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Renewable Energy

First year writing report

TABLE OF AUTHORS

Name	Sec	BN	Role
Hazem Khaled Abd-Ahakem	**2**	**4**	**Advantage, disadvantage and Applications of hydropower + Introduction**
Hussam Hassan Ahmed	**2**	**7**	**History of hydro power + The way of extracting energy from moving water**
Khaled Hossam Eldin Ezz Elarab	**2**	**10**	**Advantages and Disadvantages of Solar Energy**
Khaled Wagieh Abd El Rauof Elghobashy	**2**	**11**	**Solar Energy Introduction + Solar Energy Technology**
Rashed Ahmed Hussein	**2**	**12**	**Advantages and disadvantages of wind energy**
Ziad Ehab Mohamed Kamal	**2**	**21**	**Geothermal energy**
Zeyad Khaled Yehia	**2**	**22**	**Solar Energy Applications**
Abdullrahmen Ahmed Seif	**2**	**38**	**Wind Energy Market + Table of contents, list of figures, references, combine report parts**
Mahmoud Reda Zahran	**4**	**16**	**Introduction of Wind Energy**
Youssef Mohammed Yehia Said	**4**	**48**	**For hydro: Changing intro, color, style, collecting scattered report sections and re indexing it**

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0.1 Introduction to Renewable Energy

0.1.1 Renewable Energy

Where does "Renewable Energy" come from and what does it mean? We all believe we are knowledgeable with renewable energy sources, and some of us may even be able to name a few of the more well-known ones, but are we truly aware of their uses, potential energy output, larger economic implications, and other advantages? Here, we try to cut through the confusion and provide a concise and authoritative overview of the knowledge currently available on renewable energy and related technologies. Renewable energy, which are often derived from natural sources like solar electricity, wind power, and waterpower, are simply those that can be recycled or come from sources that do not have an end. When we hear the term "renewable energy," these are the instances that come to mind the most, but they are not the only ones (environmentalscience, 2023).

0.1.2 Renewable energy in our life

Every day of our lives, we utilize energy – to power our electronic devices, to illuminate our streets with streetlights, to fuel our automobiles with gasoline and diesel. For lighting, heating, and device powering, we use domestic oil, propane, or electricity from a national or local grid. The website where you are reading this article is hosted on a server, and both the computer you are using to view it and the server require power. Computers, phone networks, security systems, and servers are used at the areas where we work as well as in our shopping centers, parking lots, sporting arenas, and other places. These things all require fuel to function (environmentalscience, 2023).

0.1.3 Renewable Energy and environmental

With the help of a new accord reached upon in 2015 at the Paris Climate Summit (or COP21), the globe is doing what it can to cut carbon emissions and limit the increase in the world's average temperature. As the human population grows and needs more of our energy infrastructure, we also need to accept that there is only so much that can be done to reduce GHG output. We must switch to renewable energy sources for our energy generation if we are to further protect the environment and guarantee the future of the world for our children and their children (environmentalscience, 2023).

0.1.4 Types of renewable energy

there is a lot of types of renewable energy but the most famous of them are:

- **Solar energy**
- **Wind energy**
- **Hydro energy**
- **Geothermal energy**

In this report, we'll talk about these important types, and go into their details (Figure 0.1.1).

Figure 0.1.1 Some types of renewable energy

1. Solar Energy

Solar Energy

Sun is the ultimate source of almost all the energies on Earth, so we can use it for our benefit.

1.1 Introduction

1.1.1. Definition

solar electricity is a radiant mild and warmth from the solar that is used in lots of technology together with sun strength to generate electricity, and sun thermal electricity. (wikipedia, 2023)

Figure 1.1.1.Solar energy and solar panel (just energy, 2023)

1.1.2. Solar energy conversion

The process of converting solar thermal energy into electricity. (tutorialspoint, 2023)

- The first is solar concentrators, which focus the solar energy to power heat turbines.
- The second method is used for solar water heaters and air conditioning.

The principle of converting solar light energy into electricity. (tutorialspoint, 2023)

- Absorption of photons.
- Photovoltaic conversion.
- Combination of current from several cells.
- Conversion of the resultant DC to AC.

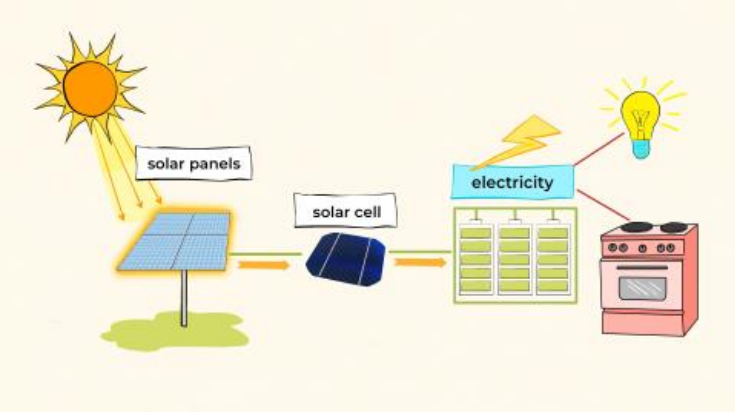

Figure 1.1.1. Solar energy conversion (mighty owl, 2023)

1.2 Technology

1.2.1. PV

- PV materials convert light energy into electrical energy. A unit PV device is called a cell.it is small and produces about 1-2 watts of power. These semiconductor materials are used to withstand the outdoors and covered with a protective material (glass, plastic). (energy.gov, 2023)
- Connect the solar cell to form a module to increase the performance of solar cells. Modules can be used individually or connected to form arrays. Array is connected to mains power. (energy.gov, 2023)
- A PV System also includes the structure that make panels toward the sun and the components that convert the direct current (DC) into alternating-current (AC). (energy.gov, 2023)
- "The largest PV systems are located in California." "The PV power station produces 579 megawatts of electricity, while the Topaz Solar Farm and Desert Solar Farm each produce 550 megawatts." (energy.gov, 2023)

