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A REVIEW OF DIFFERENT RENEWABLE ENERGY RESOURCES AND THEIR ENERGY EFFICIENCY TECHNOLOGIES

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Review

A B S T R A C T

Recently, the rising costs of fossil fuels and worries about the environmental impact of greenhouse gas emissions have sparked a fresh focus on the development of alternative energy sources. Renewable energy is currently considered a preferable fuel source to nuclear power since it lacks safety hazards and the potential for catastrophes. Given that carbon dioxide is the primary constituent of greenhouse gases, there is worldwide apprehension over the reduction of carbon emissions in order to mitigate the issue of climate change. Various strategies may be used to decrease carbon emissions, including promoting the use of renewable energy and fostering technical advancements.

1. INTRODUCTION

Energy consumption has rapidly increased since the 1950s. Energy consumption is influenced by factors such as economic growth, increasing population, and advancements in technology (Tariq et al., 2022). Combustion of fossil fuels results in the emission of substantial quantities of carbon dioxide, which is a potent greenhouse gas, into the atmosphere (Gür, 2022). Greenhouse gases, such as carbon dioxide and methane, have the ability to retain heat in the earth's atmosphere, leading to the phenomenon known as global warming (Kweku et al., 2018). There is a worldwide apprehension over the reduction of carbon dioxide emissions (Rao et al.. 2024) to mitigate carbon emissions, several strategies may be used, including promoting the use of renewable energy sources and fostering technical advancements. Furthermore, governments use various measures such as renewable portfolio requirements, tax policies, and feed-in tariffs to promote the development of renewable energy sources and enhance energy efficiency in order to save energy (Hartway et al., 1999; Pudjianto et al., 2007; Kieny et al., 2009; Frondel, et al., 2010, Abuzreda & Ahmad, 2021). The five primary sources of renewable energy are as follows:

- Hydropower;
- Wind energy;
- Solar energy from the sun Geothermal energy;
- Bioenergy; and
- Geothermal energy from heat inside the earth.

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2. TYPES OF ENERGY RESOURCES

2.1. Fossil fuel

2.1.1. How is the Fossil fuel

Fossil fuel is the main source of power in the modern human civilization. The carbon deposits preserved over millions of years have transformed into a carbon and hydrogen chemical structure called fossil fuel (Navarro et al., 2007). Various fossil fuels are categorized based on the number of carbon atoms in their structure, which have various applications. A significant part of the fossil fuel engines power up transportation and generate electricity for human needs. According to the increasing need for fossil fuel deposits with expanding industries and population, they are reducing faster than regenerating (Holechek et al. 2022).

The twentieth century saw a rapid twenty-fold increase in the use of fossil fuels. Between 1980 and 2006, the worldwide annual growth rate was 2%. According to the US Energy Information Administration's 2006 estimate, the estimated total consumption of 471.8 EJ (471.8*1018j) in 2004 was divided as follows, with fossil fuels supplying 86% of the world's energy (Holechek et al. 2022)..

Coal fueled the industrial revolution in the 18th and 19th century. With the advent of the automobile, airplanes, and the spreading use of electricity, oil became the dominant fuel during the twentieth century. The growth of oil as the largest fossil fuel was further enabled by steadily dropping prices from 1920 until 1973. After the oil shocks of 1973 and 1979, when the price of oil increased from 5 to 45 US dollars per barrel, there was a shift away from oil. Coal, natural gas, and nuclear became the fuels of choice for electricity generation, and conservation measures increased energy efficiency. From 1965 to 2008, the use of fossil fuels continued to grow, and their share of the energy supply increased. From 2003 to 2008, coal, which is one of the dirtiest sources of energy, was the fastest-growing fossil fuel.

2.1.2. Exploit and use the fossil fuel in the world

During the past century, fossil fuels - petroleum liquids, natural gas and coal- have been the dominant source of world energy production. From 1950 to 2005, fossil fuels provided 85–93% of all energy production. All fossil fuels grew substantially during this period, their combined growth exceeding the increase in world population. This growth, however, was irregular, providing for rapidly growing per capita production from 1950 to 1980, stable per capita production from 1980 to 2000, and rising per capita production again after 2000. During the past half-century, growth in fossil fuel production was essentially limited by energy demand.

