EAGLE FEATHER RESEARCH INSTITUTE

GREEN EARTH: RENEWABLE ENERGY

Renewable energy refers to wind energy, methane capture, solar, geothermal and other clean energy sources. Energy generated from clean sources like these reduce the need to generate that same energy from dirty sources like coal or gas.

Developing clean energy projects isn't as cheap as building new coal power plants, at least not yet. That's why it's important for project developers to have access to additional streams of revenue other than the electricity they get to sell. In some cases, renewable energy developers sell the environmental benefit of their projects not as tons of CO_2, but as *Renewable Energy Certificates*. Carbonfund.org supports these projects; the following examines the local energy grid's *carbon profile* to determine how much electricity from dirty sources the project is displacing. Carbon profiles for the entire country are updated each year by the Environmental Protection Agency to ensure accuracy.

Below are some of the renewable energy projects that are supported by carbonfund.com:

Iowa Lakes Wind Energy & Turbine Program - Estherville, Iowa

The Iowa Lakes Community College's Wind Energy and Turbine Program was started in response to a growing need for skilled technicians to install, maintain and service modern wind turbines. Students work on the project as part of a hands-on curriculum leading to the community college's two-year Associate in Science degree. The 230-foot tall structure generates approximately 1.65 megawatts of clean energy and is located near the college's Estherville Campus.

According to the U.S. Department of Energy (DOE), wind power contributed to more than 30 percent of the new U.S. electricity generation capacity in 2007, making it the second largest source of new power generation in the nation, second only to natural gas. Furthermore, the American Wind Energy Association (AWEA) estimates each megawatt of wind provides approximately two job-years of employment and a skilled operations/maintenance position is created for every 10 turbines.

California Solar Projects - Aliso Viejo, Stockton, Ontario, and Anderson, Calif.

Carbonfund.org supports solar projects in California and local consumers are able to take advantage of clean, alternative solar energy which is decentralized and provides increase energy security. Carbonfund.org's support goes toward helping to retrofit school and business facilities with photovoltaic solar panels.

According to the Solar Energy Industry Association (SEIA), solar energy currently represents less than one percent of the U.S. energy portfolio. However, the solar photovoltaic systems which are connected to the grid have increased almost 50% from 2006 to 2007. The U.S. is currently fourth, behind Germany, Japan and Spain, in the world for installed solar power. In addition, SEIA reports solar energy manufacturing in the U.S. increased 74% in 2007, which creates new jobs.

New Bedford Landfill Methane Project - New Bedford, Mass.

The New Bedford Landfill Methane project is a 3.3-megawatt renewable energy plant which uses otherwise wasted landfill gas (LFG) as a fuel to generate electricity. The LFG, which includes methane and carbon dioxide, is collected from the landfill to fuel four reciprocating internal combustion engine-generators. These produce electricity for export to the regional power grid. With support from Carbonfund.org, the project not only produces power, but helps to reduce the amount of methane released into our atmosphere.

The destruction of methane is important in the fight against global climate change because methane is approximately 23 times more efficient as a greenhouse gas than carbon dioxide. With this in mind, one of the real concerns about climate change is that as the frozen tundra of areas such as Siberia and northern reaches of Canada melt, an enormous amount of methane which was previously trapped in the ice will be released into our atmosphere.

North Country Landfill Methane Project - Bethlehem, N.H.

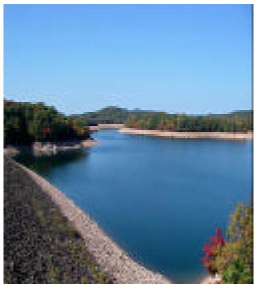
Carbonfund.org supports the North Country Landfill Methane project which safely and effectively disposes up to 7,200 gallons of landfill leachate a day from a municipal solid waste landfill in northern New Hampshire. This project not only prevents methane, a potent greenhouse gas, from being released into the atmosphere, it protects the area's local groundwater from landfill leachate.

Horse Hollow Wind Energy Center - Taylor and Nolan County, Texas

Horse Hollow Wind Energy Center is the largest wind farm in the world and is spread across approximately 47,000 acres. The facility includes over 400 wind turbines for a total capacity of 735.5 megawatts. In addition to providing clean electricity, Carbonfund.org supports the Horse Hollow Wind Energy Center because it financially supports the local communities and is a leading example of how wind energy can significantly contribute to the United States' energy portfolio.

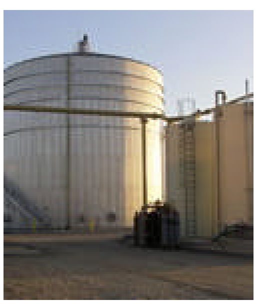
The American Wind Energy Association notes that wind energy could provide 20% of the U.S.'s electricity, and wind is currently providing between 10% and 25% of the electricity for the countries of Germany, Spain and Denmark. For the U.S., Texas is the largest supplier of wind energy followed by California, Minnesota, Iowa and Washington.

Summersville Low Impact Hydroelectric Facility - Summersville, W.V.



Summersville is home to West Virginia's largest lake. Carbonfund.org has supported the Summersville Low Impact Hydroelectric Facility, which is located on the Gualey River. The project was the first of its kind to be certified as low impact in the state of West Virginia. By releasing 2,500 cubic feet of water per second, for each release the project generates clean renewable energy for southern West Virginia. To be certified as low impact by the Low Impact Hydropower Institute, the project addressed issues such as river flows, water quality, fish passage, watershed health, endangered species, cultural resources, and allowing for recreation use and access.

Chino Basin Dairy Farm Biodigester - Chino Basin, Calif.



Biodigesters capture the methane generated by manure and transform it into a clean, renewable energy source. This particular biodigester in Southern California collects manure from ten area dairy farms and is responsible for reducing more than 8,000 tons of CO2 equivalent from the atmosphere every year, while also supporting local farmers and protecting the quality of the region's groundwater. Carbonfund.org supports the Chino Basin Dairy Farm Biodigester to help reduce methane emissions and global warming.

The U.S. EPA Climate Leaders program notes that more than two billion livestock exist in the U.S. and account for 7% for anthropogenic methane emissions.

New York State Landfill Methane Project - Rodman, N.Y.

The New York Landfill Methane Project serves the countries of Jefferson, Lewis, St. Lawrence and Hamilton and in addition, destroys the methane emitted by a landfill by converting it into CO2 and heat. The CO2 is twenty-three times less potent as a greenhouse gas than the methane. In the future, additional plans may include capturing the waste heat and using it to heat a local greenhouse along with providing alternative energy.

