Renewable Energy Resources-Overview

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Renewable Energy Sources Overview

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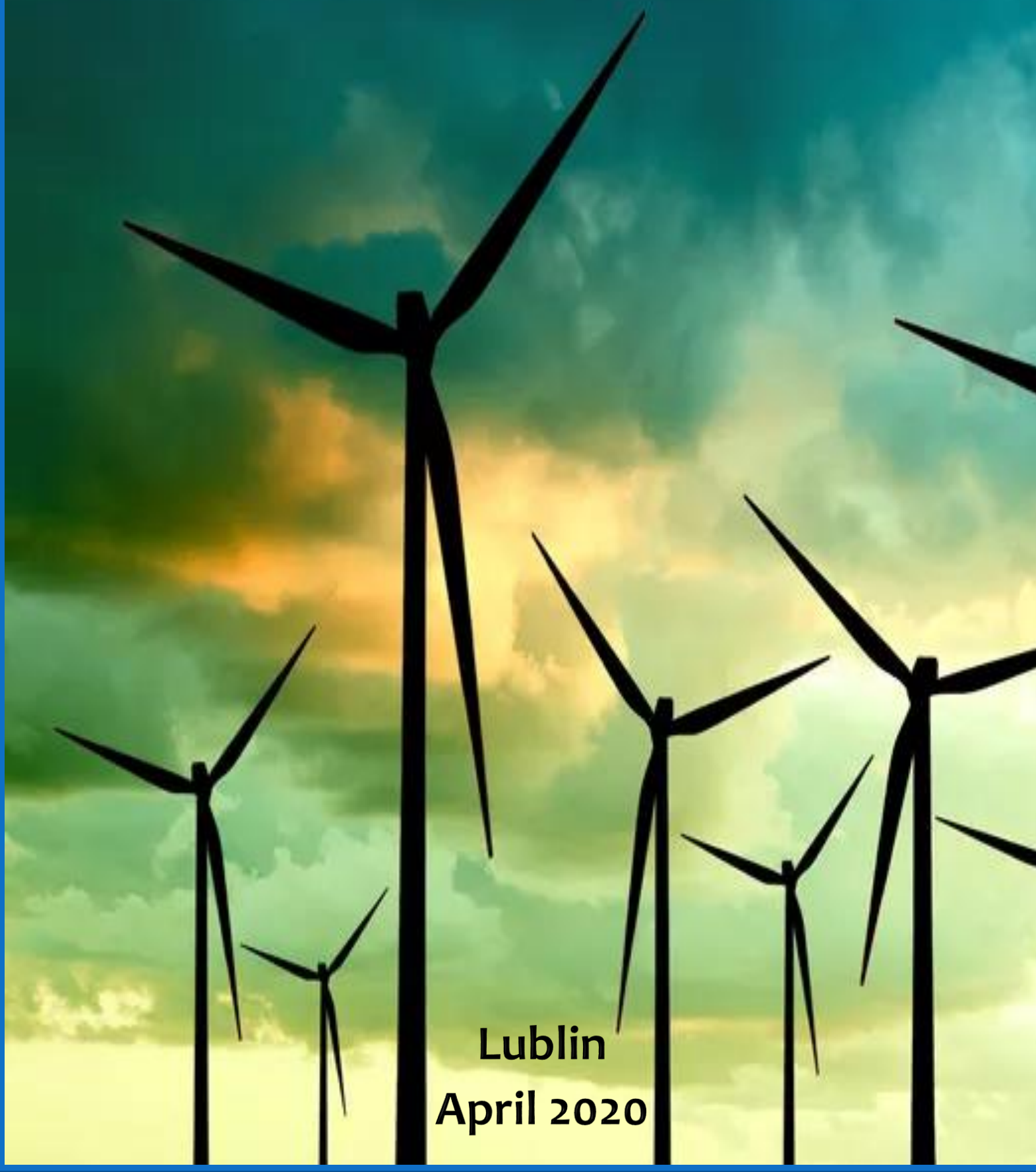

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Contents

1. Introduction: 2
2. Renewable Energy: 2
3. Renewable Energy World view: 2
4. Uses of Renewable Energy: 3
5. Mainstream Renewable Energy technologies 3
6. Solar Energy 4
7. Wind 6
8. Hydroelectric 8
9. Geothermal 10
10. Marine energy: 12
11. Bioenergy: 13
12. References 14

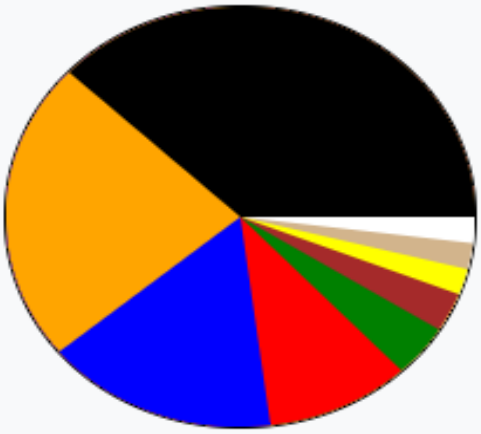
Figure 1: Transformation of Renewable Resources to Energy 3
Figure 2: Mainstream Renewable energy sources 3
Figure 3: Solar Radiation Process 4
Figure 4: The source of Earth's solar power: the Sun 5
Figure 5: Global Radiation Overview 5
Figure 6: Top Countries According to generate wind energy 6
Figure 7: Public Sentiment for wind energy 7
Figure 8: Wind Turbine Components 8
Figure 9: Hydroelectric Dam 9
Figure 10; Enhanced geothermal system 10
Figure 11: Steam rising from the Nesjavellir Geothermal Power Station in Iceland 11
Figure 12: Tidal Energy 12
Figure 13: Tidal Energy 12