Levels of primary energy sources are the reserves in the ground. Flows are production. The most important primary energy source is carbon-based fossil energy. Levels reserves:

• Oil: 1,050,691 to 1,277,702 billion barrels (167 to 203 km³) in 2003-2005

•Gas: 6,040,208 - 6,805,830 billion cubic feet (171,040 to 192,720 km³)

• Coal: 1,081,279 million tons

Flows (daily production) during 2002:

• Oil: (10,230*0.349)*7.9/365=77 MBD

• Gas: (10,230*0.212)*7.9/365=47 MBOED

• Coal: (10,230*0.235)*7.9/365=52 MBOED

2.1.3. Renewable energy in the world

2008, renewable energy supplied around 19% of the world's energy consumption. The renewable sector has been growing significantly since the last years of the 20th century, and in 2009,, the total new investment was estimated to have been 150 billion US dollars. This resulted in an additional 80 of capacity during the year.

2.2. Renewable energy

Renewable energy comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (Rahman et al, 2022). In 2008, about 19% of global final energy consumption came from renewables, with 13% from traditional biomass mainly used for heating and 3.2% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) account for another 2.7% and are growing rapidly. The share of renewables in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewables.

2.2.1. Solar energy

Solar energy is a fact that all life depends on and comes from the sun. The production of oxygen and food would be impossible without solar energy (Sen, 2004). Farmers know the value of a large field with a plentiful supply of sunlight, and now, individuals worldwide are taking this boundless source of diffuse energy more seriously as the finite supply of fossil fuels dwindles.

Today, less than 0.1% of our heating, transportation, and power energy comes from direct sunlight, although it is now possible to meet all our energy needs with this simple, renewable resource.

The earth receives 174 petawatts (PW) of incoming radiation (insolation) in the upper atmosphere. Approximately 30% is reflected back to space while clouds, oceans and land masses absorb the rest. 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.

The total solar energy absorbed by the earth's atmosphere, oceans, and land masses is approximately 3,850,000 exajoules (EJ) annually. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year, it is about twice as much as will ever be obtained from all of the earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

2.2.2. Water Power or Hydropower

Hydropower, hydraulic power, or water power is power that is derived from the force or energy of moving water and may be harnessed for useful purposes (Yüksel et al. 2010). Prior to the widespread availability of commercial electric power, hydropower was used for irrigation and the operation of various machines, such as watermills, textile machines, sawmills, dock cranes, and domestic lifts.

In hydrology, hydropower is manifested in the force of the water on the riverbed and banks of a river. It is particularly powerful when the river is in flood. The force of the water results in the removal of sediment and other materials from the riverbed and banks of the river, causing erosion and other alterations.

Now, in Vietnam, there are many hydroelectric plants, which are our country's main sources of electricity. Examples of some Hydroelectric plants are Hoa Binh, Son la, Thac Bac…

2.2.3. Wave, Tidal, or Ocean Energy

Tidal power traditionally involves erecting a dam across the opening to a tidal basin. The dam includes a sluice that is opened to allow the tide to flow into the basin; the sluice is then closed, and as the sea level drops, traditional hydropower technologies can be used to generate electricity from the elevated water in the basin. Some researchers are also trying to extract energy directly from tidal flow streams.

Tidal energy systems can have environmental impacts on tidal basins because of reduced tidal flow and silt buildup. There are three basic ways to tap the ocean for its energy. We can use the ocean's waves, we can use the ocean's high and low tides, or we can use temperature differences in the water.

a. Wave Energy

Kinetic energy (movement) exists in the moving waves of the ocean. That energy can be used to power a turbine. The wave rises into a chamber in this simple example (illustrated to the right). The rising water forces the air out of the chamber. The moving air spins a turbine which can turn a generator.

When the wave goes down, air flows through the turbine and back into the chamber through normally closed doors.

This is only one type of wave-energy system. Others actually use the up-and-down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator.

Most wave-energy systems are very small. But they can be used to power a warning buoy or a small lighthouse.

b. Tidal Energy

Another form of ocean energy is called tidal energy. Tides can be trapped in reservoirs behind dams when they come to the shore. Then, when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant.

For this to work well, you need large increases in tides. An increase of at least 16 feet between low and high is needed. There are only a few places where this tide change occurs around the earth. Some power plants are already operating using this idea. One plant in France makes enough energy from tides to power 240,000 homes.

c. Ocean Thermal Energy

The final ocean energy idea uses temperature differences in the ocean. If you had ever gone swimming in the ocean and dove deep below the surface, you would have noticed that the water gets colder the deeper you go. It's warmer on the surface because sunlight warms the water. But below the surface, the ocean gets very cold. That's why scuba divers wear wet suits when they dive down deep. Their wet suits trapped their body heat to keep them warm.

Power plants can be built that use this difference in temperature to make energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water.

Using this type of energy source is called Ocean Thermal Energy Conversion or OTEC. It is being used in some demonstration projects in both Japan and Hawaii.

