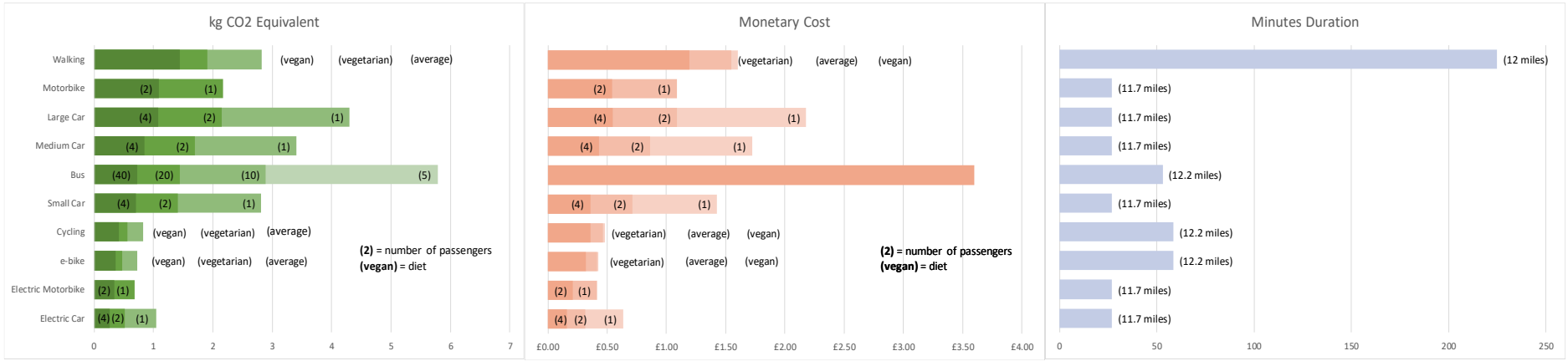
Carbon Cost of Fueling Journeys

(see the end for details on calculations and sources)

