Commute analysis

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Problem statement

Compare the energy and CO2 costs of these different commuting methods:

-Angelenos car driver with 40-mile roundtrip
-New York subway rider with 15-mile roundtrip
-Evanstonian bike rider with 4-mile roundtrip
-Bostonian bus rider with 6-mile roundtrip
-Chicago El rider with 15-mile roundtrip
-Venetian rider of a "vaporetto" with 4-mile roundtrip

Given assumptions

- Roads are assumed to be existing.
- Rail/tunnels (for subway) must be fully accounted for.
- Consider typical recycling rates given by CES, both for creating and disposing of vehicles.
- Maintenance costs can be ignored.

Venice vaporetto

Venice vaporetto assumptions

- Approximately same composition, weight, and lifetime as subway car.
- From nzsses.auckland.ac.nz Sustainable Transport study, emit 1.37 kg of CO_2 per mile
- From Wikipedia, 150 passengers per trip

Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37

Boston bus assumptions

- From greencarcongress.com, get 2.3 miles per gallon
- From wiki.answers.com, average mass is 11364 kg
- CO2 emissions scaled up from car based on mass
- From Wikipedia, diesel contains 38.7 MJ per liter
- Composition is 100% steel
- Bus lifetime is 5 years

Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37
Bus	49.32	3.3

New York subway "assumptions"

- From 1904 NY subway info from *Railway Age* (2004), subway car composition.
- From nycsubway.org, ridership and track trivia (length, cars in service, etc.).
- Linear increase in usage from 1900 to 2005.

Rail			
Fraction of total NY subway in 15 mi	0.07		Not all riders will travel over this part of the track
Steel needed for rail (g/mi)	83823870		http://www.railway-technical.com/track.shtml
Energy from steel production (J/g)	25583		CES for carbon steel AISI 1080
CO2 from steel production (g/g)		2.17	CES for carbon steel AISI 1080
Wooden ties needed for rail (g/mi)	211200000		http://www.railway-technical.com/track.shtml
Energy from wood production (J/g)	15141		CES for wood
CO2 from wood production (g/g)		-1.11	CES for wood
Stone ballast needed for rail (g/mi)	1047062780		www.railway-technical.com/track.shtml and track gauge
Energy from stone production (J/g)	190		CES for stone
CO2 from stone production (g/g)		0.01	CES for stone
Track gauge (m)	1.435		wikipedia.org
Lifespan of rails (yr)	40		Estimated from ask.metafilter.com (How long do the rails in a subway last?)
Riders in rail lifespan	223259010		Calculated from population data

Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37
Bus	49.32	3.3
Subway	65	4.3

Chicago elevated train assumptions

- Use New York subway data, except
  - Subtract out tunnel costs.
  - Scale down based on ridership.

Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37
Bus	49.32	3.3
Subway	65	4.3
El	115.00	6.4

Los Angeles car assumptions

- From autoalliance.org, car is 62% steel, 12% iron 9% aluminum, 9% plastic, 3% glass, and 5% rubber.
- One person per car
- Gets 25 miles per gallon
- Weighs 1306 kg (autoalliance.org)
- Lifespan is 150,000 miles
- From uvi.edu, 60,360,000 J per gallon of gasoline
- From Hu et. al. (*Appl. Energy* 2004), 0.23 J needed to produce 1 J of gasoline
- From bee.gov.in, 2393.1 MJ needed to manufacture one car
- From cleancarcampaign.org, 100% of the car is recycled.

Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37
Bus	49.32	3.3
Subway	65	4.3
El	115.00	6.4
Car	140	11.9

Evanston bike assumptions

- From depts.washington.edu bike materials case study, bike is 90% aluminum, 7% steel, and 3% plastic.
- Commuter bikes last about 6 years (estimated via ridemonkey.com).
- Bike weighs 25 pounds

Food, embedded energy (cal/cal ingested)	11	www.holon.se (Folke Günther)
Distance traveled by food (miles)	1,318.0	Assume food travels halfway across the USA (www.timeanddate.com)
Bike calories per mile	35	Florida Urban Transport Research
Efficiency of human body (calories output/calories input)	0.2	mb-soft.com
Volume of semi (cubic meters)	90	http://autoline.info/sales.php?cat=004
Semi truck miles per gallon	6.0	2006 average
Energy per volume of food (MJ/oz)	0.106	wikipedia, for a banana