Main renewable energy technologies

Three energy sources

The majority of renewable energy technologies are powered by the sun. The Earth-Atmosphere system is in equilibrium such that heat radiation into space is equal to incoming solar radiation, the resulting level of energy within the Earth-Atmosphere system can roughly be described as the Earth's "climate." The hydrosphere (water) absorbs a major fraction of the incoming radiation. Most radiation is absorbed at low latitudes around the equator, but this energy is dissipated around the globe in the form of winds and ocean currents. Wave motion may play a role in the process of transferring mechanical energy between the atmosphere and the ocean through wind stress.[15] Solar energy is also responsible for the distribution of precipitation which is tapped by hydroelectric projects, and for the growth of plants used to create biofuels.

Renewable energy flows involve natural phenomena such as sunlight, wind, tides and geothermal heat, as the International Energy Agency explains:

"Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources."[16]

Each of these sources has unique characteristics which influence how and where they are used.

Wind power

Main article: Wind power

Vestas V80 wind turbines

Airflows can be used to run wind turbines. Modern wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power output of a turbine is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically.[17] Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms.

Since wind speed is not constant, a wind farm's annual energy production is never as much as the sum of the generator nameplate ratings multiplied by the total hours in a year. The ratio of actual productivity in a year to this theoretical maximum is called the capacity factor. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favourable sites.[18][19] For example, a 1 megawatt turbine with a capacity factor of 35% will not produce 8,760 megawatt-hours in a year, but only 0.35x24x365 = 3,066 MWh, averaging to 0.35 MW. Online data is available for some locations and the capacity factor can be calculated from the yearly output.[20][21]

Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand. This could require large amounts of land to be used for wind turbines, particularly in areas of higher wind resources. Offshore resources experience mean wind speeds of ~90% greater than that of land, so offshore resources could contribute substantially more energy.[22] This number could also increase with higher altitude ground-based or airborne wind turbines.[23]

Wind power is renewable and produces no greenhouse gases during operation, such as carbon dioxide and methane.

Water power

Main article: Hydropower

Energy in water (in the form of kinetic energy, temperature differences or salinity gradients) can be harnessed and used. Since water is about 800 times denser than air,[24][25]

even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.

One of 3 PELAMIS P-750 Ocean Wave Power engines in the harbour of Peniche/ Portugal.

There are many forms of water energy:

- Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Examples are the Grand Coulee Dam in Washington State and the Akosombo Dam in Ghana.

- Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a Remote Area Power Supply (RAPS). There are many of these installations around the world, including several delivering around 50 kW in the Solomon Islands.
- Damless hydro systems derive kinetic energy from rivers and oceans without using a dam.
- Ocean energy describes all the technologies to harness energy from the ocean and the sea:
    - Marine current power. Similar to tidal stream power, uses the kinetic energy of marine currents
    - Ocean thermal energy conversion (OTEC) uses the temperature difference between the warmer surface of the ocean and the colder lower recesses. To this end, it employs a cyclic heat engine. OTEC has not been field-tested on a large scale.
    - Tidal power captures energy from the tides. Two different principles for generating energy from the tides are used at the moment:
    4. *Tidal motion in the vertical direction* — Tides come in, raise water levels in a basin, and tides roll out. Around low tide, the water in the basin is discharged through a turbine, exploiting the stored potential energy.
    5. *Tidal motion in the horizontal direction* — Or tidal stream power. Using tidal stream generators, like wind turbines but then in a tidal stream. Due to the high density of water, about eight-hundred times the density of air, tidal currents can have a lot of kinetic energy. Several commercial prototypes have been build, and more are in development.
    - Wave power uses the energy in waves. Wave power machines usually take the form of floating or neutrally buoyant structures which move relative to one another or to a fixed point. Wave power has now reached commercialization.

- Saline gradient power, or osmotic power, is the energy retrieved from the difference in the salt concentration between seawater and river water. Reverse electrodialysis (PRO) is in the research and testing phase.
- Vortex power is generated by placing obstacles in rivers in order to cause the formation of vortices which can then be tapped for energy.
- Deep lake water cooling, although not technically an energy generation method, can save a lot of energy in summer. It uses submerged pipes as a heat sink for climate control systems. Lake-bottom water is a year-round local constant of about 4 °C.

Solar energy use

Main article: Solar energy

Monocrystalline solar cell

In this context, "solar energy" refers to energy that is collected from sunlight. Solar energy can be applied in many ways, including to:

- Generate electricity using photovoltaic solar cells.
- Generate electricity using concentrated solar power.
- Generate electricity by heating trapped air which rotates turbines in a Solar updraft tower.
- Generate electricity in geosynchronous orbit using solar power satellites.
- Generate hydrogen using photoelectrochemical cells.
- Heat and cool air through use of solar chimneys.
- Heat buildings, directly, through passive solar building design.
- Heat foodstuffs, through solar ovens.
- Heat water or air for domestic hot water and space heating needs using solar-thermal panels.
- Solar air conditioning

Biofuel

Main article: Biofuel

Plants use photosynthesis to grow and produce biomass. Also known as biomatter, biomass can be used directly as fuel or to produce biofuels. Agriculturally produced biomass fuels, such as biodiesel, ethanol and bagasse (often a by-product of sugar cane cultivation) can be burned in internal combustion engines or boilers. Typically biofuel is burned to release its stored chemical energy. Research into more efficient methods of converting biofuels and other fuels into electricity utilizing fuel cells is an area of very active work.

Liquid biofuel

Information on pump, California.

Liquid biofuel is usually either a bioalcohol such as ethanol fuel or an oil such as biodiesel or straight vegetable oil. Biodiesel can be used in modern diesel vehicles with little or no modification to the engine. It can be made from waste and virgin vegetable and animal oils and fats (lipids). Virgin vegetable oils can be used in modified diesel engines. In fact the diesel engine was originally designed to run on vegetable oil rather than fossil fuel. A major benefit of biodiesel use is the reduction in net CO_2 emissions, since all the carbon emitted was recently captured during the growing phase of the biomass. The use of biodiesel also reduces emission of carbon monoxide and other pollutants by 20 to 40%.[*citation needed*]

In some areas corn, cornstalks, sugarbeets, sugar cane, and switchgrasses are grown specifically to produce ethanol (also known as grain alcohol) a liquid which can be used in internal combustion engines and fuel cells. Ethanol is being phased into the current energy infrastructure. E85 is a fuel composed of 85% ethanol and 15% gasoline that is sold to consumers. Biobutanol is being developed as an alternative to bioethanol. There is growing international criticism of the production of biofuel crops in association with food crops with respect to issues such as food security, environmental impacts (deforestation) and energy balance.[*citation needed*]

Solid biomass

Main article: Biomass

Sugar cane residue can be used as a biofuel

Solid biomass is mostly commonly usually used directly as a combustible fuel, producing 10-20 MJ/kg of heat.

