CE 9800:
Sustainability in Civil Engineering

X. Transportation

Transportation over time

5-15 kph

- 3000 BCE: horses
- 1500 CE: long-distance shipping
- 1800: canals

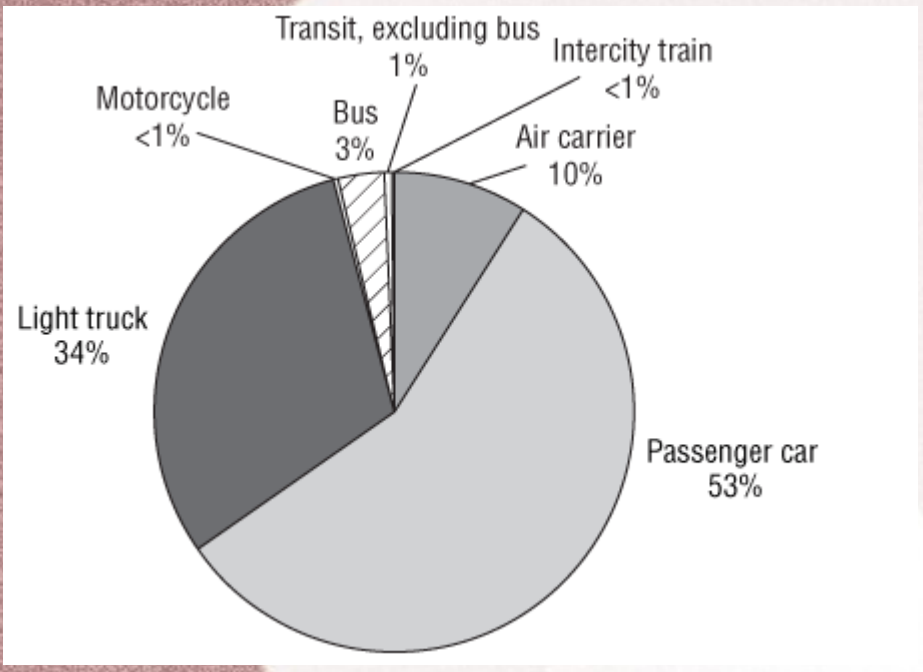
Fossil fuels

40-1000 kph

- 1850: railroads, steamships
- 1920: motorcars
- 1960: aircraft

(still spend similar amount of time traveling)