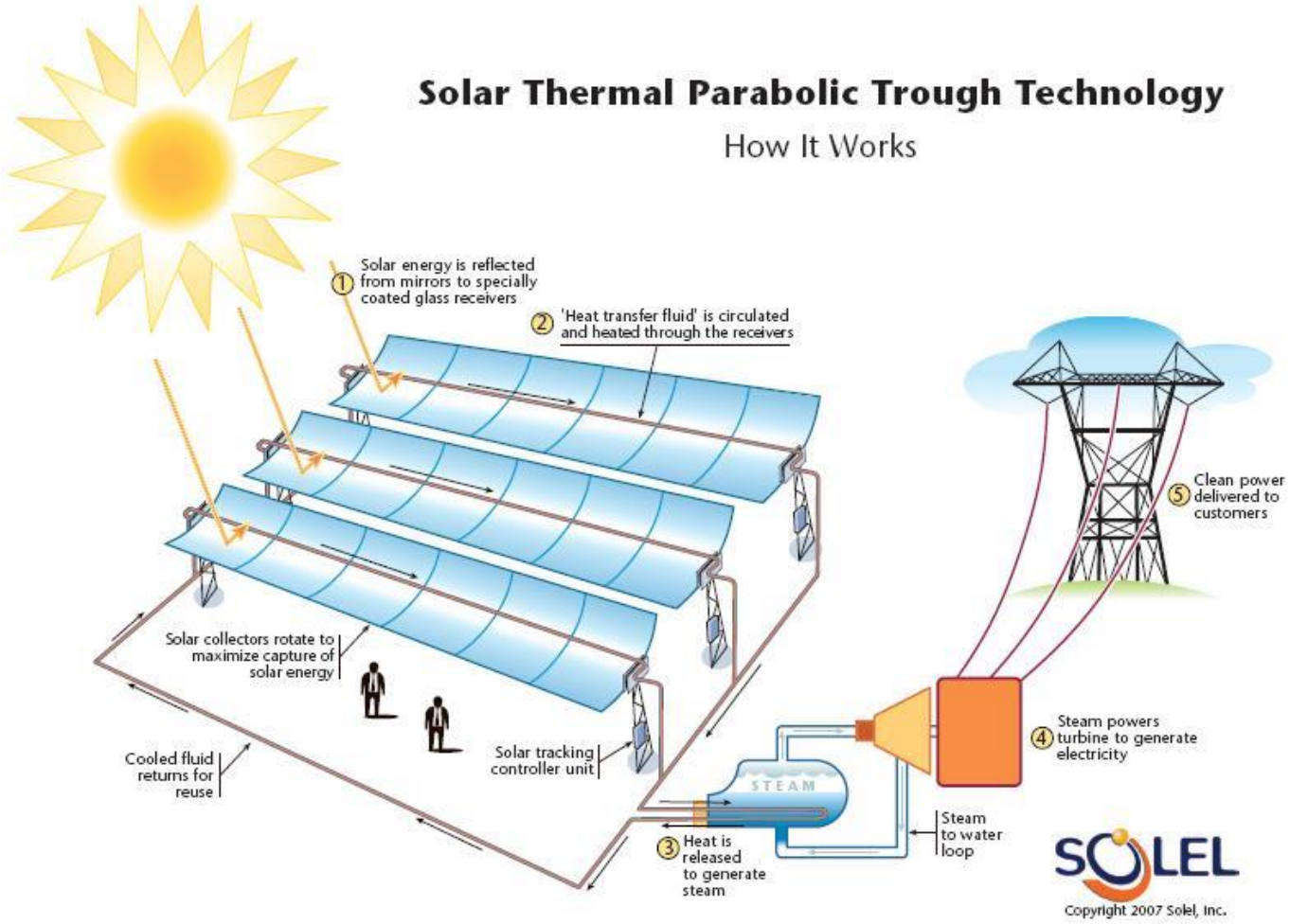

Figure 1.2.1. Role of PV in generation of electricity (sotel, 2007)

1.2.2 CSP

- CSP technologies use mirrors to reflect light onto a receiver to heats fluid in the receiver. (energy.gov, 2023)
- "This thermal energy can be used to rotate a turbine to generate electricity." "It can also be used in industrial applications, like water desalination, enhanced oil recovery, food processing, chemical production, and mineral processing." (energy.gov, 2023)
- CSP is also used for utility-scale projects. They can be configured in various ways. A power tower system places mirrors around a central tower that acts as a receiver. A linear system has a row of mirrors that focus sunlight onto a parallel tube receiver above. (energy.gov, 2023)

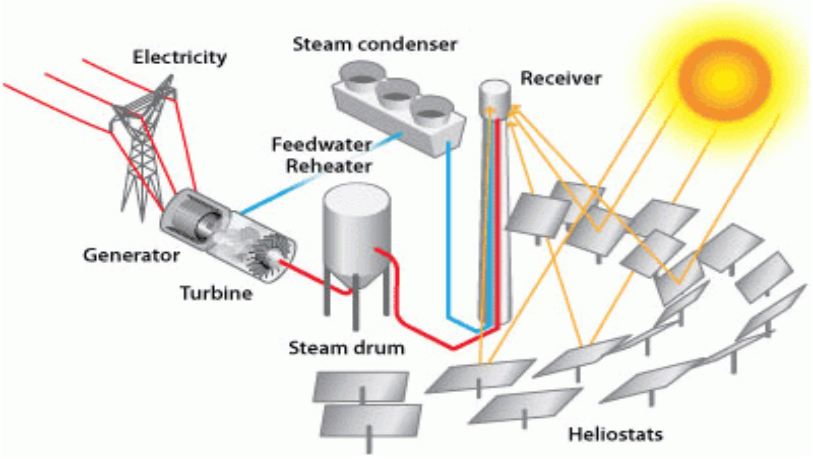

Figure 1.2.2 Role of CSP in generation of electricity (raolab, 2023)

- "Smaller CSP systems can be located where power is needed" "For example, single dish systems can produce 5 to 25 kilowatts of power per dish." (energy.gov, 2023)

1.3 Advantages and Disadvantages of Solar Energy

1.3.1 Introduction to Advantages and Disadvantages of Solar Energy

Solar energy technology like any other technology has its own advantages and disadvantages. One of the most important advantages of solar energy is that "Solar energy is considered green since it uses a renewable resource that never runs out and has nearly no negative environmental impact." As it depends mainly on the thermal and light energies from the sun. In addition, building an electric power plant is more economical than most of the other plants (Figure 1.3.1) (Nussey, 2018)

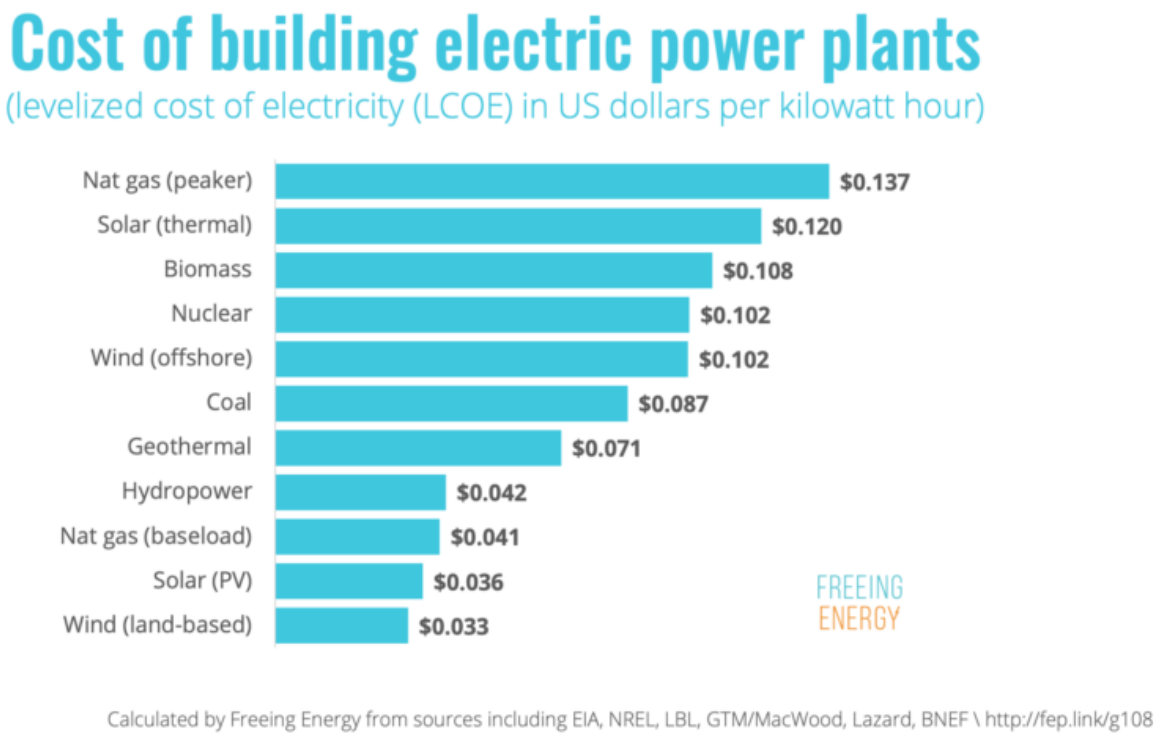

Figure 1.3.1 Cost of building electric power plants. (Nussey, 2018)

1.3.2 Advantages of Solar Photovoltaic

Some of the advantages of solar photovoltaic are that the operating and maintenance costs of PV Panels are almost negligible compared to the costs of other renewable energy systems as PV modules have no moving mechanical parts, except for the solar tracking machine base. In addition, PV modules are completely silent. As a result, they are the perfect solution for urban and residential applications. (Green, 2012)

1.3.3 Disadvantages of Solar Photovoltaic

Solar photovoltaic is considered a less reliable solution due to absence of solar energy at night and, in daytime, there could be cloudy or rainy weather "Low clouds can block light from the sun, which means less solar energy." (How Do Clouds Affect Solar Energy?, 2023) (Green, 2012)

Solar Panels need inverters to convert direct current to alternative current and they also need batteries for storage, which increases the initial cost for the PV panels significantly. (Green, 2012)

1.3.4 Advantages of Concentrated Solar Power

One of the best advantages of concentrated solar power is its low cost of operating and maintenance and its uncomplicated implementation as it is very similar to most of the turbine-based power plants. "Plants running on fossil fuels can technically be used for CSP systems." (Baranski, 2018)

Unlike solar photovoltaics, concentrated solar power is considered relatively uninterrupted and more reliable as "certain CSP plants can store energy in the form of molten salts." (Baranski, 2018)

"CSP can also be used in effective and efficient oil recovery. Through so-called solar thermal enhanced oil recovery, the steam it produces is used to make heavy oil less viscous and easier to pump" (Baranski, 2018)