Its forms and sources include wood fuel, the biogenic portion of municipal solid waste, or the unused portion of field crops. Field crops may or may not be grown intentionally as an energy crop, and the remaining plant byproduct used as a fuel. Most types of biomass contain energy. Even cow manure still contains two-thirds of the original energy consumed by the cow. Energy harvesting via a bioreactor is a cost-effective solution to the waste disposal issues faced by the dairy farmer, and can produce enough biogas to run a farm.

With current technology, it is not ideally suited for use as a transportation fuel. Most transportation vehicles require power sources with high power density, such as that provided by internal combustion engines. These engines generally require clean burning fuels, which are generally in liquid form, and to a lesser extent, compressed gaseous phase. Liquids are more portable because they can have a high energy density, and they can be pumped, which makes handling easier.

Non-transportation applications can usually tolerate the low power-density of external combustion engines, that can run directly on less-expensive solid biomass fuel, for combined heat and power. One type of biomass is wood, which has been used for millennia. Two billion people currently cook every day, and heat their homes in the winter by burning biomass, which is a major contributor to man-made climate change global warming.[citation needed] The black soot that is being carried from Asia to polar ice caps is causing them to melt faster in the summer.[citation needed] In the 19th century, wood-fired steam engines were common, contributing significantly to industrial revolution unhealthy air pollution.[citation needed] Coal is a form of biomass that has been compressed over millennia to produce a non-renewable, highly-polluting fossil fuel.

Wood and its byproducts can now be converted through processes such as gasification into biofuels such as woodgas, biogas, methanol or ethanol fuel; although further development may be required to make these methods affordable and practical. Sugar cane residue, wheat chaff, corn cobs and other plant matter can be, and are, burned quite successfully. The net carbon dioxide emissions that are added to the atmosphere by this process are only from the fossil fuel that was consumed to plant, fertilize, harvest and transport the biomass.

Processes to harvest biomass from short-rotation trees like poplars and willows and perennial grasses such as switchgrass, phalaris, and miscanthus, require less frequent cultivation and less nitrogen than do typical annual crops. Pelletizing miscanthus and burning it to generate electricity is being studied and may be economically viable.[26]

Biogas

Main articles: Biogas and Anaerobic digestion

Biogas can easily be produced from current waste streams, such as paper production, sugar production, sewage, animal waste and so forth. These various waste streams have to be slurried together and allowed to naturally ferment, producing methane gas. This can be done by converting current sewage plants into biogas plants. When a biogas plant has extracted all the methane it can, the remains are sometimes more suitable as fertilizer than the original biomass.

Alternatively biogas can be produced via advanced waste processing systems such as mechanical biological treatment. These systems recover the recyclable elements of household waste and process the biodegradable fraction in anaerobic digesters.

Renewable natural gas is a biogas which has been upgraded to a quality similar to natural gas. By upgrading the quality to that of natural gas, it becomes possible to distribute the gas to the mass market via the existing gas grid.

Geothermal energy

Main article: Geothermal energy

Krafla Geothermal Station in northeast Iceland

Geothermal energy is energy obtained by tapping the heat of the earth itself, usually from kilometers deep into the Earth's crust. It is expensive to build a power station but operating costs are low resulting in low energy costs for suitable sites. Ultimately, this energy derives from heat in the Earth's core.

Three types of power plants are used to generate power from geothermal energy: dry steam, flash, and binary. Dry steam plants take steam out of fractures in the ground and use it to directly drive a turbine that spins a generator. Flash plants take hot water, usually at temperatures over 200 °C, out of the ground, and allows it to boil as it rises to the surface then separates the steam phase in steam/water separators and then runs the steam through a turbine. In binary plants, the hot water flows through heat exchangers, boiling an organic fluid that spins the turbine. The condensed steam and remaining geothermal fluid from all three types of plants are injected back into the hot rock to pick up more heat.

The geothermal energy from the core of the Earth is closer to the surface in some areas than in others. Where hot underground steam or water can be tapped and brought to the surface it may be used to generate electricity. Such geothermal power sources exist in certain geologically unstable parts of the world such as Chile, Iceland, New Zealand, United States, the Philippines and Italy. The two most prominent areas for this in the United States are in the Yellowstone basin and in northern California. Iceland produced 170 MW geothermal power and heated 86% of all houses in the year 2000 through geothermal energy. Some 8000 MW of capacity is operational in total.

There is also the potential to generate geothermal energy from hot dry rocks. Holes at least 3 km deep are drilled into the earth. Some of these holes pump water into the earth, while other holes pump hot water out. The heat resource consists of hot underground radiogenic granite rocks, which heat up when there is enough sediment between the rock and the earths surface. Several companies in Australia are exploring this technology.

Renewable energy commercialization

Main article: Renewable energy commercialization

Costs

Renewable energy systems encompass a broad, diverse array of technologies, and the current status of these can vary considerably. Some technologies are already mature and economically competitive (e.g. geothermal and hydropower), others need additional development to become competitive without subsidies. This can be helped by improvements to sub-components, such as electric generators.

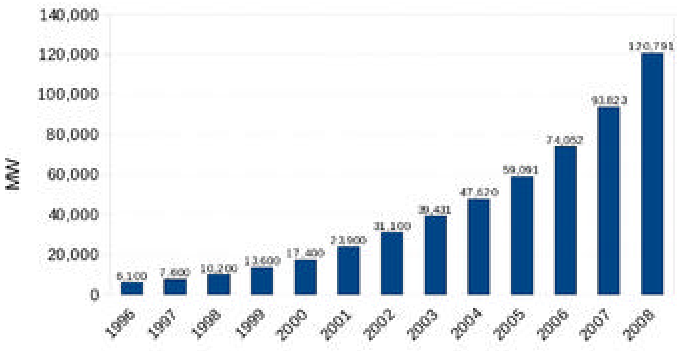
The table shows an overview of costs of various renewable energy technologies. For comparison with the prices in the table, electricity production from a conventional coal-fired plant costs about 4¢/kWh.[27] Though in some G8 nations the cost can be significantly higher at 7.88p (~15¢/kWh).[28] Achieving further cost reductions as indicated in the table below requires further technology development, market deployment, an increase in production capacities to mass production levels,[29] and of the establishment of an emissions trading scheme and/or carbon tax which would attribute a cost to each unit of carbon emitted; thus reflecting the true cost of energy production by fossil fuels which then could be used to lower the cost/kWh of these renewable energies.

