P2_9 Feasibility of Outrunning Climate Change

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Abstract

In this paper we investigate the feasibility of moving the Earth away from the Sun to combat climate change. We found that the energy needed to move the Earth 5.44×10^6 m is 8.71×10^{30} J per year for the lower bound and 5.29×10^{33} J to move it 1.31×10^8 J for the upper bound. For the lower bound, the number of rockets required to generate this energy is 1.21×10^{30} and would cost \$$4.97 \times 10^{39}$ USD. For the upper bound, 1.77×10^{34} rockets would be needed, costing \$$7.26 \times 10^{43}$ USD. We conclude that this is not a feasible method for combating climate change as using renewable energy sources to power the entire planet would be much more cost effective.

Introduction

In the paper "P2_7 Outrunning Climate Change" [1], it was found that the Earth would need to be moved away from the Sun at a rate of 5.44×10^6 m per year as a lower bound (0.2 Case), and 1.31×10^8 m per year for the upper bound (4.8 Case) to keep surface temperature constant despite a constant rate of greenhouse gas emissions. This paper aims to investigate the feasibility of this idea. We will calculate the number of rockets that would be required to generate the energy needed to move the Earth and the cost of building these. We have chosen to assume Space Launch System (SLS) rockets would be used - developed by NASA for the Artemis missions - as these are currently the most powerful rockets [2]. We will then compare this with the costs of using nuclear power plants or solar panels to generate all of the world's energy needs.

Method

In "P2_9 Leap Year? Get Outta Here!" [3], the authors calculate the energy needed to move the Earth to remove the leap year, we will follow a similar method. Firstly, the potential energy will be calculated using Eq. (1) for the initial and final positions for each case. The initial position for both is $1AU$.

$$U = -\frac{GMm}{r}, \qquad (1)$$

where G is the gravitational constant, M is the solar mass, m is the Earth's mass and r is the radial distance from the Earth to the Sun. Next, we calculate the kinetic energy of the initial and final positions for both cases using Eq. (2).

$$K = \frac{1}{2}mv^2, \qquad (2)$$

where v is the tangential velocity of Earth. This was calculated by equating Eq. (1) and (2) to derive the following:

$$v = \sqrt{\frac{GM}{r}}, \qquad (3)$$

and the values substituted into Eq. (2). Then for both cases, the total energy of the initial

position and final position were calculated by adding the potential and kinetic energies for each. Subtracting the initial total energy from the final total energy gives the energy needed to move Earth. For the upper bound case this was 8.71×10^{30} J, and for the lower bound case this was 5.29×10^{33} J. Using the energies calculated, we can find the force needed to move Earth using

$$F = W \Delta r, \qquad (4)$$

and compare to the force of the rockets. We found the forces for the lower and upper bounds to be 4.74×10^{37} N and 6.93×10^{41} N respectively.

Discussion

NASA's SLS rockets can produce a maximum thrust of 3.91×10^7 N [2]. This means that 1.21×10^{30} rockets would be needed for the lower bound case and 1.77×10^{34} rockets in upper bound case. It costs \$4.10 Billion USD to build an SLS rocket [4]. This means it would cost \$$4.97 \times 10^{34}$ USD to move Earth in the lower bound and \$$7.26 \times 10^{43}$ USD in upper bound (USD will be the currency used throughout this paper).

As a comparison, we will compare these prices to the price of using nuclear power plants or solar panels to produce the energy projected to be needed in 2100. In 2019, 628×10^{18} J was used worldwide and in 2050 it is estimated we will use 760×10^{18} J [5]. Assuming this trend is linear we are expected to use 973×10^{18} J in 2100. The upcoming Sizewell C nuclear power plant cost \$22.6 Billion to construct and will generate 3.20 GW of power [6] - generating 10.01×10^{17} J in a year. For nuclear power plants like this to produce sufficient energy for the planet, 9630 would need to be built costing \$$21.8 \times 10^{14}$ in total.

A typical solar panel generates 250 W of power [7] - generating 7.8×10^9 J in a year. This means 1.23×10^{11} solar panels would be needed to answer the energy demands of the globe in 2100. This would cost \$$8.42 \times 10^{14}$ assuming one panel costs \$623, a battery costs \$5660 and installation of one panel is \$566 [7]. By comparing the costs of these three possible solutions to the climate crisis, it is clear that moving the Earth is unfeasible. Other factors which would also need to be considered include the amount of material needed to build this many rockets and the effect on the climate of them burning fuel.

Conclusion

In conclusion, the energy needed to move the Earth is 8.71×10^{30} J, costing \$$4.97 \times 10^{34}$, for the lower bound case and for the upper bound 5.29×10^{33} J is needed costing \$$7.26 \times 10^{43}$. Comparing these to the possible solutions of using nuclear power plants or solar panels as a way of combating climate change shows how unfeasible moving Earth would be, considering costs alone. It would be much more realistic to replace fossil fuels with renewable energy sources.

References

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