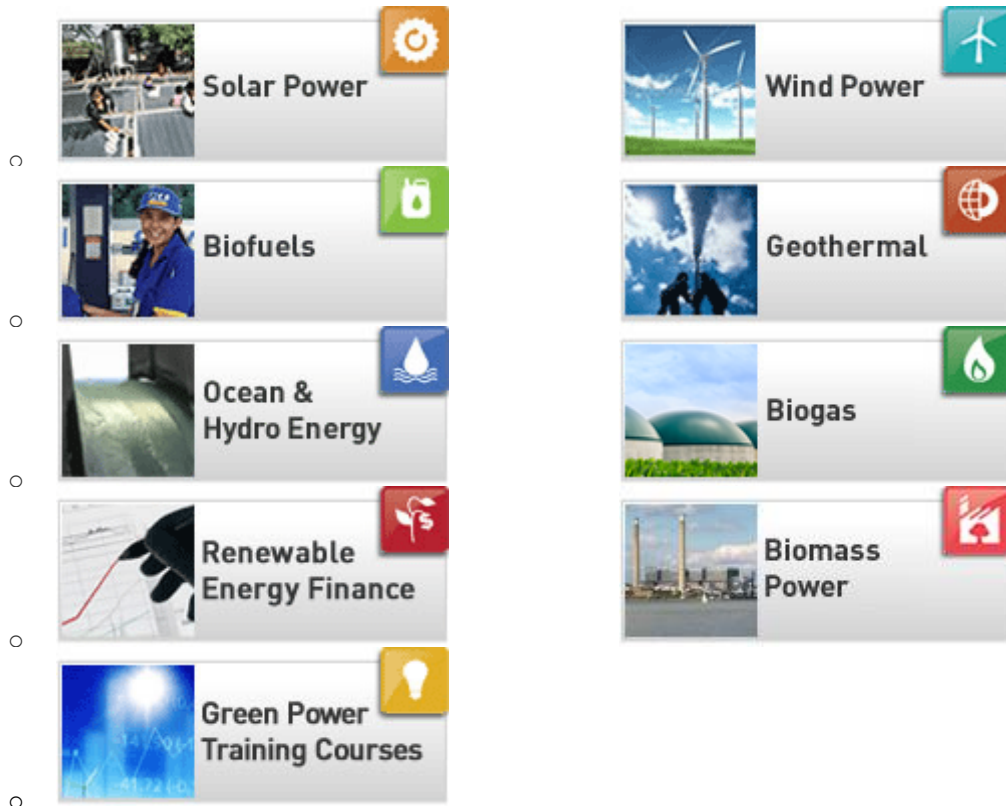
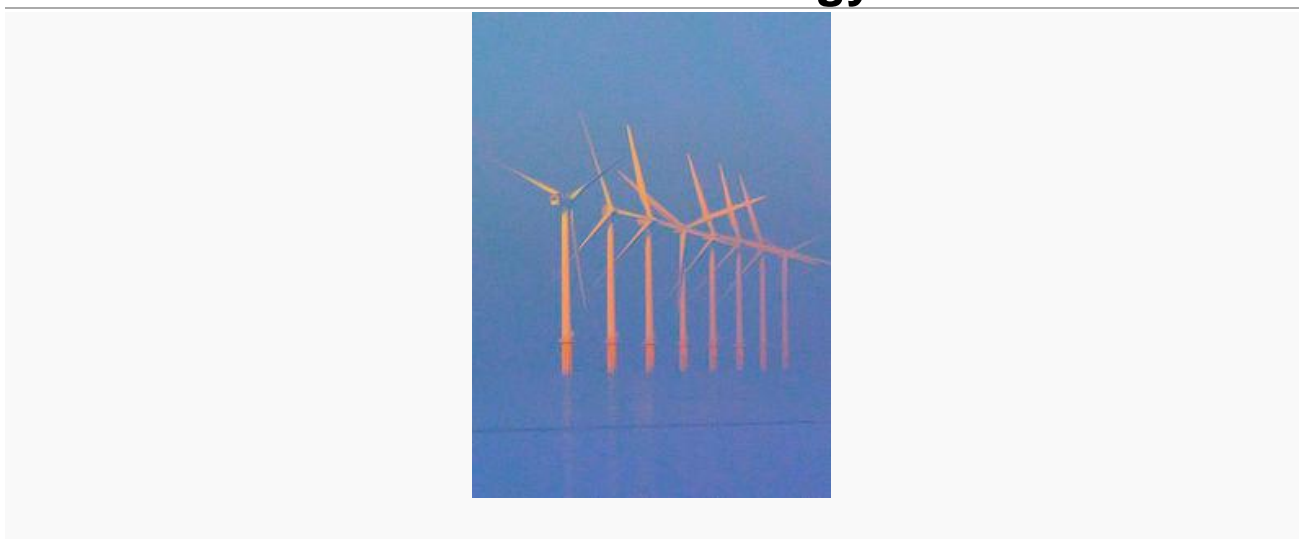


