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Global Energy Consumption: The Numbers for Now and in the Future

Seger, Brian

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Global Energy Consumption: The Numbers for Now and in the Future

While most educated people know that there are around 8 billion people, very few know how much energy the world uses. Very broadly speaking the more energy we consume, the more stuff we can get, the more places we can, and the faster we can get there. Thus economic prosperity is directly linked to energy consumption as shown by a multitude of sources. Yet for some reason this number is never mentioned. Is it because it is extremely complicated and involves many assumptions? Not really. The answer is really simple: 17.4 Terrawatts for 2015.

To a large extent everything we have such as food, cars, and electricity is derived from these 17.4 terrawatts (TW). What exactly is a terawatt though? Let's break this down into 2 parts. 'Terra' is the prefix for 10^{12}. Thus, on average, we are using 17,400,000,000,000 watts every day and night. 'Watts' is simply an energy per a given time. A typical LED light bulb uses 3 watts, whereas a laptop uses ~40W. While a normal car engine could provide up to ~150,000 W, on average they typically run at about 20-30% of that value.

While manufactures for lightbulbs, computers and cars must provide how much power they consume, who provides the number for how much energy we use? Again, a pretty simple answer. Oil companies such as BP, Exxon, and OPEC publish this data annually, but also governmental agencies such as the International Energy Agency (OECD based) and the Energy Information Agency (USA based) provide this data as well. Fortunately all these sources are in very good agreement with each other. Not only do these reports state how much energy we use, but they also state where the energy comes from.

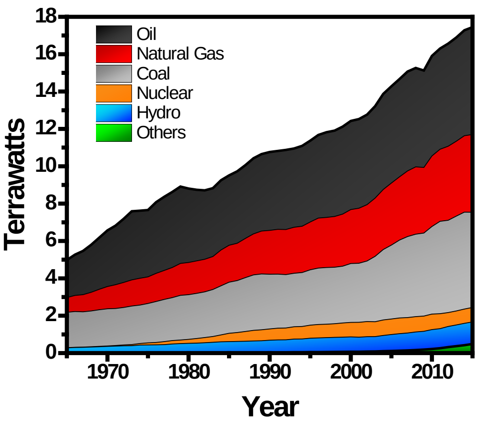

Figure 1: Global energy consumption (Based off of the BP Statistical Review of World Energy)

Broadly speaking, 5% of the energy comes from nuclear, 10% from renewables and the other 80% comes from an almost even split between oil, coal and natural gas. Of the 10% from renewable energy two thirds of this is from hydroelectric with the remaining third consisting of wind, solar, and biomass. The BP report also shows the years of fossil fuels we have left for coal (~ 110), oil (~ 50), and natural gas (~ 50) assuming we continue the same production rate as today. An important point to note though is that the amount of fossil fuels that BP reports we have left is actually the amount of fossil fuels, which we know where they are and how to get them out of the ground. The actual amount of fossil fuels in the ground is much larger than their reported data. The impending advancements of renewable energies almost certainly ensures that we will never come close to depleting the world's supply of coal and most probably oil and natural gas as well.

Renewable Energy

While renewable energy has taken off at breakneck speed, this has also led to many misunderstandings. One of the biggest issues is how much energy can we get from renewable sources. There are really only 3 sources: the sun, earth's internal heat, and the gravitational pull of the moon on earth resulting in ocean tides. Everything else is derived from these 3 sources.

The sun strikes earth with 167,000 TW. However about 30% is reflected by clouds and earth's surface, 2/3 of it strikes the ocean, and much of it is needed to maintain our ecosystem. Nevertheless we should have no problem getting 17.4 TW from this. Currently much of these 167,000 TW is used to heat up the earth, some of which evaporates water, which then recondenses in the form of rain at the top of mountains. This high elevation water can then be dammed up and used for hydroelectric power. While this is quite effective, estimations based on a survey of the earth's geography shows the maximum economically viable energy we can obtain from this method is around 3-4 TW.

Another issue that occurs when the sun heats up the earth relates to inconsistent heating due to differences in geography and clouds. As the world tries to balance out this heating, it produces wind, which we can then harvest for energy. Given that wind is thus a by-product of the sun, the amount of energy we can achieve from wind power is significantly less than 167,000 TW, but the exact value is not known. However reasonable estimates have suggested this could be in the 25-70 TW range, thus making this a very promising avenue to meet our demands.

While the earth's core produces about 40-50 TW of geothermal energy through leftover heat from planet formation and nuclear reactions, this energy is spread out relatively uniformly throughout the entire surface of the earth, thus harvesting it is extremely difficult. At certain areas, such as the edge of tectonic plates, this energy is concentrated and we can recover some energy, but it is estimated this could only provide less than 1 TW of energy. Tidal power is realistically limited by the amount of shores, and the height difference between low and high tide. Rough estimations have shown this approach could produce less than 1 TW of energy as well.

Thus solar and wind have the most potential with hydroelectric coming in a distant third. The simplicity, consistency, and economic viability of hydroelectric power are the primary reasons why this method currently is the largest renewable energy source. Currently though, our scientific understanding behind both wind energy and solar energy is finally maturing to the point where we can translate this knowledge into economically feasible engineering designs, thus accounting for the sharp rise in both these techniques. However one needs to be aware of some of the exaggerated marketing in this field. When a company announces the built a 50 MW solar cell field or wind farm check the numbers carefully. Typically what they report is the capacity, which means how much energy they could produce on a perfect day. For solar cells this would be noon on a sunny day and for wind turbines this would be a hard blowing wind at just the right direction. Typically the average power for a solar cell is ~15-20% of its capacity and the average wind turbine produces 40% of its capacity. Thus it is important not to read capacity and then think average power.

Another important point to realize is that electrical power only makes up about 30% of the world total energy needs. Thus while a headline might read that renewable energy provided all the power for a country for a given day, week, etc., these headlines borders between being highly misleading and completely wrong (example 1, 2, 3). What they typically mean is that renewable energy provided 100% of the electrical energy. While this is quite impressive there still is ~70% to go. Additionally, leading renewable energy countries such as Denmark, Germany, and Portugal oftentimes trade their renewable electricity to other countries when their production is greater than consumption. When their production does not meet consumption they import electricity from these neighboring countries. While this is a viable technique when neighboring countries have low renewable energy penetration, if everybody starts to transition to renewables, the entire system gets stressed and there becomes an immense need for energy storage. Ensuring we have sufficient storage for our intermittent renewable energies is a major impending issue, which is a full discussion in of itself.

In conclusion, there is very good publicly available energy data and you do not need to be an expert in the field to understand this. However knowing how much energy we use, where it currently comes from, and where it will come from in the future can allow one to make well informed decisions with regards to investment, business, politics, as well as many other areas.