

Energy and Transportation

or the things they carried

Jimmy Jia

jimmy@jimmyjia.com

Last Edit: April 14, 2019



This work is licensed under a [Creative Commons Attribution 4.0 International License](#)

Preparatory Discussion

What are the advantages and disadvantages between:

A government
services
business model

VS

A free market
business model

Energy of Motion

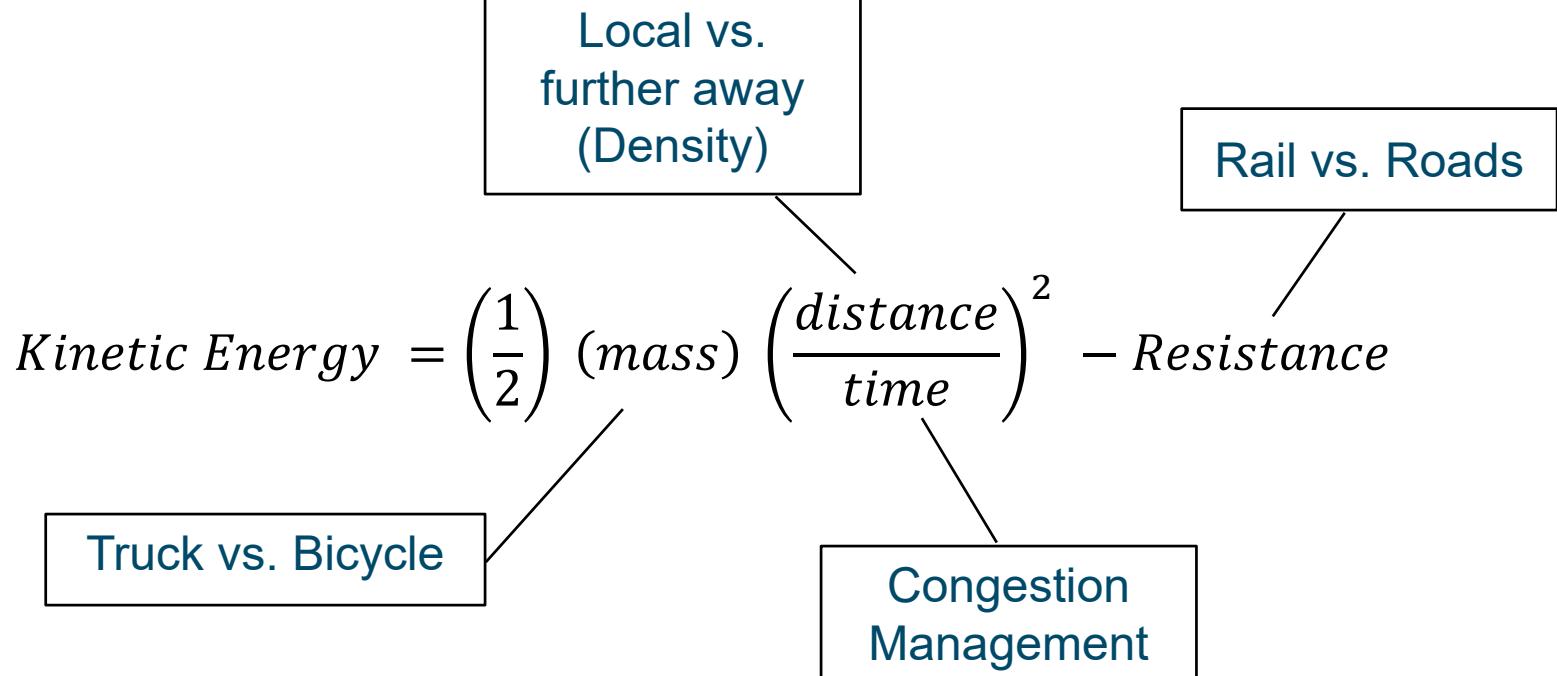
$$Kinetic\ Energy = \left(\frac{1}{2}\right) (mass) (velocity)^2 - Resistance$$

$$Kinetic\ Energy = \left(\frac{1}{2}\right) (mass) \left(\frac{distance}{time}\right)^2 - Resistance$$

Energy increases when you

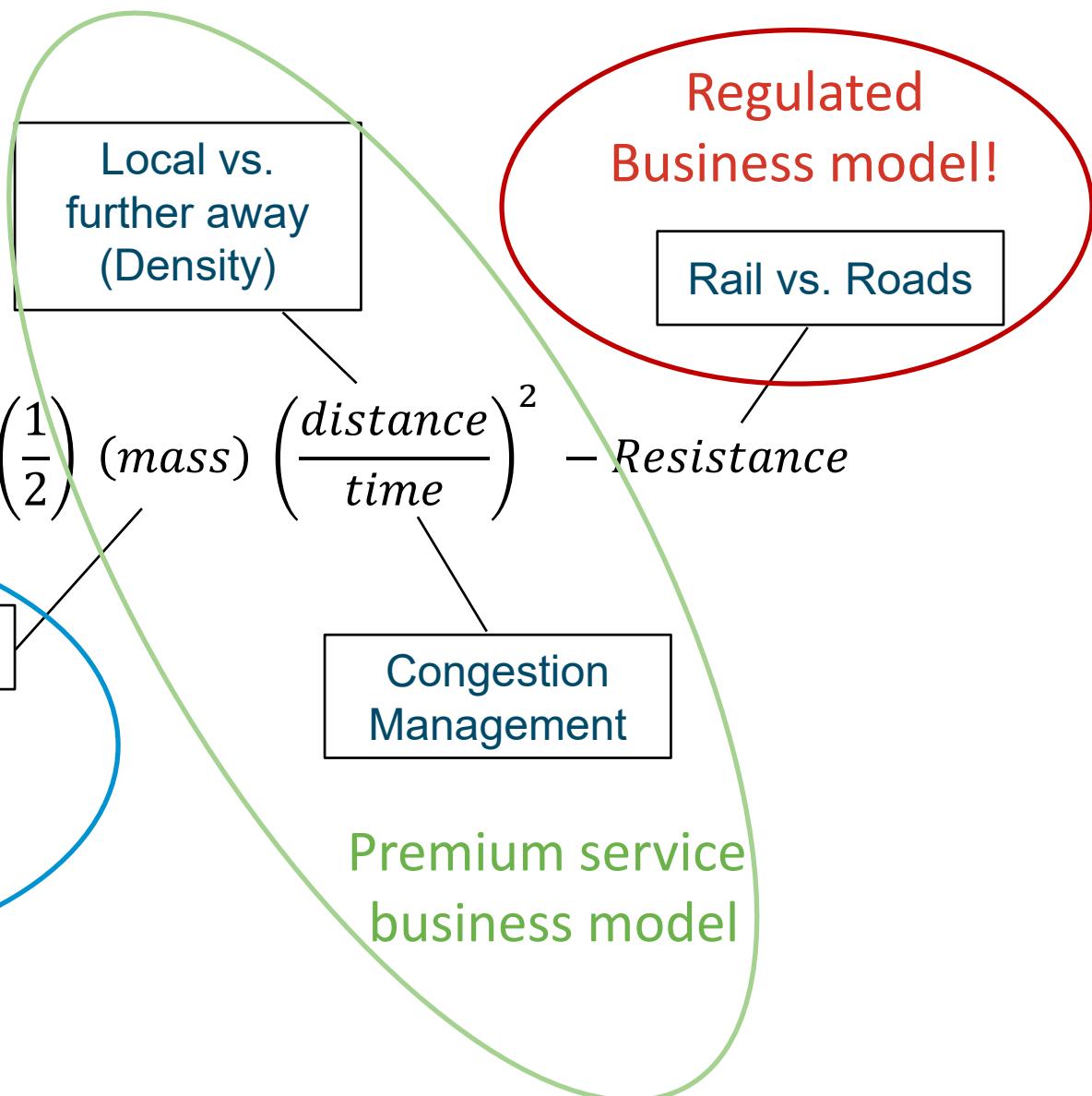
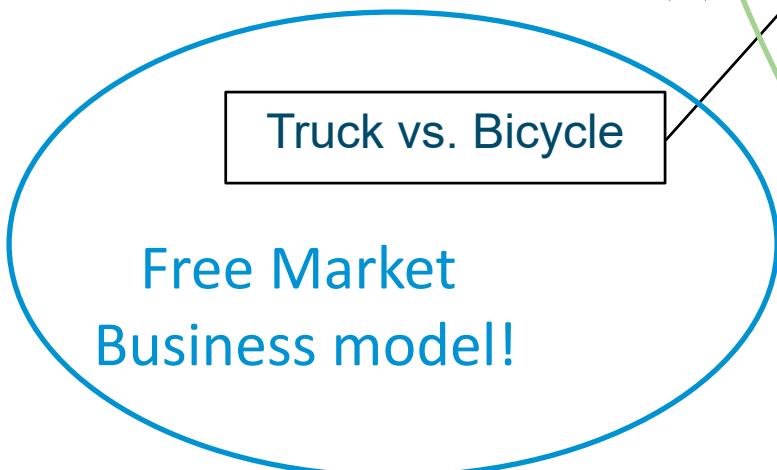
- ★ - move heavier things ★
 - move faster
 - move further