1.3.5 Disadvantages of Concentrated Solar Power

A fundamental downside of the concentrated solar power plants is that they require spacious land areas to be built, and also, they are not suitable in populated areas as they need locations with high solar irradiance such as deserts and open spaces to be considered economical. (Baranski, 2018)

When CSPs direct and redirect sunlight, the high temperature around them may lead to death of birds and insects in the area which affects the wildlife negatively. (Baranski, 2018)

1.4 Solar Energy Applications

1.4.1 Water Heating

Solar hot water systems use the sun's rays to heat water. 60-70% can be provided by solar thermal systems. The most common types of solar water heaters are evacuated tube collectors (44%) and glazed flat collectors (34%), commonly used for hot water supply. Mainly Unglazed plastic collectors used for heating swimming pools (21%). (wikipedia, 2023)

Figure 1.4.1 Solar water heaters facing the sun to maximize gain (wikipedia, 2008)

1.4.2 Water treatment

"Solar distillation can be used to make saline or brackish water potable." "The first recorded instance of this was by 16th-century Arab alchemists." "A large-scale solar distillation project was first constructed in 1872 in the Chilean mining town of Las Salinas." "The plant, which had solar collection area of 4,700 m^2 (51,000 square feet), could produce up to 22,700 L (5,000 imp gal; 6,000 US gal) per day and operate for 40 years." "Individual still designs include single-slope, double-slope (or greenhouse type), vertical, conical, inverted absorber, multi-wick, and multiple effect." "These stills can operate in passive, active, or hybrid modes." "Double-slope stills are the most economical for decentralized domestic purposes, while active multiple effect units are more suitable for large-scale applications."

"Solar water disinfection (SODIS) involves exposing water-filled plastic polyethylene terephthalate (PET) bottles to sunlight for several hours." "Exposure times vary depending on weather and climate from a minimum of six hours to two days during fully overcast conditions." "It is recommended by the World Health Organization as a viable method for household water treatment and safe storage." "Over two million people in developing countries use this method for their daily drinking water."

"Solar energy may be used in a water stabilization pond to treat waste water without chemicals or electricity." "A further environmental advantage is that algae grow in such ponds and consume carbon dioxide in photosynthesis, although algae may produce toxic chemicals that make the water unusable" (Shilton A.N.; Powell N.; Mara D.D.; Craggs R, 2008*)*

Figure 1.4.2 Solar-powered water treatment plant installed at Mtwapa town

1.4.3 Electricity production

Solar energy is the conversion of energy from sunlight into electricity, either directly through photovoltaics (PV) or indirectly through concentrated solar energy. Solar cells use the photovoltaic effect to convert light into electricity. Concentrated solar energy systems use lenses or mirrors and sun tracking systems to focus sunlight over large areas into hot spots, often to power steam turbines. Solar power was originally used only as a power source for small and medium-sized applications, from handheld computers powered by a single solar panel to remote homes powered by off-grid rooftop PV arrays. was Commercial concentrated solar power plants were first developed in the 1980s. Grid-connected solar systems have grown more or less exponentially since the cost of solar power dropped. Millions of gigawatt-scale facilities and solar power plants continue to be built, and by 2021 half of the new generating capacity will be solar. (wikipedia, 2023)

1.4.4 Agriculture and horticultur

Agriculture and horticulture strive to optimize solar energy uptake in order to optimize plant productivity. Techniques such as staggering and mixing plant varieties can improve yields. Although sunlight is generally considered an abundant resource, exceptions highlight the importance of solar energy in agriculture. The short growing season of the Little Ice Age. Agricultural uses of solar energy other than growing crops include water pumping, crop drying, chick hatching, and chicken manure drying. Greenhouses convert sunlight into heat, allowing special crops and other crops not naturally suited to the local climate to be produced and grown year-round (in a closed environment). (wikipedia, 2023)

1.4.5 Transport

“In 1975, the first practical solar boat was constructed in England.” “By 1995, passenger boats incorporating PV panels began appearing and are now used extensively.” “In 1996, Kenichi Horie made the first solar-powered crossing of the Pacific Ocean, and the *Sun21* catamaran made the first solar-powered crossing of the Atlantic Ocean in the winter of 2006–2007.” “There were plans to circumnavigate the globe in 2010.”

“In 1974, the unmanned Astro Flight Sunrise airplane made the first solar flight.” “On 29 April 1979, the *Solar Riser* made the first flight in a solar-powered, fully controlled, man-

carrying flying machine, reaching an altitude of 40 feet." (*Electrical Review* Vol. 201, No. 7, 12 August 1977)

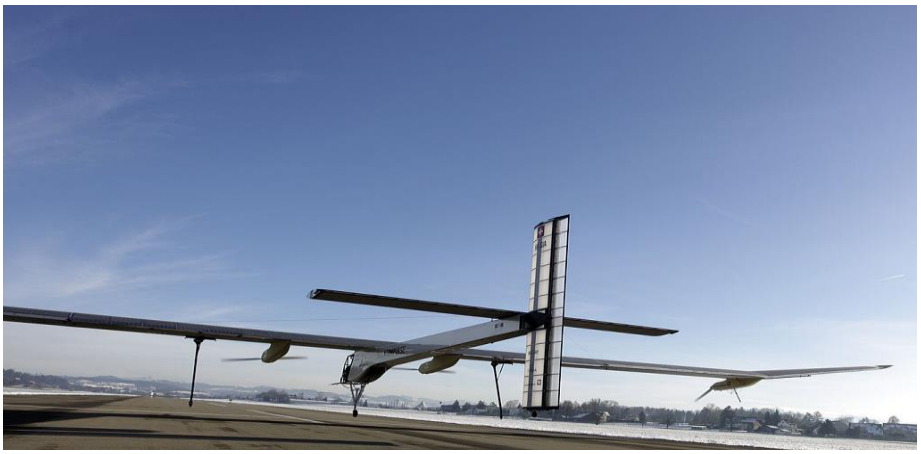

Figure 1.4.3 Solar electric aircraft circumnavigating the globe in 2015

2. Wind Energy

Wind Energy

The wind is a clean, free, and unlimited available renewable energy source.

2. Introduction to Wind Energy

2.1.1 Introduction

Wind energy is a renewable, clean and cheap alternative energy compared to the other energy sources. Wind is available everywhere, so any country can generate electricity from it easily. Wind energy is the process of converting wind movement into another form of energy (converting wind movement into physical movement) and it can be used by using turbines often to generate electric power, where the wind rotates the turbines of electric generators. By using modern technologies, the costs of using renewable energy in its different forms are reduced to expand its spread instead of traditional sources that contribute to environmental pollution and global warming (Morse, 2022).

2.1.2 History of wind energy

The wind is not a modern source of energy, so the beginnings of using this energy were due to the ancient Paranoiac civilization of Egypt, where the pharaohs used it to run sailboats, and that was in the year 3000 BC, and mills were also used in the ancient Babylonian civilization to grind grain, which was built on a vertical axis with sails or blades moving around the middle mast .The uses of this energy did not stop, but work was always underway to develop it, as the windmill arrived in Europe in the 12th century, and European windmills were built on a horizontal axis. High towers with wooden blades became a symbol of the Dutch, as mills pumped water for reclaimed land in the Netherlands. The first person to use wind to generate electricity was Charles Brush, who built the Brush Windmill in Cleveland, Ohio, USA as it is shown in Figure 2.1.1 It looked like a large propeller with a tail, and the mill produce ab about 12 kilowatts. The Brush Mill operated for about 12 kilowatts. The Brush Mill operated for 20 years. on to other things. In the 1920s, propeller-style turbines were developed, and interest in wind energy ceased with World War II, as access to fossil fuels was limited. To return interest in it again in 1940, when Denmark became the center for the study of air turbines. However, the real development of the wind energy industry was only after the increase in oil prices in the 1970s. In the 1980s, a real thought was given about how to develop turbines into their modern form, and the term wind farms and the specifications they should have appeared (Morse, 2022).

