuric acid). The combined production of batteries for such a large part of the population would thus still not quite environmental. Besides car batteries however, other [large-scale energy storage suggestions for the grid](http://en.wikipedia.org/wiki/Grid_energy_storage) have been done which make use of less polluting energy carriers (eg compressed air tanks and flywheel energy storage).

**Green energy and labeling by region**

**European Union**

See also: [Green electricity in the United Kingdom](http://en.wikipedia.org/wiki/Green_electricity_in_the_United_Kingdom)

Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of [cogeneration](http://en.wikipedia.org/wiki/Cogeneration) based on a useful heat demand in the [internal energy market](http://en.wikipedia.org/wiki/Internal_energy_market)[[56]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-55) includes the article 5 (*Guarantee of origin of electricity* from high-efficiency cogeneration).

Finnish electricity markets are among the most liberal of the world. Markets were partially opened for big electricity users in 1995 and for all users in 1997.[[57]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-56) In 1998 the [Finnish Association for Nature Conservation](http://en.wikipedia.org/w/index.php?title=Finnish_Association_for_Nature_Conservation&action=edit&redlink=1) launched an [ecolabel](http://en.wikipedia.org/wiki/Ecolabel) for electricity. The ecolabel is called [EKOenergy](http://en.wikipedia.org/wiki/EKOenergy). 10 out of 70 Finnish electricity retailers have managed to fulfill the criteria of EKOenergy. Almost 4% of the electricity in Finland was sold under the label in 2008. End users buying EKOenergy influence in profitability of different electricity production plants.[[58]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-57) In 2009 25.7% of all the energy consumed in Finland was from renewable energy sources.[[59]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-58) Only part of electricity produced by renewables fulfills the EKOenergy criteria.

A [Green Energy Supply Certification Scheme](http://en.wikipedia.org/wiki/Green_electricity_in_the_United_Kingdom#The_Green_Energy_Supply_Certification_Scheme) was launched in the United Kingdom in February 2010. This implements guidelines from the Energy Regulator, [Ofgem](http://en.wikipedia.org/wiki/Ofgem), and sets requirements on transparency, the matching of sales by renewable energy supplies, and additionality.[[60]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-59)

**United States**

The [United States Department of Energy](http://en.wikipedia.org/wiki/United_States_Department_of_Energy) (DOE), the [Environmental Protection Agency](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) (EPA), and the Center for Resource Solutions (CRS)[[61]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-60) recognizes the voluntary purchase of electricity from renewable energy sources (also called renewable electricity or green electricity) as green power.[[62]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-renewableenergyworld.com-61)

The most popular way to purchase renewable energy as revealed by [NREL](http://en.wikipedia.org/wiki/NREL) data is through purchasing [Renewable Energy Certificates](http://en.wikipedia.org/wiki/Renewable_Energy_Certificate) (RECs). According to a [Natural Marketing Institute](http://en.wikipedia.org/w/index.php?title=Natural_Marketing_Institute&action=edit&redlink=1) (NMI)[[63]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-62) survey 55 percent of American consumers want companies to increase their use of renewable energy.[[62]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-renewableenergyworld.com-61)

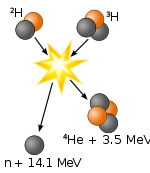
DOE selected six companies for its 2007 Green Power Supplier Awards, including [Constellation NewEnergy](http://en.wikipedia.org/w/index.php?title=Constellation_NewEnergy&action=edit&redlink=1); [3Degrees](http://en.wikipedia.org/w/index.php?title=3Degrees&action=edit&redlink=1); [Sterling Planet](http://en.wikipedia.org/wiki/Sterling_Planet); [SunEdison](http://en.wikipedia.org/wiki/SunEdison); [Pacific Power](http://en.wikipedia.org/wiki/Pacific_Power) and [Rocky Mountain Power](http://en.wikipedia.org/wiki/Rocky_Mountain_Power); and [Silicon Valley Power](http://en.wikipedia.org/wiki/Silicon_Valley_Power). The combined green power provided by those six winners equals more than 5 billion [kilowatt-hours](http://en.wikipedia.org/wiki/Kilowatt-hour) per year, which is enough to power nearly 465,000 average U.S. households.