Energy of Motion

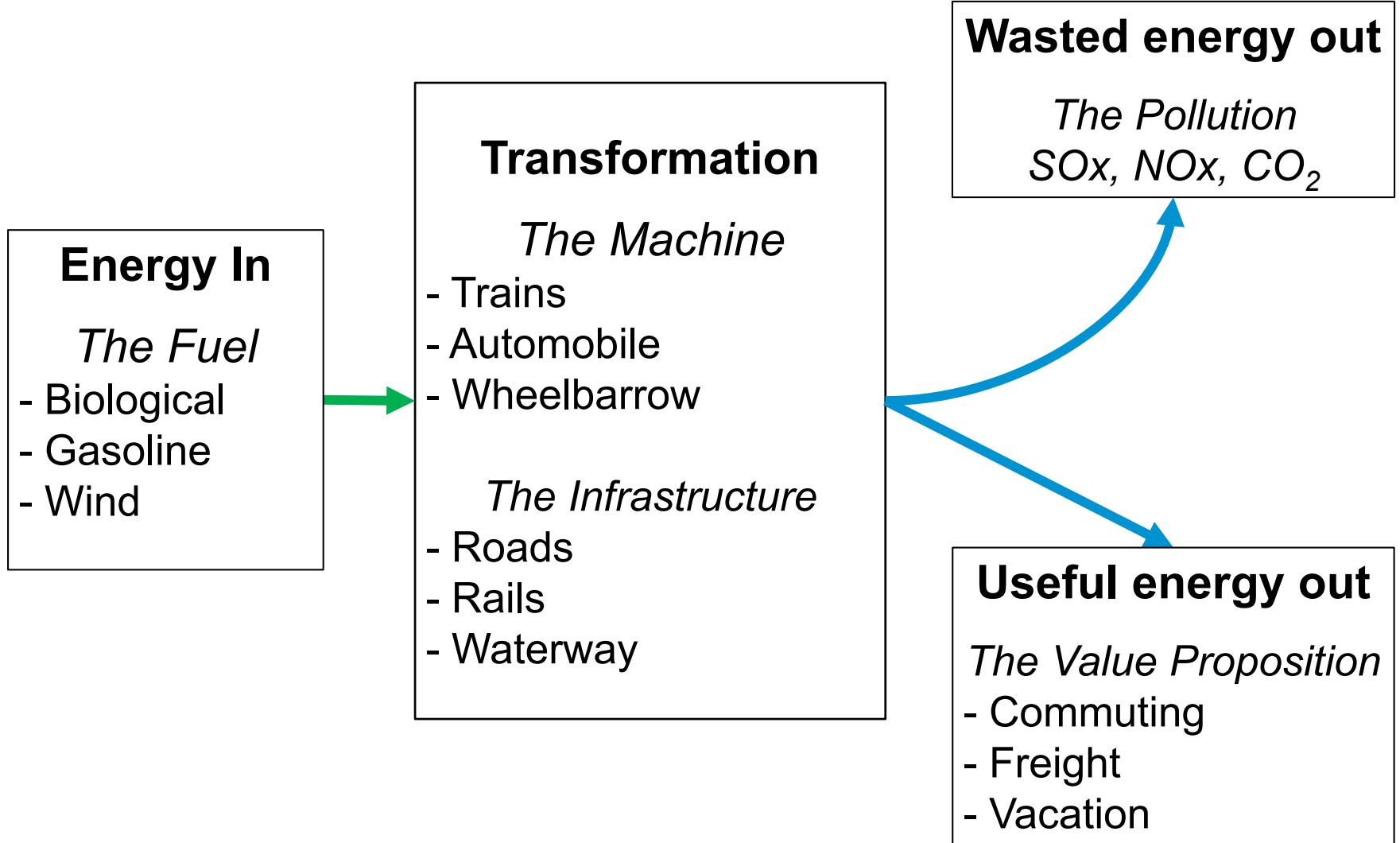


Energy of Motion

$$\text{Kinetic Energy} = \left(\frac{1}{2}\right) (\text{mass}) \left(\frac{\text{distance}}{\text{time}}\right)^2 - \text{Resistance}$$



Energy Framework of Transportation

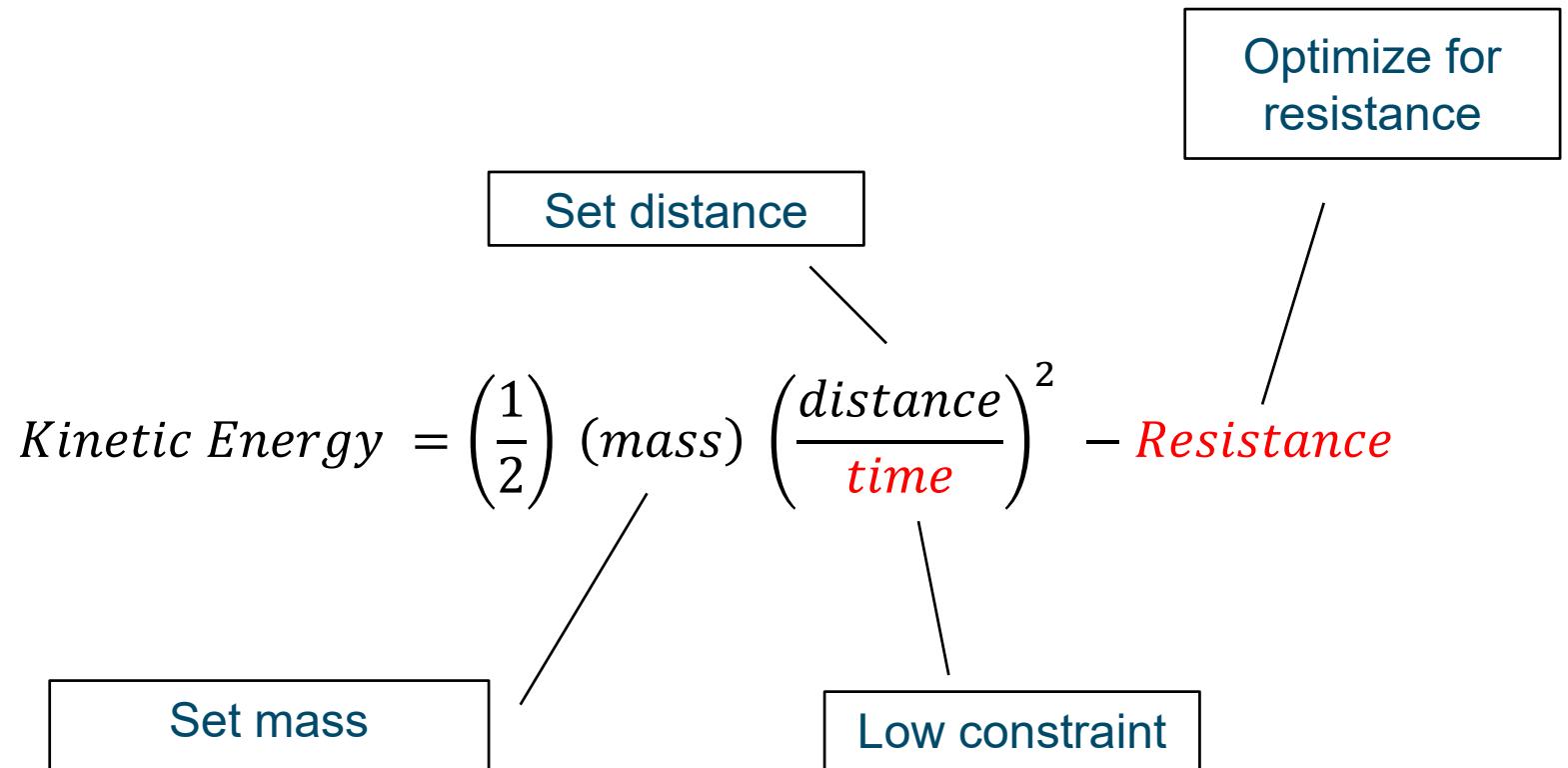


Move AROUND or IN / OUT ?



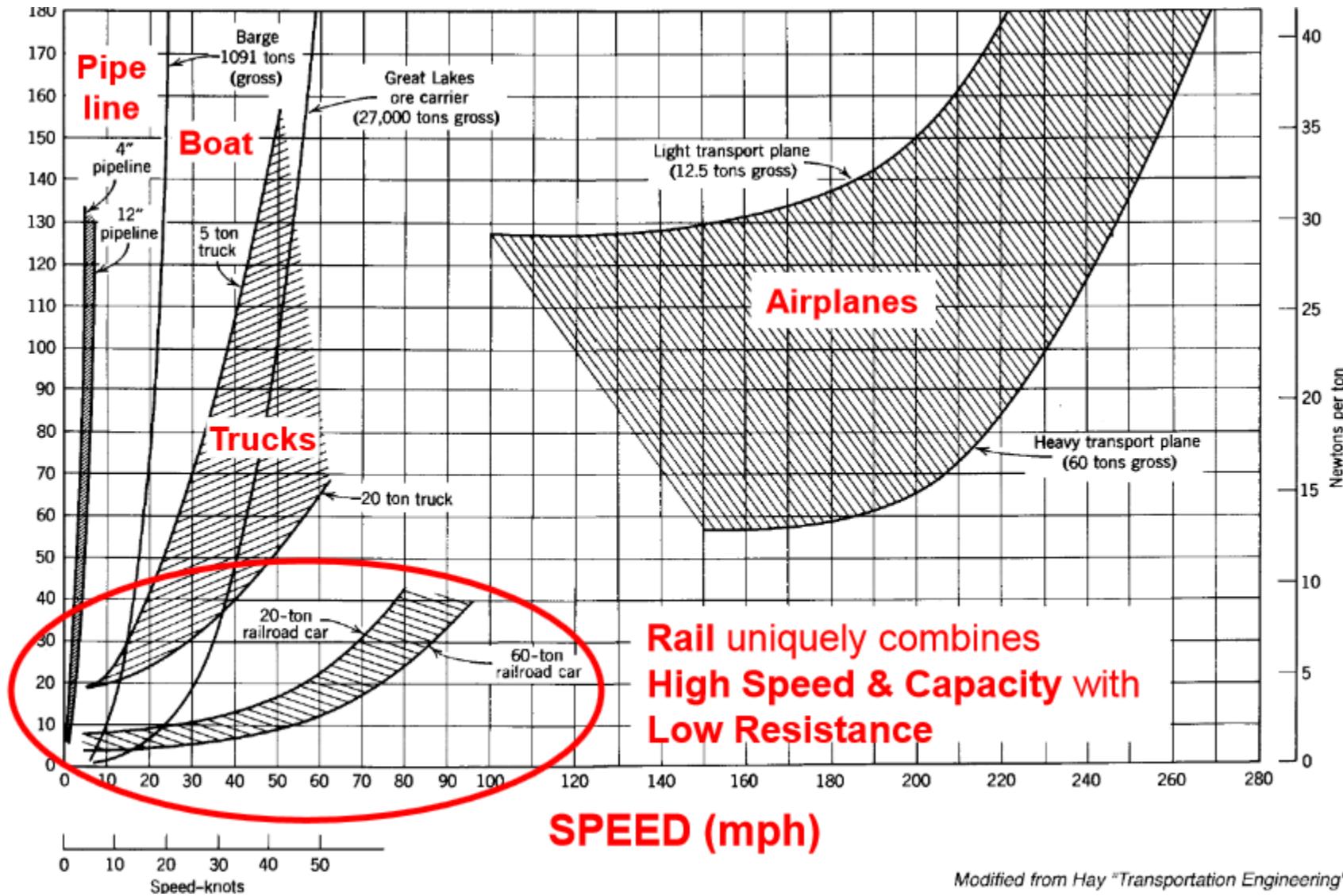
Scenario A:

Move 2,000 tons of potatoes from Boise to Los Angeles next week



Role of Rail

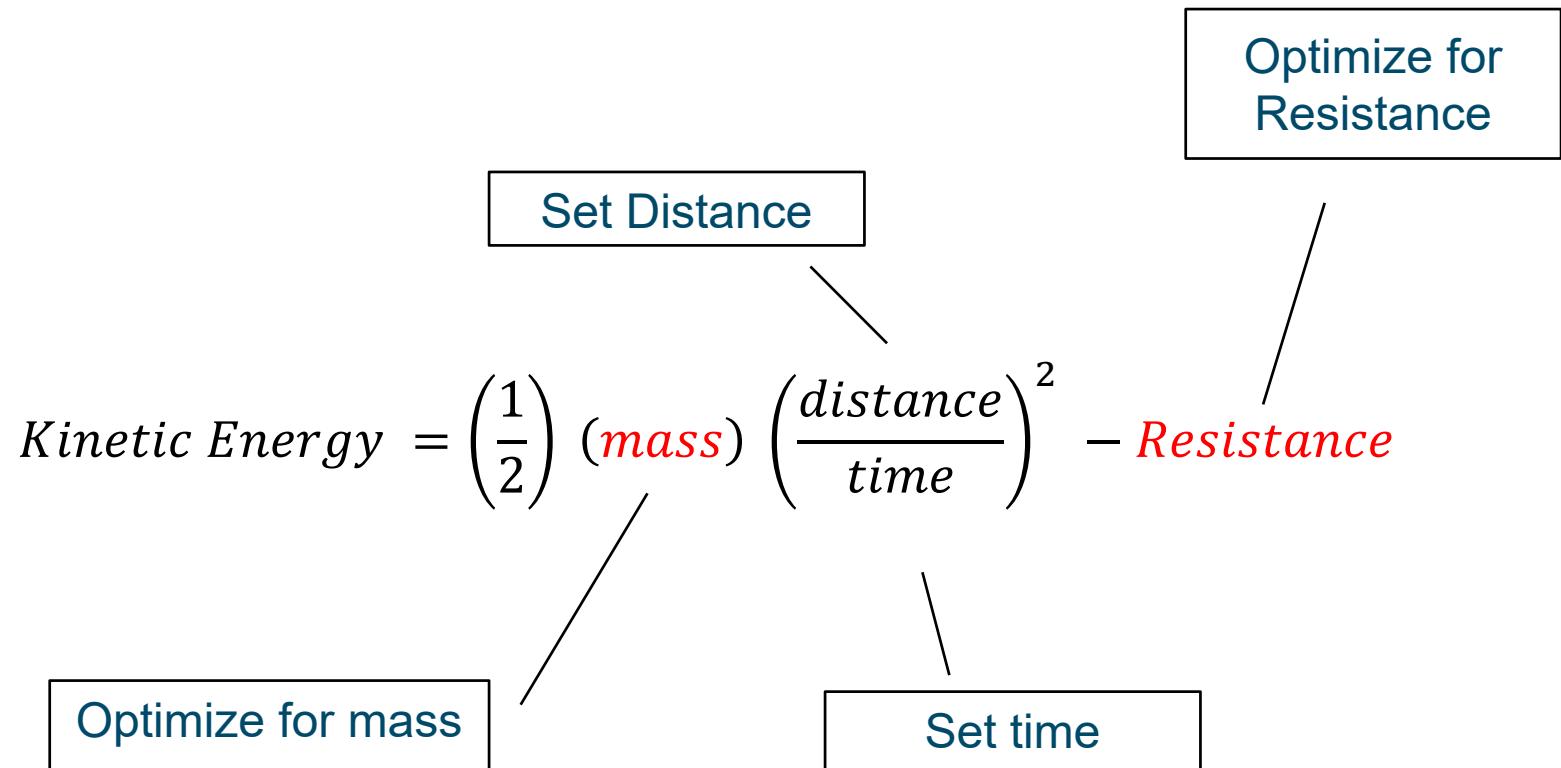
RESISTANCE (lbs./ton)



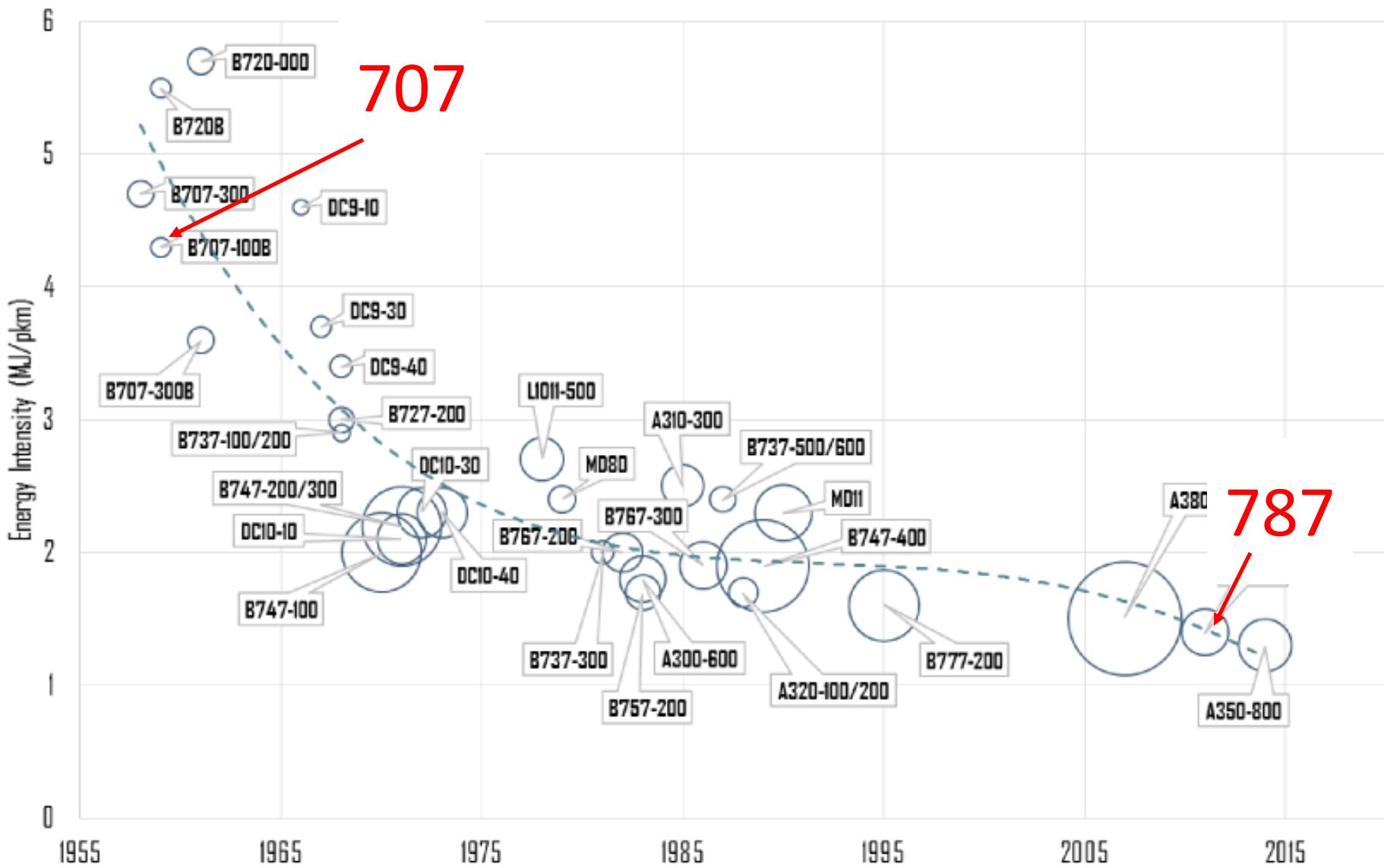
Modified from Hay "Transportation Engineering"

Scenario B:

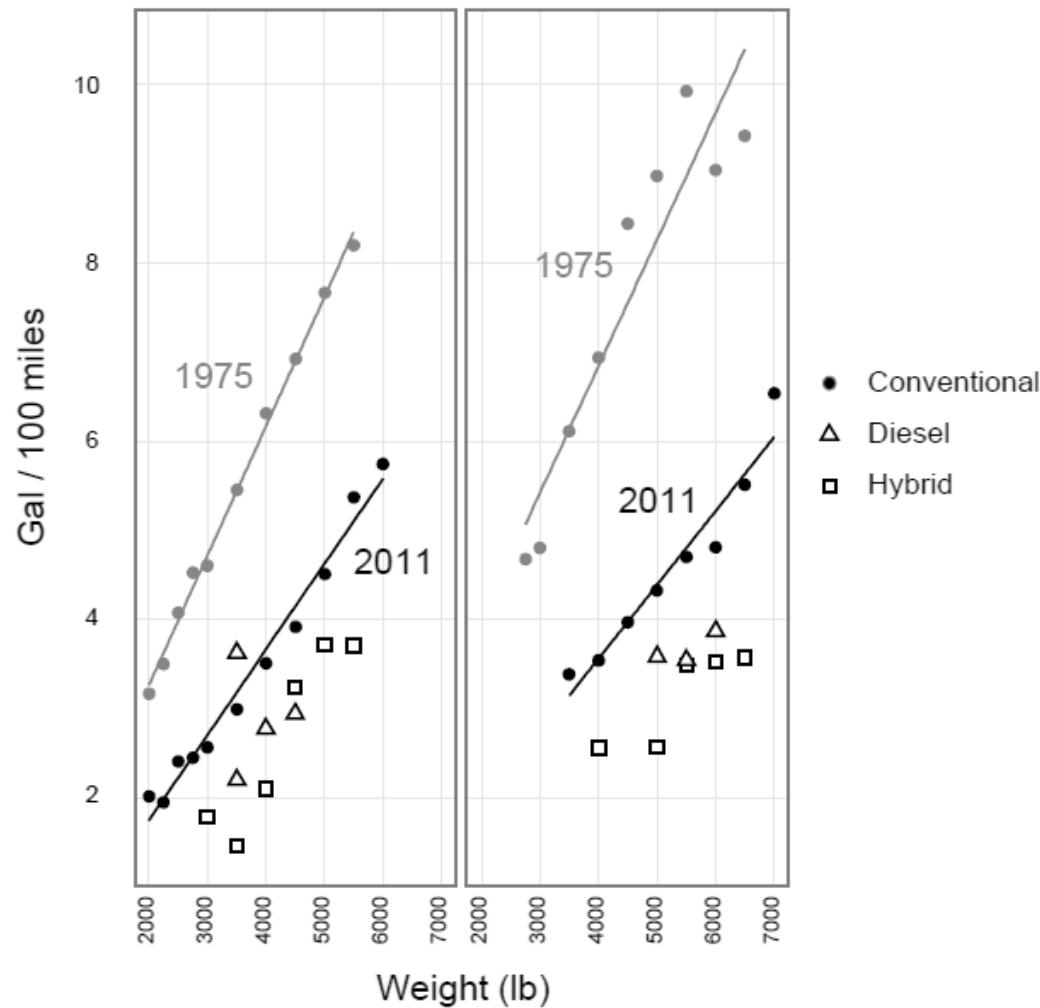
Business trip from Seattle to New York tomorrow morning