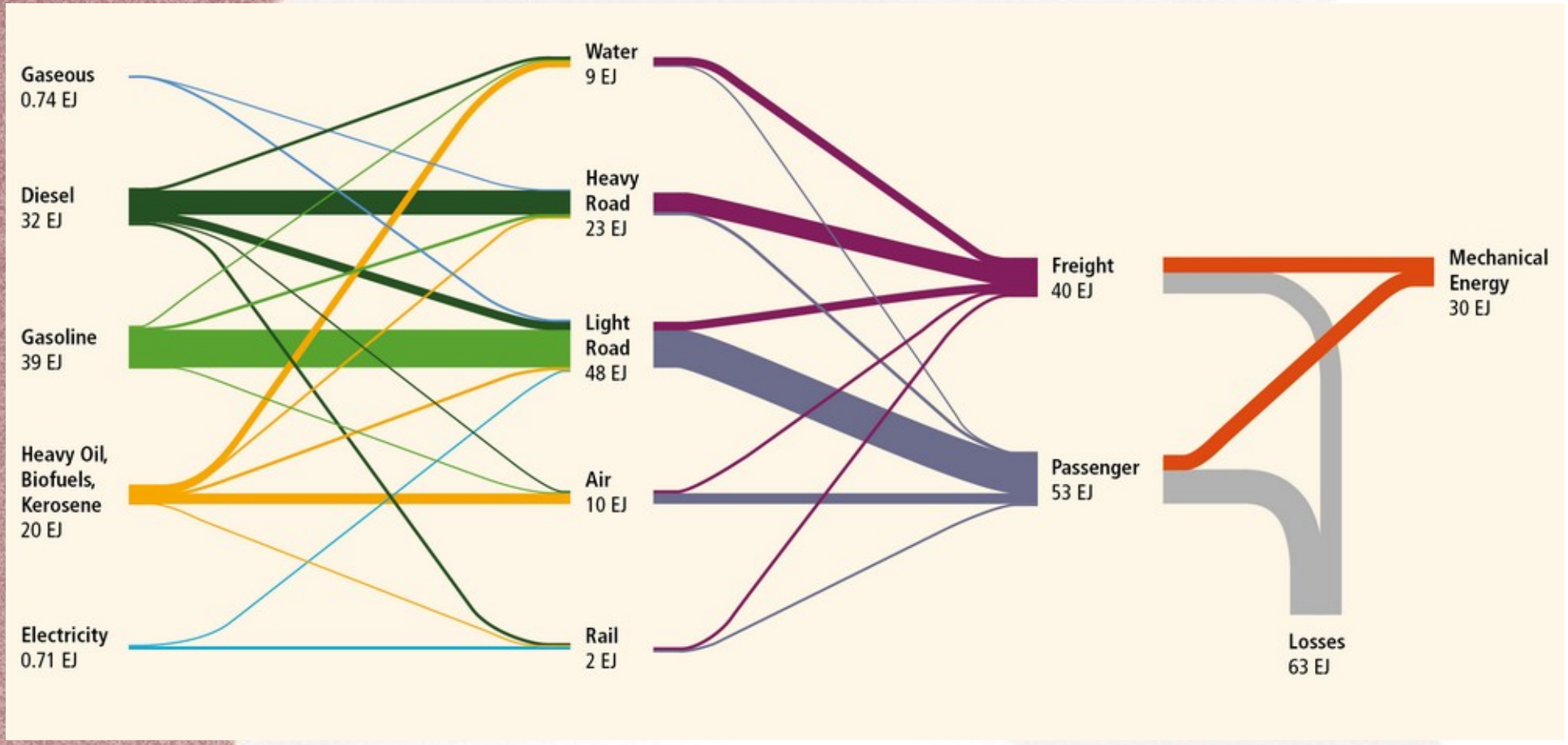
Transportation today



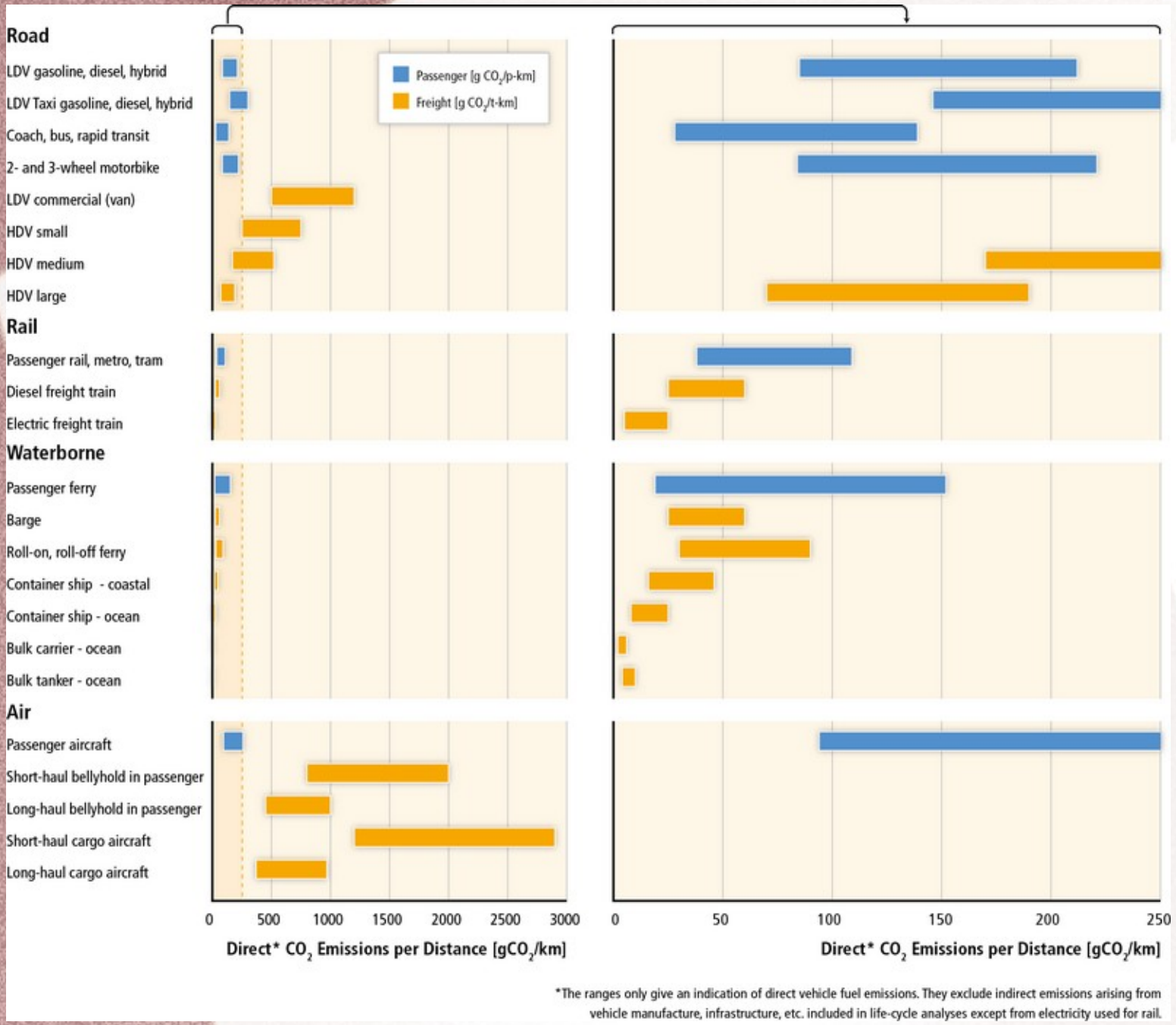
Fraction of distance traveled by mode, USA, 2002

- Americans travel 70 km per person per day; 55 ton-km of freight per day
- 99% fossil-fueled, 97% oil
- 67% of USA oil consumption, 27% of greenhouse gas emissions
- A leading cause of death (directly or thru pollution, inactivity)

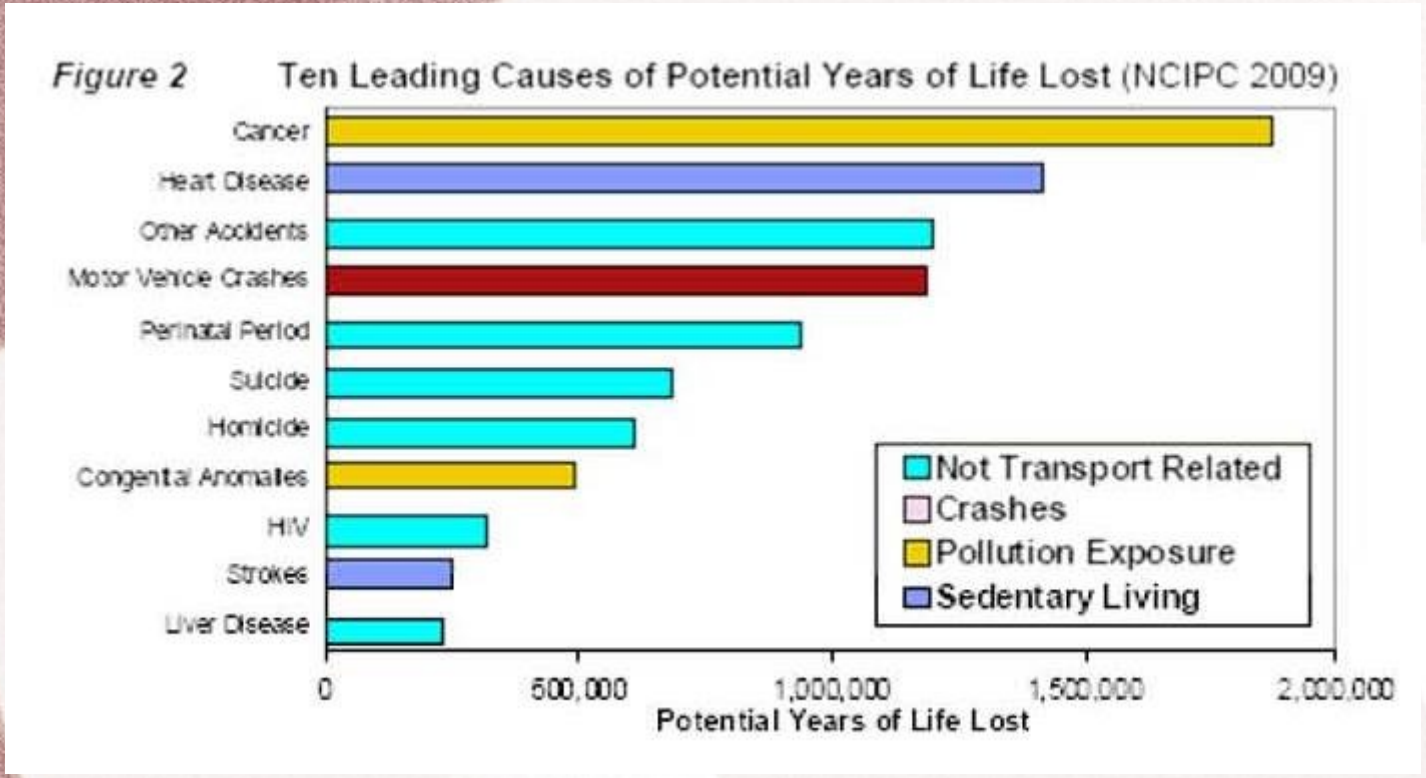
World transportation (yearly exergy)