Ottery to Exeter

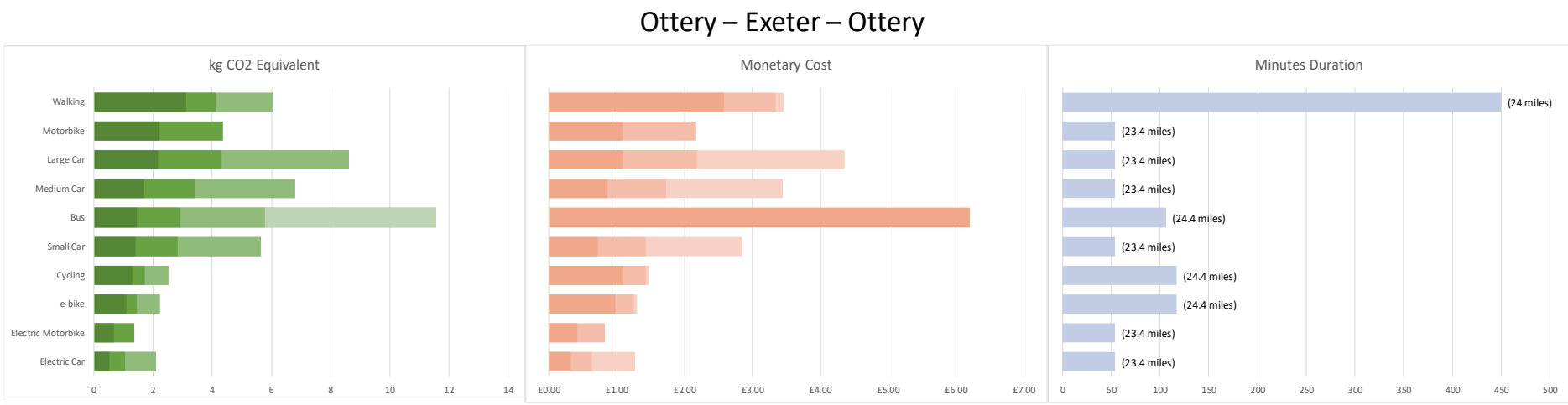


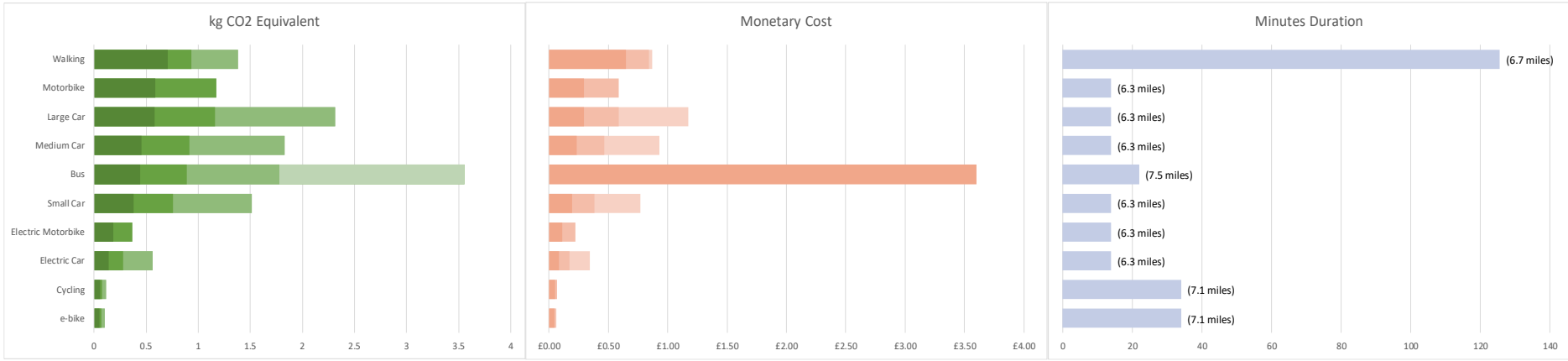
We are only looking at the emissions and costs from fueling the journey and not including figures from manufacturing, maintenance etcetera. The emissions figures *do* include the emissions from fuel production as well as fuel use (e.g. oil refinement).

Human-powered transport is complicated – differences in diet are significant since different foods have widely different carbon footprints as well as costs – but you also need a certain level of exercise to stay healthy. Emissions/costs from recommended exercise are therefore unavoidable and can be discounted if used for travel. If journey distance leads to exercise beyond recommended levels, this superfluous exercise should not be discounted. Human power is therefore more favourable for short journeys:

Ottery to West Hill

Below are charts for two more distances:





Take-away Messages

Electric vehicles, despite their infancy, are amazingly low impact. A popular talking point is the greater environmental impact of manufacturing an EV, however it is now looking like EV's will also last much longer and require less maintenance than a traditional car. Tesla will soon be manufacturing a battery with a usable lifespan of 1 million miles (source [14]), and batteries beyond their usable lifespan are still perfectly usable in storing surplus energy from renewable power generation. Meanwhile EV's simplicity and reliability is such that the Peugeot group believe they threaten the current industry model (source [15]), as there will be much less need to regularly buy a newer vehicle. It is therefore important to replace combustion vehicles with electric vehicles as rapidly as possible, and we

need to work hard to remove the financial (purchase cost) and logistical (charging points) barriers in the way. Short-term hire companies such as Co-cars are making EV's available without the need to purchase; installation of such a car may be possible in Ottery if there were enough interest.

Lift sharing / greater bus use is powerful for reducing cost and environmental impact. The differences between transport methods are small enough that dividing between more people is a big influence on which transport is the right choice. Outside of workplaces lift sharing is little explored and there may be big benefits to making it easier for people to lift share in their day-to-day, for example by spreading the word on services such as liftshare.com.

Buses can be wonderful or awful for the environment, depending on how utilised they are. It's clearly important to encourage more people onto buses, yet Stagecoach Bus' pricing model is shockingly bad for this. It is only slightly cheaper to take a much shorter journey, and the savings on a return ticket are also minimal. If these prices really reflect the cost to the company then subsidies may need to be explored.

Food's impact is not to be ignored. It's high enough that human-powered transport is not always the greenest option, and dietary difference is great enough that it can affect this comparison.

<u>Calculations</u>

Emissions

- Car, motorbike, electric car, bus – from source [1]
- Electric motorbike – derived from source [1]'s emissions difference between an average car and an average motorbike:
    - Motorbike = 0.186 per mile
    - Car = 0.285 per mile
    - Ratio = 0.652
    - Average Electric Car = 0.089 per mile
    - Average Electric Motorbike = 0.089 x 0.652 = 0.058 kg CO2e per mile

Human Power

- kcal per hour (for human power) assuming 77.25kg person (source [3])
- 30 minutes discounted following recommended exercise in source [7] (150 minutes per week averaged over 5 days)
- Dietary kg CO2 equivalent per kcal – from source [2]
- Walking:
    - Miles per hour = 3.2
    - kcal per hour = 308 (source [4], walking to work)
    - kcal per mile = 96.25
      then applied to CO2e per kcal
    - 30 minutes discounted = 1.6 miles

