Renewable Energy

Engineering and Society Project Report

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Renewable energy

What is the meaning of the renewable energy?

Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy, often referred to as clean energy, comes from natural sources or processes that are constantly replenished. For example, sunlight or wind keep shining and blowing, even if their availability depends on time and weather.

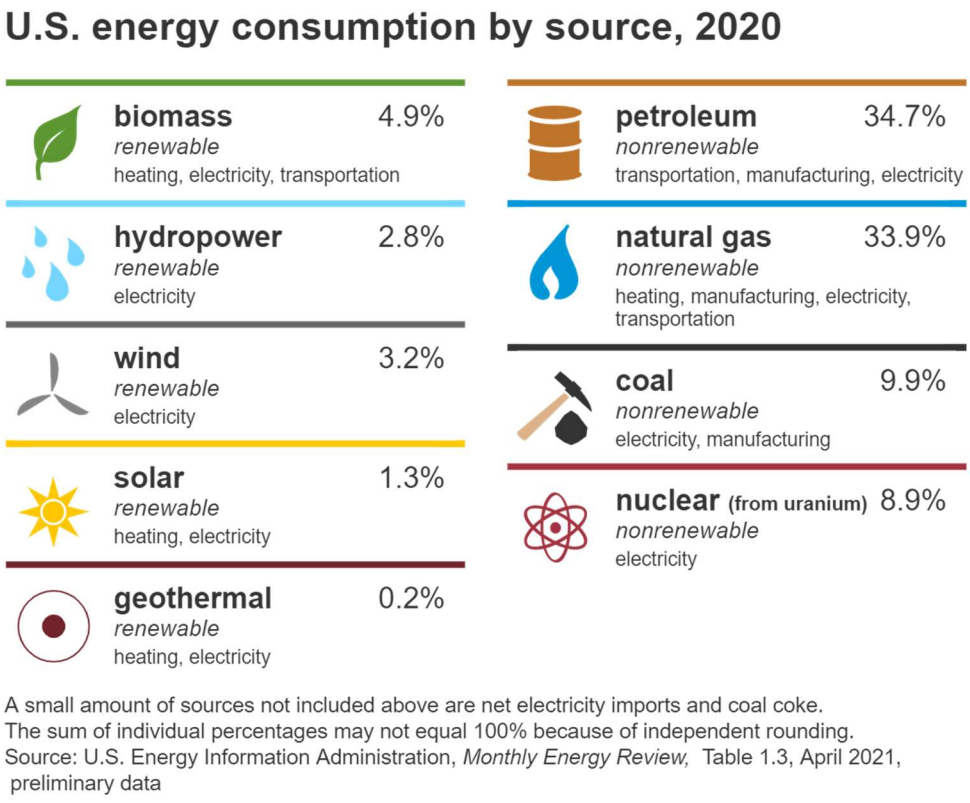
Note: Now that we have increasingly innovative and less-expensive ways to capture and retain wind and solar energy, renewables are becoming a more important power source, accounting for more than one-eighth of U.S. generation. The expansion in renewables is also happening at scales large and small, from rooftop solar panels on homes that can sell power back to the grid to giant offshore wind farms. Even some entire rural communities rely on renewable energy for heating and lighting.

Sources of renewable energy

The major types or sources of renewable energy are:

- **Solar energy** from the sun
- **Geothermal energy** from heat inside the earth
- **Wind energy**
- **Biomass** from plants
- **Hydropower** from flowing water

They are called renewable energy sources because they are naturally replenished. Day after day, the sun shines, plants grow, wind blows, and rivers flow.



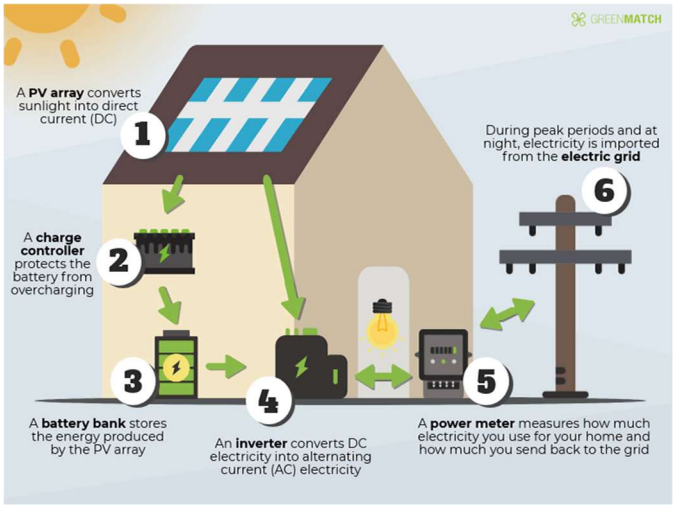
A small amount of sources not included above are net electricity imports and coal coke.
The sum of individual percentages may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review,* Table 1.3, April 2021, preliminary data