Relative pollution by mode



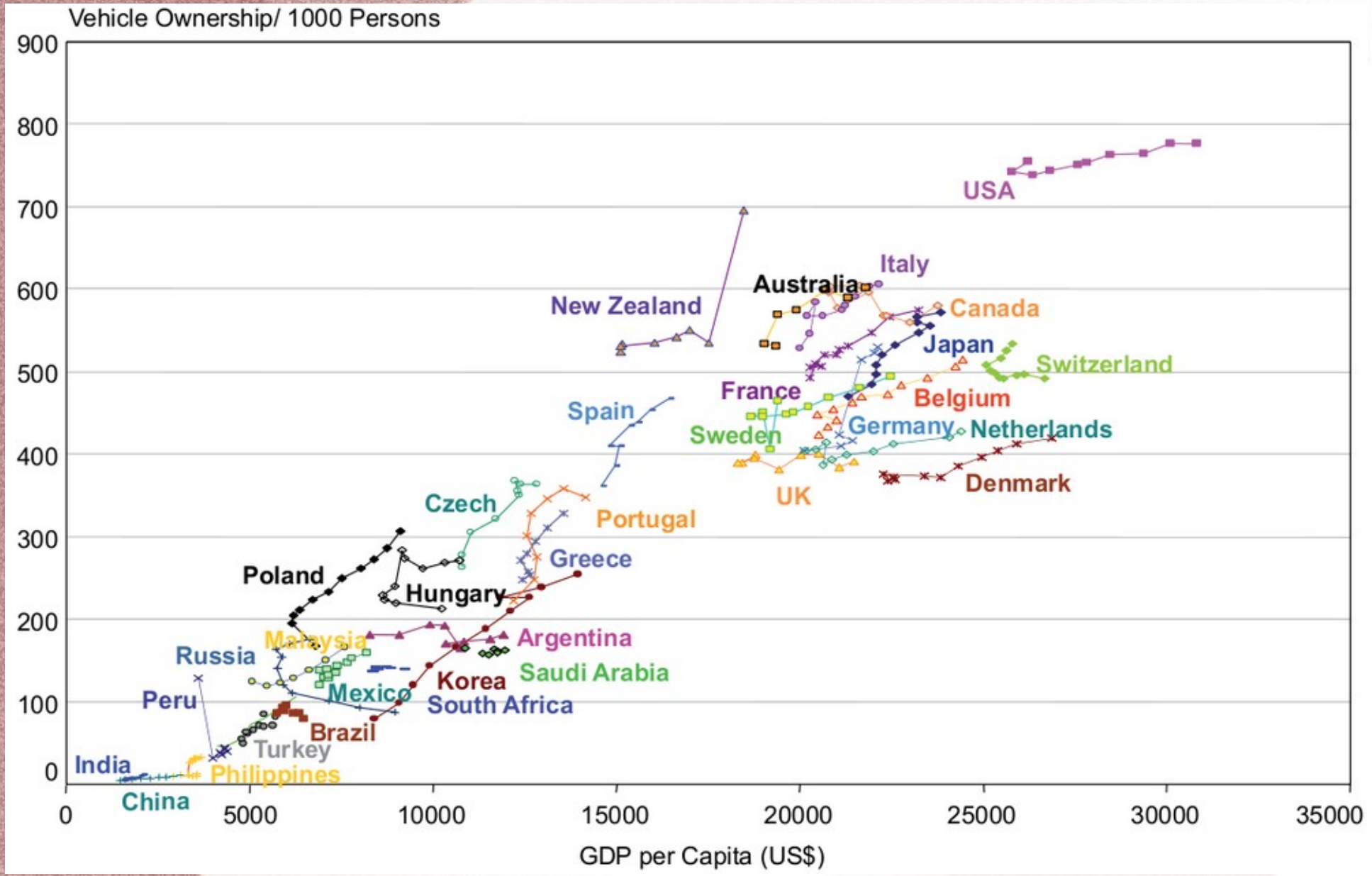
Cars vs. health



"Pollution can indeed affect the intelligence of children of all ages (even those still in utero). The primary culprit is smog—ground level pollution comprised of vehicle and smokestack emissions that can form a dense haze on and near busy roadways." (HealthNewsDigest, 2010)

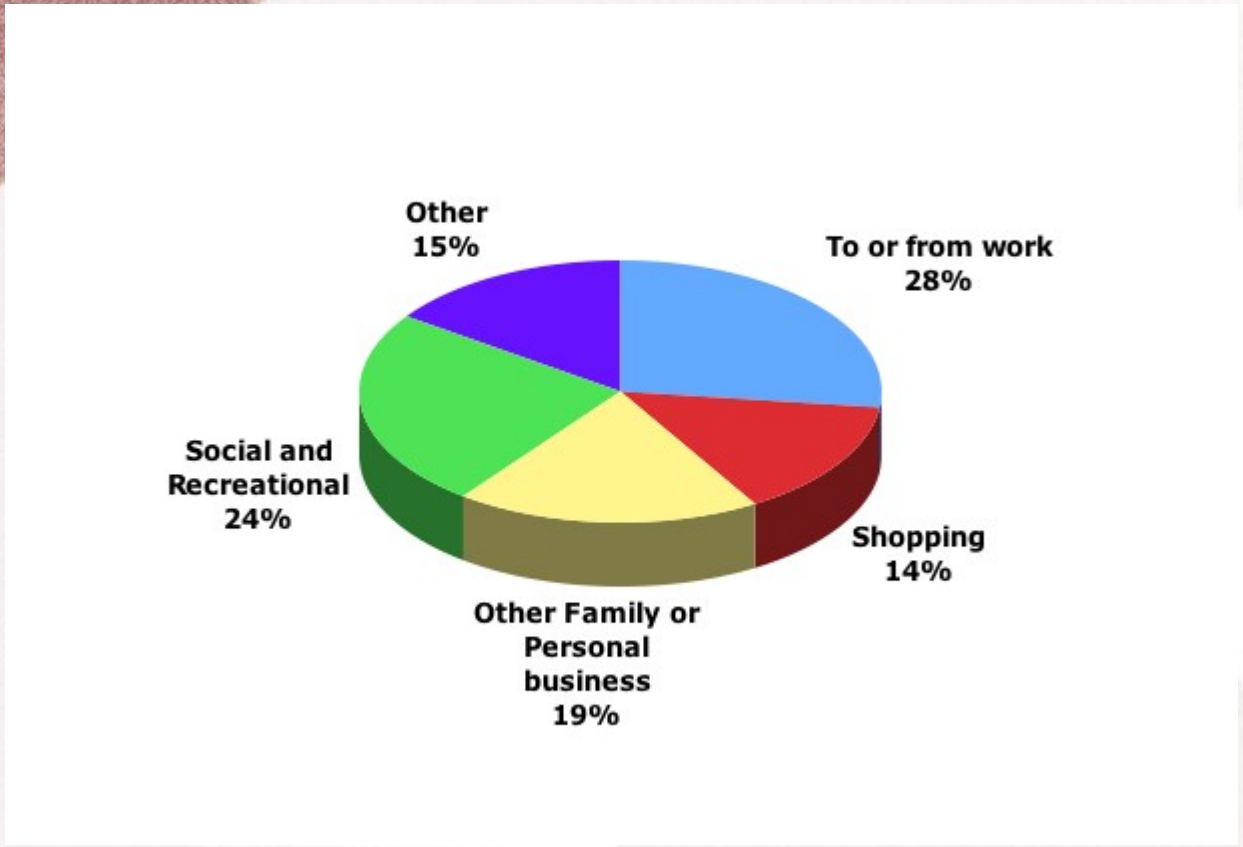
5,000 walkers & cyclists killed by cars in US each year

Cars international



Private cars have caught on worldwide, although US still stands out

Why do people drive?