Efficiency of different Jet Liners

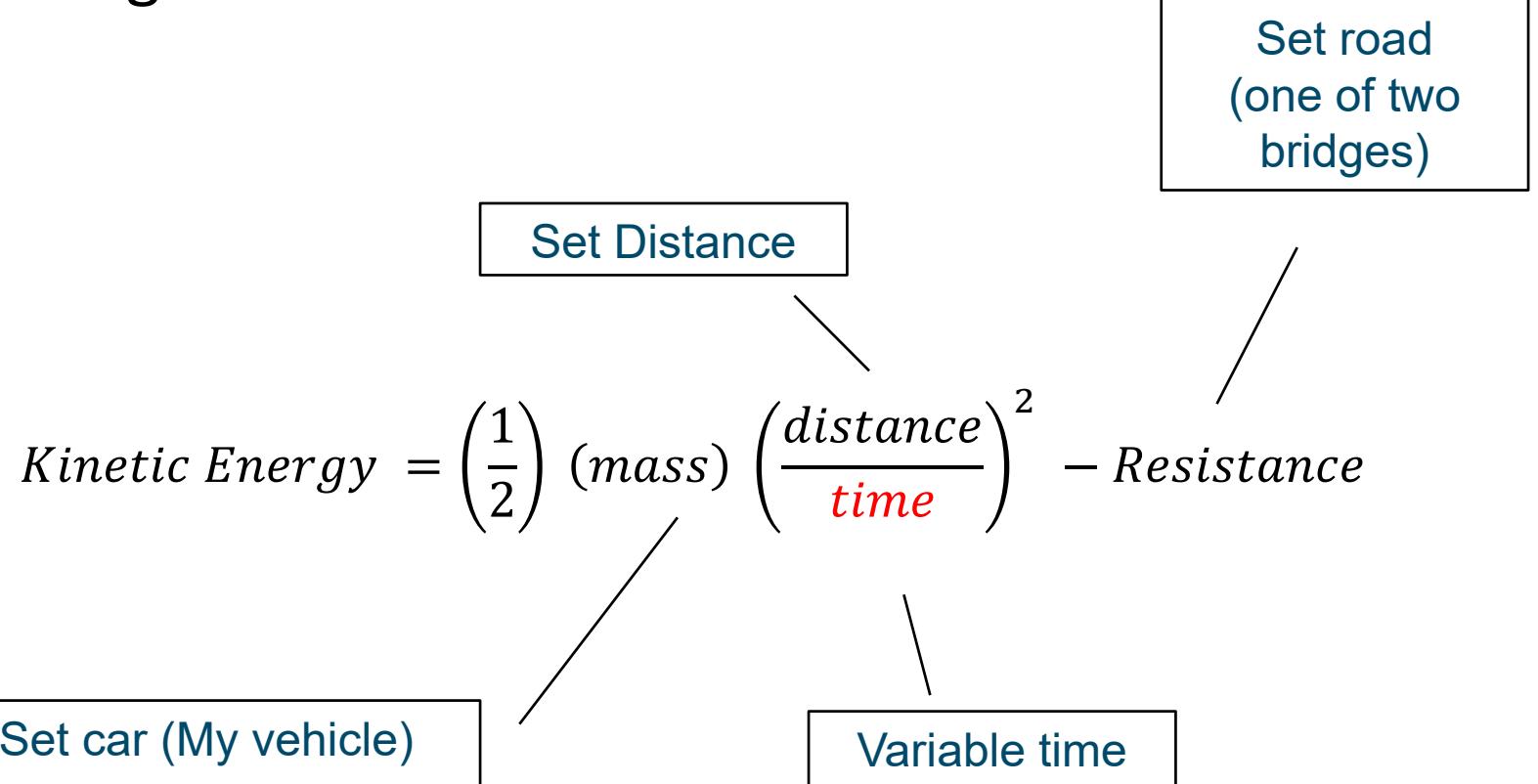


Weight is the foe of transportation

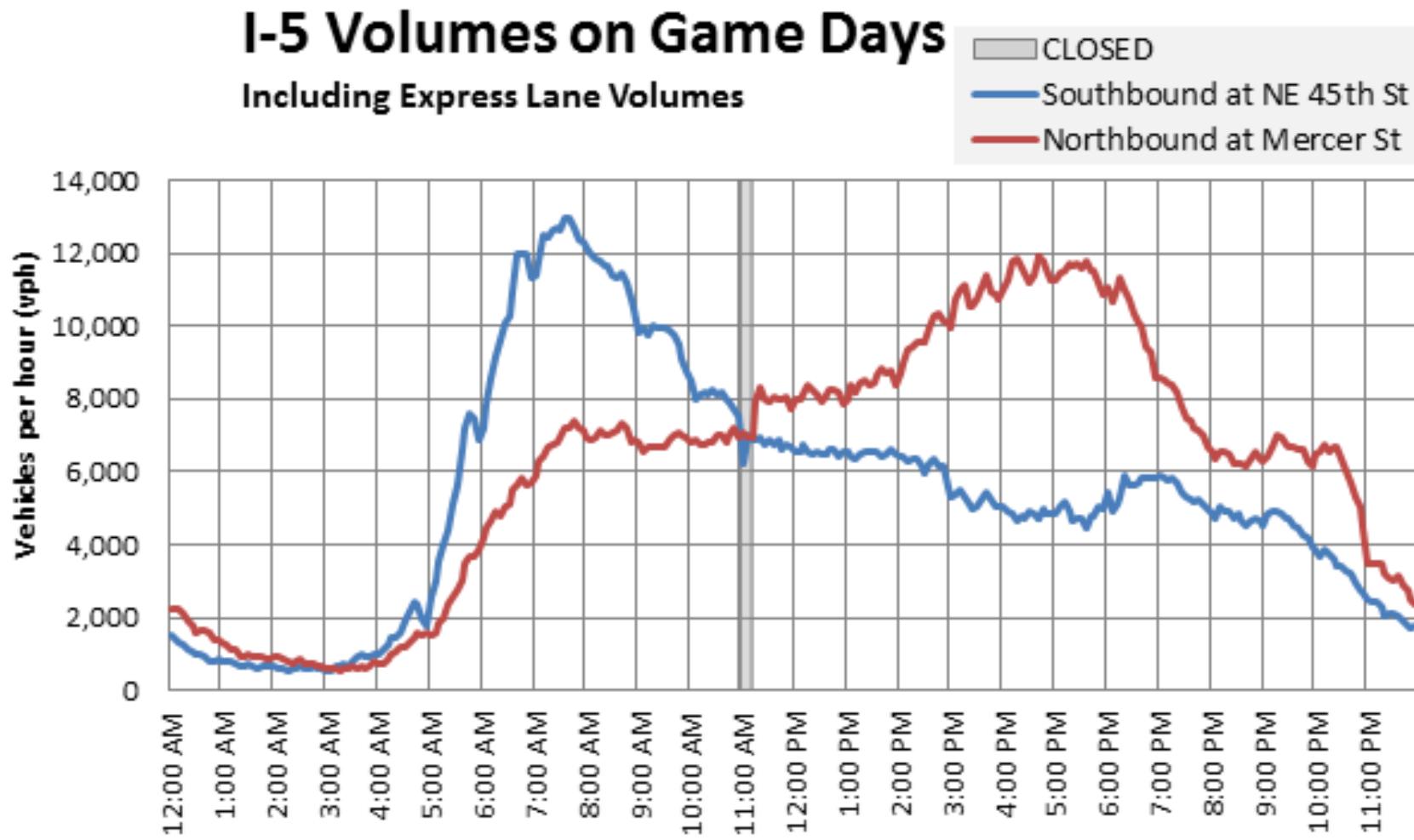


Scenario C:

Daily commute from Seattle to Microsoft across one of two bridges



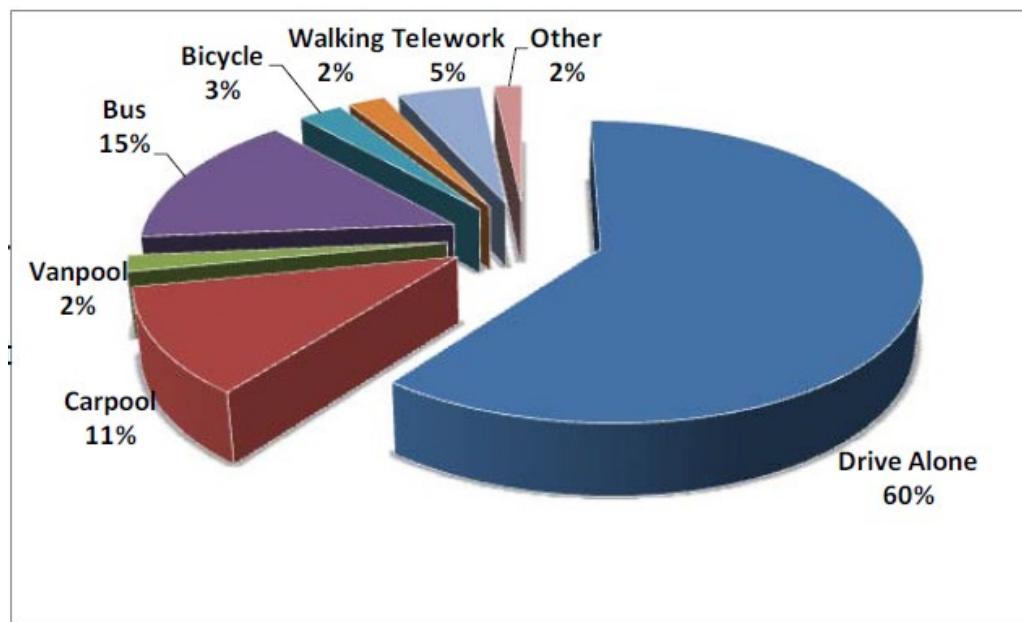
I5 Congestion



Commuting - Time

Microsoft Shuttle

- 74 busses
- 19,000 employees from Seattle to Redmond
- 40.5 million miles eliminated



Commuting - Time

Microsoft Shuttle

- 74 busses
- 19,000 employees from Seattle to Redmond
- 40.5 million miles eliminated

	Average Annual Daily Trips (number of vehicles)	Maximum Volume (vehicles per hour)
SR 520	68,000 (after tolling)	3,500
I 90	148,000	7,000
MSFT	38,000	9,500
MSFT %	8.7%	60-90%

Can technology replacing needs of transportation?

Diverse in their characteristics



Home Worker



Mixed Worker



Onsite Worker

total workers	9.4 million	4.0 million	128.2 million
median age	47.5 yr. old	45.5 yr. old	41.3 yr. old
median salary	\$25,500/yr.	\$52,800/yr.	\$30,000/yr.
hours worked	37.4 per wk.	41.4 per wk.	37.4 per wk.
bachelor's degree or higher	50.5 percent	63.3 percent	29.7 percent

Source: Survey of Income and Program Participation (SIPP)

- 9.2 million (in 1997) to 13.4 million (in 2010)
- 1 in 4 are in business or management fields
- Growing rapidly in Engineering and Science fields

Why do we travel?

- How Many Trips We Take in a Year

- 411 billion daily trips a year or about 1,500 trips per person
- 4 trillion miles — 14,500 miles per person

- Why We Travel

- 45 percent of daily trips are taken for shopping and errands
- 27 percent of daily trips are social and recreational
- 15 percent of daily trips are taken for commuting

- When We Travel

- The most daily trips are made on Friday (16 percent)
- The fewest daily trips are made on Sunday (13 percent)
- More daily trips are taken between noon and 1 p.m. (7.4 percent) than between 8 a.m. - 9 a.m. (5.5 percent)

Accomplishing Errands - Distance



Hello : Your

Elect
Gift

amazon Try Prime Your Amazon.com Today's Deals Gift Cards Sell Help

Shop by Department Search Coffee Machines

Kitchen & Dining Best Sellers Small Appliances Kitchen Tools Cookware Bakeware Tabletop Cutlery Food Service Gift Ideas Wedding Registry Go

Department Home & Kitchen Kitchen & Dining Coffee, Tea & Espresso Coffee Makers Coffee Machines

Product Grade Commercial Grade (154)

Color

Eligible for Free Shipping Free Shipping by Amazon

Coffee Machine Features Clear Manual ☑ Coffee Grinder (8) Permanent Filter (42) Thermal (14)

Capacity Under 5 Cups (27) 5 to 7 Cups (8)

Hamilton Beach 49316 12-Cup Coffeemaker, Black \$19.99 Prime Order in the next 22 hours and get it by Friday, Nov 15. FREE Shipping on orders over \$35 More Buying Choices \$18.86 new (27 offers) See Color Options

BUNN BT Velocity Brew 10-Cup Thermal Carafe Home Coffee Brewer, Black \$460.99 \$126.45 Prime Order in the next 22 hours and get it by Friday, Nov 15. FREE Shipping on orders over \$35 More Buying Choices \$65.00 \$29.99 Prime Order in the next 21 minutes and get it by Thursday, Nov 14. FREE Shipping on orders over \$35 More Buying Choices See Size Options See Color Options

Cuisinart DCC-450BK 4-Cup Coffeemaker with Stainless-Steel Carafe, Black \$65.00 \$29.99 Prime Order in the next 21 minutes and get it by Thursday, Nov 14. FREE Shipping on orders over \$35 More Buying Choices

Home & Kitchen > Kitchen & Dining > Coffee, Tea & Espresso > Coffee Makers > Coffee Machines > Manual

Showing 1 - 24 of 299 Results Detail Image

A screenshot of an Amazon search results page for "Coffee Machines". The search bar at the top contains "Coffee Machines". Below the search bar, there are filters for "Shop by Department" (Kitchen & Dining), "Product Grade" (Commercial Grade), and "Color". The main content area shows three products: "Hamilton Beach 49316 12-Cup Coffeemaker, Black", "BUNN BT Velocity Brew 10-Cup Thermal Carafe Home Coffee Brewer, Black", and "Cuisinart DCC-450BK 4-Cup Coffeemaker with Stainless-Steel Carafe, Black". Each product listing includes the price, Prime status, shipping information, and a "More Buying Choices" link.