- Cycling:
  - Miles per hour = 12.5
  - kcal per hour = 626 (source [4], moderate cycling)
  - kcal per mile = 49.28
    then applied to CO2e per kcal
  - 30 minutes discounted = 6.25 miles
- e-bike:
  - Energy ratio vs normal cycling = 6.1 to 5.2 = 0.852 (source [5])
  - kcal per mile = 49.28 x 0.852 = 42.01
    then applied to CO2e per kcal
  - 30 minutes discounted = 6.25 miles

  - Electricity kW per mile = 0.015 (source [6])
  - Electricity kg CO2 equivalent per kW = 0.2556 (source [1])
  - Electricity kg CO2 equivalent per mile = 0.015 * 0.256 = 0.004
    then combined with CO2e from diet

Monetary Costs

- Litres fuel per kg CO2: (source [10])
  - Petrol = 0.418
  - Diesel = 0.379
  - Average = 0.398
- Cost per litre fuel: (source [11])
  - Petrol = £1.26
  - Diesel = £1.30
  - Average = £1.28
- Car and motorbike – cost per mile calculated using kg CO2 per mile from source [1], then converting through average litres per kg CO2 (see above) and applying average cost per litre (see above)
- Electric car:
  - kg CO2 equivalent per mile = 0.089 (source [1])
  - kg CO2 equivalent per kW = 0.2556 (source [1])
  - kWh per mile = 0.089 / 0.2556 = 0.349
  - Cost per kWh = 15.5p (source [12])

    - Cost per mile = 0.349 x 0.155 = 5.4p
- Electric motorbike:
    - Using same conversion ratio from electric car as the emissions section = 0.652
    - kWh per mile = 0.349 x 0.652 = 0.228
    - Cost per mile = 0.228 x 0.155 = 3.5p

Human Power

- UK daily kcal intake = 3450 (source [9])
- UK annual kcal intake = 1,259,250
- Average annual costs of diets taken from source [8], divided by annual kcal intake to provide costs per kcal
- See emissions section for kcal used in each human powered transport
- e-bike:
    - Electricity kW per mile = 0.015 (source [6])
    - Cost per kWh = 15.5p (source [12])
    - Electricity cost per mile = 0.015 * 0.155 = 0.2p
      then combined with dietary costs

<u>Routes</u>

Route times used for bus, car, motorbike. For walking and cycling, standard speed (see emissions section) was applied to the route distance

Note that the bus route varies slightly depending on the time of day

Walking Ottery to Exeter https://goo.gl/maps/H4EGF5AomLB2ZSBn6

Cycling Ottery to Exeter https://goo.gl/maps/LHLSGkJb4LnR8dmf6

Bus Ottery to Exeter https://goo.gl/maps/JXd4AzSDJgY6Mgs1A

Car/Motorbike Ottery to Exeter https://goo.gl/maps/usrqk9bM7UxfDh4NA

Walking Ottery to Cranbrook https://goo.gl/maps/UW2Le1MjRMJ7gmqV9

Cycling Ottery to Cranbrook https://goo.gl/maps/pN1pEbw4UAcHfvXy7

Bus Ottery to Cranbrook https://goo.gl/maps/rrDGJnEtaXKZ6kzY7

Car/Motorbike Ottery to Cranbrook https://goo.gl/maps/9jdGaMwKCFB1LHrF9

Walking Ottery to West Hill https://goo.gl/maps/GXJbBo9QhH2wWJXs6

Cycling Ottery to West Hill https://goo.gl/maps/dktvC34iqiGTb9Xe9

Bus Ottery to West Hill https://goo.gl/maps/h9TG5XXxrzAckeFq6

Car/Motorbike Ottery to West Hill https://goo.gl/maps/Mqf479qs38WxJgcC6

Sources

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1b & methodology paper https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/829336/2019_Green-house-gas-reporting-methodology.pdf

2 Dietary carbon footprints https://link.springer.com/article/10.1007/s10584-014-1169-1

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4 BUPA kcal from exercise https://www.bupa.co.uk/health-information/tools-calculators/calories-calculator

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8 UK Diet Costs https://www.finder.com/uk/uk-diet-trends

9 UK Daily kcal http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/FoodConsumptionNutrients_en.xls#

10 CO2 to litres conversion http://ecoscore.be/en/info/ecoscore/co2

11 UK fuel prices (using 2019-11-04) https://www.gov.uk/government/statistical-data-sets/oil-and-petroleum-products-weekly-statistics

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13 Stagecoach Bus Fares https://www.stagecoachbus.com/tickets

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15 EV threat to industry https://www.autocar.co.uk/car-news/industry/psa-group-evs-threaten-car-industry