Renewable Energy

Renewable energy resources



Renewable energy



Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable naturally replenished (восстанавливаются естественным путем). About 16% of global final energy consumption (потребление) comes from

renewables, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.8% and are growing very rapidly. The share of renewables in electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity and 3% from new renewables.

Wind power is growing at the rate of 30% annually, with a worldwide installed capacity (установленная мощность) of 198 gigawatts (GW) in 2010, and is widely used in Europe, Asia, and the United States. At the end of 2010, cumulative global photovoltaic (PV - фотоэлектрические) installations surpassed (превосходят) 40 GW and PV power stations are popular in Germany and Spain. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 megawatt (MW) SEGS power plant in the Mojave Desert. The world's largest geothermal power installation is the Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

While many renewable energy projects are large-scale (крупномасштабные проекты), renewable technologies are also suited to rural and remote areas, where energy is often crucial (решающий) in human development. As of 2011, small solar PV systems provide electricity to a few million households (домохозяйств), and micro-hydro configured into mini-grids serves many more. Over 44 million households use biogas made in household-scale digesters for lighting and/or cooking, and more than 166 million households rely on (надеяться на) a new generation of more-efficient biomass cookstoves (кухонных плит). United Nations' Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity.

Climate change concerns (проблемы), coupled with high oil prices, peak oil (пик добычи нефти), and increasing government support, are driving increasing renewable energy legislation (законодательство), incentives (стимулы) and commercialization. New government spending, regulation and policies helped the industry weather the global financial crisis better than many other sectors. According to a 2011 projection (проект) by the International Energy Agency, solar power generators may produce most of the world's electricity within 50 years (в течение 50 лет), dramatically reducing the emissions of greenhouse gases that harm the environment.

Overview

Renewable energy flows involve natural phenomena such as sunlight, wind, tides, plant growth, 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.

Renewable energy replaces conventional fuels in four distinct areas: power generation, hot water/space heating, transport fuels, and rural (off-grid) energy services:

- **Power generation.** Renewable energy provides 18 percent of total electricity generation worldwide. Renewable power generators are spread across many countries, and wind power alone already provides a significant share of electricity in some areas: for example, 14 percent in the U.S. state of Iowa, 40 percent in the northern German state of Schleswig-Holstein, and 20 percent in Denmark. Some countries get most of their power from renewables, including Iceland and Paraguay (100 percent), Norway (98 percent), Brazil (86 percent), Austria (62 percent), New Zealand (65 percent), and Sweden (54 percent).
- **Heating.** Solar hot water makes an important contribution to renewable heat in many countries, most notably in China, which now has 70 percent of the global total (180 GWth). Most of these systems are installed on multi-family apartment buildings and meet a portion of the hot water needs of an estimated 50–60 million households in China. Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households. The use of biomass for heating continues to grow as well. In Sweden, national use of biomass energy has surpassed that of oil. Direct geothermal for heating is also growing rapidly.
- **Transport fuels.** Renewable biofuels have contributed to a significant decline (снижаться) in oil consumption (потребление) in the United States since 2006. The 93 billion liters of biofuels produced worldwide in 2009 displaced the equivalent of an estimated 68 billion liters of gasoline, equal to about 5 percent of world gasoline production.

Wind power



Wind Turbines located outside of Palm Springs, California

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. Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms (ветровые электростанции). Typical capacity (мощность) factors are 20-40%, with values at the upper end of the range in particularly favourable sites.

Globally, the long-term (долгосрочный) technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand (спрос). This could require wind turbines to be installed over large areas, 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.

Hydropower



Grand Coulee Dam is a hydroelectric gravity dam on the Columbia River in the U.S. state of Washington. The dam supplies four power stations with an installed capacity of 6,809 MW and is the largest electric power-producing facility in the United States.

Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell (умеренное волнение моря), can yield considerable amounts of energy. 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).
- Run-of-the-river hydroelectricity systems derive kinetic energy from rivers and oceans without using a dam.

Solar energy



Monocrystalline solar cell.

Solar energy is the energy derived from the sun through the form of solar radiation. Solar powered electrical generation relies on photovoltaics and heat engines. A partial list of other solar applications includes space heating and cooling through solar architecture, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute (преобразование и распределение) solar energy. Active solar techniques

include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Biomass

Biomass (plant material - растительный материал) is a renewable energy source because the energy it contains comes from the sun. Through the process of photosynthesis, plants capture the sun's energy. When the plants are burnt, they release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy. As long as biomass is produced sustainably (устойчиво), with only as much used as is grown, the battery will last indefinitely.

In general there are two main approaches to using plants for energy production: growing plants specifically for energy use, and using the residues from plants that are used for other things. The best approaches vary from region to region according to climate, soils (почвах) and geography.

Biofuel



Brazil has bioethanol made from sugarcane available throughout the country. Shown a typical Petrobras gas station at São Paulo with dual fuel service, marked A for alcohol (ethanol) and G for gasoline.

Biofuels include a wide range of fuels which are derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Liquid biofuels include bioalcohols, such as bioethanol, and oils, such as biodiesel. Gaseous biofuels include biogas, landfill gas and synthetic gas.

Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops (крахмала зерновых культур). With advanced technology being developed, cellulosic (целлюлозной) biomass, such as trees and grasses, are also used as feed stocks for ethanol production. Ethanol can be used as a fuel for vehicles (транспортных средств) in its pure form, but it is usually used as

a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil.

Biodiesel is made from vegetable oils, animal fats (животные жиры) or recycled greases (переработанные жиры). Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification (переэтерификации) and is the most common biofuel in Europe.

Biofuels provided 2.7% of the world's transport fuel in 2010.

Geothermal energy



[Krafla](#) Geothermal Station in northeast Iceland

Geothermal energy is energy obtained by trapping the heat of the earth itself, both from kilometers deep into the Earth's crust in volcanically active locations of the globe or from shallow depths, as in geothermal heat pumps in most locations of the planet. It is expensive to build a power station but operating costs (эксплуатационные расходы) are low resulting in low energy costs for suitable sites. Ultimately (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 (сухой пар, вспышки и оба). 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 (известные области) 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.

Renewable energy commercialization

Growth of renewables

During the five-years from the end of 2004 through 2009, worldwide renewable energy capacity grew at rates of 10–60 percent annually for many technologies. For wind power and many other renewable technologies, growth accelerated in 2009 relative to the previous four years. More wind power capacity was added during 2009 than any other renewable technology. However, grid-connected PV increased the fastest of all renewables technologies, with a 60-percent annual average growth rate for the five-year period.

Selected renewable energy indicators

| Selected global indicators | 2008 | 2009 | 2010 |
|---|-------------|-------------|-----------------|
| Investment in new renewable capacity (annual) | 130 | 160 | 211 billion USD |
| Renewables power capacity (existing) | 1,140 | 1,230 | 1,320 GWe |
| Hydropower capacity (existing) | 950 | 980 | 1,010 GWe |
| Wind power capacity (existing) | 121 | 159 | 198 GWe |

Selected renewable energy indicators

| Selected global indicators | 2008 | 2009 | 2010 |
|--|------|------|-------------------|
| Solar PV capacity (grid-connected) | 16 | 23 | 40 GWe |
| Solar hot water capacity (existing) | 130 | 160 | 185 GWth |
| Ethanol production (annual) | 67 | 76 | 86 billion liters |
| Countries with policy targets for renewable energy use | 79 | 89 | 98 |

Scientists have advanced a plan to power 100% of the world's energy with wind, hydroelectric, and solar power by the year 2030.

According to a 2011 projection by the International Energy Agency, solar power generators may produce most of the world's electricity within 50 years, dramatically reducing the emissions of greenhouse gases that harm the environment. Cedric Philibert, senior analyst in the renewable energy division at the IEA said: "Photovoltaic and solar-thermal plants may meet most of the world's demand for electricity by 2060 -- and half of all energy needs -- with wind, hydropower and biomass plants supplying much of the remaining generation". "Photovoltaic and concentrated solar power together can become the major source of electricity," Philibert said.