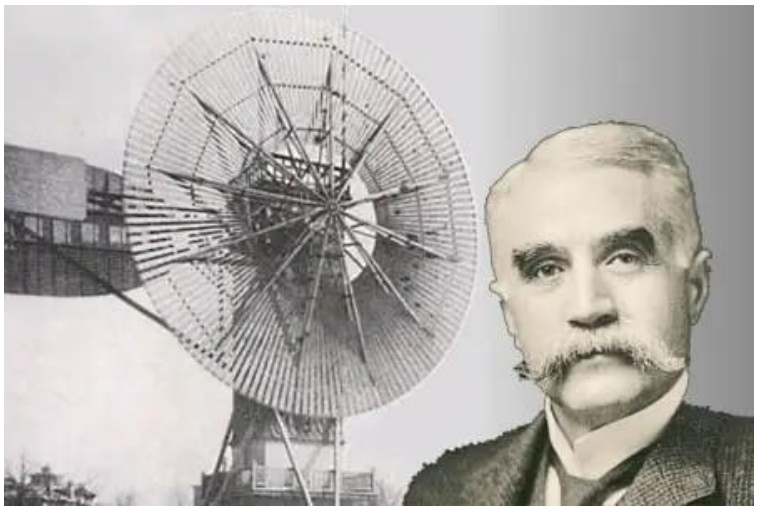

Figure 2.1.1 Charles Brush and the first wind fan (Morse, 2022)

2.1.3 Components of wind turbine

Wind turbine have many parts (gearbox, generator, pitch, controller, anemometer, wind vane, tower, yaw motor, nacelle, yaw drive, blades……) as it is shown in Figure 2.1.2 Each part is responsible for particular job. The gearbox is responsible for controlling the rotational speed of the turbine shaft. Speed should be constant to have constant power. Generator is the most important part of the turbine as it is responsible for converting mechanical energy from the wind into electrical energy using the rotating force that is transferred from the gears and turbine shaft. The yaw drive is responsible for rotating the turbine to be facing the wind. The wind vane measures the direction of the wind. Anemometer is responsible for measuring speed of wind. If speed of the wind is very strong, the turbine is damaged. Braking is responsible for stopping the blades when wind is very strong not to be damaged (Academia, n.d.) (Generator, 2023).

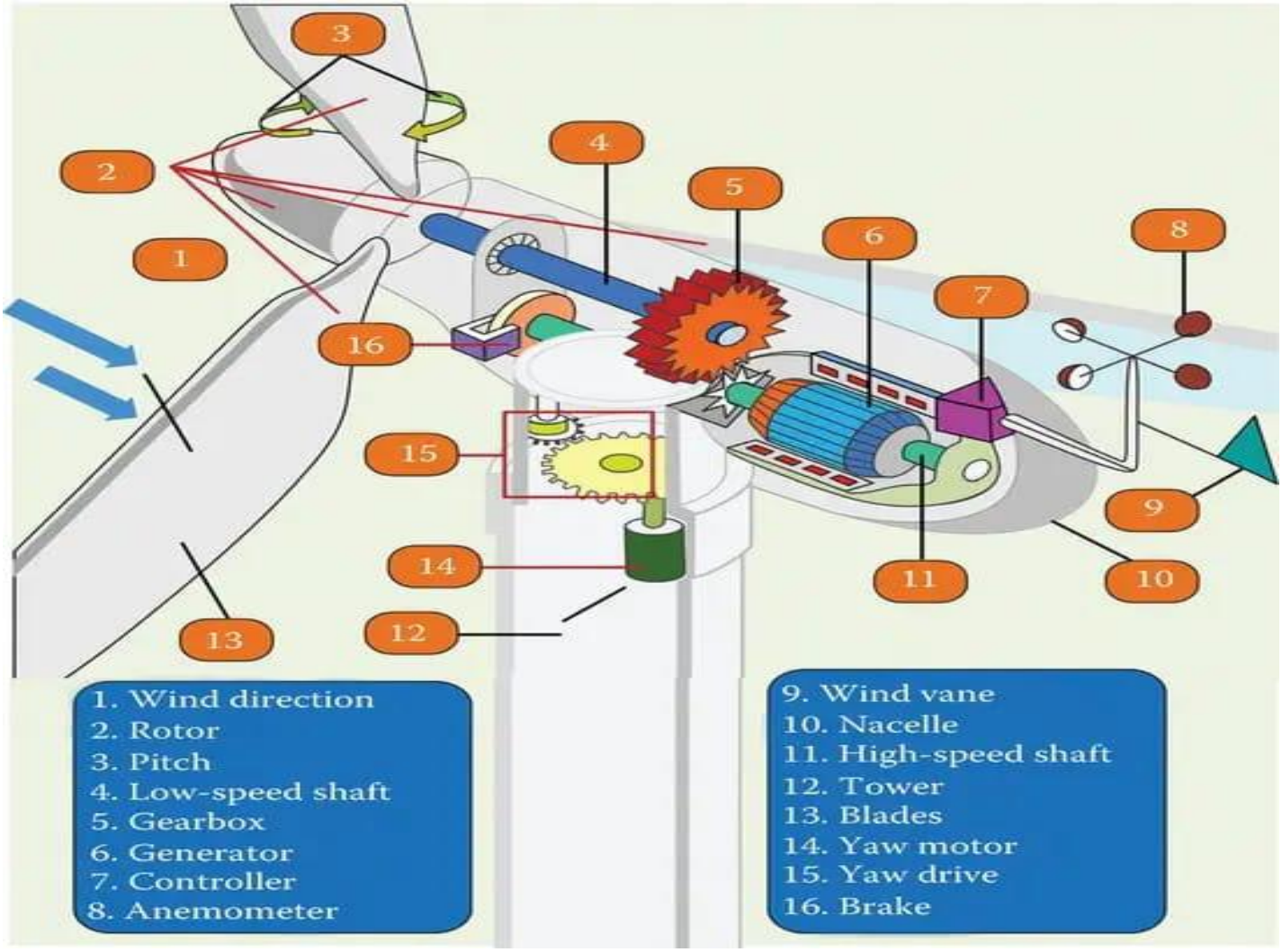

Figure 2.1.2 principal components of wind turbine. (Academia, n.d.)

2.1.4 Mechanism of wind turbine

"There are so-called traditional windmills, which consist of wooden fans, cloth sails, or metal blades, but they are impractical because they do not capture enough wind to produce electricity." "In the form of a huge fan with a high column, on which the huge propeller blades rest." "The secret behind the length of these turbines is to capture the strong winds that are available in the upper atmosphere." "Generating electricity from wind turbines is a very simple mechanism." "It starts with a very tall tower that may reach 67 meters, that is, the height of a 21-storey building." "At the top there is a specific structure that connects the fan blades to the tower with a horizontal axis." "This structure also contains a generator and a handle." "The wind moves the blades, so the shaft moves because it connects to the generator and electricity is generated." "Groups of turbines are installed over a large area called a wind farm." "Wind farms and turbines have different generating sizes according to the need of electrical energy." "Large wind farms at the regional levels have more than 200 turbines, so that each turbine generates 100 kilowatts or more until it reaches a megawatt, and turbines with an energy generation capacity of greater than that may be used, while smaller wind farms and individual windmills use turbines that generate each including less than 100 kilowatts for lighter uses such as home power, power used in telecommunications dishes and water pumps" (Morse, 2022).

Figure 2.1.3 Wind turbines shown in the wind farm (Morse, 2022)

2.1.5 Specification of wind farm

There are some characteristics that should be available on wind farm and among these characteristics that the site of the land has strong winds to obtain energy on a regular basis, it must range the wind speed is approximately 5.5 m/s. The area of the farm must be large and open, or on the top of hill. It also should be far from forests or any place contains many tall trees not to impede air movement. It also should be far from buildings because the wind turbines make noises that annoy people from high sound. The space should be sufficient to create a large number of turbines so that each turbine is far from the other. The land should be as flat as possible, which means more wind speed. Farms must be at higher altitudes where wind speeds are greater, and for this reason wind turbines are very tall. The farm should have good grid connection because all of the wind turbines need suitable three-phase electrical supply. As a rough guide you will need an 11 kV transformer or substation that is roughly double the rated power output of the wind turbine you are considering, or an 11 kV three-phase power line passing close to the wind turbine site that can have a new transformer / substation connected to it. The larger multi-MW turbines could grid connect to 33 kV power lines, though generally it is too expensive for sub-1MW wind turbine projects to connect at such a high voltage. The roads and tracks to the wind farm must be able to take over size. (RenewablesFirst, 2023)

Figure 2.1.4 The Wind Farm. (Morse, 2022)

2.2 Advantages and Disadvantages of Wind Energy

2.2.1 Wind energy is clean.

Since wind energy dose not rely on fossil fuels to power the turbines, wind energy dose not contribute to climate change by emitting greenhouse gasses during energy production. The only time that wind energy indirectly releases greenhouse gasses is during the manufacturing and transport of the wind turbines, as well as during the installation process.

