E-TUTORIAL FOR 3rd SEMESTER

ENS18301CR: Natural Resources

Credit IV: ENERGY RESOURCES

1.1. Renewable Energy Resources

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Resource: "A resource is a source of raw materials used by society." Anything used by organisms to meet their needs, including air, water, minerals, plants, fuels, and animals. These materials include all types of matter and energy that are used to build and run society. Natural resources that can be replaced and reused by nature are termed as renewable. E.g. Solar energy is actually supplied faster than we can use it. In contrast, oil, coal, soil, and some metallic mineral deposits may form again if we wait for thousands to hundreds of millions of years. However, these rates of renewal are thousands of times slower than the rates of using that, for all intents, they are nonrenewable on a human scale. Natural resources that cannot be replaced are termed nonrenewable.

Renewable Energy: Renewable energy uses energy sources that are continually replenished by nature - the sun, the wind, water, the Earth's heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy - most often electricity, but also heat, chemicals, or mechanical power.

Today we primarily use fossil fuels to heat and power our homes and fuel our cars. It's convenient to use coal, oil, and natural gas for meeting our energy needs, but we have a limited supply of these fuels on the Earth. Eventually, they will run out. However, Renewable energy can help fill the gap. Even if we had an unlimited supply of fossil fuels, using renewable energy is better for the environment. We often call renewable energy technologies "clean" or "green" because they produce few if any pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen in the past century. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often. Other pollutants are released into the air, soil, and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment and on humans.

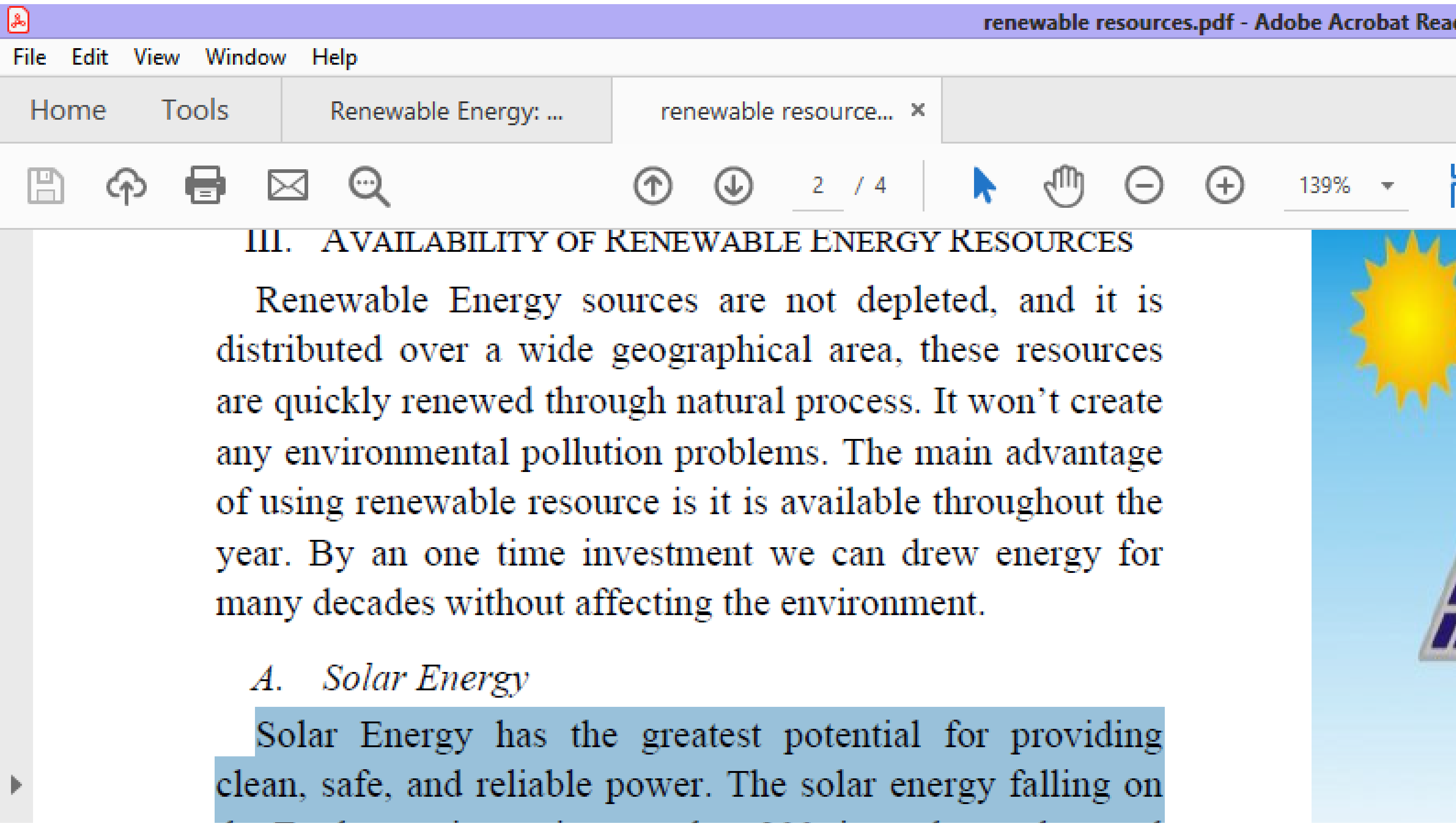
The major Renewable Energy resources includes the following:

1. Solar energy
2. Hydropower energy
3. Wind energy
4. Tidal energy
5. Geothermal energy
6. Biomass energy
7. Hydrogen as a source of energy

1. <u>Solar Energy</u>:

Solar Energy has the greatest potential for providing clean, safe, and reliable power. The solar energy falling on the Earths continents is more than 200 times the total annual commercial energy currently being used by humans.

Solar Energy can be classified into two types 1. Passive solar and 2. Active solar system, depending on the way they capture, convert, and distribute solar 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. Passive solar energy is making direct and indirect use of thermal energies from the sun. Indirect use of Energy is possible only in building (or) structures (as shown in Fig. 1). A southern exposure of a building guarantees the maximum exposure of the sun's rays. Special metal leaf covering over windows and roofs can block out the sun during the summer months. Special thermal solar collectors can circulate water through the collection unit that collect the sun's thermal energy for the purpose of heating the water for use. Active solar technologies encompass solar thermal energy, using solar collectors for heating, and solar power, converting sunlight into electricity either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP). Active Solar Energy is thus the use of the sun's Electro magnetic radiation in generating Electrical Energy. Generally semiconductor silicon Boron solar chips are used for this. The problem of these chips one that they have low Efficiency ratio and can only be used in supplying energy needs of small devices (i.e. calculators, watches, radio etc.) as shown ın Fıg.2 .