Accomplishing Errands - Distance

- Advantages

- Flexible
- ‘Emersion’
- Immediate

- Disadvantage

- Everyone makes separate trips
- Time lost

- Advantages

- Time savings
- Potential CO₂ reductions
- Variety

- Disadvantage

- Trucks on residential roads
- Multiple trips to deliver

But will same-day delivery change the game?

- Amazon Bets On Web Groceries, Expands AmazonFresh To L.A.
– *June 2013 TechCrunch*
- Google same-day delivery makes public debut
- To Catch Up, Walmart Moves to Amazon Turf
– *Oct 2013 NY Times*
-

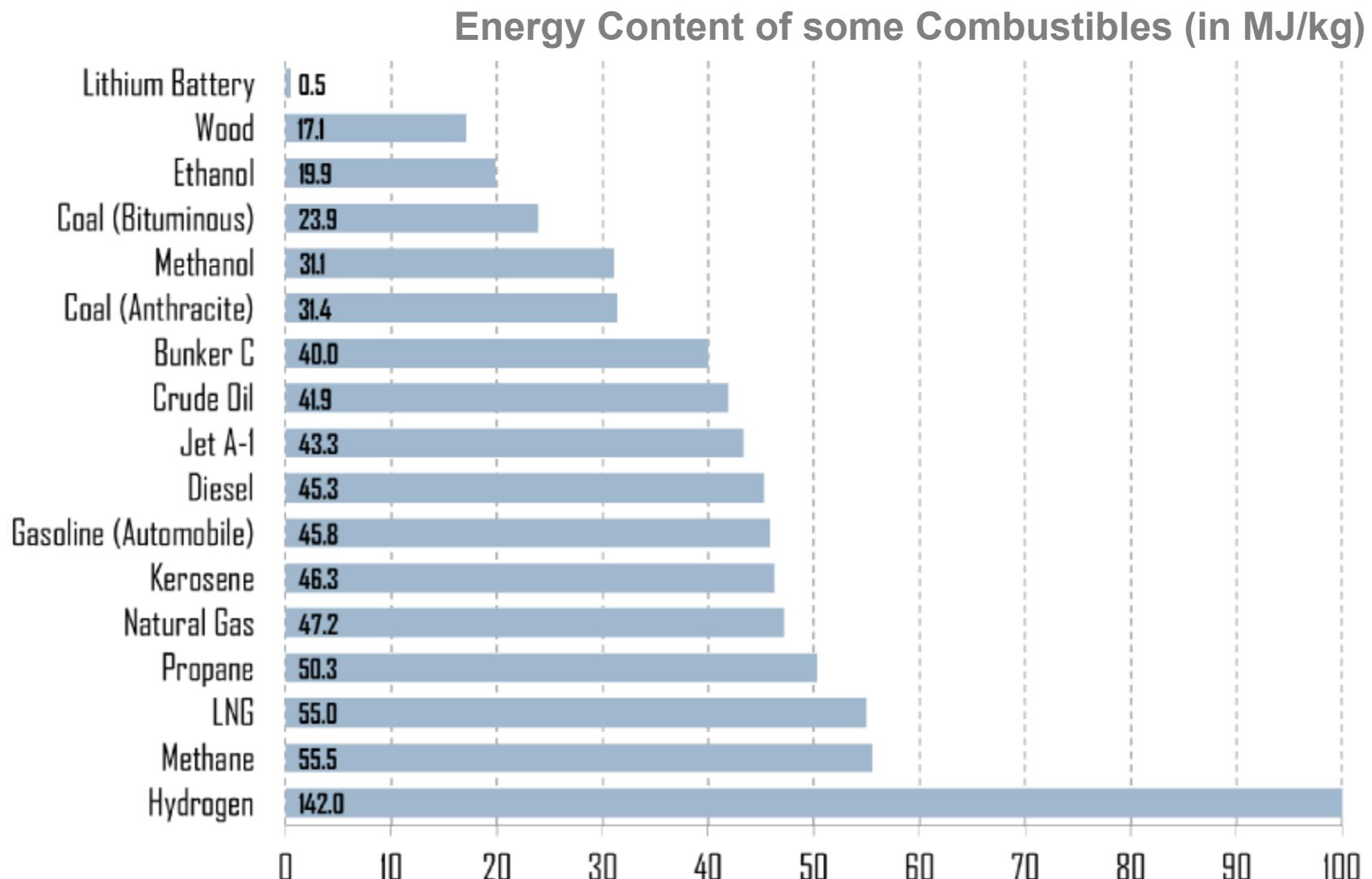


Or pickup your Amazon purchase at your local 7-11?

Modes based on distance

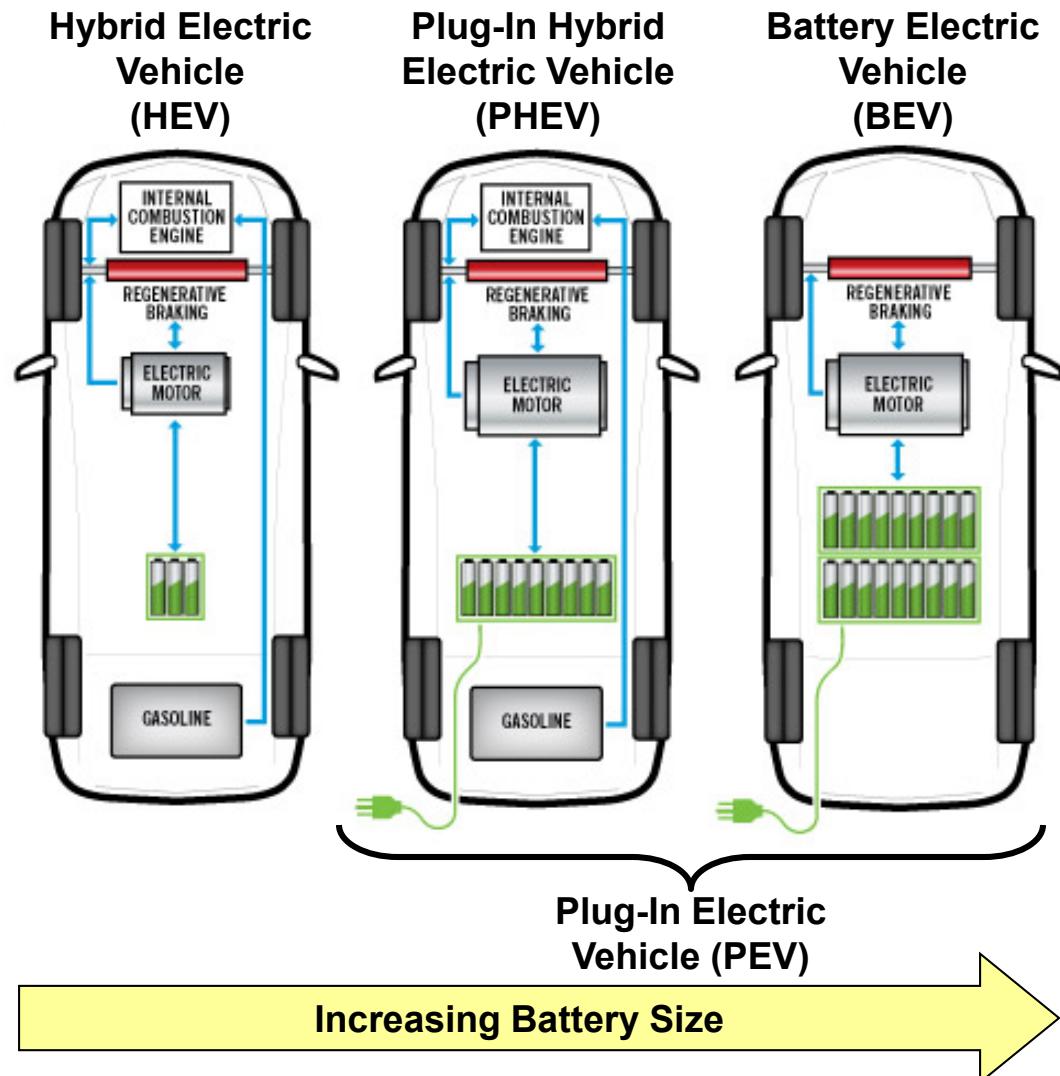
Distance	Technology	Miles per Gallon
< 1 mile	Walk	N/A
1-3 miles	Segway	280* MPGe
5-20 miles	“Smart” Car	107 MPGe
20-200 miles	Car	30 MPG
1-20 miles	Bus	100 PMPG
200-500 miles	Passenger Train	150 PMPG
> 500 miles	Airplane	70 PMPG

Many Fuel Choices



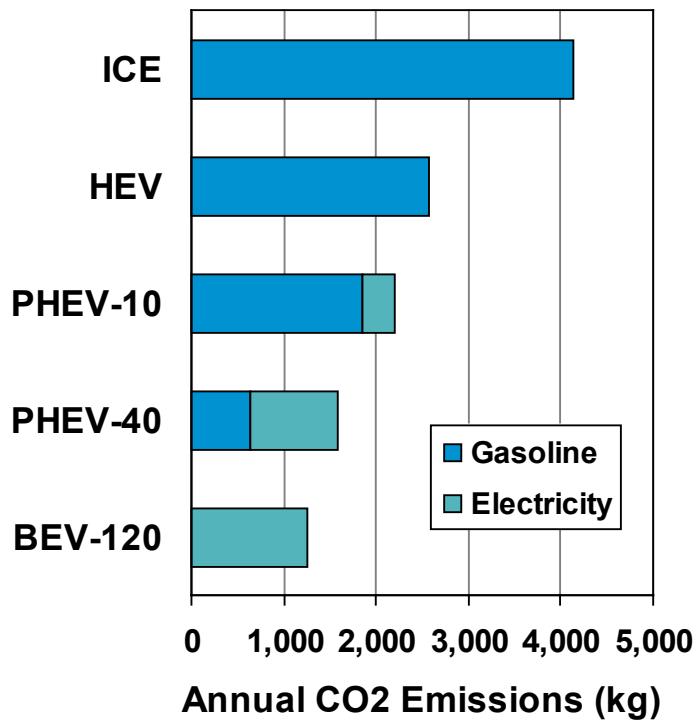
Plug-in electric vehicles (PEVs) are vehicles that store electricity from the grid to power the vehicle.