A small hint on each type of energy

- **Solar Energy**

Humans have been harnessing solar energy for thousands of years—to grow crops, stay warm, and dry foods. According to the National Renewable Energy Laboratory, "*more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year*." Today, we use the sun's rays in many ways—to heat homes and businesses, to warm water, or power devices. So, Energy can be harnessed directly from the sun, even in cloudy weather. That's why Solar energy is used worldwide and is increasingly popular for generating electricity or heating and desalinating water, as **Solar power is generated in two main ways:**

Photovoltaics (PV) also called solar cells, which are made from silicon or other materials that transform sunlight directly into electricity. The modern solar cell is likely an image most people would recognize – they are in the panels installed on houses and in calculators. They were invented in 1954 at Bell Telephone Laboratories in the United States. Today, PV is one of the fastest-growing renewable energy technologies, and is ready to play a major role in the future global electricity generation mix.

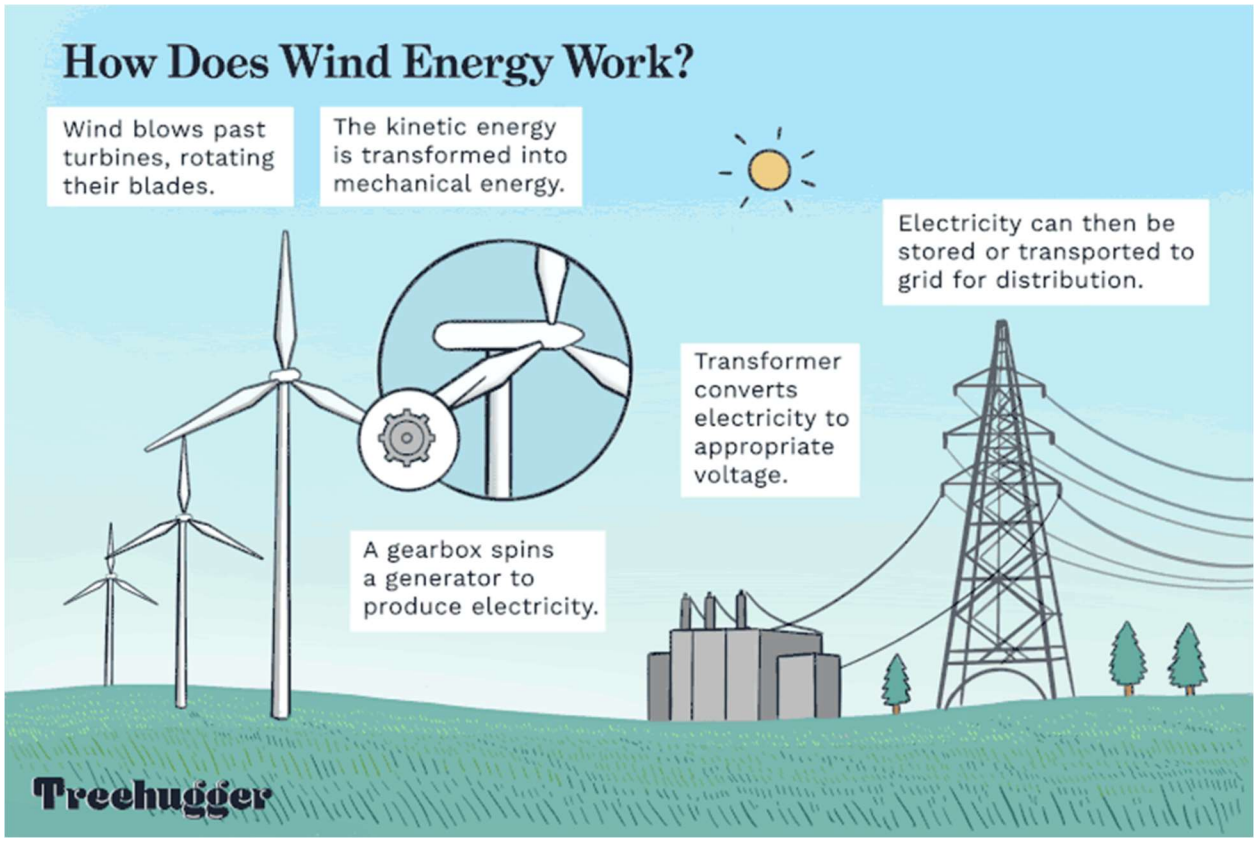


Concentrated solar power (CSP) uses mirrors to concentrate solar rays then redirect rays to a tall thin tower. These rays heat fluid, which creates steam to drive a turbine and generate electricity. CSP is used to generate electricity in large-scale power plants. One of the main advantages of a CSP power plant over a solar PV power plant is that it can be equipped with molten salts in which heat can be stored, allowing electricity to be generated after the sun has set.