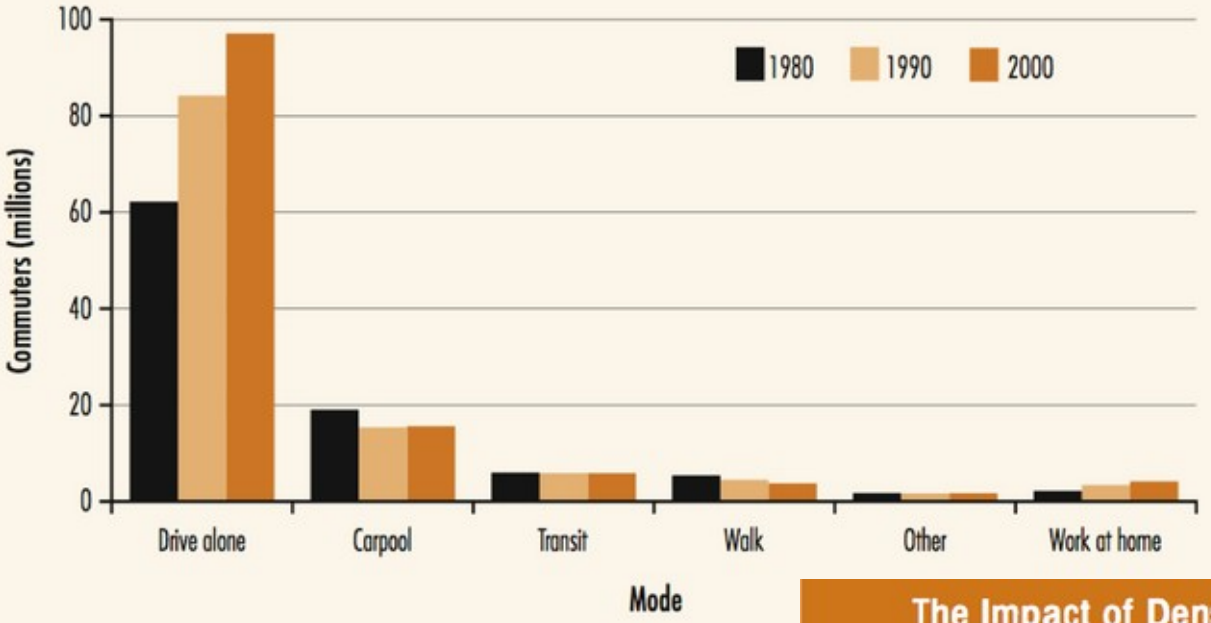


2001 National Household Travel Survey

Travel need depends on social configuration

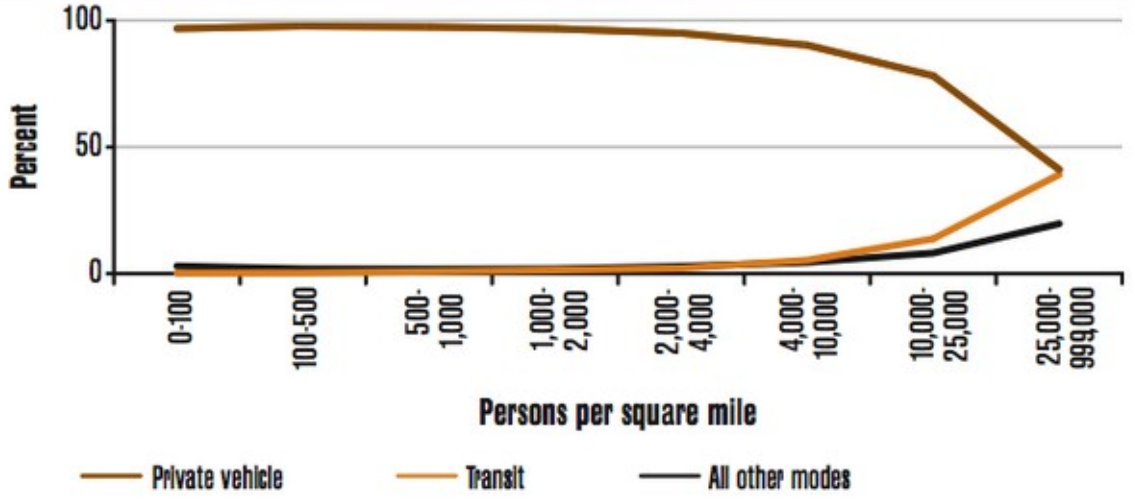
Driving to work

FIGURE ES-4 Modal Trends Summary, 1980-2000



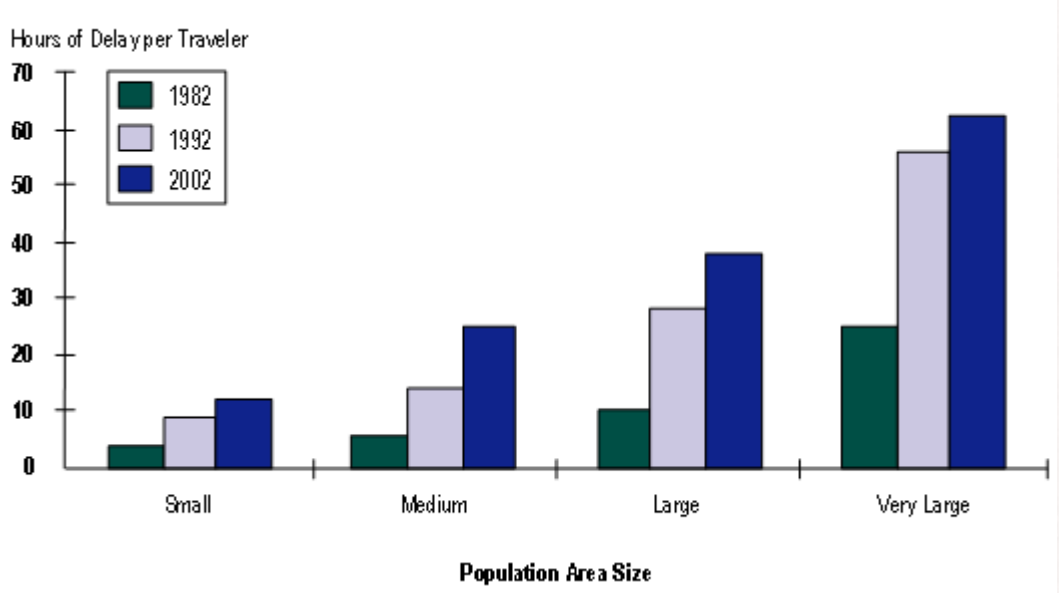
TRB

The Impact of Density on Modal Usage

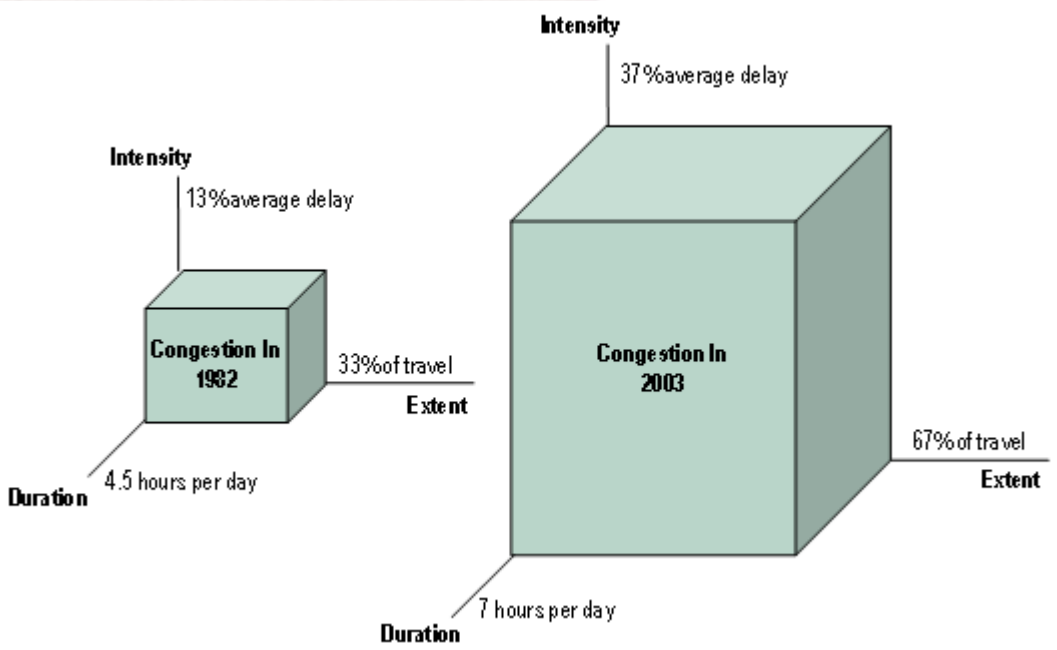


Note: Densities were calculated at the Census tract level.