2.2.2 Wind energy is cost-effective.

“Land-based, utility-scale wind turbines provide one of the lowest-priced energy sources available today.” “Furthermore, wind energy is cost competitiveness continues to improve with advances in the science and technology of wind energy” (Energy.gov, 2023)

2.2.3 Advances in Technology.

“The latest advances in technology have transformed preliminary wind turbine designs into extremely efficient energy harvesters.” “Turbines are available in a wide range of sizes (as shown in Figure 2.2.1), increasing the market to many different types’ businesses and by individuals for use at home on larger lots and plots of lands.” “As technology improve, so do the functionalities of the structure itself, creating designs that will generate even more electricity, require less maintenance, and run more quietly and safely” (JustEnergy, 2023)

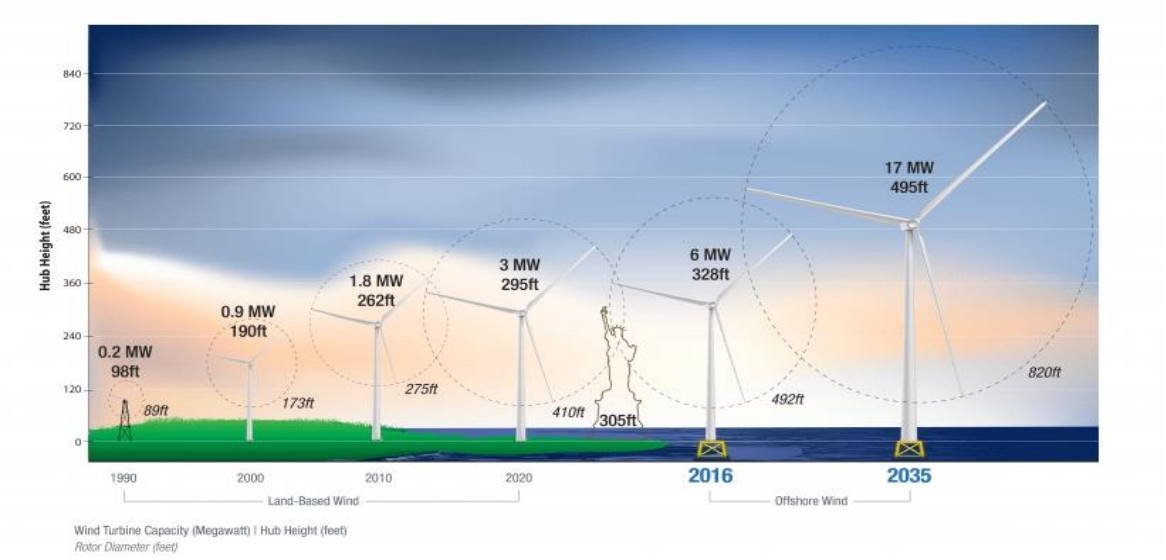

Figure 2.2.1 Increasing turbine heights and blades lengths over time. (Energy.gov, 2023)

2.2.4 Wind turbines have effects on wildlife

Have you ever thought of number of birds and bats killed by the wind power facilities? Wind turbines can be dangerous as their rotor can kill the flying animals, (like we see in Figure 2.2.2). Experts are now doing research and experiment to know more about the possible effects that turbines have on the wildlife.

Figure 2.2.2 show how can the turbines kill the birds and bats. (Max, 2020)

2.2.5 Wind energy is remote

As much as the installation of wind turbines on the land far from the populated area is an advantage, it is also kind of a hidden disadvantages. Cost of travel, maintenance, and time consumption are the main issues regarding placing a wind turbine on far and distant areas. Besides, handing offshore wind turbines need boats that means more costs and more danger to bear. (Figure 2.2.3)

Figure 2.2.3 Turbines blade convoy passing through Edenfield, England (geograph, 2023)

2.2.6 Noisy

“Wind turbines can be quite noise, which is why they are mostly found in very rural areas where most people don’t live.” “Depending on the location of the turbine, such as offshore, noise isn't issue.” “With advancements in technology, newer designs have been shown to reduce the noise complaints and have a much quieter presence.” (JustEnergy, 2023)

2.3 Wind Energy Market

2.3.1 Wind energy generation and capacity

After learning about the benefits and drawbacks of wind energy, it is time to consider how much wind energy is produced and its maximum capacity (Figure 2.3.1).

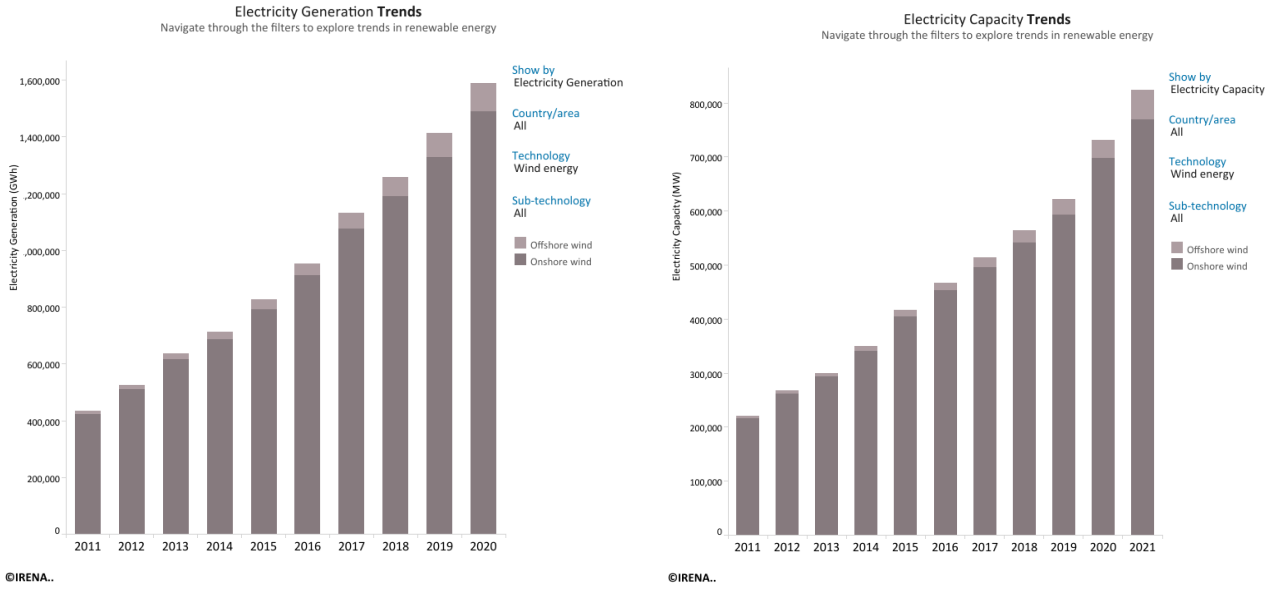

Figure 2.3.1 Wind energy total annual generation (in GWh) and capacity (in MW). (IRENA, 2023)

In general, R&D, supportive legislation, and declining costs have led to a substantial increase in the use of wind power since 2000 and according to IRENA's data, the installed wind generation capacity worldwide has expanded by a factor of 98 over the previous 20 years, rising from 7.5 GW in 1997 to about 733 GW by 2018. (IRENA, 2023)

2.3.2 Wind energy generation vs other energy sources

"The challenges and uncertainties facing the global energy system are at their greatest for almost 50 years." "bp's Statistical Review of World Energy 2022 reveals that the growing shortages and increasing prices highlight the continuing importance of energy 'security' and 'affordability' alongside 'lower carbon' when addressing the energy trilemma" (Statistical Review of World Energy, 2022)

So how much energy is being produced by wind in the world **now**? Figure 2.3.2 shows electricity generation by source and answers this question.