- HEVs optimize the use of a gasoline engine and electric motor/batteries to achieve higher fuel economy. They cannot be charged by the grid.
- PHEVs are similar to HEVs but have a larger battery, can be recharged by the grid, and offer limited electric-only driving (typically 10-40 miles).
- BEVs are propelled by only an electric motor. They do not have an internal combustion engine. They typically offer ranges of 60-200 miles.

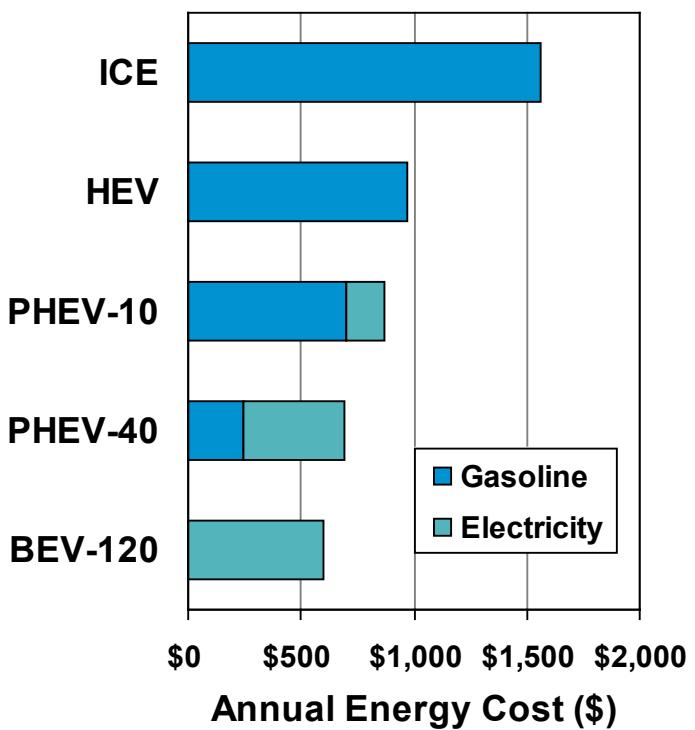


PEVs reduce CO₂ emissions and have lower energy costs compared to conventional cars and HEVs.

Comparison of CO₂ Emissions (2010)¹



Comparison of Annual Energy Costs (2010)¹

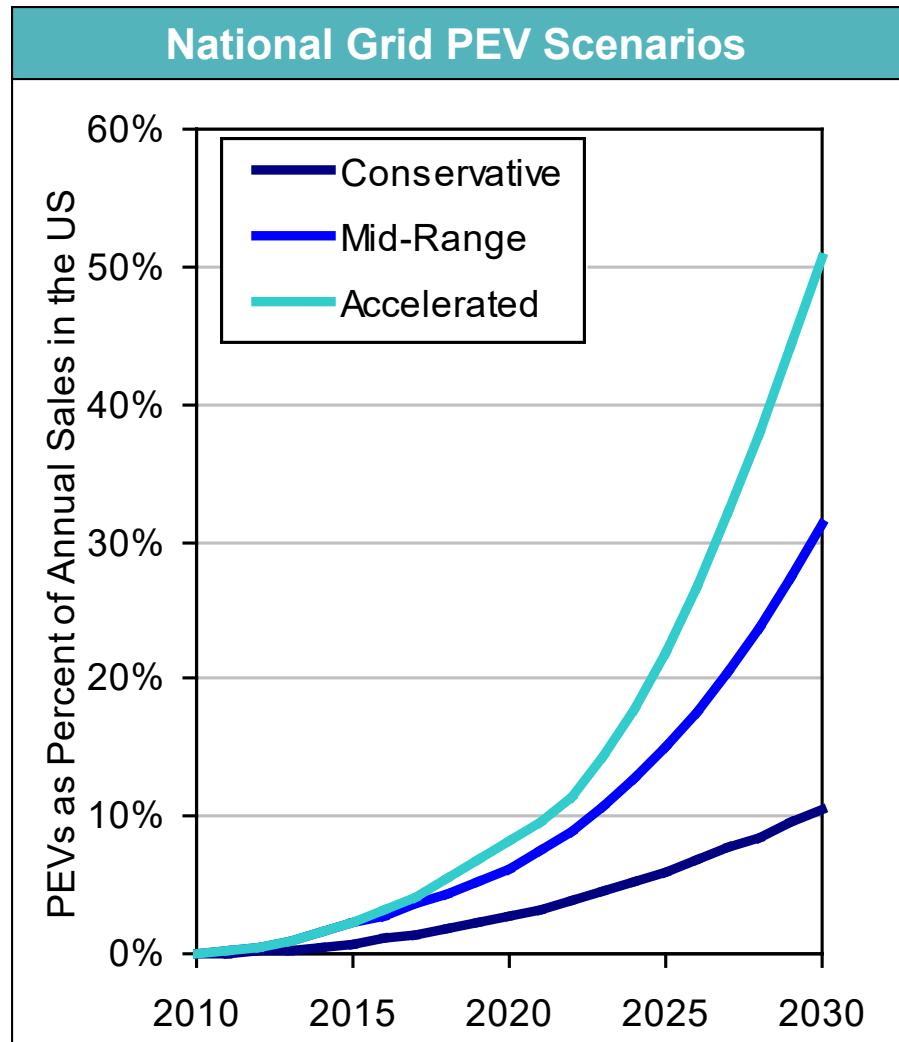


1. For 12,526 miles per year

1. For 12,526 miles per year

National Grid has developed three PEV market penetration scenarios to assess PEV impacts.

- PEVs are being introduced in limited quantities, in targeted regional markets, starting in 2010 and 2011
- HEVs took about 10 years to reach 2-3% of new car sales in the US.
- Diesel cars in Europe achieved 20-50% share of new car sales (depending on the country) over a 20-year period.



Life Cycle Analysis

Total Carbon Content LCA

Standard gasoline vehicle	24 tonnes
Hybrid vehicle	21 tonnes
Plug-in hybrid vehicle	19 tonnes
Battery electric vehicle	19 tonnes

Unfortunately, the values are not a “slam dunk”

But depend on so many external factors...

Uncertainties

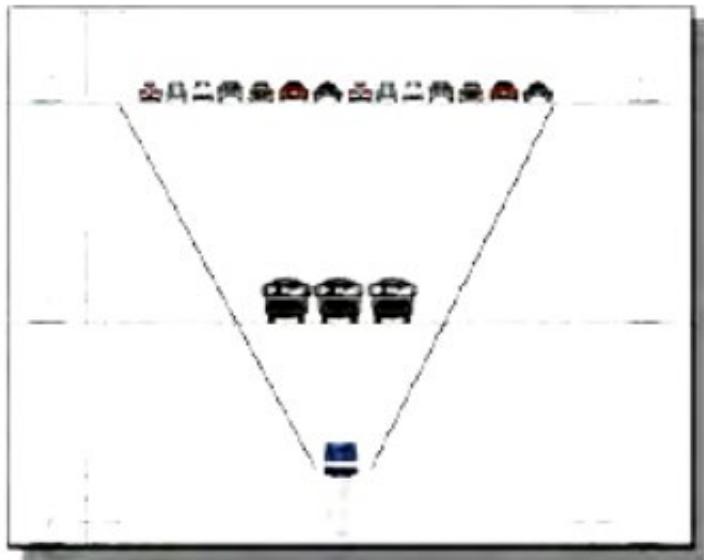
- EV's has toxicity and metal issues with battery construction.
- Supply chain / water issues
- Higher (2x) embodied energy to manufacture the vehicle
- Do EVs last longer than gasoline-powered?

Emissions of an Electric Vehicle

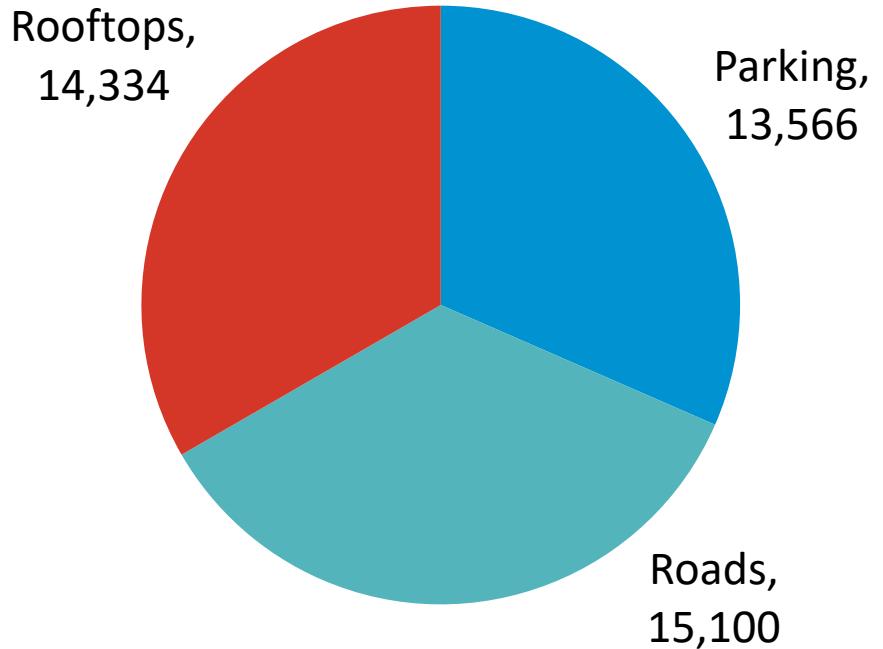
Country	Electricity Emissions (gCO ₂ /km)	
France	12	http://onlinelibrary.wiley.com/ doi/10.1111/j.1530- 9290.2012.00532.x/pdf
Canada	31	
UK	75	
USA	84	<i>It is irresponsible to promote EVs where the electricity source is from fossil fuels</i>
Car	89	<i>– Hawkins et. al.</i>
China	115	
Greece	118	