As we all know that Egypt's Solar Atlas which states that Egypt is considered a "sun belt" country with 2,000 to 3,000 kWh/m2/year of direct solar radiation, as the sun shines 9-11 hours a day from North to South in Egypt, with few cloudy days. And the first Solar Thermal Power Plant at Kuraymat was built in 2011, It has a total installed capacity of 140 MW, with solar share of 20 MW based on parabolic-trough technology integrated with a combined-cycle power plant using natural gas. And another 10 MW power plant has been operating in Siwa since March 2015, and the remaining plants are expected to be implemented and operated consequentially. The 37 square kilometer Benban Solar Park in Egypt's Western Desert added 800 MW in total installed capacity through 2018.

- **Wind Energy**

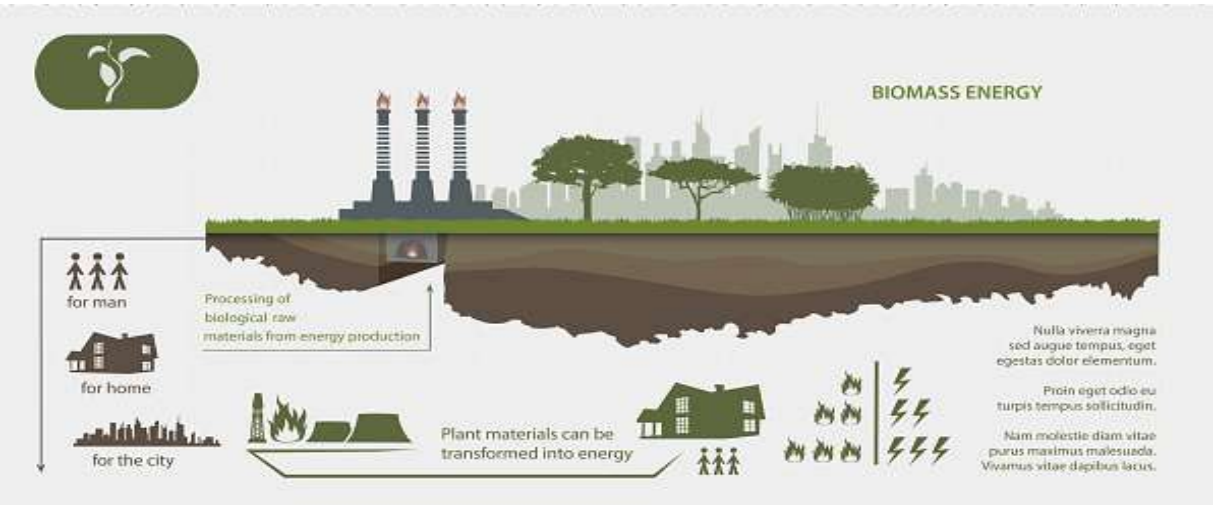
Wind is used to produce electricity using the kinetic energy created by air in motion. This is transformed into electrical energy using wind turbines or wind energy conversion systems. The amount of power that can be harvested from wind depends on the size of the turbine and the length of its blades. The output is proportional to the dimensions of the rotor and to the cube of the wind speed. Theoretically, when wind speed doubles, wind power potential increases by a factor of eight. Wind turbines first emerged more than a century ago. Following the invention of the electric generator in the 1830s, engineers started attempting to harness wind energy to produce electricity. Wind power generation took place in the United Kingdom and the United States in 1887 and 1888, but modern wind power is considered to have been first developed in Denmark.



Wind, which accounts for a little more than 6 percent of U.S. generation, has become the cheapest energy source in many parts of the country. Turbines can be placed anywhere with high wind speeds—such as hilltops and open plains—or even offshore in open water. Wind power is one of the fastest-growing renewable energy technologies. Wind energy usage is on the rise worldwide. Global installed wind-generation capacity onshore and offshore has increased by a factor of almost 75 in the past two decades according to IRENA's latest data. Production of wind electricity doubled between 2009 and 2013, and in 2016 wind energy accounted for 16% of the electricity generated by renewables.