III. AVAILABILITY OF RENEWABLE ENERGY RESOURCES

Renewable Energy sources are not depleted, and it is distributed over a wide geographical area, these resources are quickly renewed through natural process. It won't create any environmental pollution problems. The main advantage of using renewable resource is it is available throughout the year. By an one time investment we can drew energy for many decades without affecting the environment.

A. *Solar Energy*

Solar Energy has the greatest potential for providing clean, safe, and reliable power. The solar energy falling on

Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, concentrated solar power (CSP), concentrator photovoltaics (CPV) and solar architecture

Although many types of solar electric systems are available today, they all consist of basically three main items: *modules* that convert sunlight into electricity; *inverters* that convert that electricity into alternating current so it can be used by most household appliances; and possibly or sometimes *batteries* that store excess electricity produced by the system. The remainder of the system comprises equipment such as wiring, circuit breakers, and support structures.

Photovoltaics

In the last two decades, photovoltaics (PV), also known as solar PV, has evolved from a pure niche market of small scale applications towards becoming a mainstream electricity source. A solar cell is a device that converts light directly into electricity using the photoelectric effect. The first solar cell was constructed by Charles Fritts in the 1880s. In 1931, a German engineer, Dr Bruno Lange, developed a photo cell using silver selenide in place of copper oxide. Although the prototype selenium cells converted less than 1% of incident light into electricity, both Ernst Werner von Siemens and James Clerk Maxwell recognized the importance of this discovery. Following the work of Russell Ohl in the 1940s, researchers Gerald Pearson, Calvin Fuller and Daryl Chapin created the crystalline silicon solar cell in 1954. These early solar cells cost 286 USD/watt and reached efficiencies of 4.5–6%. By 2012 available efficiencies exceeded 20%, and the maximum efficiency of research photovoltaics was in excess of 40%.

Concentrated solar power

Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear fresnel reflector, the Stirling dish, and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage.

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared". Italy has the largest proportion of solar electricity in the world; in 2015, solar supplied 7.7% of electricity demand in Italy.In 2017, after another year of rapid growth, solar generated approximately 2% of global power, or 460 TWh.

Electricity production

Commercial concentrated solar power plants were first developed in the 1980s. Currently solar energy is highest for China (Tenger Desert solar power plant) with capacity of 1547 MW. Other large concentrated solar power plants include the 150 MW Solnova Solar Power Station and the 100 MW Andasol solar power station, both in Spain. The 250 MW Agua Caliente Solar Project, in the United States, and the 221 MW Charanka Solar Park in India, are the world's largest photovoltaic plants. Solar projects exceeding 1 GW are being developed, but most of the deployed photovoltaics are in small rooftop arrays of less than 5 kW, which are connected to the grid using net metering or a feed-in tariff. Solar power is anticipated to become the world's largest source of electricity by 2050, with solar photovoltaics and concentrated solar power contributing 16 and 11 percent to the global overall consumption, respectively. In 2016, after another year of rapid growth, solar generated 1.3% of global power.

2. Hydropower energy:

Generation of electricity by hydropower (potential energy in stored water) is one of the cleanest methods of producing electric power. In 2012, hydroelectric power plants contributed about 16% of total electricity generation of the world. Hydroelectricity is the most widely used form of renewable energy. It is a flexible source of electricity and also the cost of electricity generation is relatively low. The layout, basic components and working of a hydroelectric power station are presented as:
The image shown in fig.1., shows the typical layout of a hydroelectric power plant and its basic components.