1. Introduction:

Renewable energy sources are developed worldwide, owing to the high prices of fossil fuel and to limiting greenhouse gas emissions. The depletion of the known petroleum reserves makes the renewable energy sources more attractive ever before. A wide range of energy-producing technologies and equipment have been developed over time to take advantage of these natural resources. As a result, usable energy can be produced in the form of electricity, industrial heat, thermal energy for space and water conditioning, and **transportation fuels.**

2. Renewable Energy:

Renewable energy is energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate at which they are consumed. There are various forms of renewable energy, deriving directly or indirectly from the sun, or from heat generated deep within the earth. They include energy generated from solar, wind, geothermal, hydropower and ocean resources, solid biomass, biogas and liquid biofuels. Biomass, however, is a renewable resource only if its rate of consumption does not exceed its rate of regeneration.



World electricity generation by source in 2017. Total generation was 26 PWh.[1]

3. Renewable Energy World view:

Based on REN21's 2017 report, renewables contributed 19.3% to humans' global energy consumption and 24.5% to their generation of electricity in 2015 and 2016, respectively. This energy consumption is divided as 8.9% coming from traditional biomass, 4.2% as heat energy (modern biomass, geothermal and solar heat), 3.9% from hydroelectricity and the remaining 2.2% is electricity from wind, solar, geothermal, and other forms of biomass. Worldwide investments in renewable technologies amounted to more than US$286 billion in 2015. In 2017, worldwide investments in renewable energy amounted to US$279.8 billion with China accounting for US$126.6 billion or 45% of the global investments, the United States for US$40.5 billion and Europe for US$40.9 billion. Globally there are an estimated 7.7 million jobs associated with the renewable energy industries, with solar photovoltaics being the largest renewable employer. Renewable energy systems are rapidly becoming more efficient and cheaper and their share of total energy consumption is increasing. As of 2019, more than two-thirds of worldwide newly installed electricity capacity was renewable. Growth in consumption of coal and oil could end by 2020 due to increased uptake of renewables and natural gas.

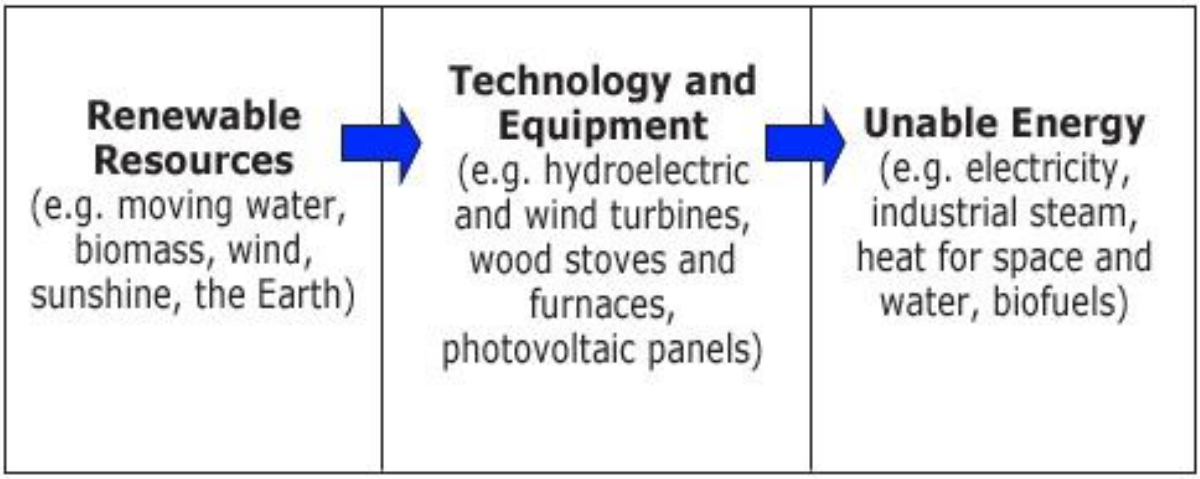


Figure 1: Transformation of Renewable Resources to Energy

"The table describes the renewable energy transformational universe from the state of a natural resource to the state of useful forms of energy. It consists of three sections with the arrows going from the first section to the second and from the second to the third. The first section shows the renewable resources, with the examples such as moving water, biomass, wind, sunshine, the Earth. The second one presents technology and equipment showing the examples of hydroelectric and wind turbines, wood stoves and furnaces, photovoltaic panels. The third section displays usable energy with the examples of electricity, industrial steam, heat for space and water, biofuels."

4. Uses of Renewable Energy:

At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Some places and at least two countries, Iceland and Norway, generate all their electricity using renewable energy already, and many other countries have the set a goal to reach 100% renewable energy in the future. At least 47 nations around the world already have over 50 percent of electricity from renewable resources. Renewable energy resources exist over wide geographical areas, in contrast to fossil fuels, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency technologies is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power.