The [U.S. Environmental Protection Agency‎](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) (USEPA) Green Power Partnership is a voluntary program that supports the organizational procurement of [renewable electricity](http://en.wikipedia.org/wiki/Renewable_electricity) by offering expert advice, technical support, tools and resources. This can help organizations lower the transaction costs of buying renewable power, reduce [carbon footprint](http://en.wikipedia.org/wiki/Carbon_footprint), and communicate its leadership to key stakeholders.[[64]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-63)

Throughout the country, more than half of all U.S. electricity customers now have an option to purchase some type of green power product from a retail [electricity provider](http://en.wikipedia.org/wiki/Electricity_market). Roughly one-quarter of the nation's utilities offer green power programs to customers, and voluntary retail sales of renewable energy in the United States totaled more than 12 billion kilowatt-hours in 2006, a 40% increase over the previous year.

**Nuclear power**

The [deuterium](http://en.wikipedia.org/wiki/Deuterium)-[tritium](http://en.wikipedia.org/wiki/Tritium) (D-T) reaction is one of the more promising for producing [fusion power](http://en.wikipedia.org/wiki/Fusion_power).

[](http://en.wikipedia.org/wiki/File:Deuterium-tritium_fusion.svg)It is said that nuclear has the potential to be sustainable, such as by the use of [breeder reactors](http://en.wikipedia.org/wiki/Breeder_reactor). However, this is often qualified with the argument that there are serious challenges that must be dealt with before it can drastically increase its role.[[65]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-64)

There are potentially two sources of nuclear power. [Fission](http://en.wikipedia.org/wiki/Nuclear_power) is used in all current nuclear power plants. [Fusion](http://en.wikipedia.org/wiki/Fusion_power) is the reaction that powers stars, including the sun, which remains impractical for use on earth. Both types create radioactive waste in the form of [activated](http://en.wikipedia.org/wiki/Neutron_activation) structural material, which is one of the sustainability issues. Note that [Aneutronic fusion](http://en.wikipedia.org/wiki/Aneutronic_fusion) such as He3-D fusion or Boron-Proton fusion produce far less or virtually zero radioactivity but are more difficult to fuse.

Fission power's long-term sustainability depends on the amount of uranium and thorium that are available to be mined, on the operators' abilities safely to dispose of the waste and on the continued prevention of major accidents. Estimates for fuel reserves vary widely. Fusion power's long-term sustainability depends on whether or not a practical, affordable technology can be developed.

**Technical sustainability of nuclear power**

Proponents, such as [Christine Todd Whitman](http://en.wikipedia.org/wiki/Christine_Todd_Whitman) and [Patrick Moore](http://en.wikipedia.org/wiki/Patrick_Moore_%28environmentalist%29) (both co-chairs of the [Clean and Safe Energy Coalition](http://en.wikipedia.org/w/index.php?title=Clean_and_Safe_Energy_Coalition&action=edit&redlink=1)) also claim that nuclear power is at least as environmentally friendly as traditional sources of renewable energy, making it part of the solution to [global warming](http://en.wikipedia.org/wiki/Global_warming) and the world's currently growing demand for energy. They note that nuclear power plants, once built and before decommissioning begins, produce little carbon dioxide emissions and point out that the radioactive waste produced is minimal and well-contained, especially compared to fossil fuels.[[66]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-nei.org-65)[[67]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-66)[[68]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-67) [Robert Bryce](http://en.wikipedia.org/wiki/Robert_Bryce_%28writer%29) argues that a future dominated by nuclear power is unavoidable since it is inherently superior, in terms of [energy density](http://en.wikipedia.org/wiki/Energy_density), reliability, and land required per unit of energy, to any other method of [low carbon power generation](http://en.wikipedia.org/wiki/Low_carbon_power_generation).[[69]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-68) Some people object to this claim on the grounds that the nuclear option is not price competitive without heavy government subsidy and the use of government bodies to store and protect such a hazardous waste component.[[66]](http://en.wikipedia.org/wiki/Sustainable_energy#cite_note-nei.org-65)