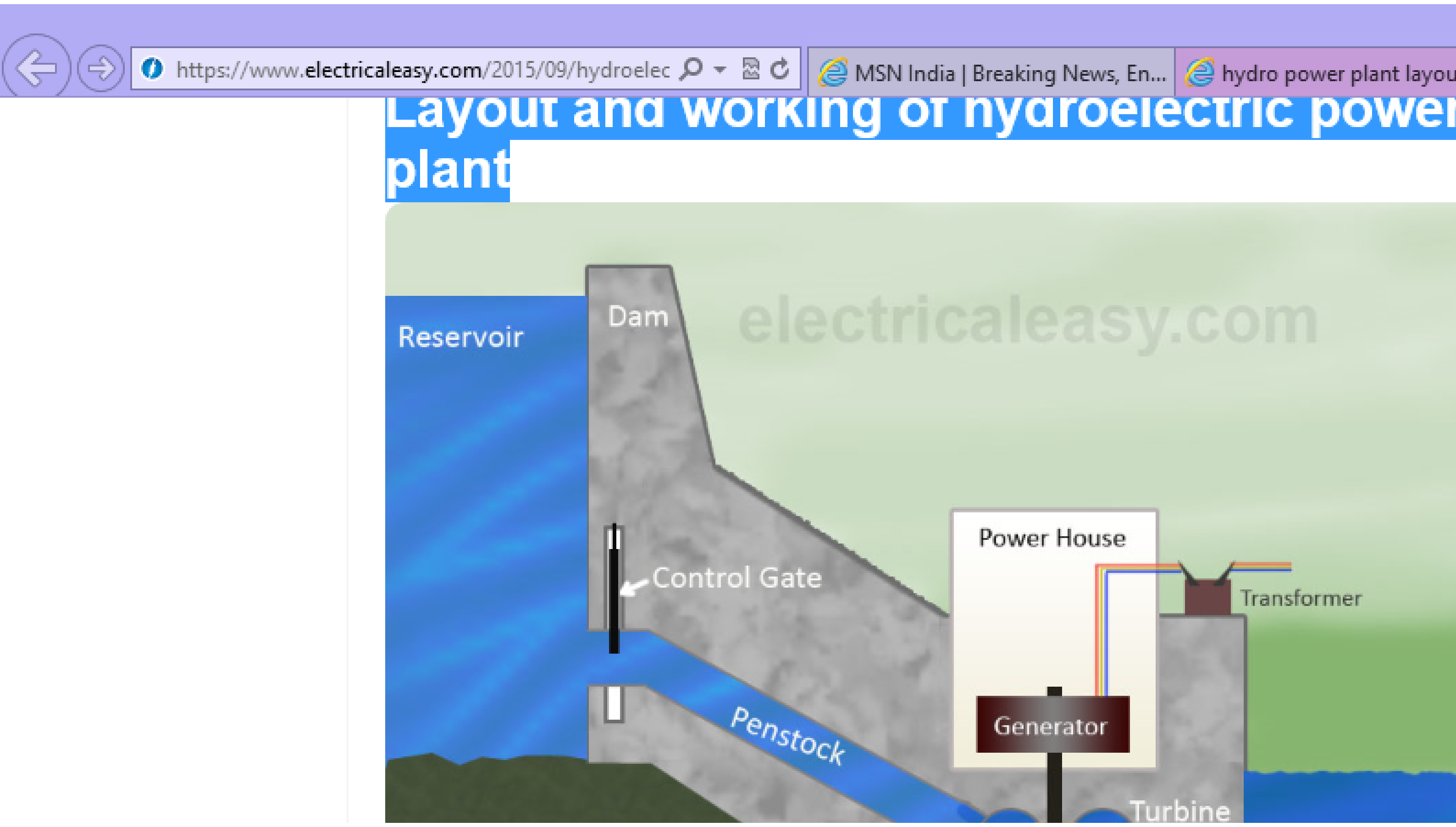


Fig. 1. Layout and working of hydroelectric power plant

Dam and Reservoir: The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (called as water head) in the reservoir determines how much of potential energy is stored in it.
Control Gate: Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water which is to be released in the penstock can be controlled by a control gate. When the control gate is fully opened, maximum amount of water is

released through the penstock.

Penstock: A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Water Turbine: Water from the penstock is taken into the water turbine. The turbine is mechanically coupled to an electric generator. Kinetic energy of the water drives the turbine and consequently the generator gets driven. There are two main types of water turbine; (i) Impulse turbine and (ii) Reaction turbine. Impulse turbines are used for large heads and reaction turbines are used for low and medium heads.

Generator: A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for the transmission purpose.

Surge Tank: Surge tanks are usually provided in high or medium head power plants when considerably long penstock is required. A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the power house. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock. When there is sudden reduction in load on the turbine, the governor closes the gates of the turbine to reduce the water flow. This causes pressure to increase abnormally in the penstock. This is prevented by using a surge tank, in which the water level rises to reduce the pressure. On the other hand, the surge tank provides excess water needed when the gates are suddenly opened to meet the increased load demand.

Types of Hydro-power plants:

Conventional plants:

Conventional plants use potential energy from dammed water. The energy extracted depends on the volume and head of the water. The difference between height of water level in the reservoir and the water outflow level is called as water head.

Pumped storage plant:

In pumped storage plant, a second reservoir is constructed near the water outflow from the turbine. When the demand of electricity is low, the water from lower reservoir is pumped into the upper (main) reservoir. This is to ensure sufficient amount of water available in the main reservoir to fulfil the peak loads.

Run-of-river plant:

In this type of facility, no dam is constructed and, hence, reservoir is absent. A portion of river is diverted through a penstock or canal to the turbine. Thus, only the water flowing from the river is available for the generation. And due to absence of reservoir, any oversupply of water is passed unused.

Historically, hydroelectric power came from constructing large hydroelectric dams and reservoirs, which are still popular in developing countries. The largest of them are the Three Gorges Dam (2003) in China and the Itaipu Dam (1984) built by Brazil and Paraguay.

Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. For countries having the largest percentage of electricity from renewables, the top 50 are primarily hydroelectric. China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, representing around 17 percent of domestic electricity use. There are now three hydroelectricity stations larger than 10 GW: the Three Gorges Dam in China, Itaipu Dam across the Brazil/Paraguay border, and Guri Dam in Venezuela.

Wave power, which captures the energy of ocean surface waves, and tidal power, converting the energy of tides, are two forms of hydropower with future potential; however, they are not yet widely employed commercially.

In year 2017, worldwide renewable hydropower capacity was 1,154 GW. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.

Advantages of a hydroelectric power plant

1. No fuel is required as potential energy is stored water is used for electricity generation
2. Neat and clean source of energy
3. Very small running charges - as water is available free of cost
4. Comparatively less maintenance is required and has longer life
5. Serves other purposes too, such as irrigation

Disadvantages

1. Very high capital cost due to construction of dam
2. High cost of transmission – as hydro plants are located in hilly areas which are quite away from the consumers

3. <u>Wind Energy:</u>

Wind energy (or wind power) refers to the process of creating electricity using the wind, or air flows that occur naturally in the earth's atmosphere. Modern wind turbines are used to capture kinetic energy from the wind and generate electricity. W ind power is one of the fastest-growing renewable energy technologies.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, where horizontal-axis wind turbines were built in 1891 and a 22.8-metre wind turbine began operation in 1897.

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. Wind first hits a turbine's blades, causing them to rotate and turn the turbine connected to them. That changes the kinetic energy to rotational energy, by moving a shaft which is connected to a generator, and thereby producing electrical energy through electromagnetism.

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-turbine capacity has increased over time. In 1985, typical turbines had a rated capacity of 0.05 megawatts (MW) and a rotor diameter of 15 metres. Today's new wind power projects have turbine capacities of about 2 MW onshore and 3–5 MW offshore.

There are three main types of wind energy:

1. Utility-scale wind: Wind turbines that range in size from 100 kilowatts to several megawatts, where the electricity is delivered to the power grid and distributed to the end user by electric utilities or power system operators.
2. Distributed or "small" wind: Single small wind turbines below 100 kilowatts that are used to directly power a home, farm or small business and are not connected to the grid.
3. Offshore wind: Wind turbines that are erected in large bodies of water, usually on the continental shelf. Offshore wind turbines are larger than land-based turbines and can generate more power.

How wind turbines work

When the wind blows past a wind turbine, its blades capture the wind's kinetic energy and rotate, turning it into mechanical energy. This rotation turns an internal shaft connected to a gearbox, which increases the speed of rotation by a factor of 100. That spins a generator that produces electricity.Typically standing at least 80 meters (262 feet) tall, tubular steel towers support a hub with three attached blades and a "nacelle," which houses the shaft, gearbox, generator, and controls. Wind measurements are collected, which direct the turbine to rotate and face the strongest wind, and the angle or "pitch" of its blades is optimized to capture energy.

A typical modern turbine will start to generate electricity when wind speeds reach six to nine miles per hour (mph), known as the cut-in speed. Turbines will shut down if the wind is blowing too hard (roughly 55 miles an hour) to prevent equipment damage.

Over the course of a year, modern turbines can generate usable amounts of electricity over 90 percent of the time. For example, if the wind at a turbine reaches the cut-in speed of six to nine mph, the turbine will start generating electricity. As wind speeds increase so does electricity production.