For Egypt, it enjoys excellent wind along the Gulf of Suez with an average wind speed of 10.5 m/sec, and consider one of the only 38 countries in the world with a published National Wind Atlas. It has projects since 2001, a series of large-scale wind farms have been established, in cooperation with Germany (KFW), Denmark (DANIDA), Spain (Siemens Gamesa), and Japan (JICA). Implementation of the Spanish project in Jebel El Ziet took place in 2013. And in 2014 the implementation of a JICA wind project started with expectations to raise imports by USD 200 million. Also launched in 2017, the Ras Ghareb windfarm project, near the Gulf of Suez produce 262.5MW, and supply power to approximately 500,000 households.

- **Biomass Energy**



Biomass is organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun, and plants produce biomass through photosynthesis. When burned directly for heat or converted to renewable liquid or gaseous fuel through various processes.

Biomass is often mistakenly described as a clean, renewable fuel, recent science shows that many forms of biomass —especially from forests— produce higher carbon emission than fossil fuel. However, some forms of it can be a low carbon energy source under right conditions such as: Sawdust and chips from sawmills.

Biomass was the largest source of total annual U.S. energy consumption until the mid-1800s, in 2020, biomass provided about 5% of total primary energy use in the United States, and continues to be an important fuel in many countries, especially for cooking and heating in developing countries, also when burned the chemical energy released can generate electricity with a steam turbine.

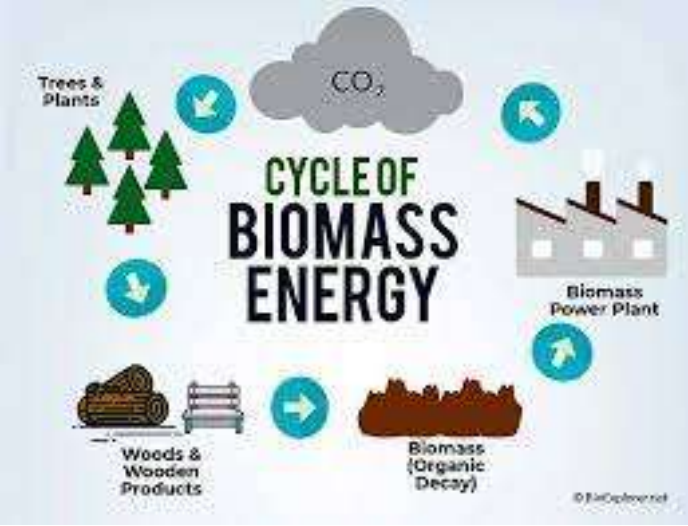
Biomass sources for energy include:

Wood and wood processing wastes—firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills.
Agricultural crops and waste materials—corn, soybeans, sugar cane, switchgrass, woody plants, and algae, and crop and food processing residues.
Biogenic materials in municipal solid waste—paper, cotton, and wool products, and food, yard, and wood wastes.

Converting biomass to energy:

Biomass is converted to energy through various processes, including:

- Direct combustion (burning) to produce heat.
- Thermochemical conversion to produce solid, gaseous, and liquid fuels.
- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels



Direct combustion is the most common method for converting biomass to useful energy.

Thermochemical conversion includes pyrolysis and gasification. Both are thermal decomposition processes in which biomass feedstock materials are heated in closed, pressurized vessels called gasifiers at high temperatures.

Pyrolysis entails heating organic materials to 800–900oF (400–500 °C) in the near complete absence of free oxygen, and it produces fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.

