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P2_1 How long would it take for Britain to leave Europe?

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Abstract

In this paper, we have calculated how long it would take for mainland Britain to move away completely from the Eurasian tectonic plate; using a powerful hypothetical motor, powered by £350 million a week. The amount of water displaced by the Great British boat was also calculated. It was found that 7.34x10^{19}kg of water would be displaced and that per week Britain could move 422m, taking 87 years to leave Europe.

Introduction

In June 2016, a referendum was held to decide whether the UK should leave the European Union. A figure of £350 million paid to the EU per week was used as a reason to leave[1]. We found the amount of kilo watt hours £350 million would pay for a week. We used this figure to find the power needed of a hypothetical motor to push Britain like a boat and the speed this much power would make Britain move at. Finally the length of time it would take for Britain to fully leave the Eurasian tectonic plate and move onto the North American plate was also calculated.

Assumptions

For this model to work there are a number of assumptions needed. The first assumption is that the shape of Britain is an irregular trapezoid of uniform density and thickness. The trapezoid Britain will be going through the gulf stream which is assumed to be non-turbulent with a steady flow. In reality, with a mass as large as Britain, the water would be turbulent. Northern Ireland was excluded from the calculations, this would require a much larger force as it would have to physically split from another land mass. The small islands around mainland Britain are also neglected in the calculations. The hypothetical motor is assumed to be 100% efficient.Most motors are not 100% efficient, so therefore the number of years would be a minimum, as the power output of the hypothetical motor would be less than the input paid for by £350 million. A final assumption is that the line of action of the force from the motor, always acts through the centre of mass and towards Iceland.

Theory

The area of Britain is known to be 2.09x10$^{11}m^2$ [2]. The depth that has been used is the average thickness of the continental crust, which is 35km [3]. Using these values we calculated that the volume of Britain is 7.32x10$^{15}m^3$. As we have used the thickness of the continental crust, which is made up of mainly granite, we have used the density of granite: $2.75gcm^{-3}$ [4] for calculating the mass using equation 1.

$$\rho_B = \frac{M}{V} \tag{1}$$

where ρ_B is density of Britain , M is the mass of Britain and V is the volume of Britain. The mass was found to be 2.01x10^{19}kg. The weight of Britain is therefore 1.97x$10^{20}N$. The amount of water displaced by this weight can be calculated using equation 2.

$$w_w = \frac{w_B \rho_w}{\rho_B}, \tag{2}$$

where w_w is weight of displaced water, w_B is weight of Britain and ρ_w is the density of seawater ($1025 kgm^{-3}$[6]). This weight of displaced water was found to be 7.34x10^{19}kg. To find the velocity for Britain to leave the Eurasian tectonic plate equation 3 is used.

$$P = Fv, \tag{3}$$

where P is power F is force and v is the velocity of escaping Britain. The total power is calculated from converting the amount of kilo watt hours 350 million would pay for, into the amount of energy per week. The current cost of a kilo watt hour is approximately 13p [7] and therefore £350 million is enough to fund 2.69x10^{9}kwh which is equivalent 9.68x$10^{15}J$. Given that a week is 604800 seconds, this means that the power of the hypothetical motor is 1.60x$10^{10} Js^{-1}$. To calculate the drag force acting on the front of the trapezoid equation 3 [10] was used.

$$F_D = \frac{1}{2} v_w^2 \rho_w A C_D, \tag{4}$$

where F_D is the drag force, v_w is velocity of water, A is the surface area of the plane facing the water and C_D is the drag coefficient [10]. The front of the trapezoid Britain would appear to be a rectangular plane from straight on, so the drag coefficient of a rectangle, 1.28, was used [10]. The area of the front rectangle of the British Trapezoid was calculated using the distance between John O Groats and Cape Wrath in Scotland [9] multiplied by the depth of the trapezoid. The area is therefore found to be 5.60x$10^{9} m^2$. The maximum velocity of the Gulf Stream sea water is $2.5 ms^{-1}$ [8]. The drag force for the water is then found to be 2.30x$10^{13}N$. Putting this force into equation 3 gives a velocity of 6.97x$10^{-4} ms^{-1}$. Assuming that the escaping Britain travels at a constant velocity, it will travel 422m per week. Raufarhöfn in Iceland which is on the border between the Eurasian plate and the North American plate is 1913km away from Lands End, the bottom of Britain [9]. Travelling 422m per week Britain would be free of the Eurasian plate in 87 years.

Conclusion

We have found that of mainland Britain acted like a boat, then to stay afloat it would have to displace 7.34x10^{19}kg of water. It would also take a minimum of 87 years for mainland Britain to leave the Eurasian tectonic plate on a budget of £350 million per week. To further develop this the resistance of the water should be looked at in more detail, and the efficiency of the hypothetical motor could be calculated.

References

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