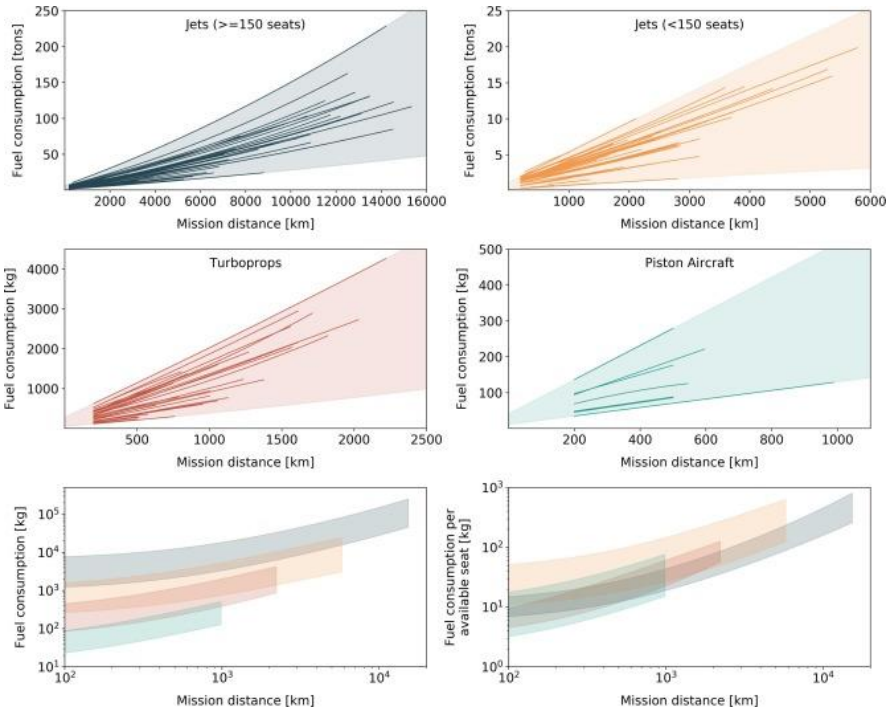
Holidays – Energy consumption for each holiday

1. Plane

- Literature for the consumption of airplanes https://doi.org/10.1016/j.trd.2020.102528



- from the graph ca. 20 - 40 kg of fuel per 1000km per passenger can be taken
- for longer distances ca. 200 - 400 kg of fuel per 10000km per passenger remains almost the same
- this is equal to 2 - 4 kg/100km fuel per passenger
- together with the density of jet A-1 fuel of 0,8 kg/l we get 2 - 5 litres/100km fuel per passenger
- the International Council on Clean Transportation reports 3,5 l/100km in very good agreement https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf

- **3,5 l/100km/p** will be the reference for all flights in Europe and outside of Europe
- 1 litre of jet A-1 fuel contains 9,6 kWh of energy (ASTM Standard Specification D1655-16a, Jet A-1 fuel)
- we get **34 kWh/100km/p** and close to 37 kWh/100km/p in the SEWTHA book

- in Europe we assume 1100km one-way travel for holidays by plane
- this is approximately the linear distance to Mallorca, Rome, Madrid, Barcelona
- there will be also a lot of people traveling to Lisbon/Porto, which is ca. 1600km linear
- but there will be also lots of people doing city trips by plane which are less than 1100km
- for one holiday trip we take 2200km for a European flight back and forth
- this is equal to 748 kWh per person per holiday travel by plan inside Europe
- when we divide this by 365 days, we get **2 kWh/d/p inside Europe per holiday**

- typical travel distances for holiday flights outside Europe:
  6000km US East Cost, 9000km US West Cost, 9000km South Africa, 9000km South East Asia, 17000km Australia or New Zealand, 9000km Brazil, 8000 - 13000km South America
- outside Europe ca. 10000km average linear distance one-way seems reasonable (20000km in total)
- this is equal to **18,6 kWh/d/p outside Europe per holiday**

2. Bus

- for the bus we will assume the same traveling distance of 1100km as for the plane
- in this case, the values remain comparable
- bus travels might be to closer destinations than the plane, but bus travels don't go linear
- 1100km seems reasonable on the road for a bus travel one-way (2200km in total)

- data from the Federal Environment Agency of Germany https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/180607_uba_hg_fernbus_bf.pdf
- capacity of long-distance busses 60% on average (could be improved to maybe 80%)
- the average consumption is **1,2 l/100km/p**
- diesel fuel contains 9,8 kWh of energy per litre
- we get for the average energy consumption **11,8 kWh/100km/p**

- for 2200km travel distance back and forth, we get 260 kWh/p
- when we divide this by 365 days, we get **0,7 kWh/d/p per holiday**

3. Car

- for the car we will assume the same traveling distance of 1100km as for the plane
- in this case, the values remain comparable
- car travels might be to closer destinations than the plane, but car travels don't go linear
- 1100km seems reasonable on the road for a bus travel one-way (2200km in total)

- the average OECD countries consumption is **8 l/100km** by the Global Fuel Economy Initiative https://www.globalfueleconomy.org/media/44069/wp5-iea-fuel-economy-report.pdf
- petrol contains 8,9 kWh of energy per litre
- we get for the average energy consumption is **71,2 kWh/100km**

- for 2200km travel distance back and forth we get 1566 kWh
- when we divide this by 365 days, we get 4,3 kWh/d
- if there is 1 person in the car, we get **4,3 kWh/d/p per holiday**
- if there are 2 persons in the car, we get **2,1 kWh/d/p per holiday**

4. Train

- for the train we will assume the same traveling distance of 1100km as for the plane
- in this case, the values remain comparable
- train travels might be to closer destinations than the plane, but train travels don't go linear
- 1100km seems reasonable on the road for a train travel one-way (2200km in total)

- data from the SEWHTA book gives **1500 kWh/100km** energy consumption for electric trains

- for 2200km travel distance back and forth we get 33000 kWh
- when we divide this by 365 days, we get 90,4 kWh/d
- the SEWTHA book refers to trains with 498 seats
- in Germany with a large statistics, the average occupancy of long-distance trains is 56,1% https://de.statista.com/statistik/daten/studie/162886/umfrage/auslastung-der-zuege-der-deutschen-bahn-im-fernverkehr-seit-2006/
- this is equal to 279 persons in a train with 498 seats
- if there are 279 persons in the train, we get **0,3 kWh/d/p per holiday**