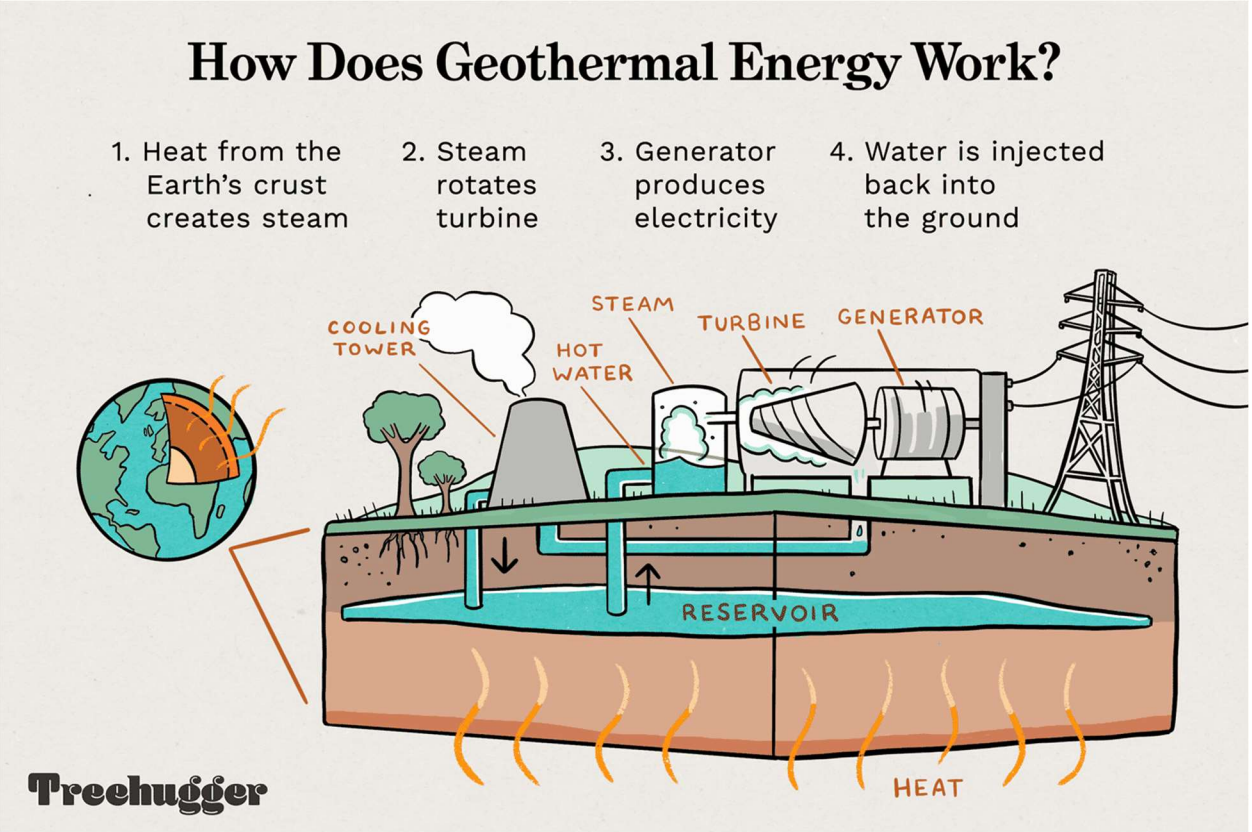
Gasification entails heating organic materials to 1,400–1700oF (800–900 °C) with injections of controlled amounts of free oxygen and/or steam into the vessel to produce a carbon monoxide and hydrogen rich gas called synthesis gas or syngas that can be used as fuel for diesel engines for heating and generating of electricity in gas turbines. It can also be treated to separate the hydrogen from the gas, and the hydrogen can be burned or used in fuel cells.

A chemical conversion process known as transesterification is used for converting vegetable oils, animal fats, and greases into fatty acid methyl esters (FAME), which are used to produce biodiesel.

The biological conversion includes fermentation to convert biomass into ethanol and anaerobic digestion to produce renewable natural gas. Ethanol is used as a vehicle fuel. Renewable natural gas—also called biogas or biomethane—is produced in anaerobic digesters at sewage treatment plants and at dairy and livestock operations. It also forms in and may be captured from solid waste landfills. Properly treated renewable natural gas has the same uses as fossil fuel natural gas.

- **Geothermal Energy**

The earth's core is about as hot as the sun's surface, due to the slow decay of radioactive particles in rocks at the center of the planet. Drilling deep wells brings very hot underground water to the surface as a hydrothermal resource, which is then pumped through a turbine to create electricity.