	2001 energy costs	Potential future energy cost
Electricity		
Wind	4–8 ¢/kWh	3–10 ¢/kWh

Solar photovoltaic	25–160 ¢/kWh	5–25 ¢/kWh
Solar thermal	12–34 ¢/kWh	4–20 ¢/kWh
Large hydropower	2–10 ¢/kWh	2–10 ¢/kWh
Small hydropower	2–12 ¢/kWh	2–10 ¢/kWh
Geothermal	2–10 ¢/kWh	1–8 ¢/kWh
Biomass	3–12 ¢/kWh	4–10 ¢/kWh
Coal (comparison)	4 ¢/kWh	
Heat		
Geothermal heat	0.5–5 ¢/kWh	0.5–5 ¢/kWh
Biomass — heat	1–6 ¢/kWh	1–5 ¢/kWh
Low temp solar heat	2–25 ¢/kWh	2–10 ¢/kWh
All costs are in 2001 US$-cent per kilowatt-hour.		
Source: World Energy Assessment, 2004 update[29]		

Wind power market

See also: Wind farm and List of wind farms



Wind power: worldwide installed capacity 1996-2008

At the end of 2008, worldwide wind farm capacity was 120,791 megawatts (MW), representing an increase of 28.8 percent during the year,[30] and wind power produced some 1.3% of global electricity consumption.[31] Wind power accounts for approximately 19% of electricity use in Denmark, 9% in Spain and Portugal, and 6% in Germany and the Republic of Ireland.[32] The United States is an important growth area and installed U.S. wind power capacity reached 25,170 MW at the end of 2008.[33]

Horse Hollow Wind Energy Center, in Texas, is the world's largest wind farm at 735.5 MW capacity. It consists of 291 GE Energy 1.5 MW wind turbines and 130 Siemens 2.3 MW wind turbines.[34] A proposed 4,000 MW facility, called the Pampa Wind Project, is to be located near Pampa, Texas.

In the UK, a licence to build the world's largest offshore windfarm, in the Thames estuary, has been granted. The London Array windfarm, 20 km off Kent and Essex, should eventually consist of 341 turbines, occupying an area of 230 km². This is a £1.5 billion, 1,000 megawatt project, which will power one-third of London homes. The windfarm will produce an amount of energy that, if generated by conventional means, would result in 1.9 million tonnes of carbon dioxide emissions every year. It could also make up to 10% of the Government's 2010 renewables target.[35]

New generation of solar thermal plants

The 11 megawatt PS10 solar power tower in Spain produces electricity from the sun using 624 large movable mirrors called heliostats.

Aerial view of one of the SEGS plants.

Main article: List of solar thermal power stations

Since 2004 there has been renewed interest in solar thermal power stations and two plants were completed during 2006/2007: the 64 MW Nevada Solar One and the 11 MW PS10 solar power tower in Spain. Three 50 MW trough plants were under construction in Spain at the end of 2007 with 10 additional 50 MW plants planned. In the United States, utilities in California and Florida have announced plans (or contracted for) at least eight new projects totaling more than 2,000 MW.[36]

In developing countries, three World Bank projects for integrated CSP/combined-cycle gas-turbine power plants in Egypt, Mexico, and Morocco were approved during 2006/2007.[36]

There are several solar thermal power plants in the Mojave Desert which supply power to the electricity grid. Solar Energy Generating Systems (SEGS) is the name given to nine solar power plants in the Mojave Desert which were built in the 1980s. These plants have a combined capacity of 354 megawatts (MW) making them the largest solar power installation in the world.

World's largest photovoltaic power plants

Main article: List of photovoltaic power stations

First Solar 40 MW PV Array installed by JUWI Group in Waldpolenz, Germany

As of January 2009, the largest photovoltaic (PV) power plants in the world are the Parque Fotovoltaico Olmedilla de Alarcon (Spain, 60 MW), the Moura photovoltaic power station (Portugal, 46 MW), and the Waldpolenz Solar Park (Germany, 40 MW). Several other PV power plants were completed in Spain in 2008: Planta Solar Arnedo (30 MW), Parque Solar Merida/Don Alvaro (30 MW), Planta solar Fuente Álamo (26 MW), Planta fotovoltaica de Lucainena de las Torres (23.2 MW), Parque Fotovoltaico Abertura Solar (23.1 MW), Parque Solar Hoya de Los Vincentes (23 MW), Huerta Solar Almaraz (22.1 MW), Solarpark Calveron (21 MW), and the Planta Solar La Magascona (20 MW).[37]

Topaz Solar Farm is a proposed 550 MW solar photovoltaic power plant which is to be built northwest of California Valley in the USA at a cost of over $1 billion.[38] Built on 9.5 square miles (25 km^2) of ranchland,[39] the project would utilize thin-film PV panels designed and manufactured by OptiSolar in Hayward and Sacramento. The project would deliver approximately 1,100 gigawatt-hours (GW·h) annually of renewable energy. The project is expected to begin construction in 2010,[39] begin power delivery in 2011, and be fully operational by 2013.[40]

High Plains Ranch is a proposed 250 MW solar photovoltaic power plant which is to be built by SunPower in the Carrizo Plain, northwest of California Valley.[40]

However, when it comes to renewable energy systems and PV, it is not just large systems that matter. Building-integrated photovoltaics or "onsite" PV systems have the advantage of being matched to end use energy needs in terms of scale. So the energy is supplied close to where it is needed.[41]

Use of ethanol for transportation

E95 trial bus operating in São Paulo, Brazil.