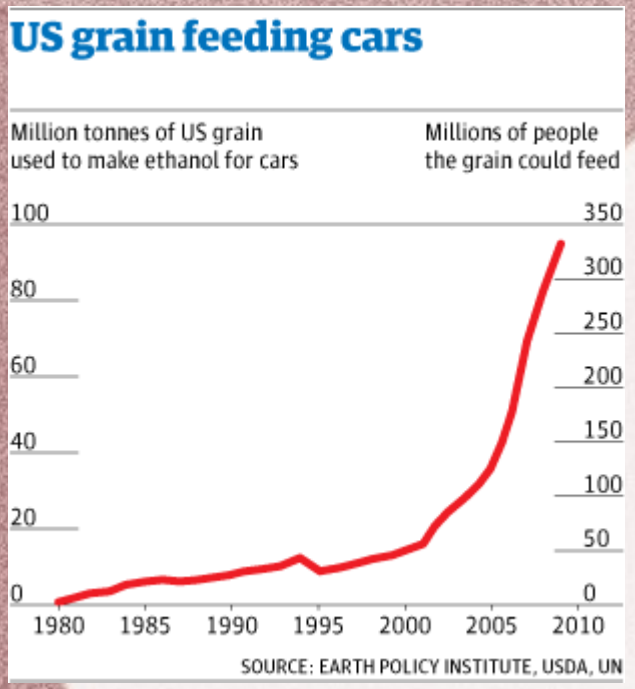
Car transportation nears logistical limits



Federal Highway Administration



A non-solution: biofuels



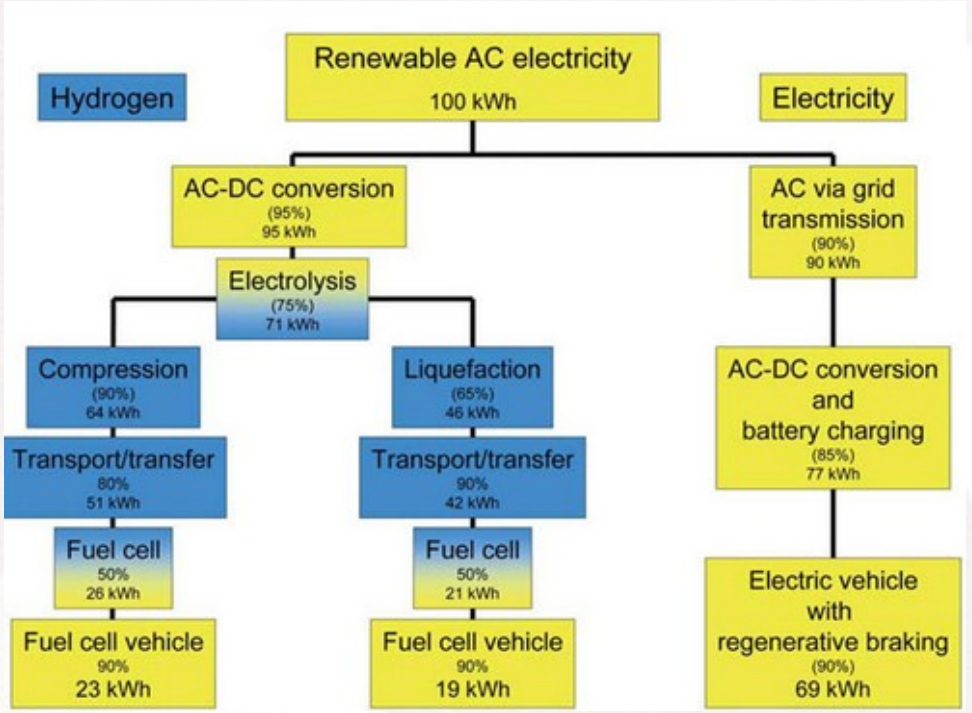
- Take 25% of US grain harvest to make 6% of liquid fuel supply
- Another case of corporate welfare (main beneficiary is ADM)

"Continuing to divert more food to fuel, as is now mandated by the US federal government in its renewable fuel standard, will likely only reinforce the disturbing rise in world hunger. By subsidising the production of ethanol to the tune of some $6bn each year, US taxpayers are in effect subsidising rising food bills at home and around the world," said [Lester] Brown.

Biofuels internationally

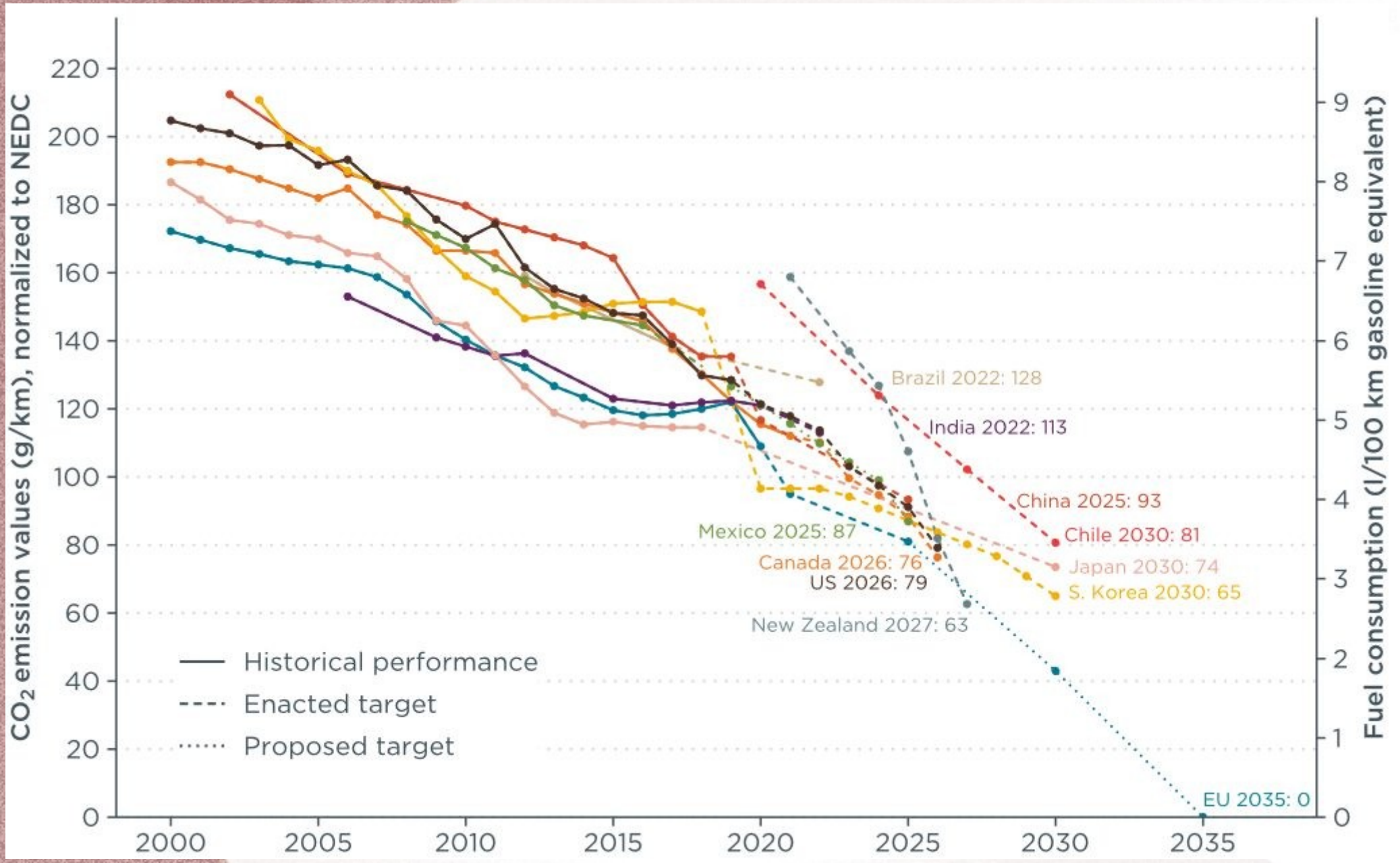
- Brazil: sugarcane alcohol (18% of liquid fuel)
- Biodiesel is likely to be made from palm oil (major commercial plant oil globally), which is linked with tropical deforestation
- “Belgium is set to ban biofuels made from soy and palm oil from next year. The country’s Federal Minister of Environment and Climate said: These fuels have little or no advantage over conventional fossil fuels from a climate point of view, but lead to deforestation, loss of biodiversity and even human rights violations.” (4/2021)