5. Mainstream Renewable Energy technologies

- Solar Energy
- Wind Energy
- Hydroelectric Energy
- Geothermal Energy
- Marine Energy
- Biomass Energy

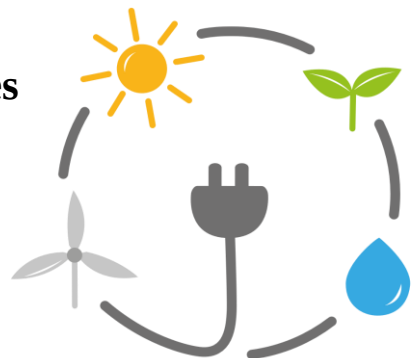


Figure 2: Mainstream Renewable energy sources

6. Solar Energy

Solar energy is derived by capturing radiant energy from sunlight and converting it into heat, electricity, or hot water. Photovoltaic (PV) systems can convert direct sunlight into electricity through the use of solar cells. It is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating 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.

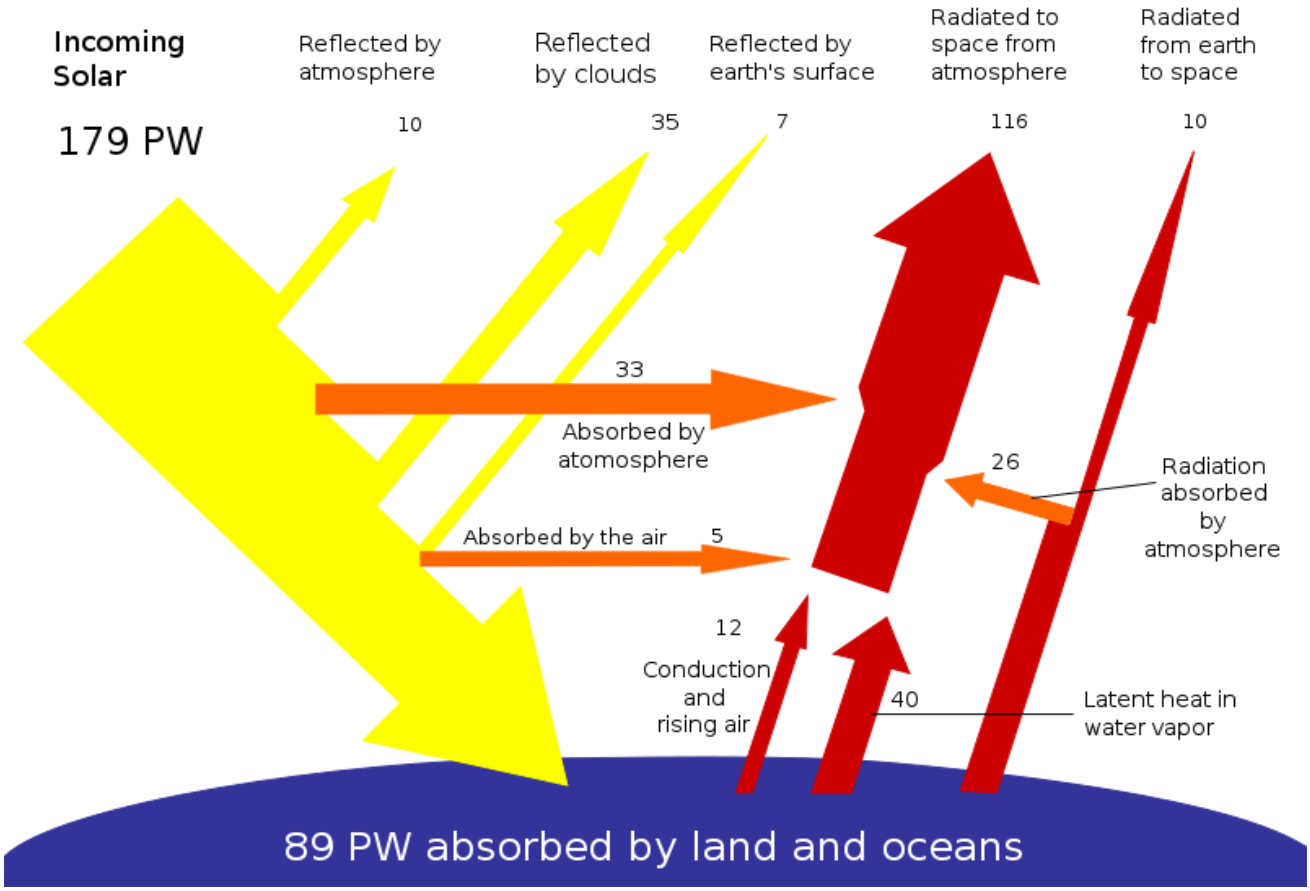


Figure 3: Solar Radiation Process

The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Most of the world's population live in areas with insolation levels of 150–300 watts/m², or 3.5 7.0 kWh/m² per day.

Figure 4: The source of Earth's solar power: the Sun

Active solar techniques use photovoltaics, concentrated solar power, solar thermal collectors, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand-side technologies.

Benefits:

One of the benefits of solar energy is that sunlight is functionally endless. With the technology to harvest it, there is a limitless supply of solar energy, meaning it could render fossil fuels obsolete. Relying on solar energy rather than fossil fuels also helps us improve public health and environmental conditions. In the long term, solar energy could also eliminate energy costs, and in the short term, reduce your energy bills.