Economic trends

All forms of energy are expensive, but as time progresses, renewable energy generally gets cheaper, while fossil fuels generally get more expensive. Al Gore has explained that renewable energy technologies are declining in price for three main reasons:

First, once the renewable infrastructure is built, the fuel is free forever. Unlike carbon-based fuels, the wind and the sun and the earth itself provide fuel that is free, in amounts that are effectively limitless.

Second, while fossil fuel technologies are more mature, renewable energy technologies are being rapidly improved. So innovation and ingenuity give us

the ability to constantly increase the efficiency of renewable energy and continually reduce its cost.

Third, once the world makes a clear commitment to shifting toward renewable energy, the volume of production will itself sharply reduce the cost of each windmill and each solar panel, while adding yet more incentives for additional research and development to further speed up the innovation process.

Wind power market



Fenton Wind Farm at sunrise

Global wind power installations increased by 35,800 MW in 2010, bringing total installed capacity up to 194,400 MW, a 22.5% increase on the 158,700 MW installed at the end of 2009. For the first time more than half of all new wind power was added outside of the traditional markets of Europe and North America, mainly driven, by the continuing boom in China which accounted for nearly half of all of the installations at 16,500 MW. China now has 42,300 MW of wind power installed. Several countries have achieved relatively high levels of wind power penetration, such as 21% of stationary electricity production in Denmark, 18% in Portugal, 16% in Spain, 14% in Ireland and 9% in Germany in 2010. As of 2011, 83 countries around the world are using wind power on a commercial basis.

Top 10 wind power countries

| Country | Total capacity end 2009 (MW) | Total capacity June 2010 (MW) |
|----------------------|-------------------------------------|--------------------------------------|
| United States | 35,159 | 36,300 |
| China | 26,010 | 33,800 |
| Germany | 25,777 | 26,400 |
| Spain | 19,149 | 19,500 |
| India | 10,925 | 12,100 |
| Italy | 4,850 | 5,300 |
| France | 4,521 | 5,000 |
| United Kingdom | 4,092 | 4,600 |
| Portugal | 3,535 | 3,800 |
| Denmark | 3,497 | 3,700 |
| Rest of world | 21,698 | 24,500 |
| Total | 159,213 | 175,000 |

As of November 2010, the Roscoe Wind Farm (781 MW) is the world's largest wind farm. As of September 2010, the Thanet Offshore Wind Project in United Kingdom is the largest offshore wind farm in the world at 300 MW, followed by Horns Rev II (209 MW) in Denmark. The United Kingdom is the world's leading generator of offshore wind power, followed by Denmark.

New generation of solar thermal plants



Solar Towers from left: PS10, PS20.

Large solar thermal power stations include the 354 megawatt (MW) Solar Energy Generating Systems power plant in the USA, Solnova Solar Power Station (Spain, 150 MW), Andasol solar power station (Spain, 100 MW), Nevada Solar One (USA, 64 MW), PS20 solar power tower (Spain, 20 MW), and the PS10 solar power tower (Spain, 11 MW).

The solar thermal power industry is growing rapidly with 1.2 GW under construction as of April 2009 and another 13.9 GW announced globally through 2014. Spain is the epicenter of solar thermal power development with 22 projects for 1,037 MW under construction, all of which are projected to come online by the end of 2010. In the United States, 5,600 MW of solar thermal power projects have been announced. In developing countries, three World Bank projects for integrated solar thermal/combined-cycle gas-turbine power plants in Egypt, Mexico, and Morocco have been approved.

Photovoltaic market



US President Barack Obama speaks at the DeSoto Next Generation Solar Energy Center, in the USA.



40 MW PV Array installed in Waldpolenz, Germany

Photovoltaic production has been increasing by an average of more than 20 percent each year since 2002, making it a fast-growing energy technology. At the end of 2010, cumulative global photovoltaic (PV) installations surpassed 40 GW and PV power stations are popular in Germany and Spain.

As of November 2010, the largest photovoltaic (PV) power plants in the world are the Finsterwalde Solar Park (Germany, 80.7 MW), Sarnia Photovoltaic Power Plant (Canada, 80 MW), Olmedilla Photovoltaic Park (Spain, 60 MW), the Strasskirchen Solar Park (Germany, 54 MW), the Lieberose Photovoltaic Park (Germany, 53 MW), and the Puertollano Photovoltaic Park (Spain, 50 MW). Many of these plants are integrated with agriculture and some use innovative tracking systems that follow the sun's daily path across the sky to generate more electricity than conventional fixed-mounted systems. There are no fuel costs or emissions during operation of the power stations.