The electricity generated by wind increased by near 273 TWh in 2021 (+ 17%) and 45% higher growth than 2020 and the largest of all power generation technologies. "Wind remains the leading non-hydro renewable technology, generating 1870 TWh in 2021, almost as much as all the others combined." (Bojek, 2022)

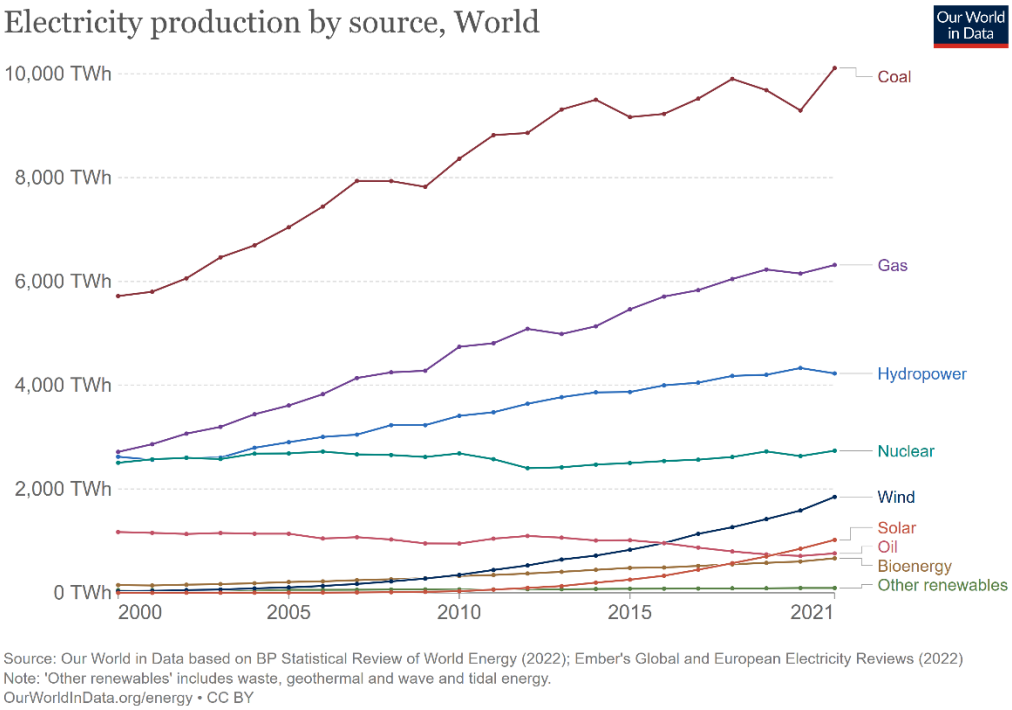

Figure 2.3.2 Electricity generation by source in the world. (Statistical Review of World Energy, 2022)

2.3.3 Leading countries in wind energy generation

China will account for nearly 70% of wind power growth in 2021, followed by the United States at 14% and Brazil at 7%. (Bojek, 2022)

One possible reason that "The Chinese government has implemented subsidies to increase renewable energy generation in the last decade to lower carbon emissions." (Reve, 2023)

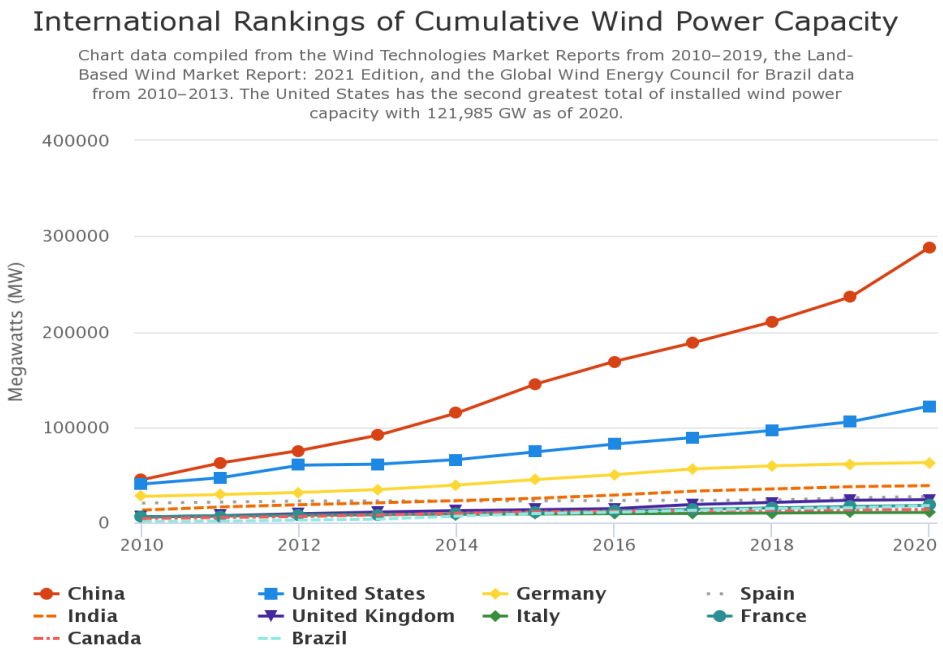

Figure 2.3.3 Leading countries in wind energy generation (IRENA, n.d.)

2.3.4 Conclusion and future expectations

Onshore technologies account for most of the increase in wind capacity, while offshore technologies are increasing their share year after year. (Figure 2.3.4)

Conclusion: wind generation has grown at a record rate in 2021, but even faster growth is needed to reach the zero-scenario. (Bojek, 2022)

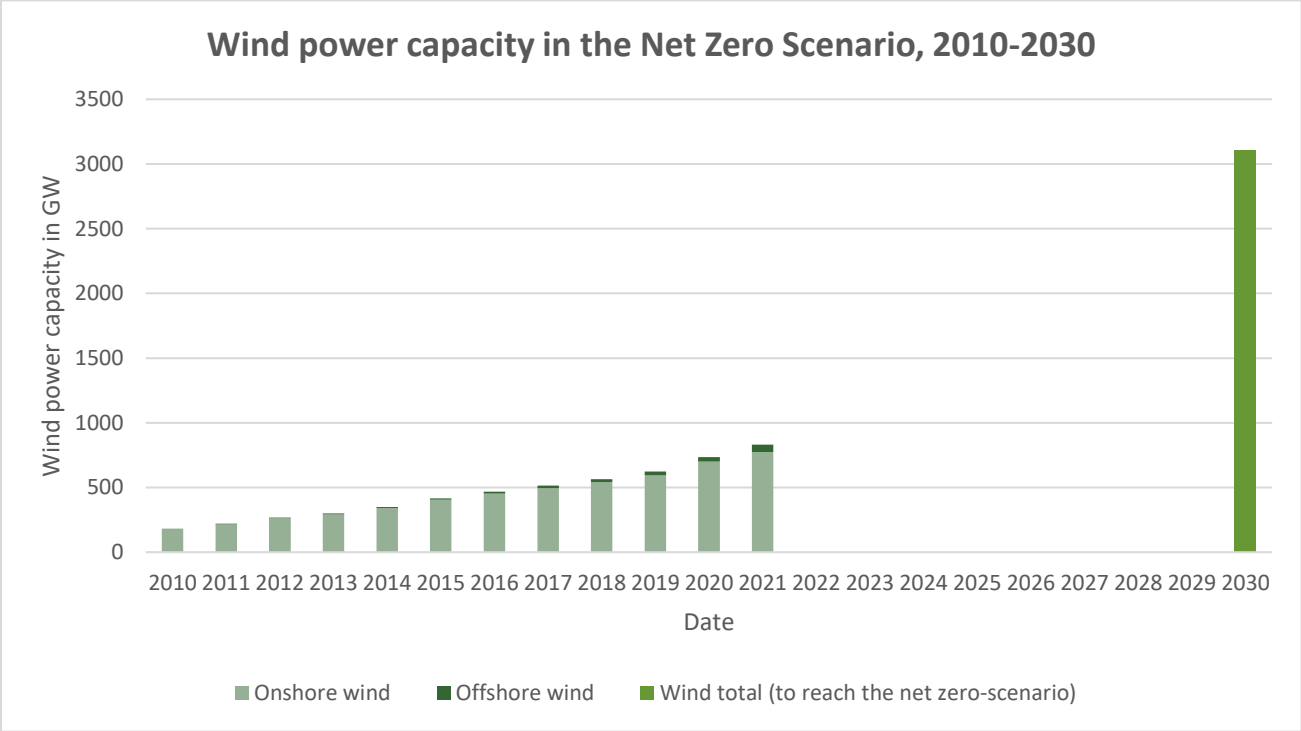

Figure 2.3.4 Wind power capacity in the net zero scenario. Data have been taken from (Bojek, 2022) and represented in charts by word.

Hydro Energy

The water is a clean, free and unlimited available renewable energy source.

3.1 Introduction to Hydro Energy

3.1.1 Definition

Hydro energy is a renewable, clean and cheap alternative energy compared to the other energy sources. Rivers are available in many countries, and we can generate electricity from it easily. water energy is the process of converting water potential energy into kinetic energy) and it can be used by turbines often to generate electric power, Hydropower currently accounts for 31.5% of total U.S. renewable electricity generation and about 6.3% of total U.S. electricity generation.