See also: Ethanol fuel and BioEthanol for Sustainable Transport

Since the 1970s, Brazil has had an ethanol fuel program which has allowed the country to become the world's second largest producer of ethanol (after the United States) and the world's largest exporter.[42] Brazil's ethanol fuel program uses modern equipment and cheap sugar cane as feedstock, and the residual cane-waste (bagasse) is used to process heat and power.[43] There are no longer light vehicles in Brazil running on pure gasoline. By the end of 2008 there were 35,000 filling stations throughout Brazil with at least one ethanol pump.[44]

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, DaimlerChrysler, and GM 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.[45] The challenge is to expand the market for biofuels beyond the farm states where they have been most popular to date. Flex-fuel vehicles are assisting in this transition because they allow drivers to choose different fuels based on price and availability. The *Energy Policy Act of 2005*, which calls for 7.5 billion gallons of biofuels to be used annually by 2012, will also help to expand the market.[45]

Geothermal energy prospects

See also: Geothermal energy in the United States

The West Ford Flat power plant is one of 21 power plants at The Geysers

The Geysers, is a geothermal power field located 72 miles (116 km) north of San Francisco, California. It is the largest geothermal development in the world outputting over 750 MW.[9]

By the end of 2005 worldwide use of geothermal energy for electricity had reached 9.3 GWs, with an additional 28 GW used directly for heating.[46] If heat recovered by ground source heat pumps is included, the non-electric use of geothermal energy is estimated at more than 100 GWt (gigawatts of thermal power) and is used commercially in over 70 countries.([46] sec 1.2) During 2005 contracts were placed for an additional 0.5 GW of capacity in the United States, while there were also plants under construction in 11 other countries.[46]

Wave farms expansion

Main article: Wave farm

Portugal now has the world's first commercial wave farm, the *Agucadoura Wave Park*, officially opened in September 2008. The farm uses three Pelamis P-750 machines generating 2.25 MW.[47][48] Initial costs are put at €8.5 million. A second phase of the project is now planned to increase the installed capacity to 21MW using a further 25 Pelamis machines.[49]

Funding for a wave farm in Scotland was announced in February, 2007 by the Scottish Government, at a cost of over 4 million pounds, as part of a £13 million funding packages for ocean power in Scotland. The farm will be the world's largest with a capacity of 3MW generated by four Pelamis machines.[50]

Developing country markets

Main article: Renewable energy in developing countries

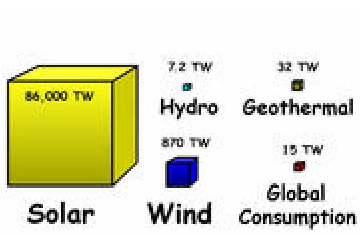
Renewable energy can be particularly suitable for developing countries. In rural and remote areas, transmission and distribution of energy generated from fossil fuels can be difficult and expensive. Producing renewable energy locally can offer a viable alternative.[51]

Renewable energy projects in many developing countries have demonstrated that renewable energy can directly contribute to poverty alleviation by providing the energy needed for creating businesses and employment. Renewable energy technologies can also make indirect contributions to alleviating poverty by providing energy for cooking, space heating, and lighting. Renewable energy can also contribute to education, by providing electricity to schools.[52]

Kenya is the world leader in the number of solar power systems installed per capita (but not the number of watts added). More than 30,000 very small solar panels, each producing 12 to 30 watts, are sold in Kenya annually. For an investment of as little as $100 for the panel and wiring, the PV system can be used to charge a car battery, which can then provide power to run a fluorescent lamp or a small television for a few hours a day. More Kenyans adopt solar power every year than make connections to the country's electric grid.[53]

Potential future utilization

Present renewable energy sources supply about 18% of current energy use and there is much potential that could be exploited in the future. As the table below illustrates, the technical potential of renewable energy sources is more than 18 times current global primary energy use and furthermore several times higher than projected energy use in 2100.



Primary renewable energy resources - the volume of each cube shows the relative supply of each source, compared to total energy use in 2004.

The Renewable Energy Resource Base (Exajoules per year)			
	Current use (2001)	Technical potential	Theoretical potential

Hydropower	9	50	147
Biomass energy	50	>276	2,900
Wind energy	0.12	640	6,000
Solar energy	0.1	>1,575	3,900,000
Geothermal energy	0.6	--	--
Ocean energy	not estimated	not estimated	7,400
Total	60	>1,800	>4,000,000

Current use is in primary energy equivalent.
For comparison, the global primary energy use was 402 EJ per year in 2001.
Source: World Energy Assessment 2001[54]

There are many different ways to assess potentials. The theoretical potential indicates the amount of energy theoretically available for energy purposes, such as, in the case of solar energy, the amount of incoming radiation at the earth's surface. The technical potential is a more practical estimate of how much could be put to human use by considering conversion efficiencies of the available technology and available land area. To give an idea of the constraints, the estimate for solar energy assumes that 1% of the world's unused land surface is used for solar power.

The technical potentials generally do not include economic or other environmental constraints, and the potentials that could be realized at an economically competitive level under current conditions and in a short time-frame is lower still.

Sustainable development and global warming groups propose a 100% Renewable Energy Source Supply, without fossil fuels and nuclear power.[55] Scientists from the University of Kassel have been busy proving that Germany can power itself entirely by renewable energy.[56]

Trends with renewable energy

See also: Renewable energy industry and Renewable energy policy

The renewable market will boom when cost efficiency attains parity with other competing energy sources. The following trends are a few examples by which the renewables market is being helped to attain critical mass so that it becomes competitive enough vs fossil fuels:

Other than market forces, renewable industry often needs government sponsorship to help generate enough momentum in the market. Many countries and states have implemented incentives — like government tax subsidies, partial copayment schemes and various rebates over purchase of renewables — to encourage consumers to shift to renewable energy sources.[57] Government grants fund for research in renewable technology to make the production cheaper and generation more efficient.[58]

Development of loan programs that stimulate renewable favoring market forces with attractive return rates, buffer initial deployment costs and entice consumers to consider and purchase renewable technology. A famous example is the solar loan program sponsored by UNEP helping 100,000 people finance solar power systems in India.[59] Success in India's solar program has led to similar projects in other parts of developing world like Tunisia, Morocco, Indonesia and Mexico.