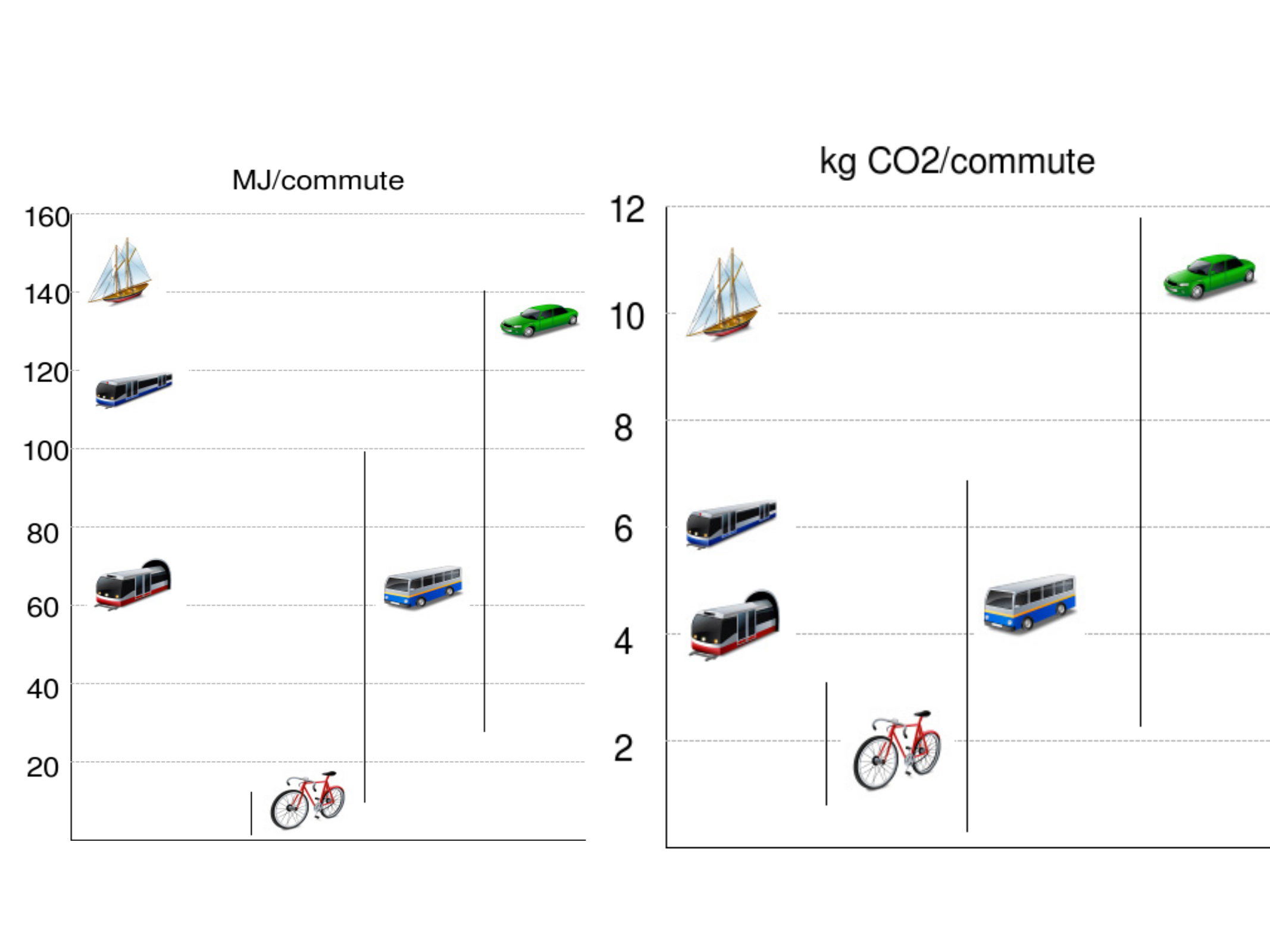
Totals

	MJ/commute	kg CO2/commute
Vaporetto	142.24	10.37
Bus	49.32	3.3
Subway	65	4.3
El	115.00	6.4
Car	140	11.9
Bike	5.74	2.1

Best- and worst-case analysis of car, bike, and bus

-We vary within reason the parameters of these four modes of transportation.

- Car: change mpg (50) and weight (730 kg) to that of a small, European car; account for car-pooling (4 riders); factor in cost of road (estimated from DOT and DOE info on miles traveled per year and money spent on maintenance and lighting)
- Bike: vary distance that food travels (20-3000 miles)
- Bus: vary ridership (10-110% capacity); factor in cost of road


MJ/commute
160
140
120
100
80
60
40
20
kg CO2/commute
12
10
8
6
4
2

Numbers (in case anyone is interested)

	MJ/commute	kg CO2/commute	
Car 25, 1, big, road	140.90	11.94	road cost for car is .9 MJ/commute and .04 kg/commute
Car 50, 1, big, road	81.40	6.72	
Car 50, 1, small, road	72.40	6.13	
Car 50, 4, small, no road	26.90	2.18	
Bike near	2.88	1.06	
Bike far	9.45	3.50	
Bus 10%, road	99.50	6.62	road cost for bus is 6.01 MJ/commute and .29 kg CO2/commute
Bus 110% no road	9.00	0.60	

The end!!