Hydrogen



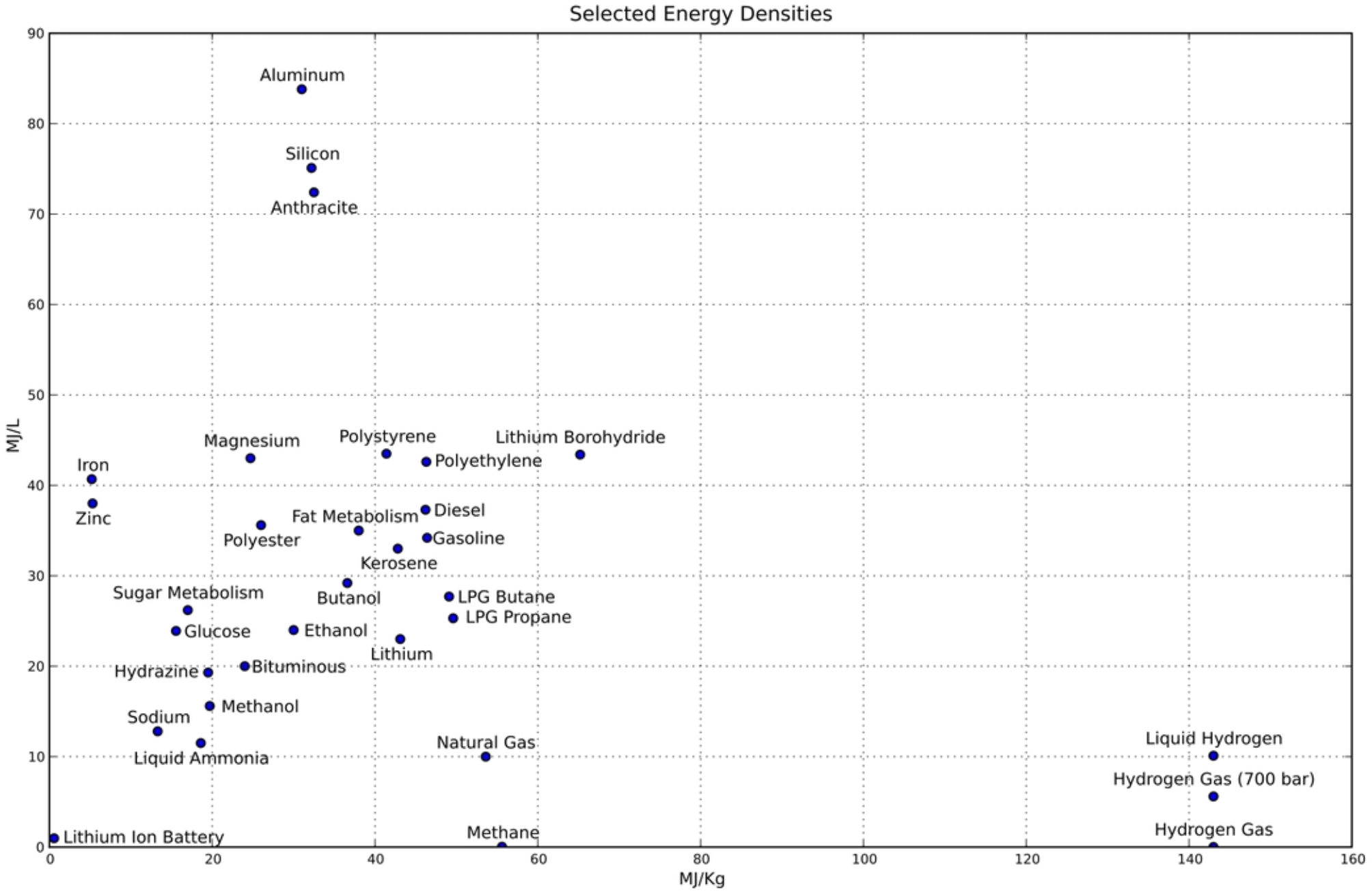
- An inefficient way of burning natural gas

Requiring reasonable fuel efficiency



The International Council on Clean Transportation (“light trucks” are less efficient)