Another common measure of wind energy production is called capacity factor. This measures the amount of electricity a wind turbine produces in a given time period (typically a year) relative to its maximum potential.

For example, suppose the maximum theoretical output of a two megawatt wind turbine in a year is 17,520 megawatt-hours (two times 8,760 hours, the number of hours in a year). However, the turbine may only produce 7,884 megawatt-hours over the course of the year because the wind wasn't always blowing hard enough to generate the maximum amount of electricity the turbine was capable of producing. In this case, the turbine has a 45 percent (7,884 divided by 17,520) capacity factor. It does not mean the turbine only generated electricity 45 percent of the time. Modern wind farms often have capacity factors greater than 40 percent, which is close to some types of coal or natural gas power plants.

Windmills vs. Wind Turbines

Sometimes people use the terms "windmill" and "wind turbine" interchangeably, but there are important differences. People have been using windmills for centuries to grind grain, pump water, and do other work. Windmills generate mechanical energy, but they do not generate electricity. In contrast, modern wind turbines are highly evolved machines with more than 8,000 parts that harness wind's kinetic energy and convert it into electricity.

Wind farm:

Oftentimes a large number of wind turbines are built close together, which is referred to as a wind project or wind farm. A wind farm functions as a single power plant and sends electricity to the grid.

How wind energy is harnessed:

The turbines in a wind farm are connected so the electricity they generate can travel from the wind farm to the power grid. Once wind energy is on the main power grid, electric utilities or power operators will send the electricity to where people need it.

Smaller transmission lines, called distribution lines, collect electricity generated at the wind project and transport it to larger "network" transmission lines, where the electricity can travel across long distances to the locations where it is needed. Finally, smaller distribution lines deliver electricity directly to your town, home or business. Usage is on the rise worldwide, in part because costs are falling. Global installed wind-generation capacity onshore and offshore has increased by a factor of almost 75 in the past two decades, jumping from 7.5 gigawatts (GW) in 1997 to some 564 GW by 2018, 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. Many parts of the world have strong wind speeds, but the best locations for generating wind power are sometimes remote ones. Offshore wind power offers tremendous potential.

Commercially available wind turbines have reached 8 MW capacity, with rotor diameters of up to 164 metres. The average capacity of wind turbines increased from 1.6 MW in 2009 to 2 MW in 2014. Currently it is 7965 MW for China which is leading.

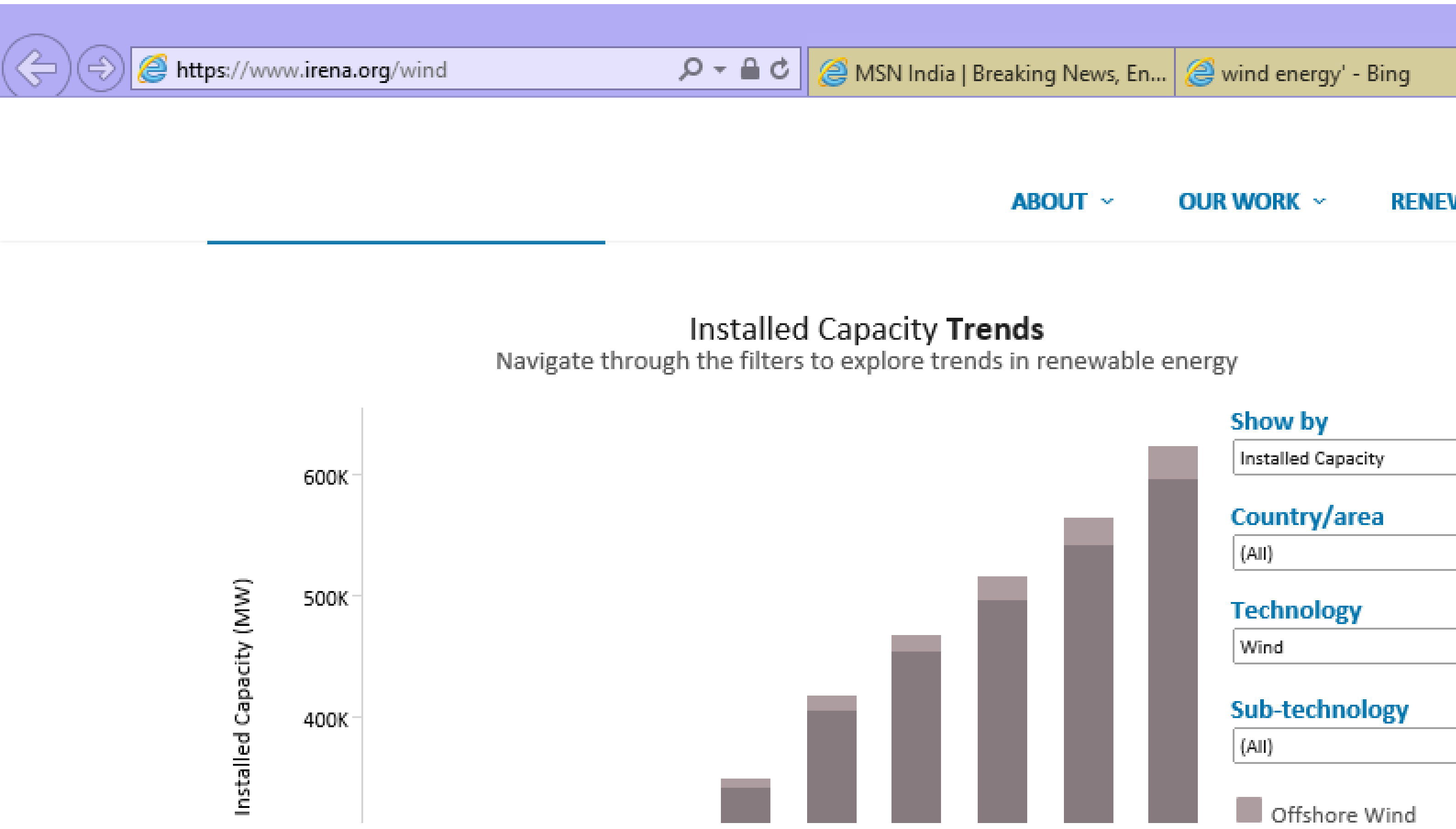


Fig. 2. Wind Energy Data

According to IRENA's latest data, the production of wind electricity in 2016 accounted for a 6% of the electricity generated by renewables. Many parts of the world have strong wind speeds, but the best locations for generating wind power are sometimes remote ones. Offshore wind power offers tremendous potential.