3.1.2 History of hydro energy

Hydropower was used in China at least 2000 years ago; the waterwheel was invented in ancient Greece and Rome, and in the year 13 B.C., the Roman engineer and writer Marcus Vitruvius Pollio described a grain mill driven by a waterwheel and a cogwheel gear. Archeologists later proved the early existence of such drives of mills and of water- wheels used for the irrigation of fields. The variety of waterwheel applications increased greatly through the Middle Ages. Around 1500, the waterwheel was the most important tool for power generation in Europe and elsewhere. Waterwheels were used to drive elevators for the conveyance of water, ore, and debris out of mines; to drive hammer mills, as well as the large bellows for the air supply of blast furnaces and smelting ovens in the ancient iron works; and, of course, to drive the thousands of grain mills along the rivers. In the 16th century, Leonardo da Vinci made some sketches that are almost recognizable as water turbines as we know them today.

In 1737, the French engineer B.F. Bélidor built a waterwheel with curved blades; in 1738, Daniel Bernoulli (1700-1782) published a book on hydrodynamics in which he developed a theory of waterwheels. In 1754, Leonhard Euler (1707-1783) published a theory of water turbines with wicket gates, although he did not refer to his machinery as turbines. After 1770, waterwheels were consistently improved, and wheels made from cast iron or even sheet metal began to appear. Finally, by 1826, a detailed theory of waterwheels existed and some types of speed control were proposed in publications. However, there is no reliable proof of any practical application of such control. The first step toward a turbine was taken in France by Jean Victoire Poncelet (1788-1867). In 1825, he built a waterwheel with curved blades (figure 3.2.1), as Bélidor had done earlier. The curved blades effectively reduced internal hydraulic losses. In addition, Poncelet invented an installation to change the flow (and thus both speed and torque) of what water turbines are neither the oldest nor the only prime movers controlled in such a way.

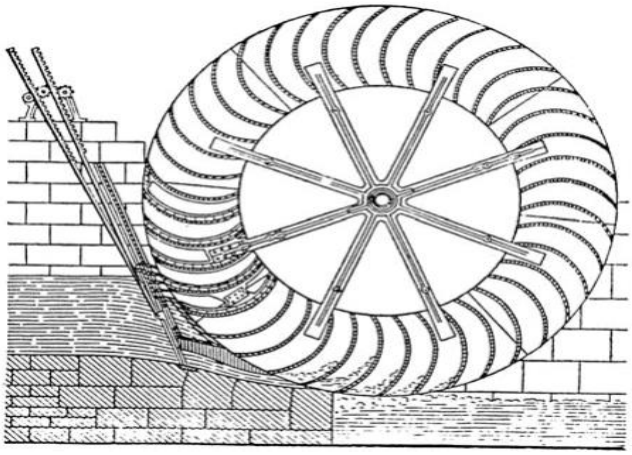

Figure 3.2.1 Poncelet waterwheel with wicket gate (Giaquinto, Disadvantage of Hydropower, 2023) (studentlesson, Applications of Hydropower, 2023)

3.2 How is energy extracted from moving water?

"Because the source of hydroelectric power is water, hydroelectric power plants are usually located on or near a water source." "The volume of the water flow and the change in elevation—or fall, and often referred to as head—from one point to another determine the amount of available energy in moving water." "In general, the greater the water flow and the higher the head, the more electricity a hydropower plant can produce." "At hydropower plants water flows through a pipe, or penstock, then pushes against and turns blades in a turbine to spin a generator to produce electricity." (Hydropower explained, 2022)

3.3 Mathematical parameters

The power available from falling water can be calculated from the flow rate and density of water, the height of fall, and the local acceleration due to gravity:

$$p = \eta \times \rho \times \dot{V} \times g \times \Delta h$$

Where:

p is the power output (SI unit: watt)

η ("eta") is the efficiency of the turbine (dimensionless)

$\dot{V}$ is the volumetric flow rate (SI unit: cubic meters per second)

ρ ("rho") is the density of water (SI unit: kilograms per cubic meter)

g is the acceleration due to gravity (SI unit: meters per second squared)

Δh ("Delta h") is the difference in height between the outlet and inlet (SI unit: meters)

3.4 Advantages and Disadvantages of Hydro

3.4.1 Advantages of Hydropower

- Hydroelectricity can be produced if there is water.
- The main benefit of using renewable energy is that it emits none when in use.
- the Water is pure and has no carbon in it. Therefore, using hydroelectricity reduces greenhouse gas emissions.
- Water can always be made to flow, even when the sun sets, and the wind isn't blowing. Flexible: A hydroelectric plant can simply regulate the water flow.
- They can reach capacity in about two minutes during peak demand. And when demand is minimal, stopping the flow can be accomplished just as rapidly.
- Recreation: A dam can create lakes or reservoirs that can be used for a variety of recreational activities, including fishing, swimming, and water activities (Figure 3.4.1).
- Land development - Dams take a long time to construct and can only be built in specific areas. Therefore, constructing them can also aid in the infrastructure and transportation development of the neighborhood.
- Hydropower is used by several nations to provide affordable energy to rural areas, creating jobs.
- For the nearby villages, it produces employment opportunities. For some 250,000 individuals, the Three Gorges Dam in China brought about employment.
- Low maintenance costs make hydro stations less expensive to operate than other types of generating plants (Topping, 2023).

Figure 3.4.1 this figure shows one of the advantages of hydropower, creating leaks

3.4.2 Disadvantages of Hydropower

- Impact on Fish: Construction of a hydroelectric plant necessitates the damming of a running water supply. This makes it difficult for fish to get to their spawning areas, which affects any animal that eats fish. As soon as the water in rivers stops flowing, the habitats there begin to disappear. This might prohibit even animals from getting to the water.
- Although hydropower is renewable, only a few places on earth are suitable for the construction of plants. Furthermore, some of these areas are located far from major cities where the energy can be utilized to its fullest.
  Added startup expenses While there is never a straightforward solution when building a power plant, hydroelectric plants do require a dam to stop the flow of water. As a result, they are more expensive than fossil fuel facilities of a similar size. However, they won't have to worry about buying gas going forward. So, it does balance out over time.
- Hydropower is the most dependable renewable energy source, but because it depends on local water supplies, it is susceptible to droughts. Therefore, a drought might significantly affect how effectively a hydro plant runs. Additionally, as a result of climate change, our globe could continue to warm**.** Any settlement nearby that is below the dam faces a major risk when dams are constructed at higher heights (Giaquinto, 2023).
- Despite the strength of the dams' construction, there are still dangers. The Banqiao Dam failure is the biggest dam disaster in recorded history. The dam broke because of excessive rainfall brought on by a typhoon. As a result, 171,000 people perished (Figure 3.4.2).

Figure 3.4.2 This sign warns of the risk of flooding.

3.5 Applications of hydropower

Even that electricity is one of our essential needs today, hydroelectric power has a wide range of applications. For decades, millwheels and other early industrial machines were powered by hydropower. Thousands of years ago, it was also used to grind grain and turn paddle wheels on rivers. Today, electricity is produced via hydropower. Hydropower was the renewable energy source that the United States used to produce the most electricity. The most developed nations use hydropower for the reasons listed below.

3.5.1 Electricity

For producing clean electricity, which is its main function.

3.5.2 business benefits

A large production plant might be well-located at a hydro site for business reasons because of the cheap and extra energy they produce.

3.5.3 Entertainment usages.

Providing the general population with leisure amenities like swimming, fishing, and boating is another beneficial use of hydropower.

3.5.4 Flood risk

Flood risk management uses hydropower energy.

3.5.5 irrigation system

The system is utilized to make agricultural irrigation possible (studentlesson, 2023).

4. GEOTHERMAL ENERGY

GEOTHERMAL ENERGY

heat that is generated within the Earth, It is a renewable resource that can be harvested for human use.