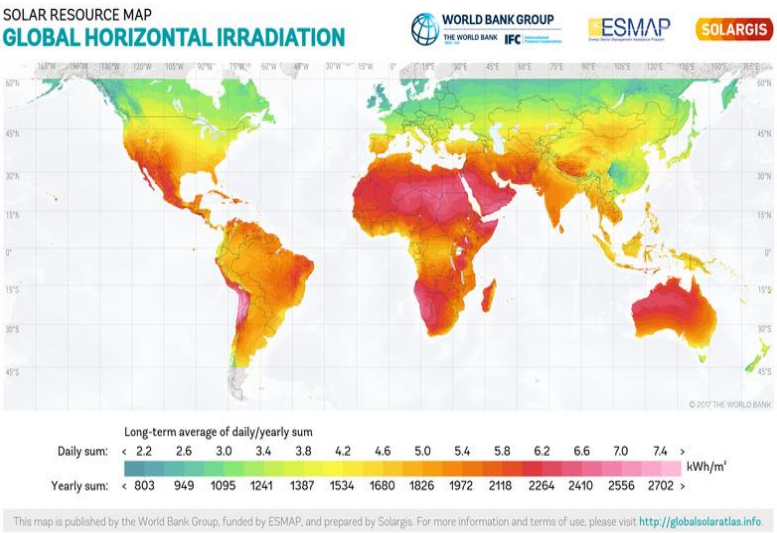


Figure 5: Global Radiation Overview

Current Limitations:

Although solar energy will save you money in the long run, it tends to be a significant upfront cost and is an unrealistic expenses for most households. For personal homes, homeowners also need to have the ample sunlight and space to arrange their solar panels, which limits who can realistically adopt this technology at the individual level.

7. Wind

Wind power or wind energy is the use of wind to provide the mechanical power through wind turbines to turn electric generators and traditionally to do other work, like milling or pumping. Wind power is a sustainable and renewable energy, and has a much smaller impact on the environment compared to burning fossil fuels.

Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Onshore wind farms also have an impact on the landscape, as typically they need to be spread over more land than other power stations and need to be built in wild and rural areas, which can lead to "industrialization of the countryside and habitat loss. Offshore wind is steadier and stronger than on land and offshore farms have less visual impact, but construction and maintenance costs are higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