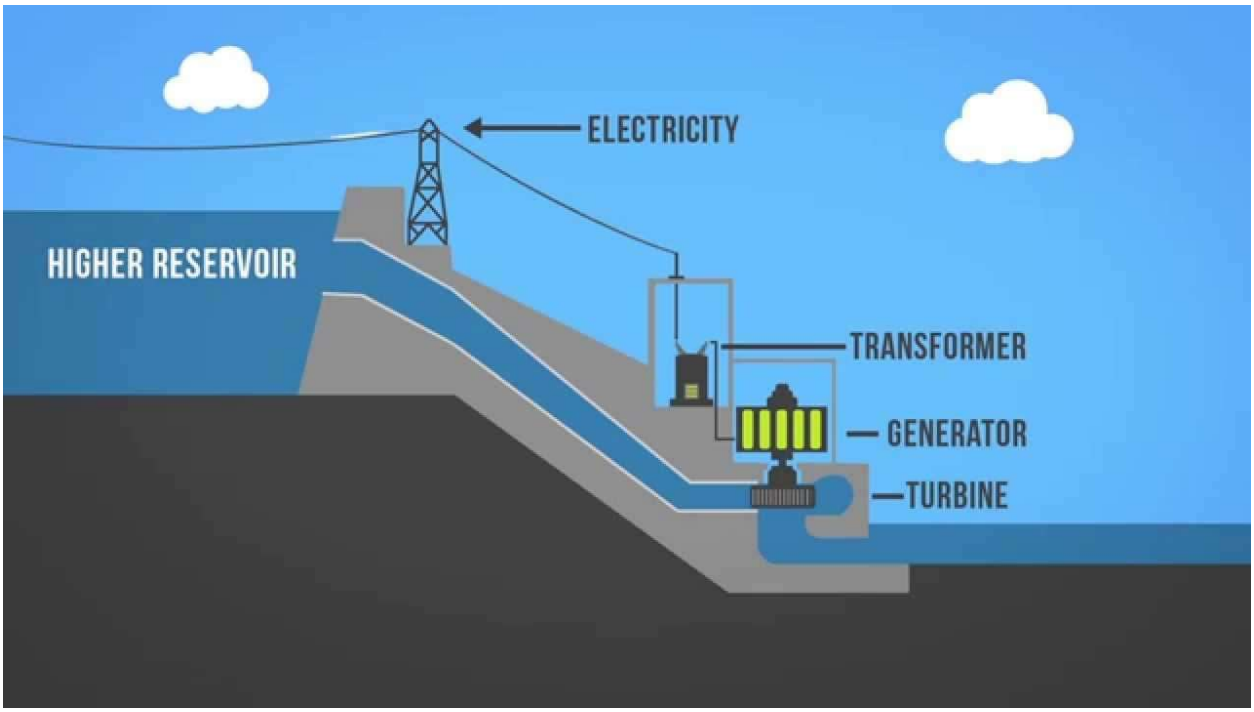
Geothermal plants typically have low emissions if they pump the steam and water they use back into the reservoir. There are ways to create geothermal plants where there are not underground reservoirs, but there are concerns that they may increase the risk of an earthquake in areas already considered geological hot spots.

Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity. The technology for electricity generation from hydrothermal reservoirs, and has been operating since 1913. This key renewable source covers a significant share of electricity demand in many countries and more than 90% of heating demand in Iceland.

The main advantages are that it is not depending on weather conditions and has very high-capacity factors; for these reasons, geothermal power plants are capable of supplying baseload electricity. There are different geothermal technologies with distinct levels of maturity. Technologies for direct uses like district heating, geothermal heat pumps, greenhouses. Many of the power plants in operation today are dry steam plants or flash plants harnessing temperatures of more than 180°C. However, medium temperature fields are more used for electricity generation or for combined heat and power thanks to the development of binary cycle technology, in which geothermal fluid is used via heat exchangers to heat a process fluid in a closed loop. Additionally, new technologies are being developed like Enhanced Geothermal Systems (EGS), which are in the demonstration stage.

- **Hydropower Energy.**

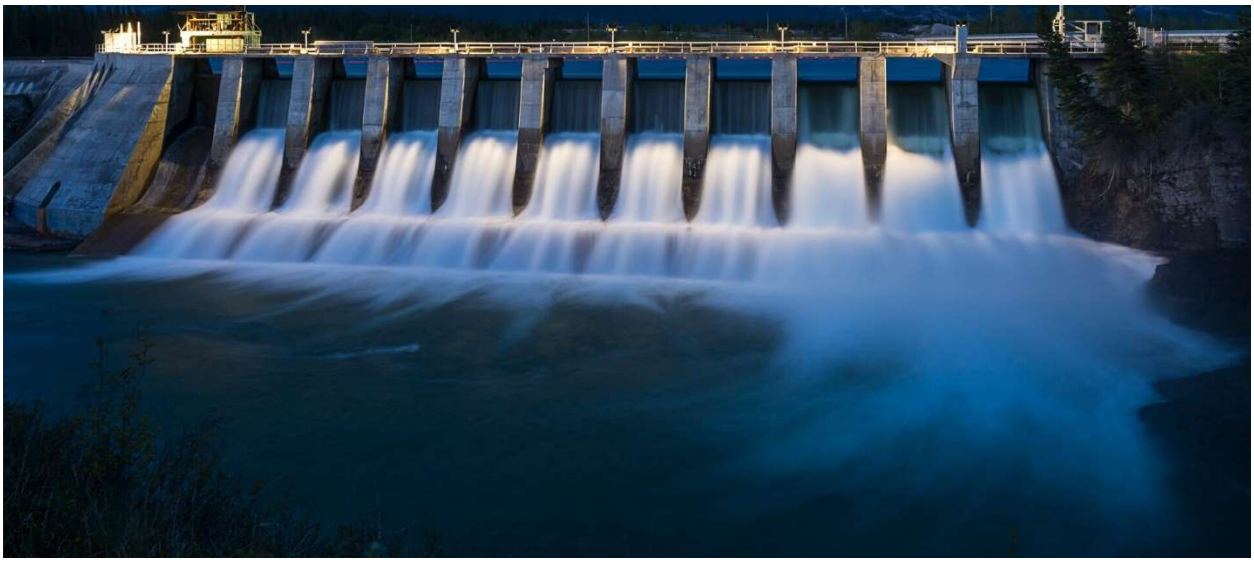
Hydropower is energy derived from flowing water; The basic principle of hydropower is using water to drive turbines. More than 2,000 years ago, the ancient Greeks used waterpower to run wheels for grinding grain; today it is among the most cost-effective means of generating electricity and is often the preferred method where available. In Norway, for example, 99% of electricity comes from hydropower. The world's largest hydropower plant is the 22.5-gigawatt Three Gorges Dam in China. It produces enough to supply between 70 million and 80 million households. Small-scale micro-hydropower projects can make a big difference to communities in remote locations.