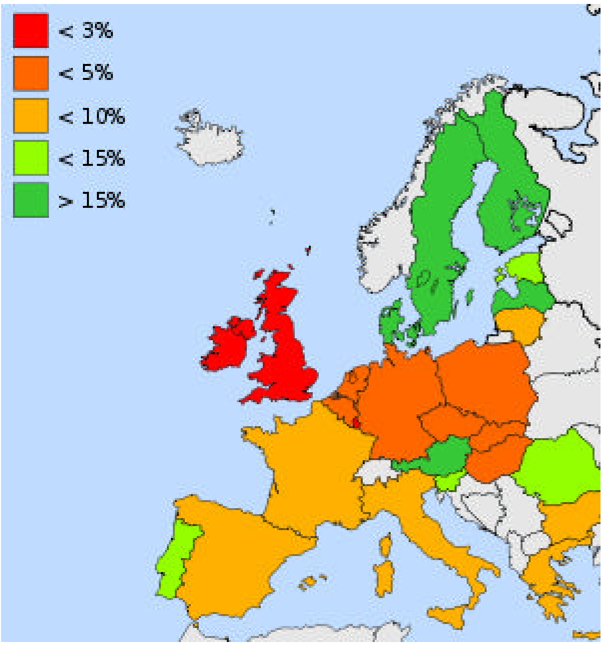
Imposition of fossil fuel consumption and carbon taxes, and channel the revenue earned towards renewable energy development.[60]

Also oil peak and world petroleum crisis and inflation are helping to promote renewables.

Many think-tanks are warning that the world needs an urgency driven concerted effort to create a competitive renewable energy infrastructure and market. The developed world can make more research investments to find better cost efficient technologies, and manufacturing could be transferred to developing countries in order to use low labor costs. The renewable energy market could increase fast enough to replace and initiate the decline of fossil fuel dominance and the world could then avert the looming climate and peak oil crises.[61]

Most importantly, renewables is gaining credence among private investors as having the potential to grow into the next big industry. Many companies and venture capitalists are investing in photovoltaic development and manufacturing. This trend is particularly visible in Silicon valley, California, Europe, Japan.[62][63][64]

Constraints and opportunities



Percentage of renewables in primary energy consumption of EU-member states in 2005. *Source: Primärenergieverbrauch und erneuerbare Energien in der EU, Fig 55*[65]

Critics suggest that some renewable energy applications may create pollution, be dangerous, take up large amounts of land, or be incapable of generating a large net amount of energy. Proponents advocate the use of "appropriate renewables", also known as soft energy technologies, as these have many advantages.

Availability and reliability

Further information: Energy security and renewable technology and Intermittent power source

There is no shortage of solar-derived energy on Earth. Indeed the storages and flows of energy on the planet are very large relative to human needs.

- Annual photosynthesis by the vegetation in the United States is 50 billion GJ, equivalent to nearly 60% of the nation's annual fossil fuel use.
- The amount of solar energy intercepted by the Earth every minute is greater than the amount of energy the world uses in fossil fuels each year.
- The energy in the winds that blow across the United States each year could produce more than 16 billion GJ of electricity—more than one and one-half times the electricity consumed in the United States in 2000.
- Tropical oceans absorb 560 trillion gigajoules (GJ) of solar energy each year, equivalent to 1,600 times the world's annual energy use.

A criticism of some renewable sources is their variable nature. But renewable power sources can actually be integrated into the grid system quite well, as Amory Lovins explains:

> Variable but forecastable renewables (wind and solar cells) are very reliable when integrated with each other, existing supplies and demand. For example, three German states were more than 30 percent wind-powered in 2007—and more than 100 percent in some months. Mostly renewable power generally needs less backup than utilities already bought to combat big coal and nuclear plants' intermittence.[66]

The challenge of variable power supply may be readily alleviated by grid energy storage. Available storage options include pumped-storage hydro systems, batteries, hydrogen fuel cells, thermal mass and compressed air. Initial investments in such energy storage systems may be high, although the costs can be recovered over the life of the system.

Lovins goes on to say that the unreliability of renewable energy is a myth, while the unreliability of nuclear energy is real. Of all U.S. nuclear plants built, 21 percent were abandoned and 27 percent have failed at least once. Successful reactors must close for refueling every 17 months for 39 days. And when shut in response to grid failure, they can't quickly restart. This is simply not the case for wind farms, for example.[66]

Wave energy and some other renewables are continuously available. A wave energy scheme installed in Australia generates electricity with an 80% availability factor.

Aesthetics

Both solar and wind generating stations have been criticized from an aesthetic point of view.[67] However, methods and opportunities exist to deploy these renewable technologies efficiently and unobtrusively: fixed solar collectors can double as noise barriers along highways, and extensive roadway, parking lot, and roof-top area is currently available; amorphous photovoltaic cells can also be used to tint windows and produce energy.[68] Advocates of renewable energy also argue that current infrastructure is less aesthetically pleasing than alternatives, but sited further from the view of most critics.[69]

Environmental and social considerations

While most renewable energy sources do not produce pollution directly, the materials, industrial processes, and construction equipment used to create them may generate waste and pollution. Some renewable energy systems actually create environmental problems.

Land area required

Another environmental issue, particularly with biomass and biofuels, is the large amount of land required to harvest energy, which otherwise could be used for other purposes or left as undeveloped land. However, it should be pointed out that these fuels may reduce the need for harvesting non-renewable energy sources, such as vast strip-mined areas and slag mountains for coal, safety zones around nuclear plants, and hundreds of square miles being strip-mined for oil sands. These responses, however, do not account for the extremely high biodiversity and endemism of land used for ethanol crops, particularly sugar cane.

In the U.S., crops grown for biofuels are the most land- and water-intensive of the renewable energy sources. In 2005, about 12% of the nation's corn crop (covering 11 million acres (45,000 km^2) of farmland) was used to produce four billion gallons of ethanol—which equates to about 2% of annual U.S. gasoline consumption. For biofuels to make a much larger contribution to the energy economy, the industry will have to accelerate the development of new feedstocks, agricultural practices, and technologies that are more land and water efficient. Already, the efficiency of biofuels production has increased significantly[45] and there are new methods to boost biofuel production.[70]

Hydroelectric dams

The major advantage of hydroelectric systems is the elimination of the cost of fuel. Other advantages include longer life than fuel-fired generation, low operating costs, and the provision of facilities for water sports. Operation of pumped-storage plants improves the daily load factor of the generation system. Overall, hydroelectric power can be far less expensive than electricity generated from fossil fuels or nuclear energy, and areas with abundant hydroelectric power attract industry.

However, there are several major disadvantages of hydroelectric systems. These include: dislocation of people living where the reservoirs are planned, release of significant amounts of carbon dioxide at construction and flooding of the reservoir, disruption of aquatic ecosystems and birdlife, adverse impacts on the river environment, potential risks of sabotage and terrorism, and in rare cases catastrophic failure of the dam wall. (See Hydroelectricity article for details.)

Hydroelectric power is now more difficult to site in developed nations because most major sites within these nations are either already being exploited or may be unavailable for other reasons such as environmental considerations.