4. Geothermal Energy:

Geothermal energy comes from deep inside the earth. The slow decay of radioactive particles in the earth's core, a process that happens in all rocks, produces geothermal energy.

The earth has four major parts or layers:

1. An inner core of solid iron that is about 1,500 miles in diameter
2. An outer core of hot molten rock called magma that is about 1,500 miles thick.
3. A mantle of magma and rock surrounding the outer core that is about 1,800 miles thick
4. A crust of solid rock that forms the continents and ocean floors that is 15 to 35 miles thick under the continents and 3 to 5 miles thick under the oceans.

Scientists have discovered that the temperature of the earth's inner core is about 10,800 degrees Fahrenheit (°F), which is as hot as the surface of the sun. Temperatures in the mantle range from about 392°F at the upper boundary with the earth's crust to approximately 7,230°F at the mantle-core boundary.

The earth's crust is broken into pieces called tectonic plates. Magma comes close to the earth's surface near the edges of these plates, which is where many volcanoes occur. The lava that erupts from volcanoes is partly magma. Rocks and water absorb heat from magma deep underground. The rocks and water found deeper underground have the highest temperatures.

Deep inside the Earth, at depths near 150 kilometers, the temperature and pressure is sufficient to melt rock into magma. As it becomes less dense, the magma begins to flow toward the surface. Once it breaks through the crust it is referred to as lava. Lava is extremely hot; up to 1,250 °C. Average lava temperatures are about 750°C. A normal household oven only reaches temperatures near 260°C (500°F).The rock located just above the magma is also very hot but remains solid. What if we could harness this thermal energy and use it to generate electricity or heat homes and businesses? We would have a domestic, clean, and nearly inexhaustible energy supply. Our ancient ancestors knew about this free and reliable energy. They bathed and prepared food in hot springs and many cultures considered geysers and other surface geothermal features as sacred places. Today, due to the explorations and calculations of many scientists and engineers, it has been realized that only 1% of the geothermal energy contained in the uppermost ten kilometers of the Earth’s crust is 500 times that contained in all the oil and gas resources of the world. The next step is designing technology that can harness this immense, renewable, and low to no - emission energy reservoir.

Geothermal energy can be usefully extracted from four different types of geologic formations. These include hydrothermal, geopressurized, hot dry rock, and magma.

1. Hydrothermal reservoirs have been the most common source of geothermal energy production worldwide. They contain hot water and/or steam trapped in fractured or porous rock formations by a layer of impermeable rock on top. Hydrothermal fluids can be used directly to heat buildings, greenhouses, and swimming pools, or they can can be used to produce steam for electrical power generation. These power plants typically operate with fluid temperatures greater than 130^{o}C.

2. Geopressurized resources are from formations where moderately high temperature brines are trapped in a permeable layer of rock under high pressures. These brines are found deeper underground than hydrothermal fluids and have high concentrations of salt, minerals, and dissolved methane gas. In addition to producing steam for electrical power generation, minerals can be extracted from brines and used as supplementary revenue for a power plant. This process is known as coproduction.

3. Hot dry rock reservoirs are generally hot impermeable rocks at depths shallow enough to be accessible resources are virtually unlimited in magnitude around the world, only those at shallow depths are currently economical. To extract heat from such formations, the rock must be fractured and a fluid circulation system developed. This is known as an enhanced geothermal system (EGS). The water is then heated by way of conduction as the it passes through the fractures in the rock, thus becoming a hydrothermal fluid.

4. The final source of geothermal energy is magma, which is partially molten rock. Molten rock is the largest global geothermal resource and is found at depths below 3-10km. Its great depth and high temperature (between 700°C and 1200°C) make the resource difficult to access and harness. Thus, technology to use magma resources is not well developed.

Geothermal power is already an important energy resource for our nation and the world.

Hydrothermal plants in the western states now provide about 2,500 megawatts of constant, reliable electricity, which meets the residential power needs for a city of 6 million people. Over 8,000 megawatts are currently being produced worldwide.

A variety of industries, including food processing, aquaculture farming, lumber drying, and greenhouse operations, now benefit from direct geothermal heating. Hydrothermal systems also provide district heating. District systems distribute hydrothermal fluid from one or more geothermal wells through a series of pipes to several individual houses and buildings, or blocks of buildings.

5. Tidal Energy:

Tides are caused by **gravitational interaction and rotation of the earth-moon system about a common center of mass located inside the earth**. (There is also a minor effect from the sun's gravity.) As the earth rotates, the interaction causes two high tides and two low tides per day at any point on a coast.

The change in water level between a high tide and low tide can be harnessed to produce electrical power, or the current can be used to turn turbines.

How Does Tidal Energy Work

The gravitational pull of the moon causes the ocean to bulge in the part closest to the moon. The bulge in the ocean is known as a *high tide*. When the bulge reaches the coast, a high tide occurs. A second bulge can be found on the opposite side of the earth due to the earth's orbital motion.

The earth-moon system actually rotates about a common center of mass that is located inside the earth and in the direction of the moon.

This pivot point for rotation is the offset that causes the earth to experience a force that pushes water away from the center of mass on the opposite side, much like what happens if you swing a bucket of water in a circle.

The bulge on the side toward the moon is responsible for one tide, but the effect of centrifugal force is responsible for the bulge on the opposite side.

The actual time between high tides is approximately 12 hours and 25 minutes, which is the time required for the alignment to occur again. Because of varying ocean depths, landmasses, and other factors at different locations on earth, the actual tides vary.

When the sun, moon, and earth all align, a stronger gravitational pull occurs on the oceans, and higher and lower tides called *spring tides* are produced.