Hydropower plants consist of two basic configurations: with dams and reservoirs, or without.

Hydropower dams with a large reservoir can store water over short or long periods to meet peak demand.

Hydropower without dams and reservoirs means producing at a smaller scale, typically from a facility designed to operate in a river without interfering in its flow. For this reason, many consider small-scale hydro a more environmentally-friendly option.



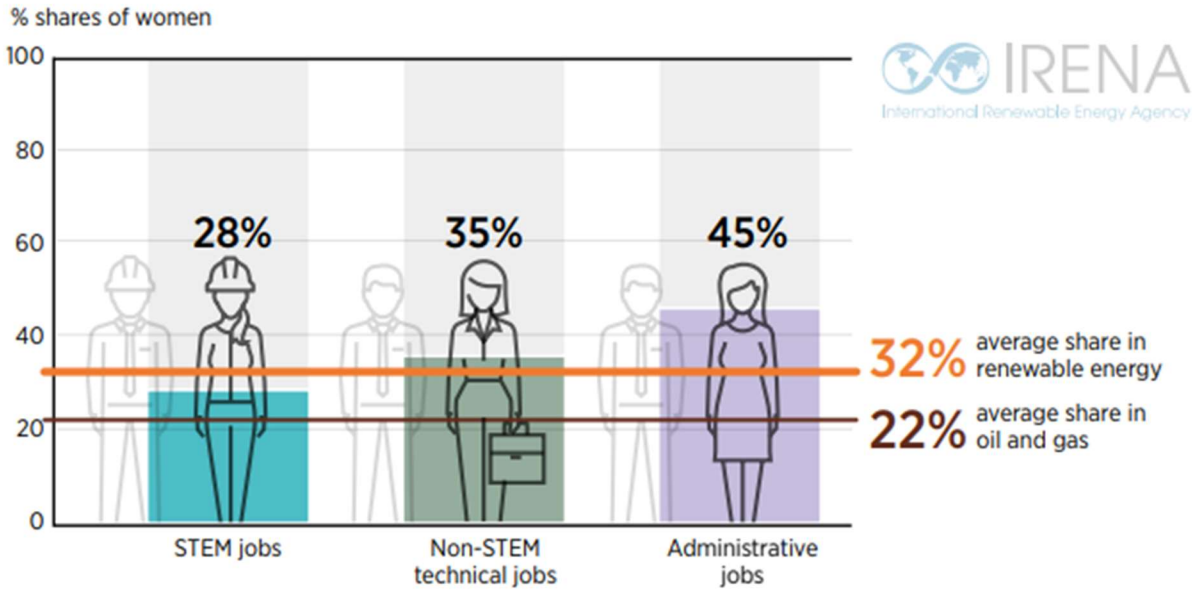
Tidal and wave energy is still in a developmental phase, but the ocean will always be ruled by the moon's gravity, which makes harnessing its power an attractive option. Some tidal energy approaches may harm wildlife, such as tidal barrages, which work much like dams and are located in an ocean bay or lagoon. Like tidal power, wave power relies on dam-like structures or ocean floor–anchored devices on or just below the water's surface.

Benefits

The environmental advantages of renewable energy, including lower carbon emissions and reduced air pollution have been widely known for decades. Its numerous socio-economic benefits, however, have only become apparent in recent decades as the deployment of renewable energy technologies has become more widespread.