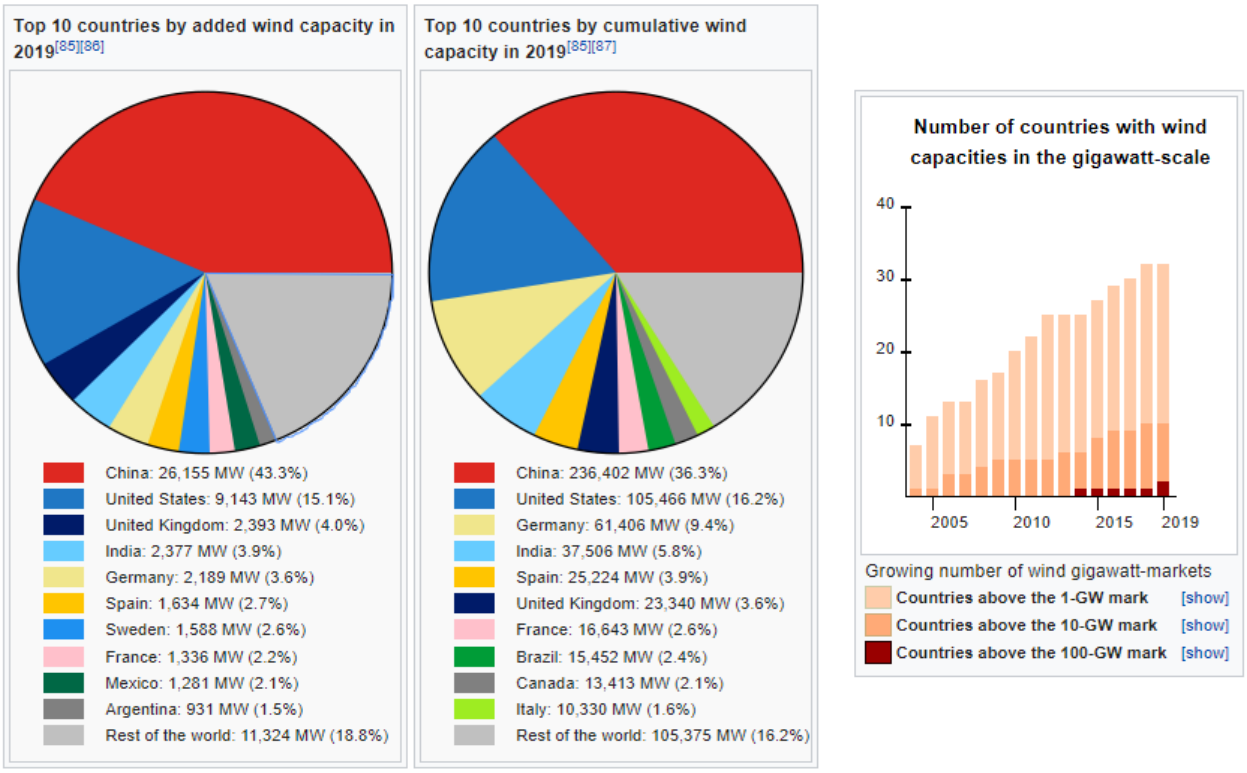


Figure 6: Top Countries According to generate wind energy

Wind is an intermittent energy source, which cannot make electricity nor be dispatched on demand. It also gives variable power, which is consistent from year to year but varies greatly over shorter time scales. Therefore, it must be used together with other electric power sources or storage to give a reliable supply. As the proportion of wind power in a region increases, more conventional power sources are needed to back it up (such as fossil fuel power and nuclear power), and the grid may need to be upgraded. Power-management techniques such as having dispatchable power sources, enough hydroelectric power, excess capacity, geographically distributed turbines, exporting and importing power to neighboring areas, energy storage, or reducing demand when wind production is low, can in many cases overcome these problems. Weather forecasting permits the electric-power network to be readied for the predictable variations in production that occur.

In 2018, global wind power capacity grew 9.6% to 591 GW and yearly wind energy production grew 10%, reaching 4.8% of worldwide electric power usage, and providing 14% of the electricity in the European Union. Wind power supplied 15% of the electricity consumed in Europe in 2019. Denmark is the country with the highest penetration of wind power, with 43.4% of its consumed electricity from wind in 2017. At least 83 other countries are using wind power to supply their electric power grids.

Environmental effects:

The environmental impact of wind power is considered to be relatively minor compared to that of fossil fuels. Compared with other low carbon power sources, wind turbines have some of the lowest global warming potential per unit of electrical energy generated. Wind farms have a negative impact on tourism in areas known for natural landscapes and panoramic views. However, land between the turbines and roads can still be used for agriculture.

Wind farms are typically built in wild and rural areas, which can lead to "industrialization of the countryside" and habitat loss. Habitat loss and habitat fragmentation are the greatest impact of wind farms on wildlife. There are also reports of higher bird and bat mortality at wind turbines as there are around other artificial structures. Wind turbines generate noise. At a residential distance of 300 metres (980 ft) this may be around 45 dB, which is slightly louder than a refrigerator. At 1.5 km (1 mi) distance they become inaudible.

Before 2019, many wind turbine blades had been made of fiberglass with designs that only provided a service lifetime of 10 to 20 years. Given the available technology, as of February 2018 there was no market for recycling these old blades, and they are commonly disposed in landfills. Because blades are designed to be hollow, they take up large volume compared to their mass. Landfill operators have therefore started requiring operators to crush the blades before they can be landfilled.

Environmental group members are both more in favor of wind power (74%) as well as more opposed (24%). Few are undecided.

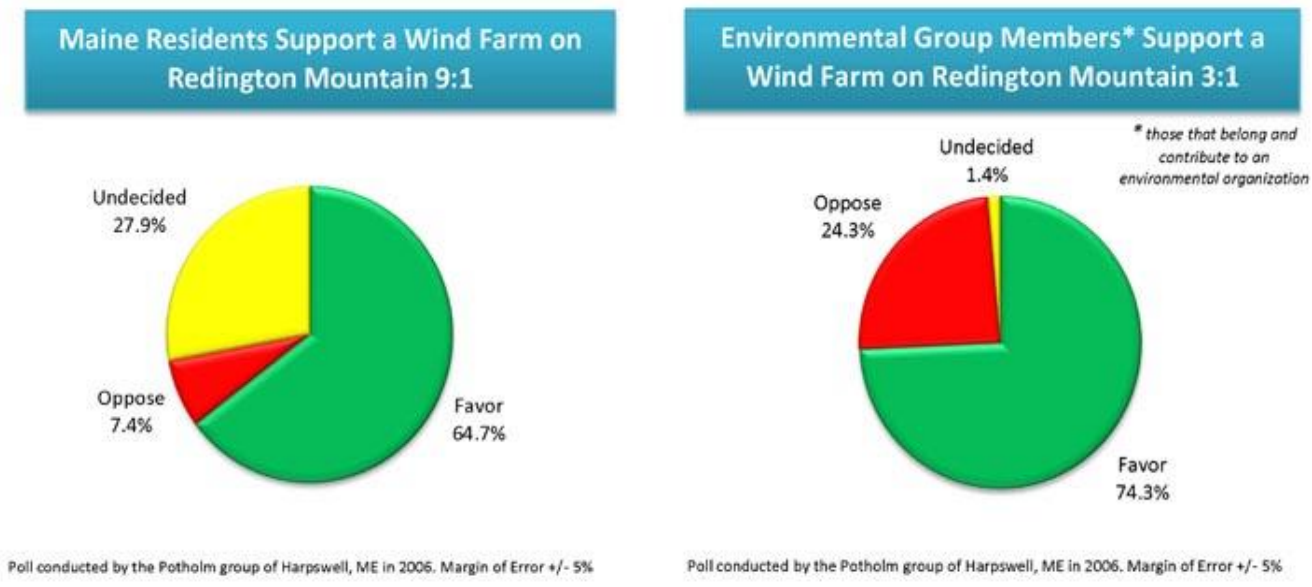


Figure 7: Public Sentiment for wind energy

Benefits:

Wind energy is a clean energy source, which means that it doesn't pollute the air like other forms of energy. Wind energy doesn't produce carbon dioxide, or release any harmful products that can cause environmental degradation or negatively affect human health like smog, acid rain, or other heat-trapping gases. Investment in wind energy technology can also open up new avenues for jobs and job training, as the turbines on farms need to be serviced and maintained to keep running.