2.2.4. Wind Energy

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, windmills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ships (Kaushika et al. 2022).

At the end of 2009, the worldwide nameplate capacity of wind-powered generators was 159.2 gigawatts (GW). Energy production was 340 TWh, about 2% of worldwide electricity usage, and has doubled in the past three years. Several countries have achieved relatively high levels of wind power penetration (with large governmental subsidies), such as 20% of stationary electricity production in Denmark, 14% in Ireland and Portugal, 11% in Spain, and 8% in Germany in 2009. As of May 2009, 80 countries around the world are using wind power on a commercial basis.

2.2.5. Bioenergy

Until the end of the nineteenth century, biomass was the predominant fuel; today, it has only a small share of the overall energy supply. Electricity produced from biomass sources was estimated at 44 GW in 2005. Biomass electricity generation increased by over 100% in Germany, Hungary, the Netherlands, Poland and Spain. A further 220 GW was used for heating (in 2004), bringing the total energy consumed from biomass to around 264 GW. The use of biomass fires for cooking is excluded.

World bioethanol production increased by 8% in 2005 to reach 33 billion liters (8.72 billion US gallons), with most of the increase in the United States, bringing it level to the levels of consumption in Brazil. Biodiesel increased by 85% to 3.9 billion liters (1.03 billion US gallons), making it the fastest-growing renewable energy source in 2005. Over 50% is produced in Germany.

3. RENEWABLE ENERGY IN VIET NAM

Vietnam has many advantages in developing renewable energy because it has very much developed agriculture. The Main RE resources in VN are small hydropower, biomass, wind, solar, and geothermal energy. This table shows the total power generation of RE electricity in Vietnam (Figure 1).

Power resource	Capacity (MW)	Share (%)
Traditional	**11,360**	**97.65**
Coal fired TPP	1,427	12.28
Oil fired TPP	573	4.93
Gas turbine	4,450	38.25
Diesel	615	5.29
Large hydropower	4,227	36.34
Renewable	**273.2**	**2.35**
Wind power	1.2	0.01
Small hydropower	121.0	1.04
Solar power	1.0	0.009
Biomass power	150	1.29
Total	**11,633.2**	**100.000**

Figure 1. Share of RE electricity in total power generation in Vietnam.

Solar Energy:
- Over 100 solar measurement stations throughout the country

The average solar radiation is 5 kWh/m2 per day.
The average number of sunny hours is about 2000-:-2500 hours/year.
Wind Energy:
- Wind energy density: 800 – 1400 kWh/m2.year on islands
- 500 -1000 kWh/m2.year in coastal areas and highlands
- Other areas: less than 500 kWh/m2.year.

Biomass Energy:
- Agricultural residues are over 60 million tons (equivalent to more than 10 million tons of oil).
- Types of biomass can be exploited at the industrial scale: rice husks; leaves, top of sugar canes & baggage, coffee husks, and wood residues.

Assessment of the potential of renewable energies Institute of Energy
Biogas energy:
- Biogas resources: landfills, animal excrements, agricultural residues
- 80,000 biogas plants have been constructed
- Biogas potential is about ten billion m3/year.

Small Hydropower Energy:
- Technical potential > 4000 MW

Geothermal energy and other types (tide, ocean waves...):
- Potential of geothermal energy resources: 200- 340 MW.
- Renewable energy types such as tides and sea waves are in the stage of potential assessment.

4. BIOFUEL, THE SOLUTION OF THE FUTURE

Biofuels are fuels made from once-living organic materials. BioFuels are commonly known as liquid fuels and blending components produced from biomass (plants) feedstocks, used primarily for transportation. In other words, those fuels can be manufactured from organic materials and produced by bio-diesel and ethanol.
When gasoline or diesel is burnt, the carbon atoms combine with Oxygen (O2) to form Carbon dioxide (CO2) (which adds to global warming and the greenhouse effect), and the hydrogen combines with oxygen to form water (H_2O). These processes produce energy, the bit that makes the car, truck, or plane go.
BioFuels, on the other hand, are made from by-products of farming. For example, using sugarcane waste, wheat corn, or from (waste) vegetable oil, biomass.