Employment

Renewable energy provides a significant - and growing - number of jobs worldwide each year. The renewable energy sector, according to IRENA's estimates, employed a record 10.3 million people worldwide in 2017, driven by rising investments. This, in turn, was the result of rapidly falling costs, technological improvements and government policies to support renewables.



Source: IRENA, 2019b.

STEM = science, technology, engineering and mathematics.

Health

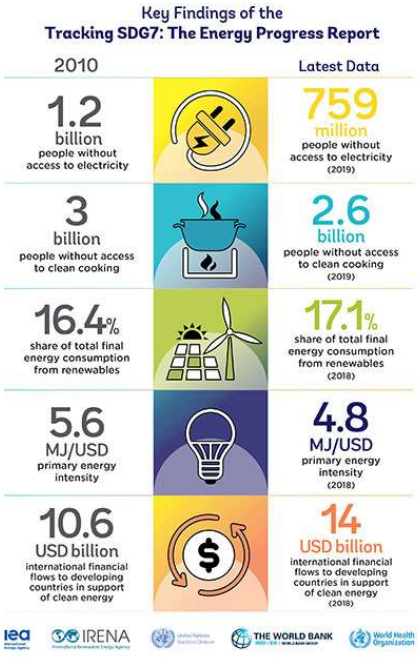
Wind, solar and hydropower produce little or no air pollution. Other renewable energy technologies, such as biomass and geothermal, do emit air pollutants, but at much lower rates than most conventional fuels. Air pollution has become a critically important issue in many developing countries, where up to 2.9 billion people still rely on wood, coal and charcoal for cooking and heating homes. Cleaner options, including biomass and solar technologies, can play a role in this regard.

Resilience

Some renewable energy technologies are deployed in a distributed, modular fashion, making them less prone to large-scale failure. This brings advantages during severe weather events or complex emergencies, as such technologies can be rolled out quickly wherever needed, getting electricity to people without complex and time-consuming infrastructure development.

Access to energy

Over one billion people lack access to electricity, while a further one billion have an unreliable supply. Improved reliability, rapidly falling technology costs and supportive policies have made stand-alone and mini-grid renewable electricity solutions viable for the 80% of those without access in rural areas or small developing island states. One of the most compelling arguments for off-grid solutions is that they are decentralized, and because project development activities occur locally, job creationn is also localized.



Note: Latest Data was in 2021

Renewable energy in Egypt:

The history of renewable energy in Egypt

Ancient Egyptians are the first people known to use solar energy on a large scale to heat their homes. They designed their houses to store the sun's heat in the building walls during the day, which would then release after the sun went down as a way to regulate the temperature of the home during cool desert nights. The ancient Greeks, Romans, Native Americans, and Chinese also used similar techniques to help regulate the temperature in their homes.

The future of the Renewable energy in Egypt

Global energy demand is set to increase 100% by 2050, maintaining energy security and creating a low carbon future are key challenges and renewable energy plays a vital, strategic role in meeting our energy needs, now and in the future. Almost two-thirds of net additions to global power capacity over the next five years will come from renewable energy.

As we know that Egypt possesses an abundance of land, sunny weather and high wind speeds, making it a prime location for renewable energy sources. Egypt intends to increase the supply of electricity generated from renewable sources to 20% by 2022 and 42% by 2035, with wind providing 14 percent, hydro power 2 percent, and solar 25 percent by 2035. So, the Egyptian government is investing billions of dollars into new renewable energy projects and looking to establish wind farms and solar power plants in around the country, as in the East and West Nile areas that will produce around 31,150 MW from wind and 52,300 MW from solar. And The Ministry of Electricity and Renewable Energy signed seven memoranda of understanding worth USD 500 million for solar and wind projects.

- **Wind Energy**

So, as you know that Egypt has wind weather so it has many projects and the upcoming projects are 540 MW project is under construction at Gulf of Suez, a 580 MW project is in financing also at the Gulf of Suez and a feasibility study is under way for a 200 MW project at West Nile. Additionally, more projects are under preparation in cooperation with Germany, AFD, EIB and EU (200 MW), MASDAR (200 MW), Germany and AFD (200 MW), and Japan (200 MW). And also, the GOE allocated an area of about 7,845 square kilometers in the Gulf of Suez region and the Nile Banks for NREA to implement additional wind energy projects.

- **Solar Energy**

As Egypt is considered “sun belt” that make Egypt has many projects so in 2012, GOE approved the Egyptian Solar Plan, which includes adding 3.5 GW (2.8 GW CSP and 700 MW PV) of solar energy by 2027. Solar-thermal power plant project using CSP technology for both electricity generation and water desalination and for industrial purposes. Designing a technical-financial mechanism to promote the use of solar water heaters in Egypt’s residential sector.