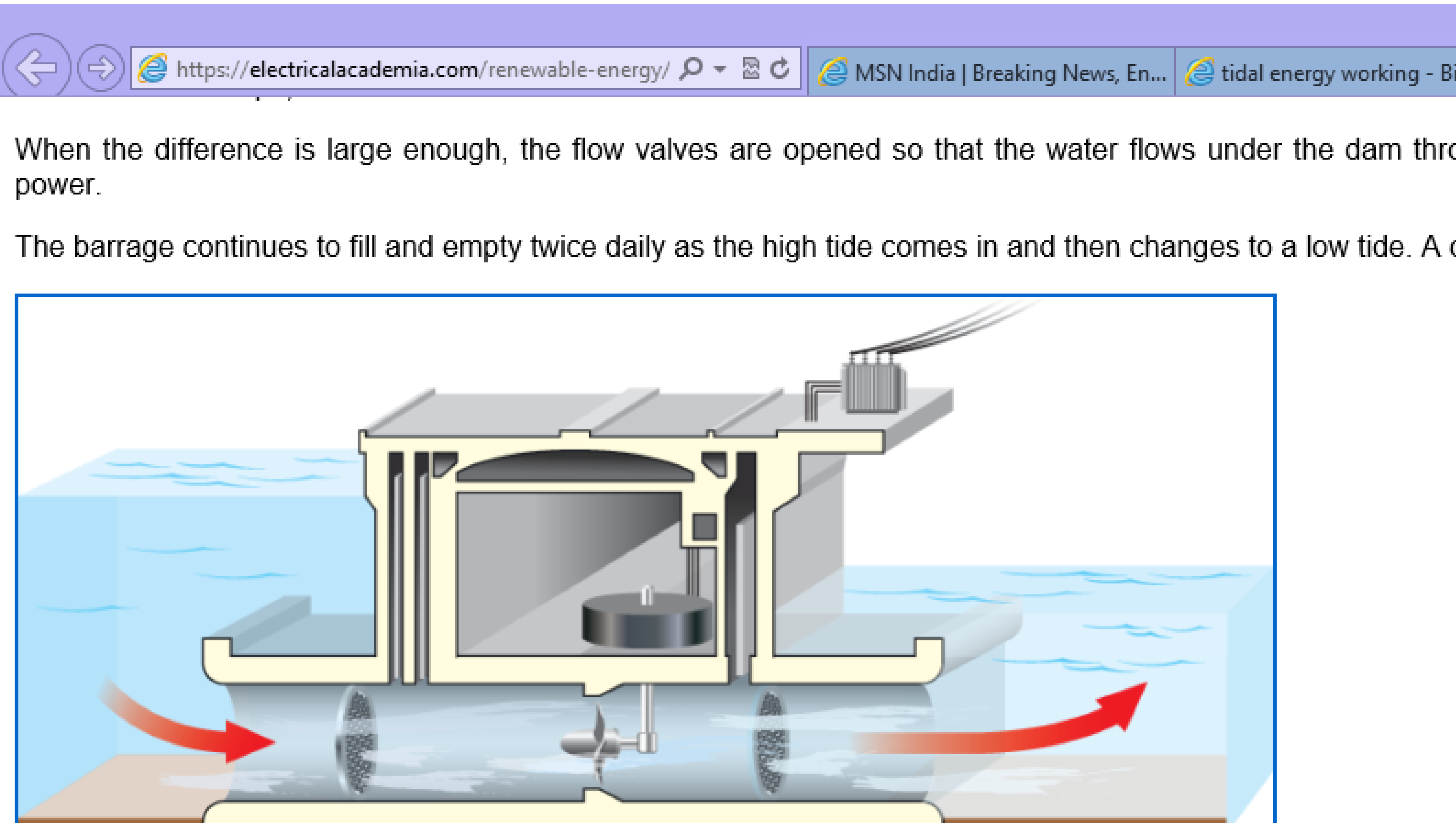
A spring tide has nothing to do with the spring season of the year; rather, it occurs at new moon and again at full moon (approximately twice a month). At first and third quarter, the net gravitational force of the sun and moon is not as pronounced, so lesser tides than normal, called neap tides, are produced (neap tides also occur twice each month).

The currents associated with the tides depend on the particular location on earth; currents from tides can vary from 0 to over 2 m/s.

Tidal Barrage System Working

A tidal barrage system is designed to convert tidal power into electricity by trapping water behind a dam, called a tidal barrage dam, and generating power from the inflow

and/or release of water.
The tidal barrage dam is a large dam that stretches completely across an estuary, harbor, or river that connects to part of the ocean that has a tide.
When the tide rises, sluice gates open to allow the tide to flow through tunnels and fill the area behind the dam.
When the water is flowing into the area behind the dam as the tide is rising, it causes the turbine to rotate and produce electricity.
When the tide reaches its highest level, the gates close, capturing the maximum amount of water behind the dam.
When the tide drops, it creates a difference between the water behind the dam and the water in front of the dam that is at the level of the low tide.
When the difference is large enough, the flow valves are opened so that the water