Electric cars

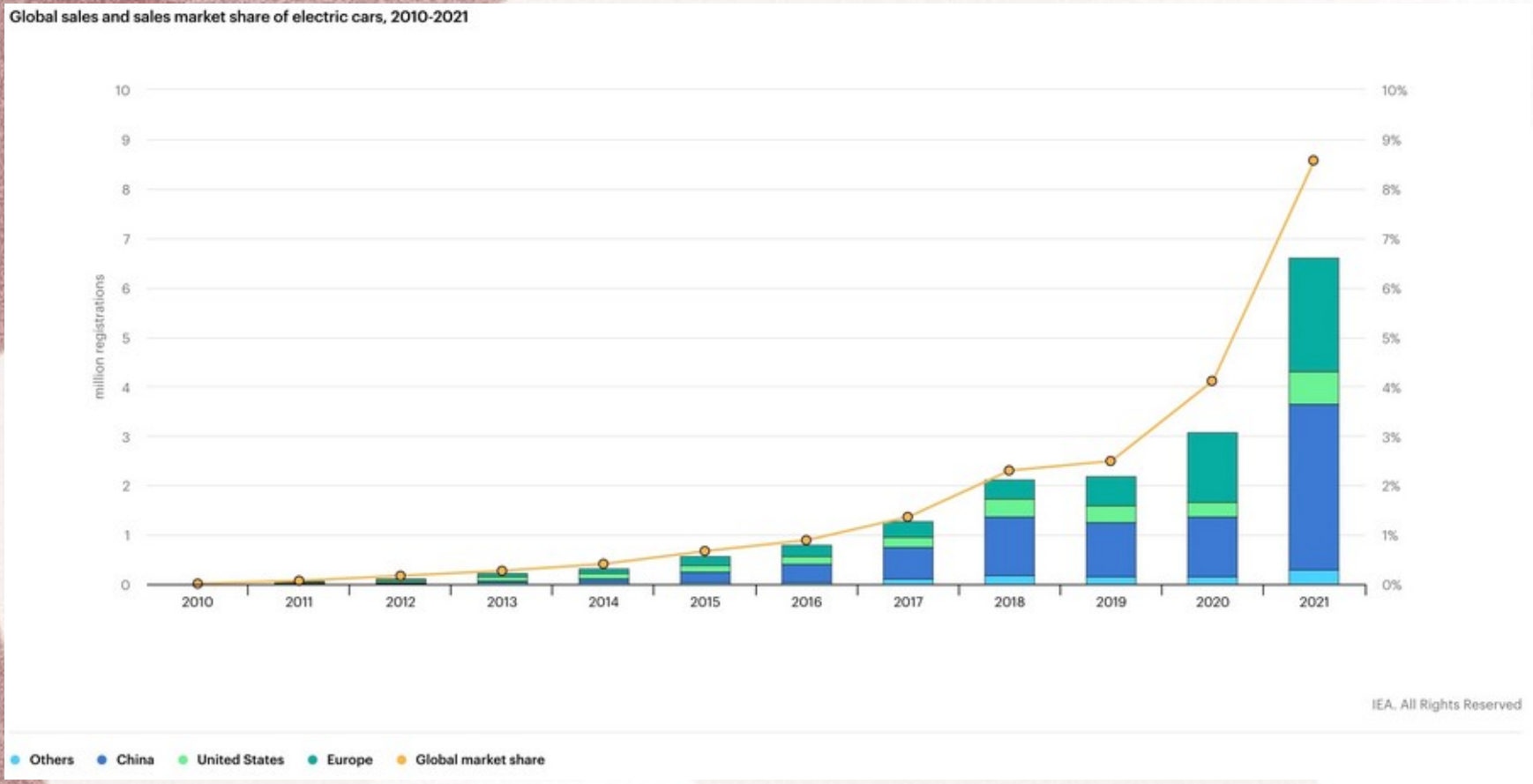


- Batteries much less energy dense than gasoline

Electricity requirements of cars

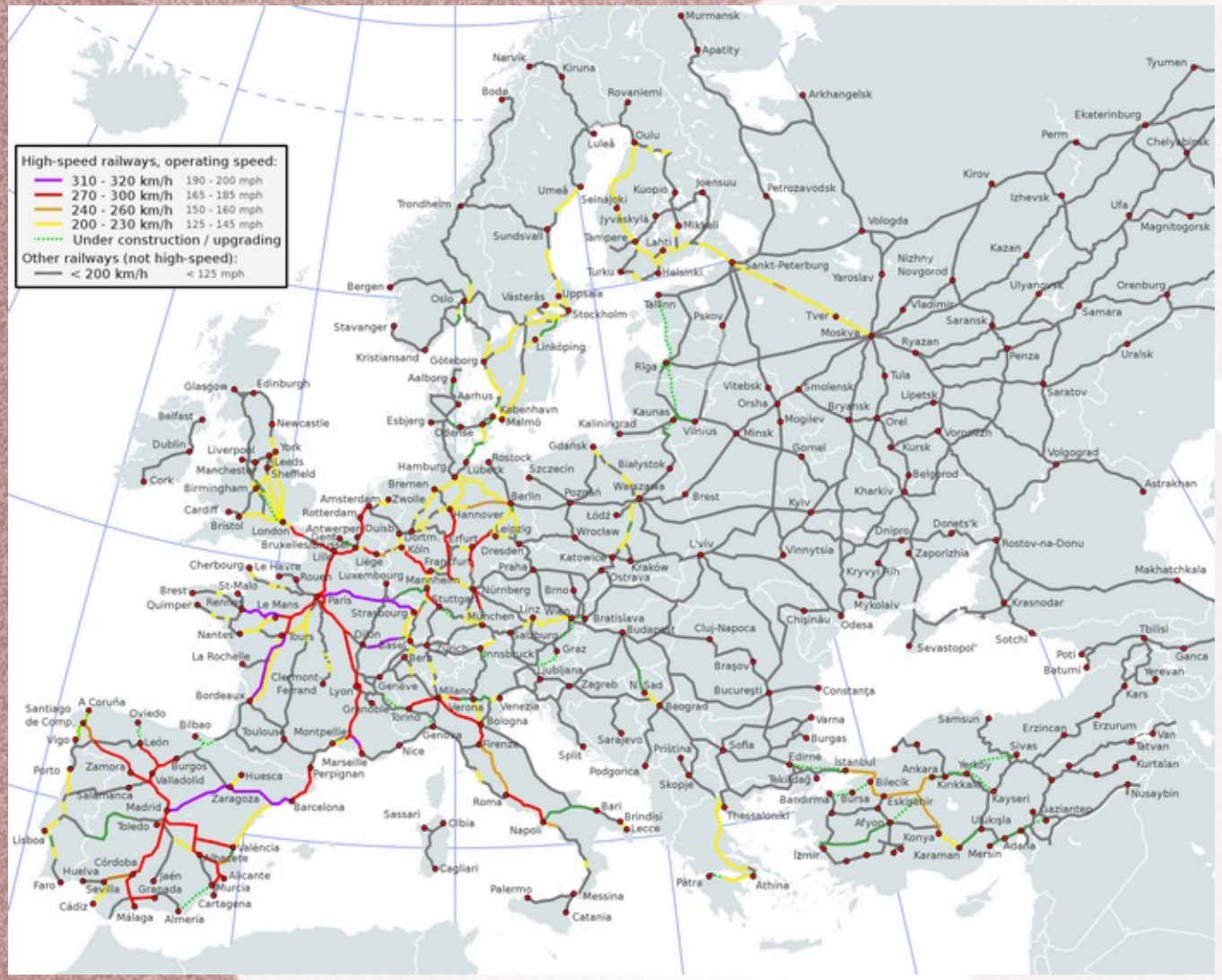
- Electric motor is much more efficient than IC one; 400 W/person could power current driving behavior
- Would not solve congestion, other quality-of-life problems
- Batteries draw large amount of power when charging, but could contribute to stabilizing the grid

