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P3_3 The Cost of Flying

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Abstract

Flying is a luxury that is costly to the environment. This paper attempts to quantify how significant the effects of flying really are. The energy contribution from flying is 0.855kWh/day/person for every 1000km flown. This is ~4% of an individual's domestic energy usage, and is equivalent boiling 7.456 litres of water every day for a year per 1000km.

Introduction

We live in a time where we are becoming increasingly aware of our consumption of fossil fuels and the size of our carbon footprints. Great Britain has one of the highest global energy consumptions per person [1], this paper investigates how significant aeroplane flights are in comparison to the average daily energy usage. The total energy usage consists of domestic, public, industry and transport sector use.

Just under a third of the total energy is accounted for by domestic energy, where use per household in 2011 was 18639kWh [2]. An assumption of 2.4 people per household on average will be used for this paper. With a population of ~60 million [3], each person in Great Britain therefore uses 21.28kWh per day to run his or her home. This implies that the total energy used per person across all sectors is ~70kWh per day.

Aeroplane fuel tanks typically have a capacity of 225000 litres [4]. The energy released from this fuel will be compared to the above values to analyse how just one or two flights per year can affect an individual's net consumption.

Theory

This paper calculates the energy consumption per 1000km flown each year. In the calculations the distance, *d,* is taken to be 1000km. It is assumed that a Boeing 747 is used for all flights, since it is a commonly used aircraft. If it flies 5630km and carries 56700kg of fuel, the plane has a fuel consumption, *C*, of 11.76 litres of fuel per kilometre [5]. Fuel commonly used for aircraft is Kerosene, which provides an energy density, ρ_E, of 38.2MJ/L [4]. The energy required for a flight (E_{flight}, in kWh) can be calculated using equation 1. The last term is divided by 3.6MJ to convert to kWh, a familiar unit used on energy bills, to make comparisons easier,

$$E_{\text{flight}} = d \times C \times \frac{\rho_E}{3.6} . \qquad (1)$$

The mean maximum capacity of a commercial airline is assumed to be 500 people. If it is also assumed that the vehicle is filled to 80% capacity, this gives an average of 400 passengers, *N*, on board each flight. The energy used annually per person, E_{person}, expressed per day for comparison with domestic energy usage, is given by

$$E_{\text{person}} = \frac{E_{\text{flight}}}{365 \times N} . \qquad (2)$$

The energy usage per day can be compared to a more relatable quantity such as the energy required to boil a kettle. The energy required, *Q*, to raise the temperature of a mass of water at room temperature to boiling point is

$$Q = mc\Delta T , \qquad (3)$$

where *m* is the mass of the water, *c* is the specific heat of water and ΔT is the temperature change.

Discussion

Using equation 1, the energy used for a plane to travel 1000km was found to be 1.25×10^{5}kWh/1000km/y. Accounting for the number of people on board, equation 2 reduces this energy to 0.855kWh/1000km/day/person. Comparing this value with those in the introduction, this total energy used per person for their annual air mileage is equivalent to more than three weeks of the energy consumption at home over the year for every 1000km flown per year.

The value for energy used per person per 1000km flown per year initially seems high, however one study into the energy consumption in Great Britain found that the energy per person due to flying is 30kWh/day; several times our result [6].

The unit of kWh/day/person can be utilised to compare with an everyday household appliance, the kettle. Assuming that 3 litres of water is boiled per day per person, 1 litre for cooking and 2 for hot drinks and ΔT is 80^{o}C with a specific heat of 4184J/kg [7], the total energy used was found to be 1.0×10^{6}J or 0.279kWh/day. This is assuming that all of the energy goes directly into heating the water, in reality the efficiency is closer to 0.81 [8] which would give 0.344kWh/day. This value would obviously decrease if the kettle were boiled for 2 or more people. The yearly aeroplane mileage is therefore equivalent to boiling 7.456 litres/person/day/1000km.

Conclusion

The average Briton who flies abroad each year consumes 0.855kWh/day/1000km, which is equivalent to ~4% of their daily domestic energy use, or ~1.2% of the total daily energy use across all sectors. It is important to note that this estimation was found from only considering air mileage in a Boeing-747, while in reality other models of aircraft are flown, with differing parameters.

These results seem fairly high, especially when compared to a familiar household appliance. If an average homeowner were told to boil 7.456 litres of water every day for a year per 1000km flown they would be very reluctant to waste that much energy, water and money. Despite this, a substantial number of people fly each day without a second thought. In an age where it is necessary to reduce energy consumption and increase renewable energy facilities, aeroplane flights are a very significant proportion of our energy consumption.

Measures certainly need to be taken to reduce the number of people flying. Further work could include investigations into the carbon emissions that arise from air travel, alternative transport methods and increasing the efficiency of planes.

It is slowly becoming evident that aeroplanes are a luxury that, as the human race, we may no longer be able to afford.

References

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