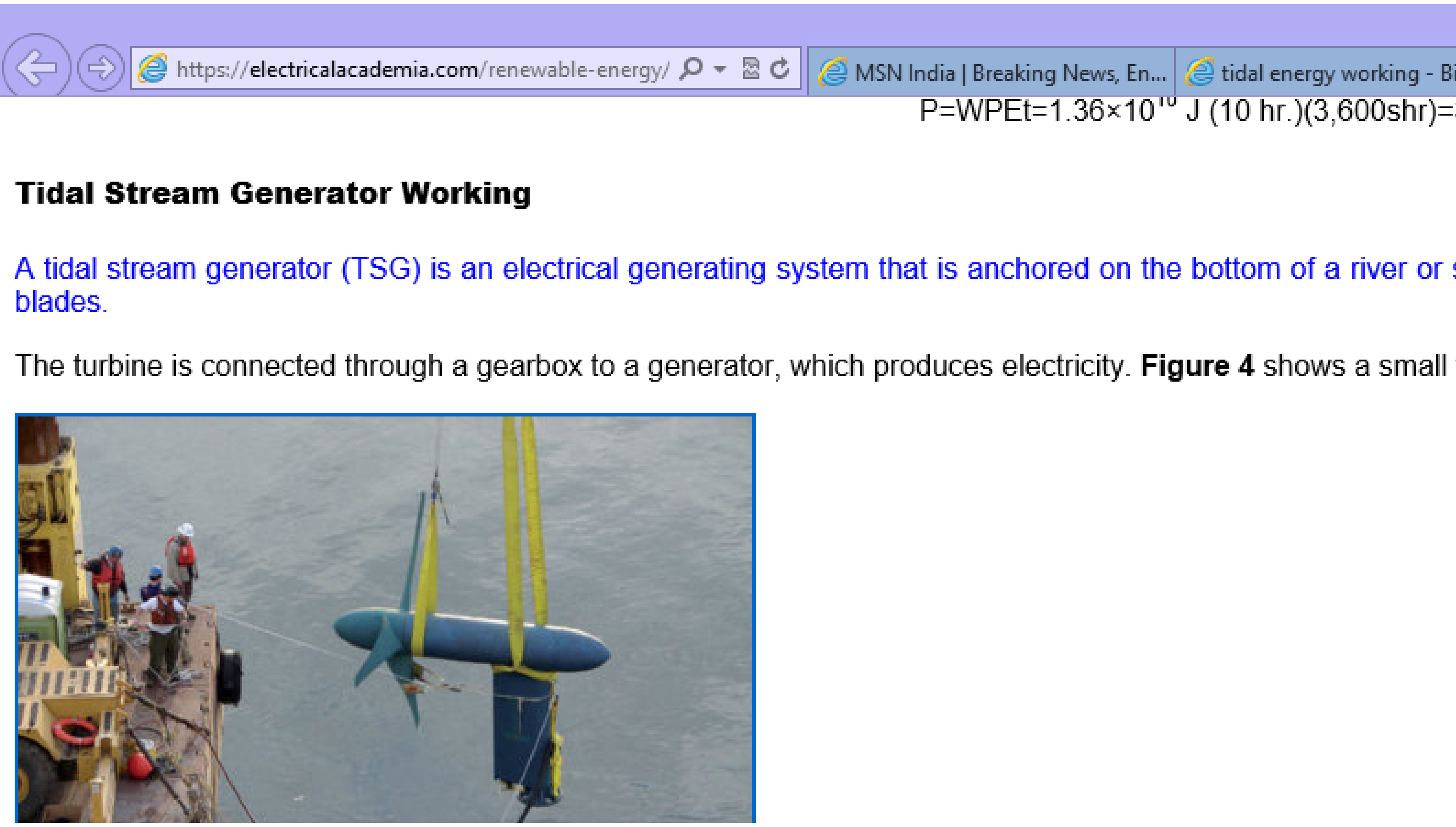


flows under the dam through the tubes and past a generator turbine, causing it to turn and produce power.
The barrage continues to fill and empty twice daily as the high tide comes in and then changes to a low tide. A conceptual plan for a tidal barrage system is shown in **Figure 3**

Figure.3. Plan View of a Tidal Barrage System
Because the barrage dam stretches completely across the harbor or river, it must have a lock to accommodate shipping or boating.
The cost for installing a tidal barrage dam is very high, and only a relatively few

locations in the world have sufficiently high tides to make it economically viable.
The world's largest tidal power system, the Sihwa Lake Tidal Power Station, is located in South Korea. This system, which opened in 2011, is a 254 MW tidal barrage dam west of Seoul, South Korea. The dam is 12.7 km (7.9 miles) long and uses ten 26 MW turbines positioned on the ocean floor. The area of the basin is huge, measuring 43 km^2 (17 mi^2).
Because of water-use concerns, the turbines run only as sea water moves into the lake and not in the opposite direction.
A problem with this method of generating power is that it depends on the height in the barrage, which drops dramatically when it is supplying energy (as opposed to a large reservoir, where the level is much less variable.)

Tidal Stream Generator Working



A tidal stream generator (TSG) is an electrical generating system that is anchored on the bottom of a river or stream to capture energy from the natural flow of the stream over the turbine blades.
The turbine is connected through a gearbox to a generator, which produces electricity. **Figure 4** shows a small three-blade tidal stream generator.

Fig. 4. Three Blade Tidal Stream Generator in the process of installation in east

Streams that empty into the ocean have water levels that raise or lower with the tides in the area.
When the tide rises, water can flow upstream in the lower portion of the river, and

when the tide becomes lower, water flows back to the ocean. **This return flow** causes a very strong current that moves a large volume of water over the blades of the water turbine generator, causing it to rotate.

The turbine is designed so it can rotate to optimize power for incoming and outgoing tides. **Figure 5a** shows an example of a water turbine rotating when the tide is coming in; **Figure 5b** shows an example when the tide is going out.

The main restriction to blade size is the depth of the water at low tide because the turbine needs to be anchored where it remains under water.