Typical wind turbine components:

1. Foundation
2. Connection to the electric grid
3. Tower
4. Access ladder
5. Wind orientation control (Yaw control)
6. Nacelle
7. Generator
8. Anemometer
9. Electric or Mechanical Brake
10. Gearbox
11. Rotor blade
12. Blade pitch control
13. Rotor hub

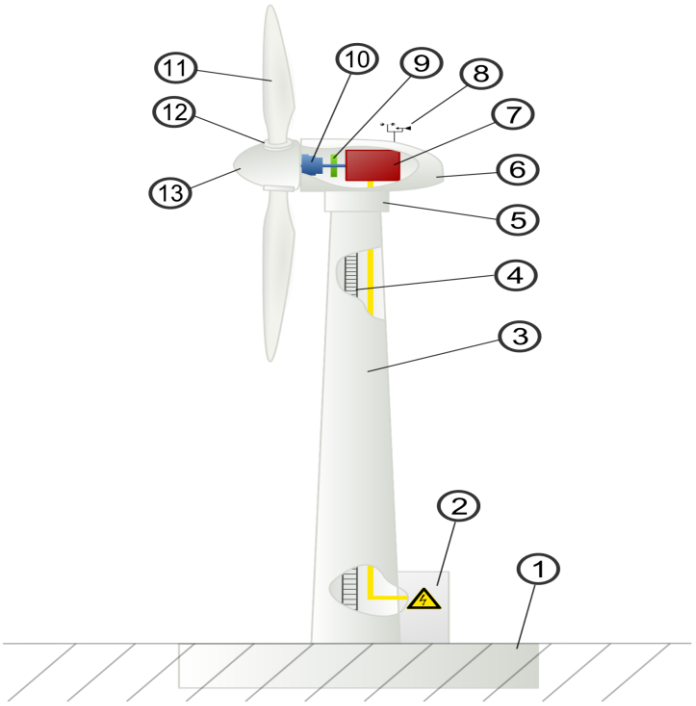


Figure 8: Wind Turbine Components

8. Hydroelectric

Hydropower or water power (from Greek: ὕδωρ, "water") is power derived from the energy of falling or fast-running water, which may be harnessed for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. A trompe, which produces compressed air from falling water, is sometimes used to power other machinery at a distance.

Hydroelectricity is the application of hydropower to generate electricity. It is the primary use of hydropower today. Hydroelectric power plants can include a reservoir (generally created by a dam) to exploit the energy of falling water, or can use the kinetic energy of water as in run-of-the-river hydroelectricity. Hydroelectric plants can vary in size from small community sized plants (micro hydro) to very large plants supplying power to a whole country. As of 2019, the five largest power stations in the world are conventional hydroelectric power stations with dams.