4.1. Benefits of BioFuel

There are many Advantage when we use
• Increased demand for domestic agricultural products.
• It is a green fuel, does not contribute to the carbon dioxide (CO2) burden, and produces drastically reduced engine emissions. It is non-toxic and biodegradable.
• Biodiesel is a much better lubricant than petroleum diesel, and its use can prolong engine life.
• Renewable - Biodiesel is derived from vegetable oil, which is essentially home-grown. It is a sustainable resource that will not run out. We need more, we grow more. Petroleum diesel is derived from crude oil, which is finite and will eventually run out.
• Carbon Neutral - BioDiesel use does not lead to any overall change in the amount of CO2 in the atmosphere. The vegetables from which the oil has been extracted remove CO2 from the atmosphere to grow. When Bio-diesel is burned, the CO2 is released back into the atmosphere, only to be taken up again when we grow more.
• Less noxious, non-toxic - Bio-diesel lacks the unpleasant odor of petroleum diesel, and exhaust emissions smell like a barbecue. Users can expect a near 100% reduction in Sulphur dioxide (SO2), 40-60% reduction in soot & particulates, 10-50% reduction in Carbon monoxide (CO).
• Unlike petroleum diesel, it is biodegradable. A spill of crude oil in the ocean or on land can be an environmental disaster. And it happens a lot more often than most people know. Between 1974 and 2004, there were 9,266 reported incidents of spills1. Nearly 1500 were larger than 7 tonnes (about 7,000 liters). Three hundred forty of them were larger than 700 tonnes, totaling more than 5.5 million tonnes (5.5 billion liters) of spilled oil. To put this into perspective, the Exxon Valdez spill in 1989 was only 37,000 tonnes, and we all know what a disaster that was. The cost of this cleanup alone was about US$2.5 billion.

• BioDiesel is simple to make and can be produced from waste animal or vegetable oil (cooking oil).
• Classed as non-hazardous because it is non-toxic and has a high flash-point.
• Burns more efficiently than petroleum diesel.
• It can be used directly in unmodified diesel engines, either neatly or blended in any ratio with petroleum diesel. In other words, if bio-diesel is unavailable, normal petroleum diesel can be used for whatever reason.
• Carbon Neutral - BioDiesel use does not lead to any overall change in the amount of CO2 in the atmosphere. The plants from which the oil has been extracted remove CO2 from the atmosphere and allow it to grow. When BioDiesel is burned, the CO2 is released back into the atmosphere, only to be taken up again when we grow more.
• Example: if 17.5 billion liters of diesel is used. This produces 52 Million tonnes of CO2. If BioDiesel were used instead, we would save 52,000,000 tonnes of CO2 annually.

4.2. Overview of Biofuel in the World

With rising concerns over energy security and the environment, governments have aggressively encouraged biofuel production (Figure 2). Current biofuel technologies use agricultural feedstocks such as grains and sugar for ethanol, rapeseed, and palm oil for biodiesel. Brazil mandates biofuel consumption and uses about half its sugar cane to produce ethanol. The United States has tax incentives, subsidies, and consumption mandates for biofuel production. At the current pace of investment, the US plans to produce 15 billion gallons of biofuel by 2010. This means that one-quarter and one-half of the current US maize crop will be used as feedstock. Germany, France, Canada, Australia, Japan, China, Indonesia, Malaysia, the Philippines, Thailand, and many other developed and developing countries also have plans to expand ethanol and biodiesel production.

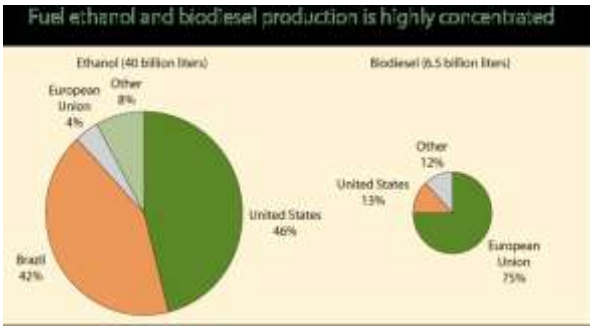

Figure 2. Fuel ethanol and Biodiesel production (in 2006)

Brazil is the world's second-largest producer of ethanol fuel and the world's largest exporter. Brazil and the United States led the industrial production of ethanol fuel, accounting for 89% of the world's production in 2009 (Coelho & Guardabassi, 2014). The European Union is the world's first largest producer of biodiesel fuel, and it is essential in France and Germany (Balat, 2007, Bórawski et al, 2023).

5. CONCLUSION

Concerns regarding climate change have elevated the significance of renewable energy sources in the global energy landscape. Given the adverse and irreversible consequences linked to traditional energy extraction and consumption, it is imperative to advocate for and advance the utilization of renewable energy. The International Energy Agency (IEA) predicts favorable advancements in renewable energy sources, as they serve as substitutes for fossil fuels and contribute to emission reduction. In the short term, certain renewable technologies may not be on par with conventional fuels regarding production costs and transmission. However, they can become comparable when considering their positive externalities, such as their environmental and social impacts

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