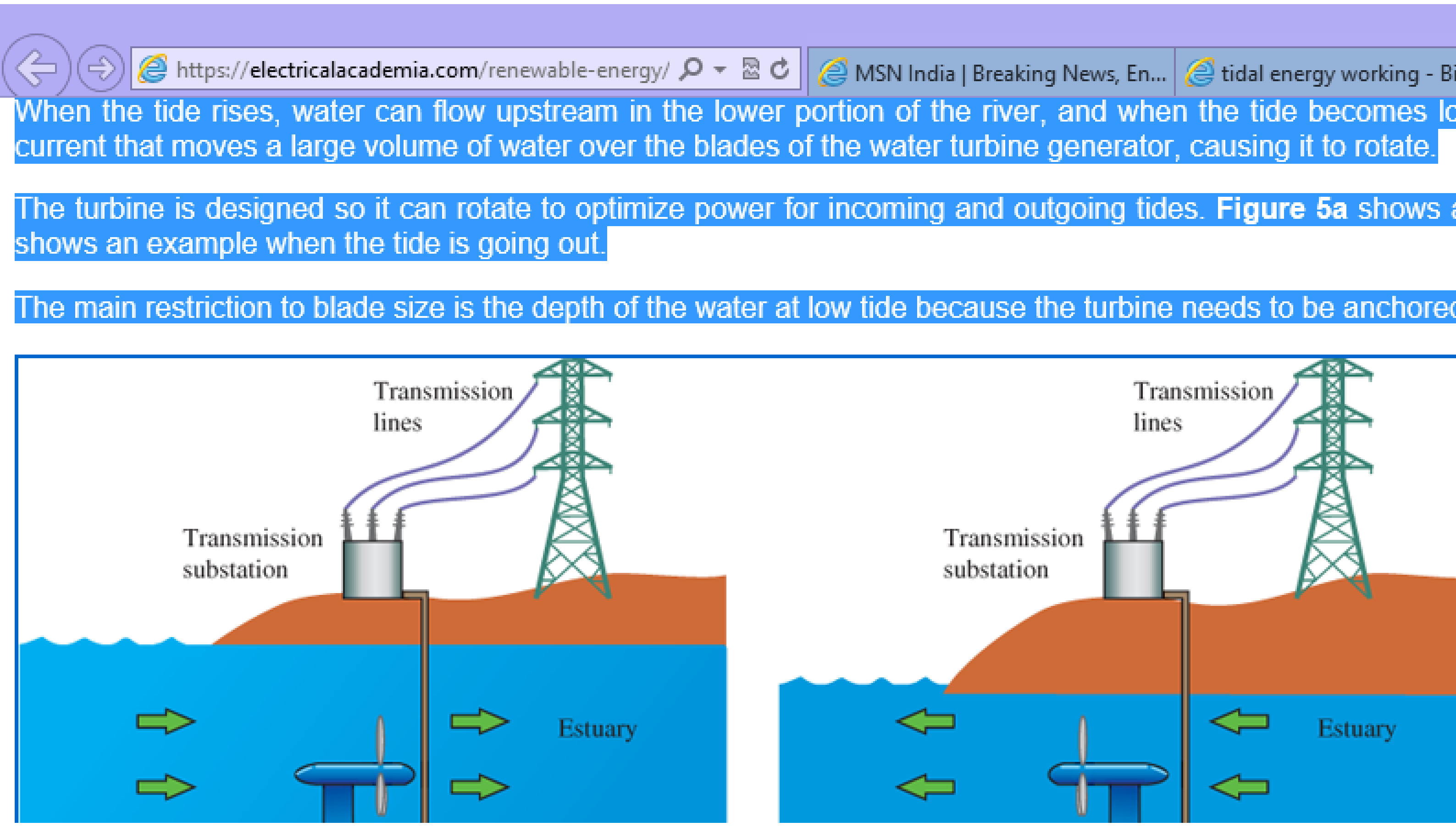


Figure 5 Tidal Stream Generator. The movement of water in a tidal current generates power for both inflow and outflow.

Tidal Energy Advantages and Disadvantages:

Generating electrical power from tidal energy has advantages and disadvantages.

One of the biggest advantages of tidal energy is that the tides are predictable and occur all along the oceanfront; however, the current is not constant but fluctuates as tides move in and out.

The location of turbines underwater is an advantage because it eliminates noise and a large visual presence.

The main disadvantage of tidal energy systems is the initial expense of installation and the upkeep of a marine system located in saltwater. Other concerns include the effects of any system on fish, seals, marine life, and birds.

A concern for barrage dams is the effect on fish migration patterns as well as fish

mortality due to passing through turbines.
Another concern is the changing patterns for sediments. When water containing sediments slows, the sediments that were suspended in the water tend to be deposited.
Sedimentation tends to decrease the intertidal area, which can affect shellfish and can kill clams. It can also affect other marine life, including fish by reducing fish spawning areas, and bird habitat.
The extent of effects on wildlife varies depending on the specific location. Depending on the source of the sediments, the net effect is cumulative changes in deposition and erosion patterns that can have negative environmental impacts.

6. Biomass Energy:

Biomass is plant or animal material used for energy production (electricity or heat), or in various industrial processes as raw substance for a range of products. It can be purposely grown energy crops (e.g. miscanthus, switchgrass), wood or forest residues, waste from food crops (wheat straw, bagasse), horticulture (yard waste), food processing (corn cobs), animal farming (manure, rich in nitrogen and phosphorus), or human waste from sewage plants. Burning plant-derived biomass releases CO_2. However, it has still been classified as a renewable energy source in the EU and UN legal frameworks because of photosynthesis cycles the CO_2 back into new crops. In some cases, this recycling of CO_2 from plants to atmosphere and back into plants can even be CO_2 negative, as a relatively large portion of the CO_2 is moved to the soil during each cycle. Cofiring with biomass has increased in coal power plants because it makes it possible to release less CO_2 without the cost associated with building new infrastructure. Co-firing is not without issues; however, often, an upgrade of the biomass is most beneficial. Upgrading to higher grade fuels can be achieved by different methods, broadly classified as thermal, chemical, or biochemical.

Biomass feedstocksError: Reference source not foundError: Reference source not foundError: Reference source not found

Historically, humans have harnessed biomass-derived energy since the time when people began burning wood fuel. Even in 2019, biomass is the only source of fuel for domestic use in many developing countries. All biomass is biologically-produced matter based in carbon, hydrogen and oxygen. The estimated biomass production in the world is approximately 100 billion metric tons of carbon per year, about half in the ocean and half on land.
Wood and residues from wood, for instance spruce, birch, eucalyptus, willow, oil palm, remains the largest biomass energy source today. It is used directly as a fuel or processed into pellet fuel or other forms of fuels. Biomass also includes plant or animal matter that can be converted into fuel, fibers or industrial chemicals. There are numerous types of plants, including corn, switchgrass, miscanthus, hemp, sorghum, sugarcane, and bamboo. The main waste energy feedstocks are wood waste, agricultural waste, municipal solid waste, manufacturing waste, and landfill gas. Sewage sludge is another source of biomass. There is ongoing research involving algae or algae-derived biomass. Other biomass feedstocks are enzymes or bacteria from various sources, grown in cell cultures or hydroponics.

7. Hydrogen Energy:

Hydrogen energy is a source of energy recently tapped to become one of the accessible forms of alternative energy, like wind, water, and solar energy. Engineers and scientists believe that hydrogen is a viable energy source because it is the most abundant element in the universe and is also the simplest of all elements, having just one proton and electron. Hydrogen energy is most beneficial to the environment, as it does not produce any toxic emissions when burnt.

Hydrogen may be the most abundant element in the universe, but on Earth, it is hardly present on its own; rather, it exists with other elements to form compounds and gases, such as with oxygen to form water. Other organic products that contain hydrogen include fossils, methanol, and other natural gases. Even algae and some bacteria contain hydrogen because they absorb sunlight, which, in turn, contains hydrogen because the Sun is basically a hydrogen-containing star. In order to create hydrogen energy, the hydrogen must be harvested from these compounds that undergo certain processes.One of the most widespread method for producing pure hydrogen is electrolysis, which separates the hydrogen atoms from oxygen ones out of water. Electrolysis is very effective and is also environmentally-friendly because the process does not produce any polluting emissions. It is, however, not as efficient as it is very expensive to operate. Another method for harvesting hydrogen is steam reforming, which splits the carbon atoms from hydrogen ones from methane. Steam reforming is not as expensive as electrolysis, but is more harmful to the environment due to the carbon it releases in the air, causing a greenhouse effect.

Under the process, the hydrogen reacts with the oxygen or the carbon and produces the hydrogen energy. In this way, the hydrogen itself is not the source of energy, but only acts as the carrier of energy. The extracted hydrogen is then stored in tanks in liquid form, making it easier to store and conserve. When it is to be used, the hydrogen is poured into fuel cells or batteries and in gas tanks. Hydrogen energy is even credited by the National Aeronautics and Space Administration (NASA) for successfully lifting off the space shuttles.

Aside from fueling space shuttles, hydrogen energy has been proven an effective fuel for cars, buses, and trains. The U.S. Energy Information Administration (EIA) has reported that there are over 300 buses and cars that use hydrogen fuel, and there are about 70 hydrogen-filling stations across the states. Hydrogen energy is also applied as a generator and power system in rural hospitals not reached by the electrical companies.