Renewable Energy: Where are We Going to Get It?

An Online Continuing Education Course for Engineers

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1. Introduction

There has been a great deal of interest in renewable energy in this country, and around the world, over the last several decades. We all know that fossil-based fuels such as oil, natural gas, and coal are by their very nature finite. Thus, these energy resources are limited to the present resources and supply. When we burn a pound of coal or a gallon of oil or a cubic foot of natural gas, they are not replaced. In 2017, world usage of oil was about 1.3019 cubic mile of oil per year, which is about 98,186,000 barrels per day. That is said to be about the flow of the Potomac River that flows through Washington, DC. Coal usage in 2017 was about 4,558,273,000 short tons (one short ton = 2000 pounds) per year. If we turn that into cubic miles, it comes to 0.737 cubic miles. A unit train was pulling 130 cars, each carrying about 110 tons of coal, contains 14,300 tons of coal. The other fossil fuel that is used in any amount is natural gas. There is a large amount of natural gas in proven reserves worldwide. It is said to be about 6.19 $*10^{15}$ cubic feet, or about $4.28*10^4$ cubic miles. It is unfair to compare cubic miles of solids and liquids such as coal and oil to cubic miles of gas. So, if liquefied, those $4.28*10^4$ cubic miles of gas would come to about 71 cubic miles. At the present time (2017) we are using about 1.42 cubic miles of liquefied natural gas per year if we use the ratio of 600 to 1 for gaseous natural gas to liquefied natural gas. All in all, we are using up about three cubic miles of the earth every year to power our homes, boats, cars, trucks, planes, and any other devices that require energy.

One of the significant disadvantages of using fossil fuels to generate electrical energy is that they all emit a lot of carbon dioxide (CO_2). Coal produces about 0.963 Kg (2.122 pounds) of CO_2 per KWH, oil about 0.883 Kg (1.836 pounds) of CO_2 per KWH, and natural gas about 0.569 Kg (1.254 pounds) of CO_2 per KWH. In 2017 the world's approximate electrical generation was about 25,551 $*10^9$ KWHs. If we think of that much energy in terms of foot-pounds, that would be about $6.784*10^{19}$ foot-pounds. That's like lifting $6.784*10^{19}$ pounds one foot high. Of the $25.551*10^9$ KWHs, about 15.721 * 10^9 KWHs or 61.5% was from burning fossil fuels. In the United States, about 4.282 $*10^{12}$ KWH of electrical energy was generated. Of that, about 2.6854 $*10^{12}$ KWHs or 62.7% was made by burning fossil fuels. A rough approximation of the CO_2 emitted by fossil fuel burning to produce electrical energy in the world is about 13,508 $*10^9$ kilograms or 29,717 * 10^9 pounds or about 14.858 * 10^9 tons. For the United States, fossil fuel burning to produce electricity produces about 2.275 * 10^9 tons of carbon dioxide. I can't even put that into perspective. The information for the above analysis was gotten from "The 67th edition of BP Statistical Review of World Energy June 2018". As an added thought, the burning of fossil fuels releases sulfur, mercury, and other unhealthy by-products into the atmosphere.

One of the other natural resources that can be thought of as being burned is Uranium. As of 2017 about 70,201 tons of Uranium worldwide, in the form of the oxide U_3O_8, is mined each year. The uranium from that U_3O_8 would be about 59,531 tons. That's only about 100,909 cubic feet if we use uranium density to be 1179.89 pounds per cubic feet (in the metric system this is 18.9 grams per cubic centimeter). To put that into perspective, that's about 0.000000686 cubic miles. 23,391

tons or 33.32 % came from Kazakhstan, 13,116 tons or 18.68 % came from Canada, and 5,882 tons or 8.38 % came from Australia. As a matter of interest, only 940 tons or 1.34 % was mined in the United States. As mined the Uranium contains about 99.3% ^{238}U, and 0.7% ^{235}U. To become usable fuel, the Uranium is enriched to about 3 to 4% ^{235}U. This is an energy-using process that converts the U_3O_8 to UF_6, a gas. Then the ^{235}U is separated from the ^{238}U by a gaseous diffusion process or using centrifuges. The Uranium is then processed and used as UO_2, Uranium Dioxide. In 2017 about 10.3% of the world's electrical energy was produced from Uranium in 450 plants in 31 countries. That amounted to 2635 billion kWh. The United States contributes about 20% of its electrical energy or about 847 billion kWh in 100 nuclear reactors. As a matter of interest, weapon grade Uranium has been enriched to about 90% U_{235}. With the recycling of atomic weapons by Russia and the United States, a large amount of enriched Uranium has been made available for use in nuclear power plants. Even though the amount of uranium that is used to generate electricity is small and no CO_2 is produced, there is radioactive waste that needs to be disposed of in such a manner that it will do no harm to the environment, the earth, and its inhabitants. See Figure 1.1, of the world Uranium production in 2017. These ratios don't change much from the year, so this is to give us some perspective in the production of Uranium. Metric tonnes are provided in the chart. One metric tonne equals 1.1023 American short tons.

Uranium Production - 2017

Country	Production	% of World Total
Kazakhstan	23,391 tonnes	39.30%
Canada	13,116 tonnes	22.00%
Australia	5882 tonnes	9.90%
Namibia	4224 tonnes	7.10%
Niger	3449 tonnes	5.80%
Russia	2917 tonnes	4.90%
Uzbekistan	2404 tonnes	4.00%
China	1885 tonnes	3.20%
United States	940 tonnes	1.60%
Ukraine	550 tonnes	1.00%
All others	773 tonnes	1.30%
Total	59531 tonnes	

Figure 1.1 World Uranium Mining Production in 2017

The energy sources listed above are nonrenewable. The earth is definitely not making any more uranium. That which is here is slowly being used up as the fissionable U_{235} which has a half-life of 704 million years. The nonfissionable U_{238} has a half-life of 4.47 billion years. With such long half-lives, the earth will probably be able to supply Uranium for a long time. As a matter of interest, U_{235} is the only naturally occurring fissionable material. Also, there is a way to turn the ^{238}U into fissionable plutonium. Another element, Thorium, can be used to generate electrical energy. Although Thorium is 3 or 4 times more abundant than Uranium in the earth, technical problems have limited its use in nuclear reactors. It is nonfissionable and needs to be converted into fissionable elements in some breeder reactor.

There doesn't seem to be any place on earth that has the right conditions needed to make oil and coal. It is said that cows produce a lot of methane gas, but it is not very harvestable. Therefore, if we want to continue using energy in the way we are doing now, some way needs to be found to generate renewable energy. There are a number of ways that this is done, and I will now cover some of them.

2. Renewable Hydro Electric Power

Renewable hydroelectric generation does wo of the hydroelectric power is to find places on the earth where lar reasonably long distance. There's Ni een Brazil and Argentina, a some countries in Africa genera erica, and Victoria Falls in Africa rate electricity, but they are li er Niagara Falls. It is the most p gara River is about 1,500,00 h the water that is used to genera d to a lake above the falls, s gh tunnels. The total useful p oximately equal to the outpu

As a matter of inte iagara River right above the fall nd gives one an idea of the imme rom going into the water there. t this fence." The sign has falls, which would have led to their deaths.

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