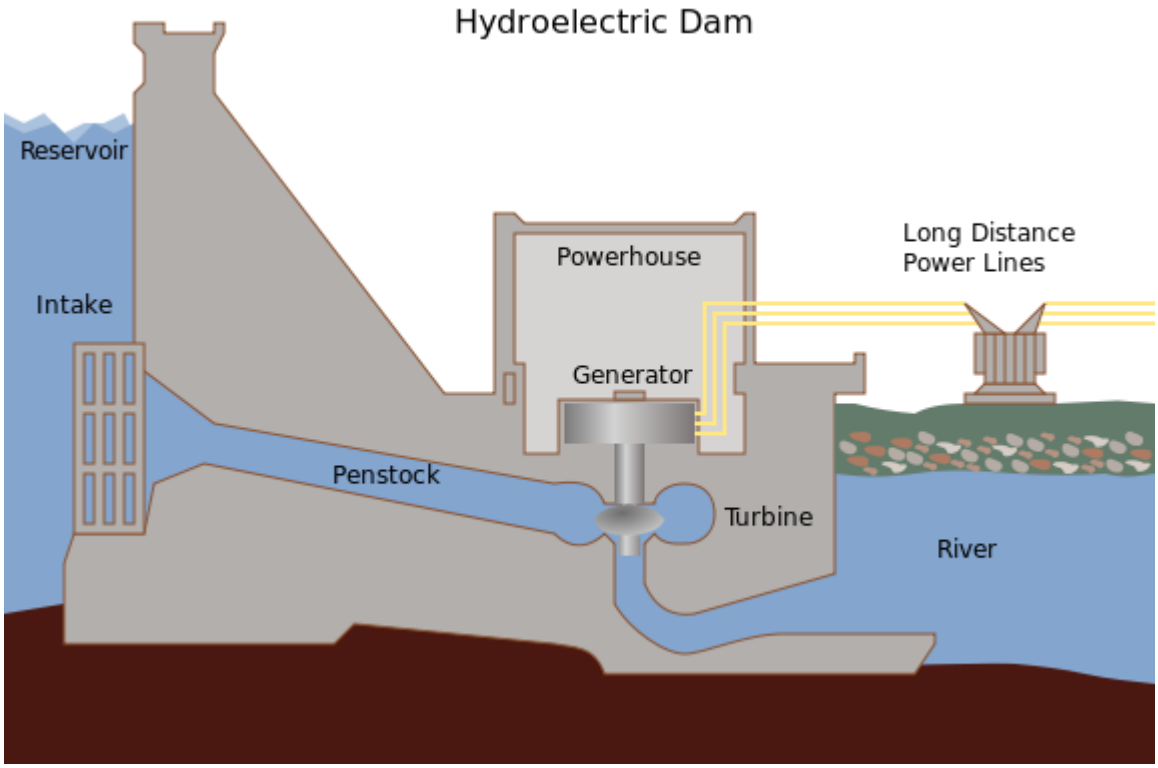


Figure 9: Hydroelectric Dam

Hydroelectricity can also be used to store energy in the form of potential energy between two reservoirs at different heights with pumped-storage hydroelectricity. Water is pumped uphill into reservoirs during periods of low demand to be released for generation when demand is high or system generation is low. Other forms of electricity generation with hydropower include tidal stream generators using energy from tidal power generated from oceans, rivers, and human-made canal systems to generating electricity

World hydroelectric capacity:

The ranking of hydroelectric capacity is either by actual annual energy production or by installed capacity power rating. In 2015 hydropower generated 16.6% of the worlds total electricity and 70% of all renewable electricity. Hydropower is produced in 150 countries, with the Asia-Pacific region generated 32 percent of global hydropower in 2010. China is the largest hydroelectricity producer. Paraguay produces 100% and Norway produces 96% of its electricity from hydroelectric sources.

Ten of the largest hydroelectric producers as at 2014.[52][54][55]

Country	Annual hydroelectric production (TWh)	Installed capacity (GW)	Capacity factor	% of total production
China	1064	311	0.37	18.7%
Canada	383	76	0.59	58.3%
Brazil	373	89	0.56	63.2%
United States	282	102	0.42	6.5%
Russia	177	51	0.42	16.7%
India	132	40	0.43	10.2%
Norway	129	31	0.49	96.0%
Japan	87	50	0.37	8.4%
Venezuela	87	15	0.67	68.3%
France	69	25	0.46	12.2%

Environmental Impact:

Hydroelectric power is very versatile and can be generated using both large scale projects, like the Hoover Dam, and small scale projects like underwater turbines and lower dams on small rivers and streams. Hydroelectric power does not generate pollution, and therefore is a much more environmentally-friendly energy option for our environment.But the storage systems may need to use fossil fuel to pump water. Although hydroelectric power does not pollute the air, it disrupts waterways and negatively affects the animals that live in them, changing water levels, currents, and migration paths for many fish and other freshwater ecosystems.

9. Geothermal

Geothermal heat is heat that is trapped beneath the earth's crust from the formation of the Earth 4.5 billion years ago and from radioactive decay. Sometimes large amounts of this heat escapes naturally, but all at once, resulting in familiar occurrences, such as volcanic eruptions and geysers. This heat can be captured and used to produce geothermal energy by using steam that comes from the heated water pumping below the surface, which then rises to the top and can be used to operate a turbine.

Enhanced geothermal system:

1:Reservoir
2:Pump house
3:Heat exchanger
4:Turbine hall
5:Production well
6:Injection well
7:Hot water to district heating
8:Porous sediments
9:Observation well
10:Crystalline bedrock

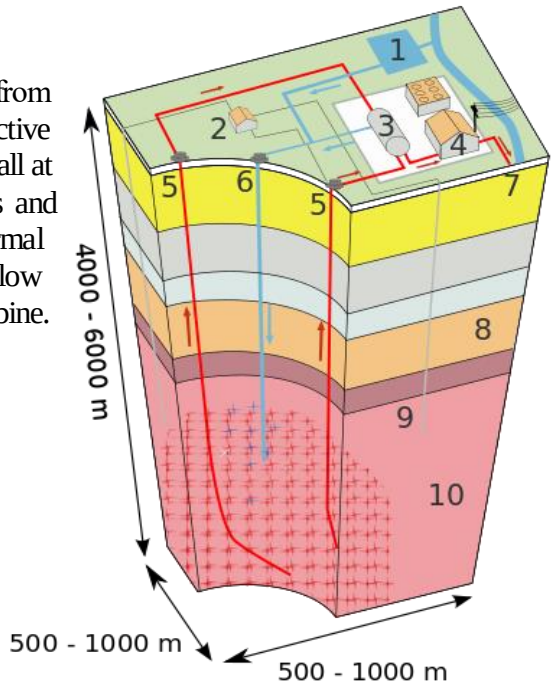


Figure 10; Enhanced geothermal system

Geothermal power is cost-effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels.

Figure 11: Steam rising from the Nesjavellir Geothermal Power Station in Iceland

Environmental effects:

Fluids drawn from the deep earth carry a mixture of gases, notably carbon dioxide (CO_2), hydrogen sulfide (H_2S), methane (CH_4) and ammonia (NH_3). These pollutants contribute to global warming, acid rain, and noxious smells if released. Existing geothermal electric plants emit an average of 122 kilograms (269 lb) of CO_2 per megawatt-hour (MW·h) of electricity, a small fraction of the emission intensity of conventional fossil fuel plants. Plants that experience high levels of acids and volatile chemicals are usually equipped with emission-control systems to reduce the exhaust.

