Cars, Planes, Trains

Physics and Mathematics of Sustainable Energy

College of the Atlantic. November 8, 2024

A few facts:

- Gasoline: 10 kWh per liter or 38 kWh per gallon
- Average gas mileage for car in US: 25mph, but this ranges considerably.
- Carbon intensity of gasoline: 240g per kWh.
- Burning one gallon of gasoline releases around 9 kg of CO_2.
- Carbon intensity of electricity in grams of CO_2e per kWh:
  - US: 376
  - Brazil: 102
  - China: 531

1. Let's compare driving 1000 miles in conventional and electric vehicles.
   (a) In the conventional car, how much gas does this use?
   (b) How much does this gas cost?
   (c) How much CO_2 is emitted by the car?
   (d) How much of the thermal energy released when burning the gasoline goes into the kinetic energy of the car? Assume that the car's engine has an efficiency of 0.25.
   (e) How many kWh of electricity would be needed by an electric car to go 1000 miles. Assume that the efficiency of the electric car is 0.85.
   (f) How much would this electricity cost?
   (g) How much CO_2 would be emitted as a result of generating this amount of electricity, assuming the US average carbon intensity.
   (h) How much CO_2 would be emitted as a result of generating this amount of electricity if the electricity was generated in a coal-burning power plant with an intensity of 1 kg/kWh?

2. Suppose you fly from New York to California twice in a year. What are the emissions associated with these flights. Put this number in perspective.

3. Suppose you want to get from London to Paris.
   (a) What are the emissions if you fly?
   (b) What are the emissions if you drive in a petrol (gas) car?
   (c) What are the emissions is you take the Eurostar train?

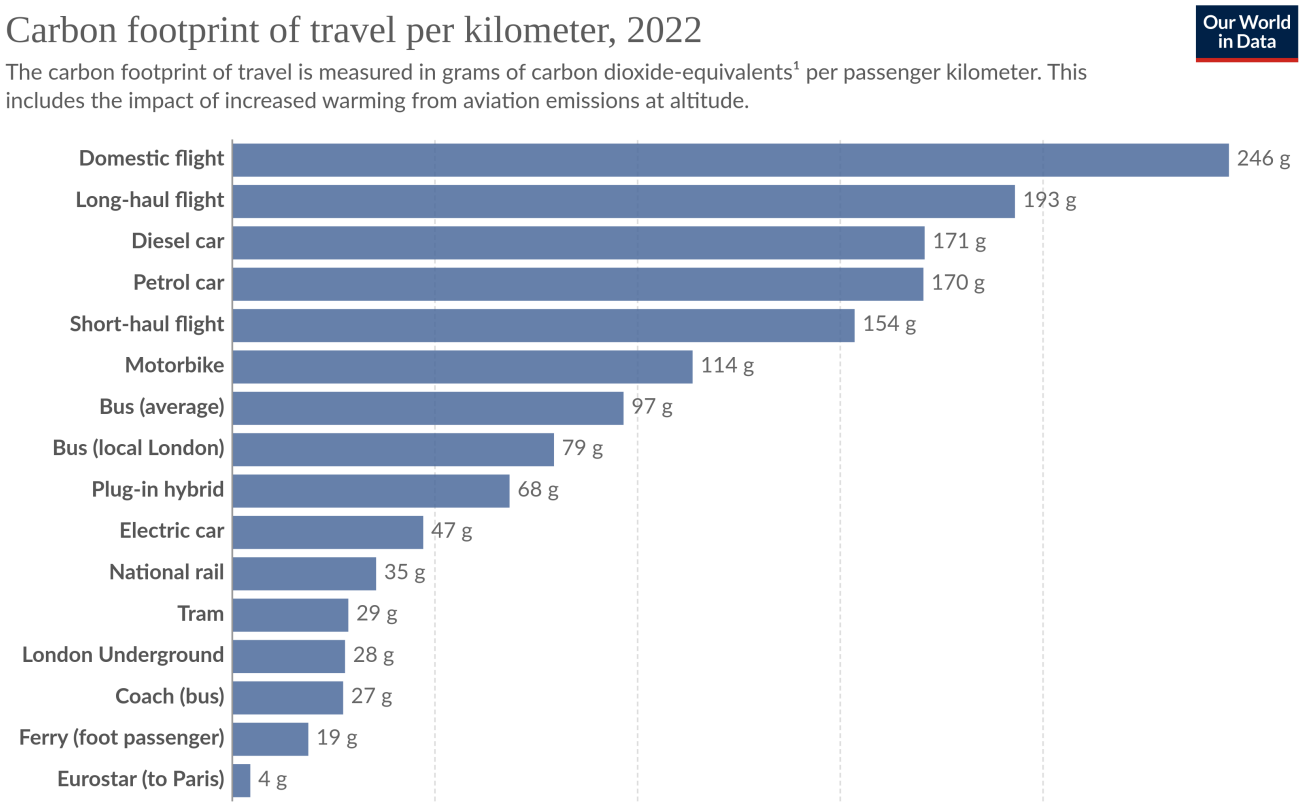

Figure 1: Carbon emissions associated with different forms of transportation. Source: Hannah Ritchie (2023) – "Which form of transport has the smallest carbon footprint?" Published online at OurWorldInData.org. Retrieved from: `https://ourworldindata.org/travel-carbon-footprint`.