Allocation of Land

Rail reduces land use 11 fold

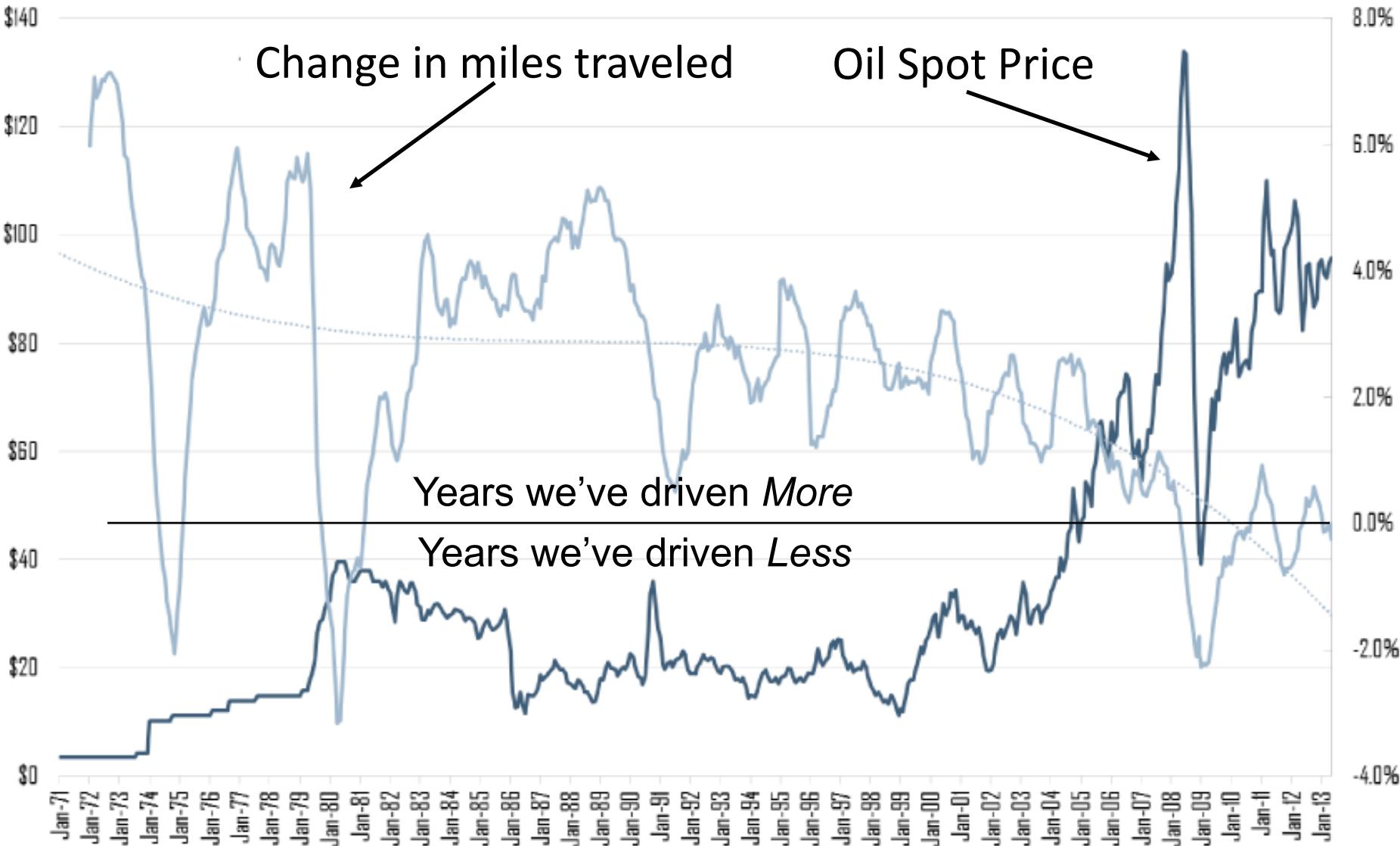


Square Miles 43,000



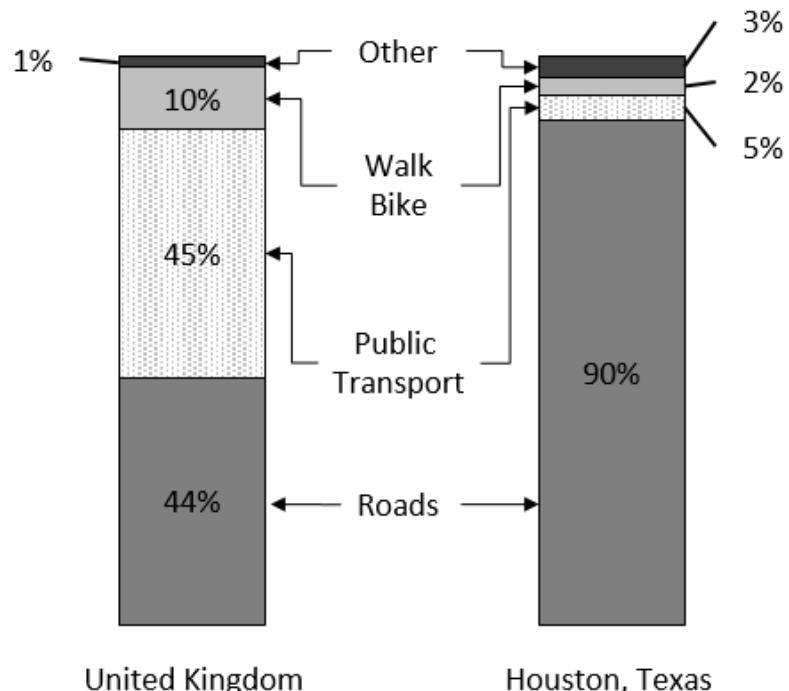
Between the size of Virginia and Ohio
35th largest state

Macro Trend: Fuel price vs. the Economy

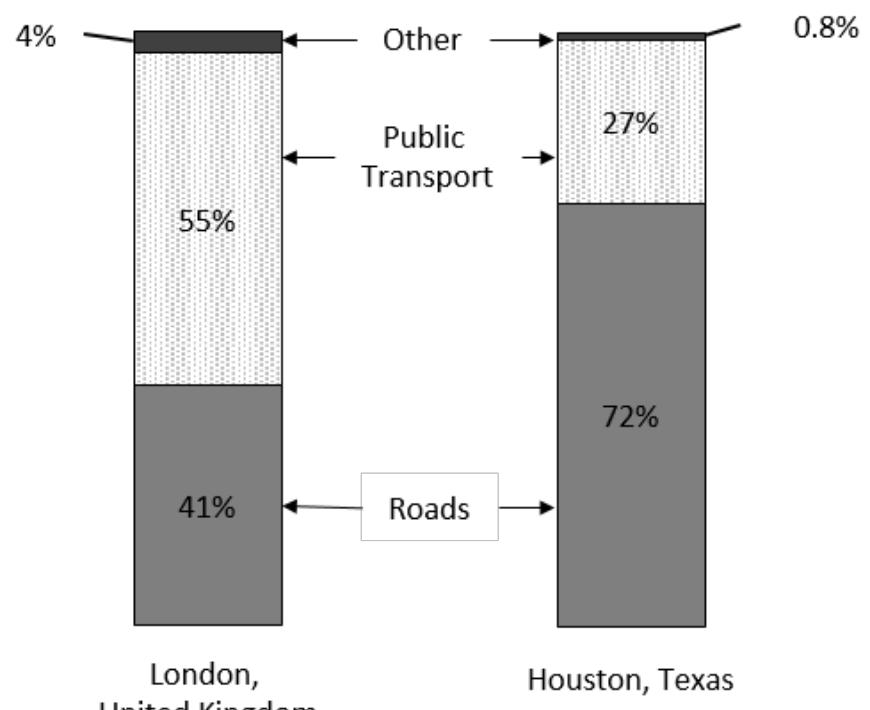


Investment Impact

(A) Mode of Transportation



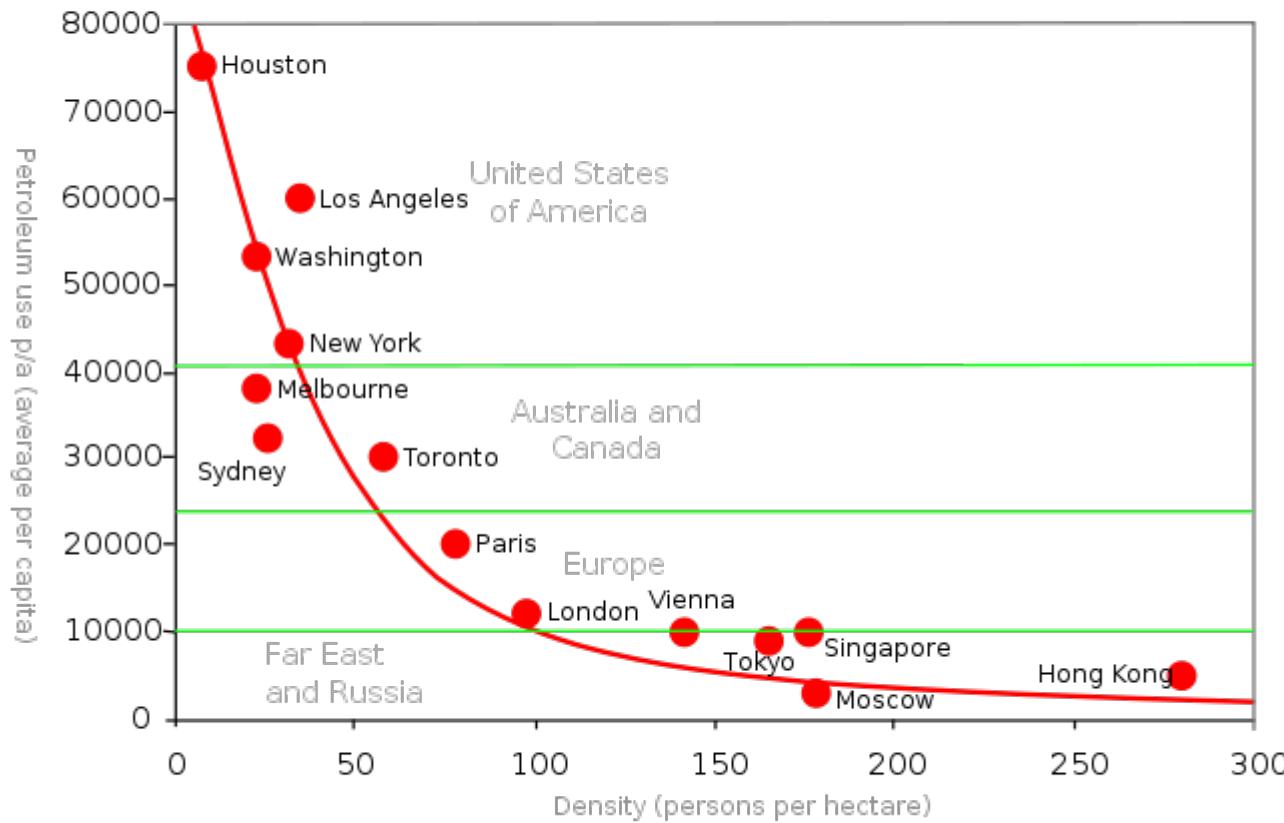
(B) Infrastructure Investment Priorities