Wind farms

Wind power is one of the most environmentally friendly sources of renewable energy

A wind farm, when installed on agricultural land, has one of the lowest environmental impacts of all energy sources:[71]

- It occupies less land area per kilowatt-hour (kWh) of electricity generated than any other energy conversion system, apart from rooftop solar energy, and is compatible with grazing and crops.
- It generates the energy used in its construction in just 3 months of operation, yet its operational lifetime is 20–25 years.
- Greenhouse gas emissions and air pollution produced by its construction are tiny and declining. There are no emissions or pollution produced by its operation.
- In substituting for base-load coal power, wind power produces a net decrease in greenhouse gas emissions and air pollution, and a net increase in biodiversity.
- Modern wind turbines are almost silent and rotate so slowly (in terms of revolutions per minute) that they are rarely a hazard to birds.[71]

Studies of birds and offshore wind farms in Europe have found that there are very few bird collisions.[72] Several offshore wind sites in Europe have been in areas heavily used by seabirds. Improvements in wind turbine design, including a much slower rate of rotation of the blades and a smooth tower base instead of perchable lattice towers, have helped reduce bird mortality at wind farms around the world. However older smaller wind turbines may be hazardous to flying birds.[73] Birds are severely impacted by fossil fuel energy; examples include birds dying from exposure to oil spills, habitat loss from acid rain and mountaintop removal coal mining, and mercury poisoning.[74]

Longevity issues

Though a source of renewable energy may last for billions of years, renewable energy infrastructure, like hydroelectric dams, will not last forever, and must be removed and replaced at some point. Events like the shifting of riverbeds, or changing weather patterns could potentially alter or even halt the function of hydroelectric dams, lowering the amount of time they are available to generate electricity.

Although geothermal sites are capable of providing heat for many decades, eventually specific locations may cool down. It is likely that in these locations, the system was designed too large for the site, since there is only so much energy that can be stored and replenished in a given volume of earth. Some interpret this as meaning a specific geothermal location can undergo depletion.

The government of Iceland states: "It should be stressed that the geothermal resource is not strictly renewable in the same sense as the hydro resource." It estimates that Iceland's geothermal energy could provide 1700 MW for over 100 years, compared to the current production of 140 MW.[75] Radioactive elements in the earth's crust continuously decay, replenishing the heat. The International Energy Agency classifies geothermal power as renewable.[76]

Biofuels production

See also: Ethanol fuel energy balance and Cellulosic ethanol commercialization

All biomass needs to go through some of these steps: it needs to be grown, collected, dried, fermented and burned. All of these steps require resources and an infrastructure.

Some studies contend that ethanol is "energy negative", meaning that it takes more energy to produce than is contained in the final product.[77] However, a large number of recent studies, including a 2006 article[78] in the journal *Science* offer the opinion that fuels like ethanol are energy positive. Furthermore, fossil fuels also require significant energy inputs which have seldom been accounted for in the past.

Additionally, ethanol is not the only product created during production, and the energy content of the by-products must also be considered. Corn is typically 66% starch and the remaining 33% is not fermented. This unfermented component is called distillers grain, which is high in fats and proteins, and makes good animal feed.[79] In Brazil, where sugar cane is used, the yield is higher, and conversion to ethanol is somewhat more energy efficient than corn. Recent developments with cellulosic ethanol production may improve yields even further.[80]

According to the International Energy Agency, new biofuels technologies being developed today, notably cellulosic ethanol, could allow biofuels to play a much bigger role in the future than previously thought.[81] 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 in many regions of the United States.[82]

The ethanol and biodiesel production industries also create jobs in plant construction, operations, and maintenance, mostly in rural communities. According to the Renewable Fuels Association, the ethanol industry created almost 154,000 U.S. jobs in 2005 alone, boosting household income by $5.7 billion. It also contributed about $3.5 billion in tax revenues at the local, state, and federal levels.[45]

Diversification

The examples and perspective in this article **deal primarily with the United States and do not represent a worldwide view of the subject**. Please improve this article or discuss the issue on the talk page.

The U.S. electric power industry now relies on large, central power stations, including coal, natural gas, nuclear, and hydropower plants that together generate more than 95% of the nation’s electricity. Over the next few decades uses of renewable energy could help to diversify the nation’s bulk power supply. Already, appropriate renewable resources (which excludes large hydropower) produce 12% of northern California’s electricity.[45]

Although most of today’s electricity comes from large, central-station power plants, new technologies offer a range of options for generating electricity nearer to where it is needed, saving on the cost of transmitting and distributing power and improving the overall efficiency and reliability of the system.[45]

Improving energy efficiency represents the most immediate and often the most cost-effective way to reduce oil dependence, improve energy security, and reduce the health and environmental impact of the energy system. By reducing the total energy requirements of the economy, improved energy efficiency could make increased reliance on renewable energy sources more practical and affordable.[45]

Other issues

Sustainability

Renewable energy sources are generally sustainable in the sense that they cannot "run out" as well as in the sense that their environmental and social impacts are generally more benign than those of fossil. However, both biomass and geothermal energy require wise management if they are to be used in a sustainable manner. For all of the other renewables, almost any realistic rate of use would be unlikely to approach their rate of replenishment by nature.[83]

Transmission

If renewable and distributed generation were to become widespread, electric power transmission and electricity distribution systems might no longer be the main distributors of electrical energy but would operate to balance the electricity needs of local communities. Those with surplus energy would sell to areas needing "top ups". That is, network operation would require a shift from 'passive management' — where generators are hooked up and the system is operated to get electricity 'downstream' to the consumer — to 'active management', wherein generators are spread across a network and inputs and outputs need to be constantly monitored to ensure proper balancing occurs within the system. Some governments and regulators are moving to address this, though much remains to be done. One potential solution is the increased use of active management of electricity transmission and distribution networks. This will require significant changes in the way that such networks are operated.

However, on a smaller scale, use of renewable energy produced on site reduces burdens on electricity distribution systems. Current systems, while rarely economically efficient, have shown that an average household with an appropriately-sized solar panel array and energy storage system needs electricity from outside sources for only a few hours per week. By matching electricity supply to end-use needs, advocates of renewable energy and the soft energy path believe electricity systems will become smaller and easier to manage, rather than the opposite (see Soft energy technology).

