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P2_7 A fire in a room.

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Abstract
This paper looks at whether power generation has any effect on global temperatures. Assuming all energy used by humans is lost as heat which is kept in the atmosphere, it is found that the Sun contributes much more power. Also, the amount this energy would heat the atmosphere is calculated, and it is also found to be an insignificant amount.

Introduction

Global warming is a hot topic in the scientific community, the media and government today. There are many competing ideas regarding severity, scale and even whether it is happening at all. It is into this conflict that this commenter on a blog wades:

> "The heat from power generation has to have an effect on global temperatures. All the waste heat has to go somewhere. If you light a fire in a room, it's not the smoke that makes you warm. Bet the Warmists haven't thought about that." [1]

The commenter asserts that global warming may indeed be due to the actions of man, however not because of carbon emissions. They believe that global temperatures have been primarily affected by the heat released in power generation. This will therefore be investigated.

Discussion

First off, some assumptions will have to be made. Firstly, it is important to define what power generation is classed as. For the purpose of this paper, it will be regarded as the entire power usage of mankind, from any source. It will be assumed that all power, once used, is radiated away as heat that does not escape the Earth.

There are also many natural sources of heat on Earth. Sources such as the Sun, volcanic activity and tidal heating all have an effect on the total amount of heat in the atmosphere. This, by the commenter's rules, should also have an effect. However in order to simplify matters, only the total flux from the Sun will be considered. This is because it is the largest source of heat, with geological heat for example only contributing $0.08Wm^{-2}$ [2], whereas the Sun contributes $1366Wm^{-2}$ [3].

The total energy use of the world per year, according to a 2008 estimate, is around $474x10^{18}$J [4]. This is a sum of the fossil fuel, nuclear energy and renewable energy used in a year. In order to calculate the number of Watts, this has to be divided by the number of seconds in a year ($3.15x10^{7}$) to give $1.5x10^{13}$W. This power (which is the average amount of Joules provided by humans per second) can then be compared to the amount of power supplied by the Sun.

The amount of power the Sun provided per metre is called the solar constant. This varies depending on time of year and time of day, as well as some minor other factors. A good average value measured by satellite however is $1366Wm^{-2}$ [4]. This is not the total amount at the surface however, as the curvature of the Earth and the amount reflected by the atmosphere has to also be taken into account.

Assuming the total power of the Sun is hitting half the Earth's surface at all times, and that the total surface area facing the Sun is $2.6x10^{14}m^{2}$ [5], the total incident flux will be $3.6x10^{17}$W. This is nearly 4 orders higher than the power generated by humans, meaning that around 0.004% of the heat energy in the atmosphere is caused by humans.

If atmospheric reflection is taken into account, at around 30-35% depending on environmental and geological features[6], the picture is much the same. In this case, the total power is decreased 30%, giving 2.47×10^{17}W. This is still significantly higher than the contribution by human sources.

Taking this further, it will be interesting to see how much this amount of power could actually warm the Earth. Using the equation of the volume of a sphere, and the density of nitrogen (as the atmosphere is 78% nitrogen), a crude estimate of the volume of the Earth's atmosphere can be calculated using this formula:

$$V = \frac{4}{3}\pi (R_E + R_A)^3 - \frac{4}{3}\pi R_E{}^3 \text{ .(1)}$$

where R_A is the radius of the atmosphere and R_E is the radius of the Earth.

Assuming the radius of the Earth is 6.4×10^6m, and that the troposphere is where the majority of the mass of the atmosphere is (which extends to around 14,000m)[7], the volume of the atmosphere can be calculated to be 7.22×10^{18}m^3. Using the density of nitrogen (1.25kgm^{-3}[7]) the mass of the atmosphere can be found to be around 9.03×10^{18}kg.

Using the specific heat capacity of nitrogen (1040 J/KgK at 25ºC [7]) and using

$$\Delta T = \frac{E}{mC_N} \text{ (2)},$$

where m is the mass of the atmosphere, C_N is the specific heat capacity of nitrogen and E is the amount of energy is Joules[5]. This gives a temperature change of 0.05°C per year. It would therefore take two decades with no energy lost from Earth to warm the world up by one degree from human activity alone. Assuming there is no radiation with the power provided by the Sun, the Earth would warm 291.8°C a year. This also assumes that all the radiation is transferred to heating the atmosphere up, regardless of radiation type. As roughly 50% of solar radiation is infrared [8], this value could be halved to compare like for like. This means that of the global temperature change in this model, human sources are responsible for 0.034%, and this would hold true if heat loss was considered also.

Conclusion

As these calculations show, the commenter is completely wrong in his assertion that the waste heat from power generation is to blame for global warming. In fact, it is shown that the amount of energy is negligible compared to the amount of flux from the Sun. From this, that amount this heat would warm the atmosphere is calculated, and again is found to be a very small amount. Both of these scenarios do not take into account how much energy is radiated away from the planet, and it is reasonable to assert that with this addition the effect of power generation would still be negligible.

Bibliography:

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