Density – Affects Distance

Relationship between Transport and Land Use

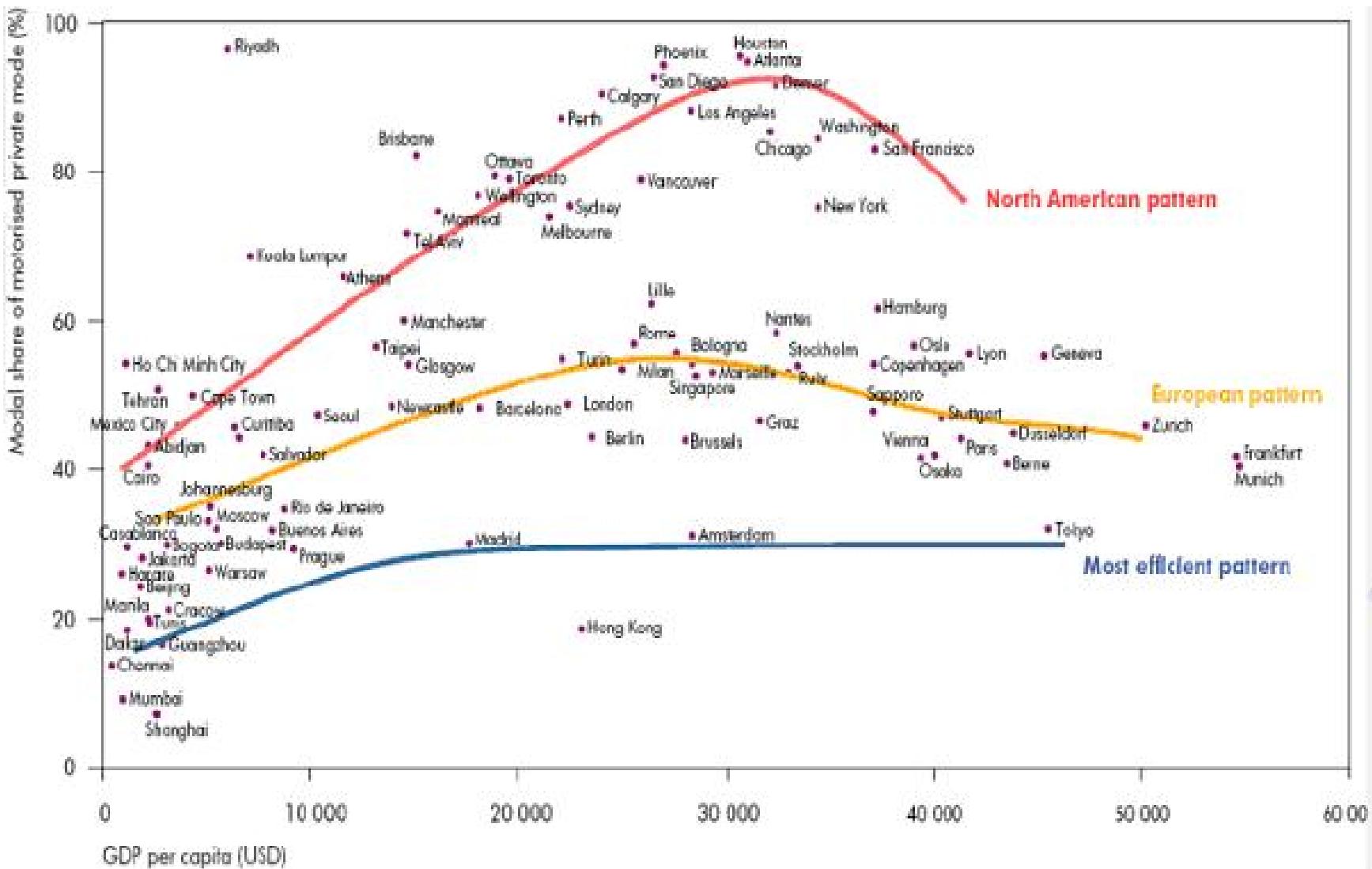
A commonly used study of 32 cities by Newman & Kenworthy in 1989 concluded that there was a strong link between urban development densities and petroleum consumption.



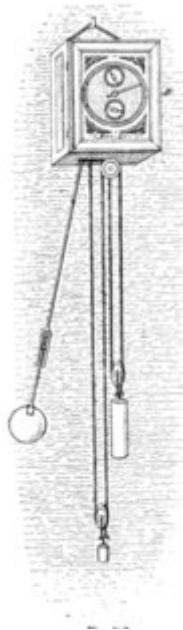
Annual petroleum use per capita adjusted to US MJ (1980)

After Andrew Wright Associates, small section taken from 'Towards an Urban Renaissance',
Urban Task Force Partnership, 1999, © DETR, 1999

Macro Trend: GDP vs. Private Vehicles



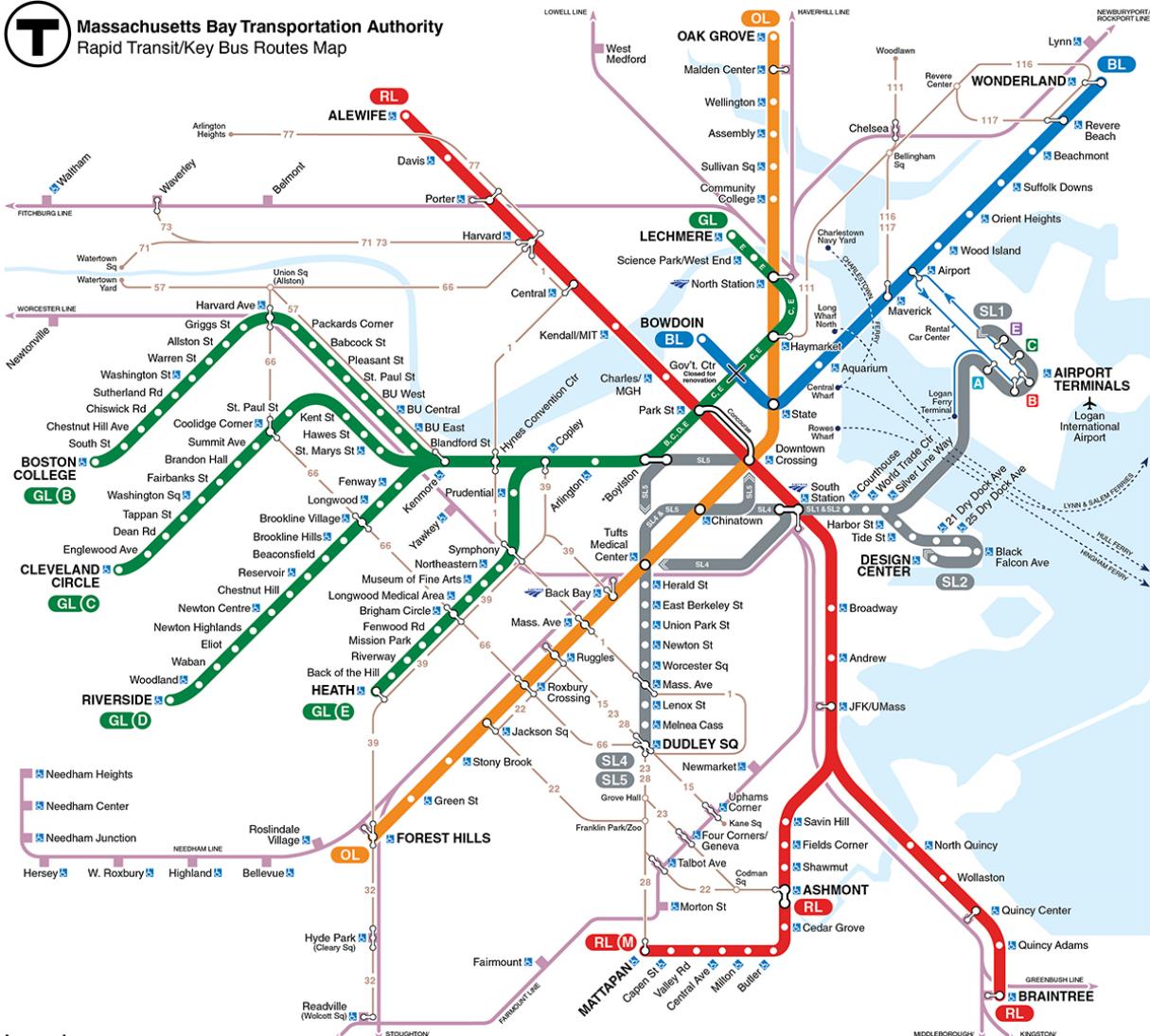
Macro Trend: Perception of Time



Transportation for fun:



Massachusetts Bay Transportation Authority Rapid Transit/Key Bus Routes Map



Legend

RED LINE

MATTAPAN LINE

ORANGE LINE

BLUE LINE

© September 2014 v25



COMMUTER RAIL

TO SOUTH STATION

TO CONVENTION CENTER

NO STANDING

TOW ZONE

NO STANDING

Accessible station

All MBTA and

Massport bus and

ferry services are

accessible

FERRIES

Free Logan Airport shuttle bus

Back Bay, North & South Stations

• Dashed line

• Solid line

• Dotted line

Not to scale

Customer Communications & Travel Info

517-522-2000, 1-800-932-5100,

TTY 617-222-5146, www.mta.com

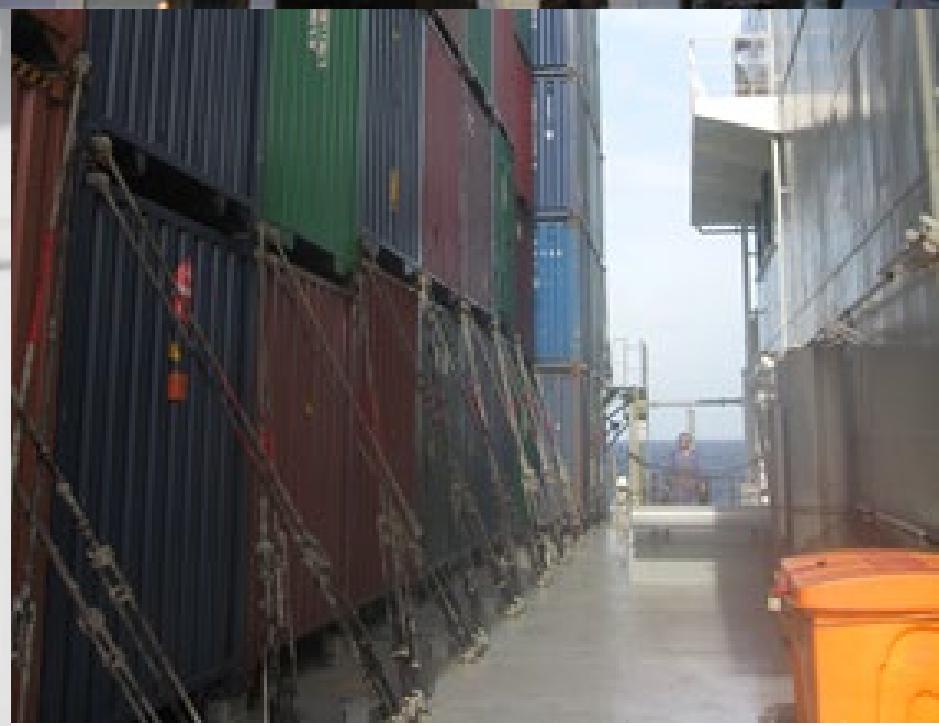
• MBTA Transit Police: 911

• TTY 617-222-1200

• Elevator/escalator/ lift updates: 800-392-6100

Not to scale















Challenge of Metrics

- Miles per gallon? (USA dominant)
- Gallons per mile? (European dominant)
- Pound miles per gallon? (freight preferred)
- Passenger mile per gallon? (Mass transit preferred)
- Depends on the Distance needed!

Match use to benefit

- Planes → good for long distances
 - Ship → good for freight
 - Rail → good for freight
 - Autos → good for rural
 - Bicycles → good for local
-
- Public Transportation → good for urban
 - Mixed Zoning → reduces distances
 - Telecommuting → eliminates travel
 - Local economies → reduce shipping needs

Annoying tradeoffs

We end up debating over minutiae tradeoffs

(Diesel vs. Biodiesel)

(EV vs. PHEV vs. Smart Car)

Or we debate values that are not comparable

(Air travel to Miami vs. bicycles to work)

The true value is in neighborhood development and zoning

(Changing the Distance we have to travel)

Q&A