In addition to dissolved gases, hot water from geothermal sources may hold in solution trace amounts of toxic elements such as mercury, arsenic, boron, and antimony. These chemicals precipitate as the water cools, and can cause environmental damage if released. The modern practice of injecting cooled geothermal fluids back into the Earth to stimulate production has the side benefit of reducing this environmental risk.

Geothermal energy is not as common as other types of renewable energy sources, but it has a significant potential for energy supply. Since it can be built underground, it leaves very little footprint on land. Geothermal energy is naturally replenished and therefore does not run a risk of depleting (on a human timescale). Cost plays a major factor when it comes to disadvantages of geothermal energy. Not only is it costly to build the infrastructure, but another major concern is its vulnerability to earthquakes in certain regions of the world.

10. Marine energy:

Marine energy refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. Some of this energy can be harnessed to generate electricity to power homes, transport and industries. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world.

Figure 13: Tidal Energy

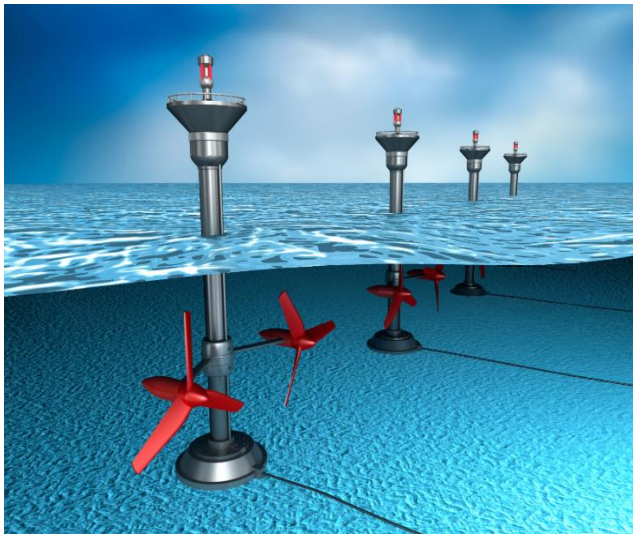


Figure 12: Tidal Energy

Environmental effects:

Common environmental concerns associated with marine energy developments include:

- the risk of marine mammals and fish being struck by tidal turbine blades
- the effects of EMF and underwater noise emitted from operating marine energy devices
- the physical presence of marine energy projects and their potential to alter the behavior of marine mammals, fish, and seabirds with attraction or avoidance
- the potential effect on nearfield and farfield marine environment and processes such as sediment transport and water quality

Unlike other forms of renewable energy, wave energy is predictable and it's easy to estimate the amount of energy that will be produced. Instead of relying on varying factors, such as sun and wind, wave energy is much more consistent. This type of renewable energy is also abundant, the most populated cities tend to be near oceans and harbors, making it easier to harness this energy for the local population.

Those who live near the ocean definitely benefit from wave energy, but those who live in landlocked states won't have ready access to this energy. Another disadvantage to ocean energy is that it can disturb the ocean's many delicate ecosystems. Although it is a very clean source of energy, large machinery needs to be built nearby to help capture this form energy, which can cause disruptions to the ocean floor and the sea life that habitats it. Another factor to consider is weather, when rough weather occurs it changes the consistency of the waves, thus producing lower energy output when compared to normal waves without stormy weather.

12.Bioenergy:

Bioenergy is renewable energy made available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, wood waste, straw, and other crop residues, manure, sugarcane, and many other by-products from a variety of agricultural processes.

In its most narrow sense it is a synonym to biofuel, which is fuel derived from biological sources. In its broader sense it includes biomass, the biological material used as a biofuel, as well as the social, economic, scientific and technical fields associated with using biological sources for energy. This is a common misconception, as bioenergy is the energy extracted from the biomass, as the biomass is the fuel and the bioenergy is the energy contained in the fuel.

Solid biomass:

Biomass is the material derived from recently living organisms, which includes plants, animals and their byproducts. Manure, garden waste and crop residues are all sources of biomass. It is a renewable energy source based on the carbon cycle, unlike other natural resources such as petroleum, coal, and nuclear fuels. Another source includes Animal waste, which is a persistent and unavoidable pollutant produced primarily by the animals housed in industrial-sized farms.

Sewage biomass:

The use of municipal and household waste is on the forefront of new sources for biomass, and is a largely discarded resource on which new research is being conducted for use of energy production. Sewage sludge is a point of focus in current research for developing bioenergy from biomass. The large quantity being produced by households at a continuous rate presents an opportunity to extract valuable compounds contained within it which can be then used to produce bioenergy. The main form of bioenergy being produced from sewage is methane which will reduces the amount of waste put into landfills, its costs of transportation and disposal, and also keeps a larger amount of gas out of the atmosphere, as more is able to be captured.

Environmental Impact:

The use of biomass in energy production creates carbon dioxide that is put into the air, but the regeneration of plants consumes the same amount of carbon dioxide, which is said to create a balanced atmosphere. Biomass can be used in a number of different ways in our daily lives, not only for personal use, but businesses as well. Although new plants need carbon dioxide to grow, plants take time to grow. We also don't yet have widespread technology that can use biomass in lieu of fossil fuels.

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