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. High Plains Ranch is a proposed 250 MW solar photovoltaic power plant which is to be built on the Carrizo Plain, northwest of California Valley.

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 use existing land and structures and generate power close to where it is consumed.

Biofuels for transportation



Biofuels provided 2.7% of the world's transport fuel in 2010. Mandates for blending biofuels exist in 31 countries at the national level and in 29 states/provinces. According to the International Energy Agency, biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050.

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. Brazil's ethanol fuel program uses modern equipment and cheap sugar cane as feedstock, and the residual cane-waste (bagasse) is used to produce heat and power. 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.

Nearly all the gasoline sold in the United States today is mixed with 10 percent ethanol, a mix known as E10, 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 6 million E85-compatible vehicles on U.S. roads. 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 US gallons (28,000,000 m³) of biofuels to be used annually by 2012, will also help to expand the market.

Geothermal energy commercialization



The West Ford Flat power plant is one of 22 power plants at The Geysers.

The International Geothermal Association (IGA) has reported that 10,715 megawatts (MW) of geothermal power in 24 countries is online, which is expected to generate 67,246 GWh of electricity in 2010. This represents a 20% increase in geothermal power online capacity since 2005. IGA projects this will grow to 18,500 MW by 2015, due to the large number of projects presently under consideration, often in areas previously assumed to have little exploitable resource.

In 2010, the United States led the world in geothermal electricity production with 3,086 MW of installed capacity from 77 power plants; the largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California. The Philippines follows the US as the second highest producer of geothermal power in the world, with 1,904 MW of capacity online; geothermal power makes up approximately 18% of the country's electricity generation.

Geothermal (ground source) heat pumps represented an estimated 30 GWth of installed capacity at the end of 2008, with other direct uses of geothermal heat (i.e., for space heating, agricultural drying and other uses) reaching an estimated 15 GWth. As of 2008, at least 76 countries use direct geothermal energy in some form.

Developing country markets



Solar cookers use sunlight as energy source for outdoor cooking.

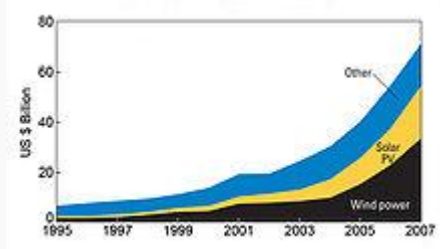
Renewable energy can be particularly suitable for developing countries. In rural and remote areas, transmission and distribution of energy generated from fossil fuels can be difficult and expensive. Producing renewable energy locally can offer a viable alternative.

As of 2011, small solar PV systems provide electricity to a few million households, and micro-hydro configured into mini-grids serves many more. Over 44 million households use biogas made in household-scale digesters for lighting and/or cooking, and more than 166 million households rely on a new generation of more-efficient biomass cookstoves.

Kenya is the world leader in the number of solar power systems installed per capita. More than 30,000 very small solar panels, each producing 12 to 30 watts, are sold in Kenya annually.

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.

Industry and policy trends



Global renewable energy investment growth (1995-2007)

U.S. President Barack Obama's American Recovery and Reinvestment Act of 2009 includes more than \$70 billion in direct spending and tax credits for clean energy and associated transportation programs. Clean Edge suggests that the commercialization of clean energy will help countries around the world pull out of the current economic malaise. Leading renewable energy companies include First Solar, Gamesa, GE Energy, Q-Cells, Sharp Solar, Siemens, SunOpta, Suntech, and Vestas.

The International Renewable Energy Agency (IRENA) is an intergovernmental organization for promoting the adoption of renewable energy worldwide. It aims to provide concrete policy advice and facilitate capacity building and technology transfer. IRENA was formed on January 26, 2009, by 75 countries signing the charter of IRENA. As of March 2010, IRENA has 143 member states who all are considered as founding members, of which 14 have also ratified the statute.

As of 2011, 119 countries have some form of national renewable energy policy target or renewable support policy. National targets now exist in at least 98 countries. There is also a wide range of policies at state/provincial and local levels.