Market development of renewable heat energy

Renewable heat is the generation of heat from renewable sources. Much current discussion on renewable energy focuses on the generation of electrical energy, despite the fact that many colder countries consume more energy for heating than as electricity. In 2005 the United Kingdom consumed 354 TWh[84] of electric power, but had a heat requirement of 907 TWh, the majority of which (81%) was met using gas. The residential sector alone consumed a massive 550 TWh of energy for heating, mainly in the form of gas. Almost half of the final energy consumed in the UK (49%) was in the form of heat.[85]

Renewable electric power is becoming cheap and convenient enough to place it, in many cases, within reach of the average consumer. By contrast, the market for renewable heat is mostly inaccessible to domestic consumers due to inconvenience of supply, and high capital costs. Heating accounts for a large proportion of energy consumption, however a universally accessible market for renewable heat is yet to emerge. Solutions such as geothermal heat pumps may be more widely applicable, but may not be economical in all cases. Also see renewable energy development.

Controversy over nuclear power as a renewable energy source

Main articles: Nuclear debate and Nuclear power

In 1983, physicist Bernard Cohen proposed that uranium is effectively inexhaustible, and could therefore be considered a renewable source of energy.[86][87] He claimed that fast breeder reactors, fueled by uranium extracted from seawater, could supply energy at least as long as the sun's expected remaining lifespan of five billion years.[86] Nuclear energy has also been referred to as "renewable" by the politicians George W. Bush,[88][89][90] Charlie Crist,[91] and David Sainsbury.[92][93]

Inclusion under the "renewable energy" classification could render nuclear power projects eligible for development aid under various jurisdictions. However, it has not been established that nuclear energy is inexhaustible, and issues such as peak uranium and uranium depletion are ongoing debates. No legislative body has yet included nuclear energy under any legal definition of "renewable energy sources" for provision of development support (see: Renewable energy development). Similarly, statutory and scientific definitions of renewable energies usually exclude nuclear energy. Commonly sourced definitions of renewable energy sources often omit or explicitly exclude nuclear energy sources as examples.[94][95][96][97] Nuclear fission is not regarded as renewable by the U.S. DOE on the website "What is Energy?"[98][99][100][101]

There are also environmental concerns over nuclear power, including the dangerous environmental hazards of nuclear waste and concerns that development of new plants cannot happen quickly enough to reduce CO_2 emissions, such that nuclear energy is neither efficient nor effective in cutting CO_2 emissions.[102]

See also

Energy portal

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Sustainable development portal

Lists

- List of countries by electricity production from renewable source
- List of photovoltaics companies
- List of renewable energy organizations
- List of renewable energy topics by country
- List of the largest hydroelectric power stations
- List of wind turbine manufacturers

Conservation and efficiency

- Distributed generation
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Renewable, alternative, and soft

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- International Renewable Energy Agency
- International Renewable Energy Alliance
- International Renewable Energy Conference
- Mitigation of global warming
- Passive solar building design
- Renewable energy development
- Renewable heat
- Soft energy technologies
- Sustainable energy

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Wikinews has related news: ***EU adopts renewable energy measures***

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Look up ***renewable energy*** in Wiktionary, the free dictionary.

- NREL - US National Renewable Energy Laboratory
- Renewables 2007 Global Status Report (Worldwatch Institute).
- Renewable Energy Sources and Climate Change Mitigation (IPCC).
- Renewable energy (UNEP)
- Renewable & Alternative Fuels data from Energy Information Administration (EIA)
- Renewable Energy Tops 10% of U.S. Energy Production
- Alternative farm energy (The Washington Times).
- Half of Global Electricity To Come From Renewables IEA Says
- Stanford gets $100 mln for alternative energy
- Will the Children of Today Be Living in a World Powered by Renewable Energy by 2050?

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Renewable energy by country (list of topics)

by region	Asia · Europe (EU)
by country	Australia · Austria · Brazil · Canada · China · Denmark · Estonia · Finland · France · Germany · Greece · India · Iran · Ireland · Italy · Morocco · New Zealand · Pakistan · Portugal · Romania · Spain · Sweden · Turkey · United Kingdom · United States

by region	South Asia · Europe (EU)
by country	Australia · Canada · China · Germany · India · Israel · Japan · Portugal · Spain · United Kingdom · United States

by country	Australia · China · Iceland · New Zealand · Portugal · Turkey · United Kingdom · United States

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Topics related to Environmental technology

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Global warming and climate change

[show]

Temperatures

[show]

Causes

Anthropogenic	Aviation · Carbon dioxide · Climate sensitivity · Global dimming · Global warming potential · Greenhouse effect · Greenhouse gases · Keeling Curve · Land use and forestry ·

	Urban heat island
Natural	Albedo · Bond events · Cloud forcing · Glaciation · Global cooling · Ocean variability (AMO · ENSO · IOD · PDO) · Orbital variations · Orbital forcing · Radiative forcing · Solar variation · Volcanism
Opinion and controversy	Scientific opinion · Scientists opposing the mainstream assessment · Climate change denial

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Models and politics

Models	Global climate model
Politics	United Nations Framework Convention on Climate Change (UNFCCC / FCCC) · Intergovernmental Panel on Climate Change (IPCC)

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Potential effects and issues

General	Climate change and agriculture ·

	[Drought](#) · [Economics of global warming](#) · [Glacier retreat](#) · [Mass extinction](#) · [Ozone depletion](#) · [Ocean acidification](#) · [Sea level rise](#) · [Season creep](#) · [Shutdown of thermohaline circulation](#)
By country	[Australia](#) · [India](#) · [United States](#)

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Mitigation

Kyoto Protocol	Clean Development Mechanism · Joint Implementation · Bali roadmap
Governmental	European Climate Change Programme · United Kingdom Climate Change Programme · Oil phase-out in Sweden
Schemes	Emissions trading · Personal carbon trading · Carbon tax · Carbon offset · Carbon credit · Carbon dioxide sink (carbon sequestration) · Cap and Share
Energy conservation	Efficient energy use · **Renewable energy** · Renewable energy commercialization · Renewable energy development · Soft energy path
Other	G8 Climate Change Roundtable · Individual and political action on climate

	change · Climate change mitigation scenarios

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Proposed adaptations

Strategies	Damming glacial lakes · Drought tolerance · Irrigation investment · Rainwater storage · Sustainable development · Weather control
Programmes	Avoiding Dangerous Climate Change · Land Allocation Decision Support System

Categories: Biomass | Renewable energy

Hidden categories: Wikipedia pages semi-protected against vandalism | Wikipedia protected pages without expiry | All articles with unsourced statements | Articles with unsourced statements since February 2009 | Articles with limited geographic scope | USA-centric

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Learning About Renewable Energy