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| [**Renewable energy by country**](http://en.wikipedia.org/wiki/List_of_renewable_energy_topics_by_country) | | |
| [Wind](http://en.wikipedia.org/wiki/Wind_power) | by region | [Asia](http://en.wikipedia.org/wiki/Wind_power_in_Asia) **·** [Europe (EU)](http://en.wikipedia.org/wiki/Wind_power_in_the_European_Union) |
|  | [by country](http://en.wikipedia.org/wiki/Category:Wind_power_by_country) | [Australia](http://en.wikipedia.org/wiki/Wind_power_in_Australia) **·** [Austria](http://en.wikipedia.org/wiki/Wind_power_in_Austria) **·** [Belgium](http://en.wikipedia.org/wiki/Wind_power_in_Belgium) **·** [Brazil](http://en.wikipedia.org/wiki/Wind_power_in_Brazil) **·** [Canada](http://en.wikipedia.org/wiki/Wind_power_in_Canada) **·** [China](http://en.wikipedia.org/wiki/Wind_power_in_China) **·**  **·** [Croatia](http://en.wikipedia.org/wiki/Wind_power_in_Croatia) **·** [Denmark](http://en.wikipedia.org/wiki/Wind_power_in_Denmark) **·** [Estonia](http://en.wikipedia.org/wiki/Wind_power_in_Estonia) **·** [Finland](http://en.wikipedia.org/wiki/Wind_power_in_Finland) **·** [France](http://en.wikipedia.org/wiki/Wind_power_in_France) **·** [Germany](http://en.wikipedia.org/wiki/Wind_power_in_Germany) **·** [Greece](http://en.wikipedia.org/wiki/Wind_power_in_Greece) **·** [India](http://en.wikipedia.org/wiki/Wind_power_in_India) **·** [Iran](http://en.wikipedia.org/wiki/Wind_power_in_Iran) **·** [Ireland](http://en.wikipedia.org/wiki/Wind_power_in_the_Republic_of_Ireland) **·** [Italy](http://en.wikipedia.org/wiki/Wind_power_in_Italy) **·** [Japan](http://en.wikipedia.org/wiki/Wind_power_in_Japan) **·** [Malta](http://en.wikipedia.org/wiki/Wind_power_in_Malta)  **·** [Morocco](http://en.wikipedia.org/wiki/Wind_power_in_Morocco)  **·** [New Zealand](http://en.wikipedia.org/wiki/Wind_power_in_New_Zealand) **·** [Pakistan](http://en.wikipedia.org/wiki/Wind_power_in_Pakistan) **·** [Portugal](http://en.wikipedia.org/wiki/Wind_power_in_Portugal) **·** [Romania](http://en.wikipedia.org/wiki/Wind_power_in_Romania) **·** [Spain](http://en.wikipedia.org/wiki/Wind_power_in_Spain) **·** [Sweden](http://en.wikipedia.org/wiki/Wind_power_in_Sweden) **·** [Turkey](http://en.wikipedia.org/wiki/Wind_power_in_Turkey) **·** [United Kingdom](http://en.wikipedia.org/wiki/Wind_power_in_the_United_Kingdom) **·** [United States](http://en.wikipedia.org/wiki/Wind_power_in_the_United_States) |
| [Solar](http://en.wikipedia.org/wiki/Solar_energy) | by region | [Asia](http://en.wikipedia.org/wiki/Renewable_energy_in_Asia) **·** [Europe (EU)](http://en.wikipedia.org/wiki/Solar_power_in_the_European_Union) |
|  | [by country](http://en.wikipedia.org/wiki/Category:Solar_power_by_country) | [Australia](http://en.wikipedia.org/wiki/Solar_power_in_Australia) **·** [Canada](http://en.wikipedia.org/wiki/Solar_power_in_Canada) **·** [China](http://en.wikipedia.org/wiki/Solar_power_in_China) **·** [Germany](http://en.wikipedia.org/wiki/Solar_power_in_Germany) **·** [Greece](http://en.wikipedia.org/wiki/Solar_power_in_Greece) **·** [India](http://en.wikipedia.org/wiki/Solar_power_in_India) **·** [Israel](http://en.wikipedia.org/wiki/Solar_power_in_Israel) **·** [Japan](http://en.wikipedia.org/wiki/Solar_power_in_Japan) **·** [Morocco](http://en.wikipedia.org/wiki/Renewable_energy_in_Morocco#Industry) **·** [Pakistan](http://en.wikipedia.org/wiki/Solar_power_in_Pakistan) **·** [Portugal](http://en.wikipedia.org/wiki/Solar_power_in_Portugal) **·** [Romania](http://en.wikipedia.org/wiki/Solar_power_in_Romania) **·** [Spain](http://en.wikipedia.org/wiki/Solar_power_in_Spain) **·** [Turkey](http://en.wikipedia.org/wiki/Solar_power_in_Turkey) **·** [United Kingdom](http://en.wikipedia.org/wiki/Solar_power_in_the_United_Kingdom) **·** [United States](http://en.wikipedia.org/wiki/Solar_power_in_the_United_States) |
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