4. Introduction to geothermal power plant

4.1.1 How geothermal work

Geothermal energy is a clean form of energy that can be harvested for human, we use steam to produce produce electricity, Hot water reservoirs produce steam. Few miles below the earth's surface, steam is found. The steam turns the turbine, which activates a generator, which then produce electricity, We can use geothermal energy in different ways depending on the resource and technology chosen, we can use it in heating and cooling buildings by using heat pumps network that is spread across the residential area chosen.
(U.S. Department of Energy, 2022)

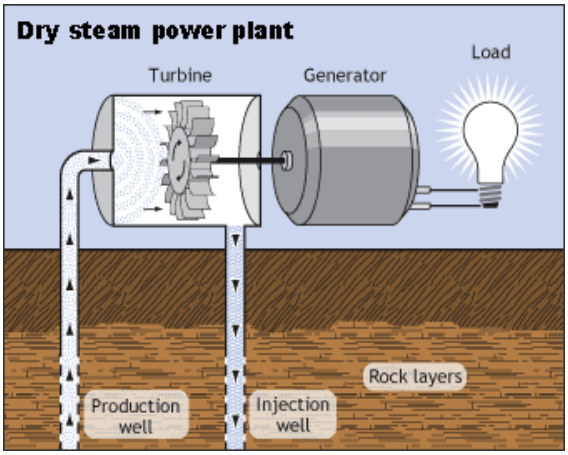

Figure 4.1.1 Dry steam power plant (U.S. Department of Energy, 2022)

4.1.2 Types of geothermal power plant

Geothermal power plants have three main types, Dry steam power plant, Flash steam power plant and binary cycle power plant. We going to talk about each one them, **Dry steam Plants**: uses the hot steam from the hot reservoirs directly by injecting a pipe system deep in the earth under neath the rock layers, hot steam moves the turbine then it's connected to a generator which generates the electricity needed, first dry steam In Tuscany, Italy, where natural steam was erupting from the earth, a power plant was established in 1904. **Flash steam power:** absorb the high-pressure Water from deep inside the soil is used to power the turbine by being converted to steam, which is then injected back into the ground for further use. We can use waste water in this prosses so we don't waste drinkable water, most geo thermal power plants are flash steam plants. **Binary cycle power plant:** we use another fluid with water, which has very low boiling point, the exchange of heat between the water and the other liquid make it turn in to steam which moves the turbine.
(U.S. Department of Energy, 2022)

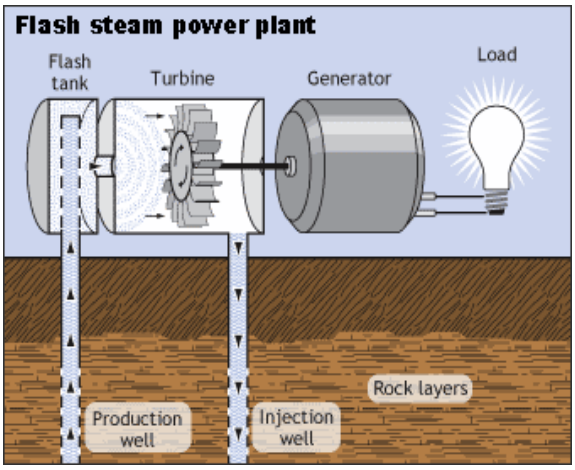

Figure 4.1.2 Flash steam power plant (U.S. Department of Energy, 2022)

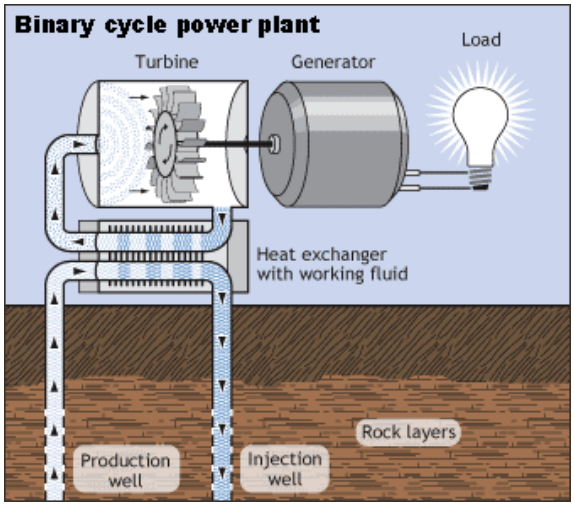

Figure 4.1.3 Binary cycle power plant (U.S. Department of Energy, 2022)

4.2 Benefits of Geothermal Energy

4.2.1 Benefits and differences of geothermal energy

geothermal energy has a lot of benefits to mankind First the energy is renewable the flowing underneath the earth surface is continually replenished by the decay of the radioactive elements and will remain for billions of years. The solid waste produced by the plants has many valuable elements like Sulphur, Baseload energy its always on 24/7 regardless of the weather conditions it can produce the power we need. Small footprint geothermal power plant doesn't need very large areas to be built on they can use less land per gigawatt. And at last, it's a clean source of energy emits no greenhouse gasses and have a life cycle four times lower than solar pv. Also, if you think it consumes a lot of water it doesn't geothermal power plant consumes less water on average over the life time energy output than most conventional electricity generation technologies. (Alyssa Kagel, 2007)

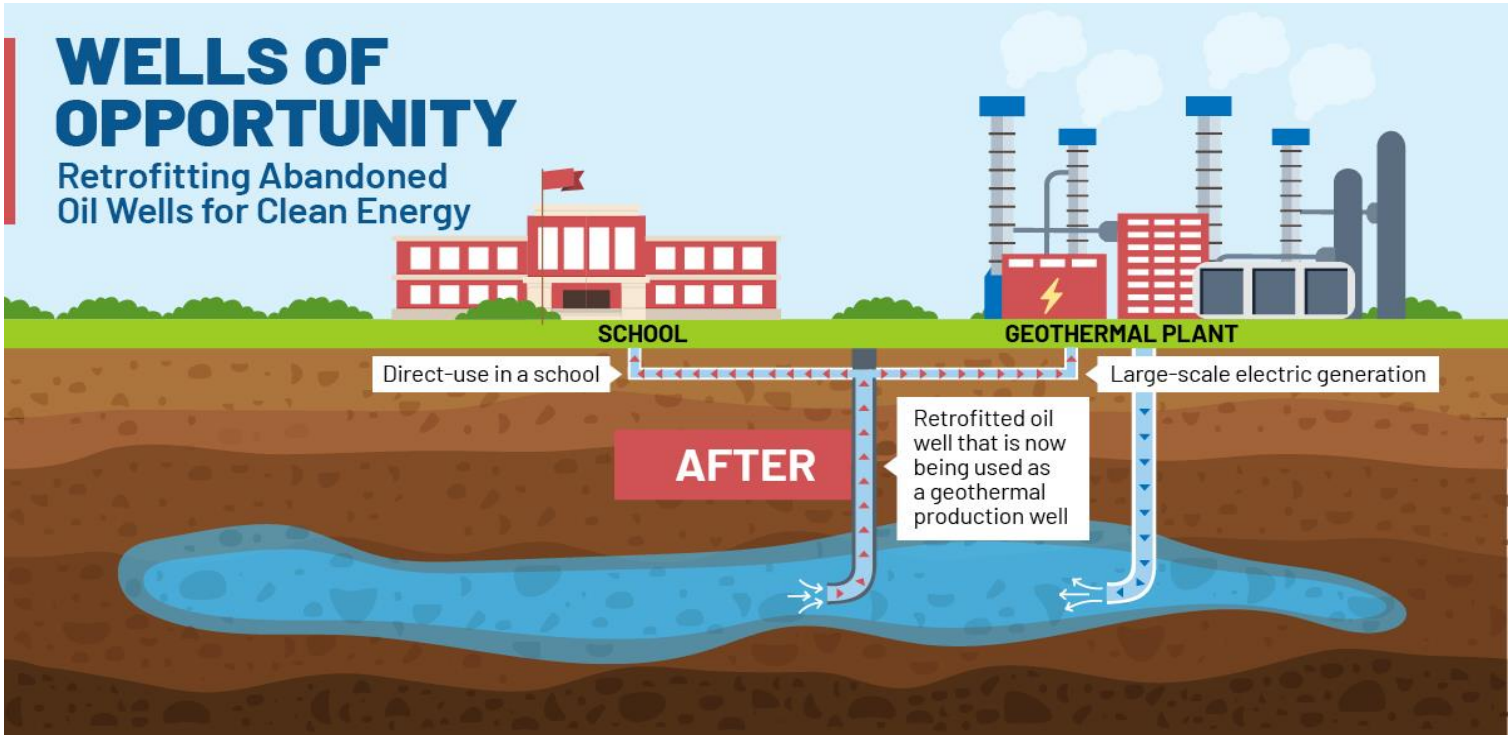

Figure 4.2.1 benefits of geothermal energy (U.S., 2022)

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