Electric cars boom



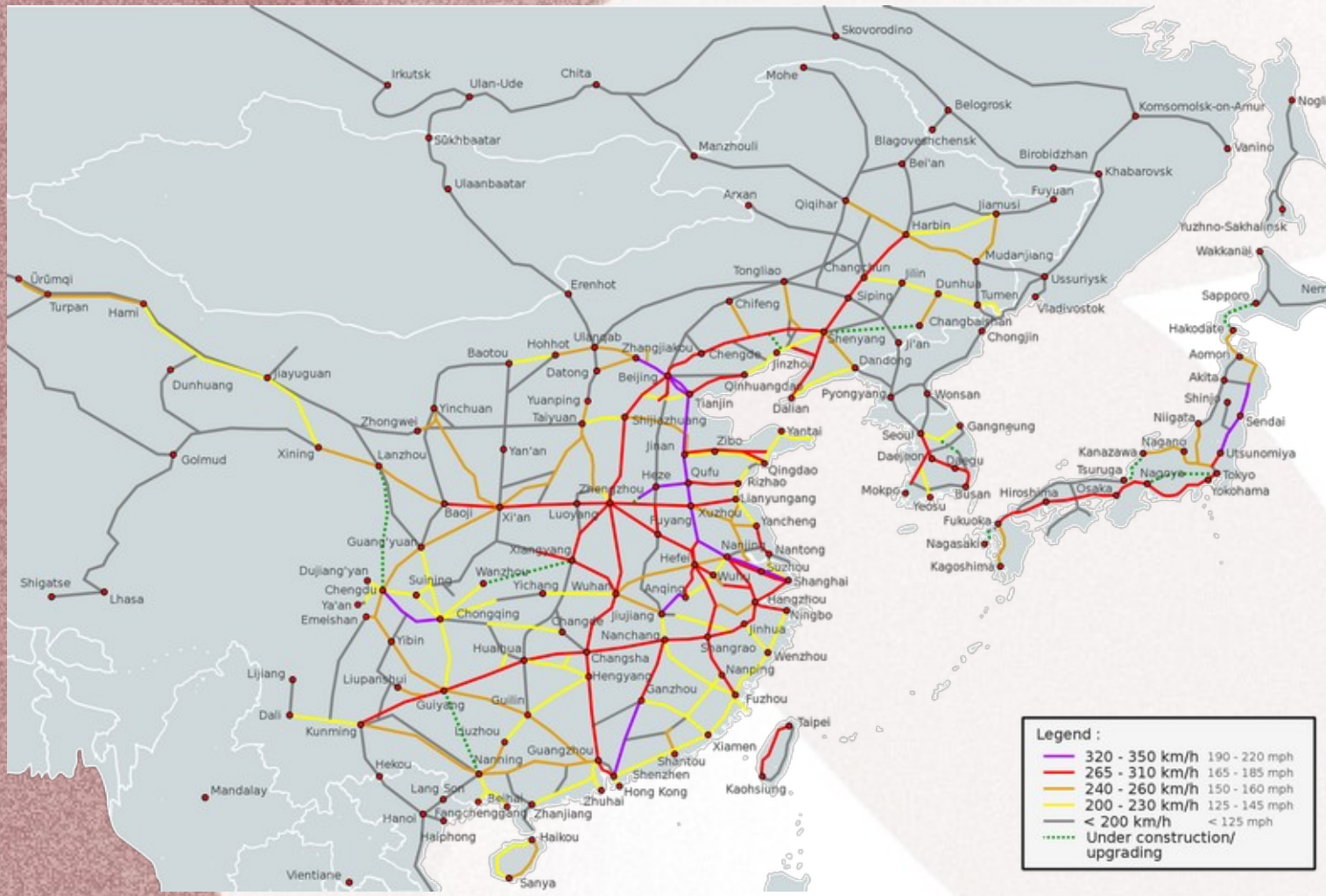
- Better batteries (material use still a concern); govt. incentives being phased out
- 7% of new cars in US [<1% of fleet], 80% in Norway [20% of fleet]
- Local buses and delivery vehicles make the most sense to electrify immediately

Rail



- Oil-powered in US (though less profligate than cars); being electrified elsewhere
- Being maintained and expanded in Europe and Asia

China and Japan



- China has most high-speed rail in the world, spending $100 bn/y (while also building a freeway system)
- Electric rails, so battery storage not needed

What keeps people from driving?

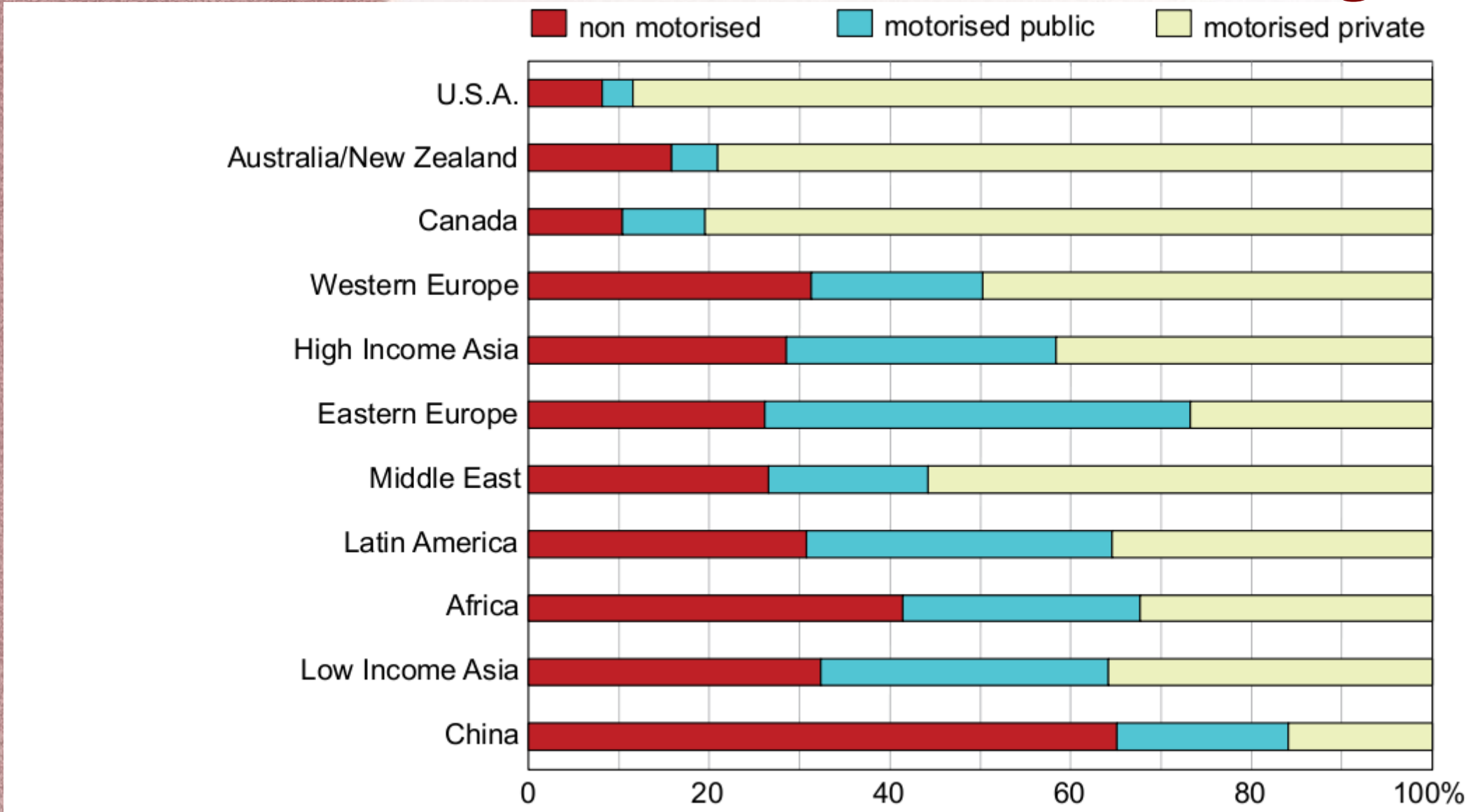


Figure 5.17: *Modal split for the cities represented in the Millennium Cities Database for Sustainable Transport by region*

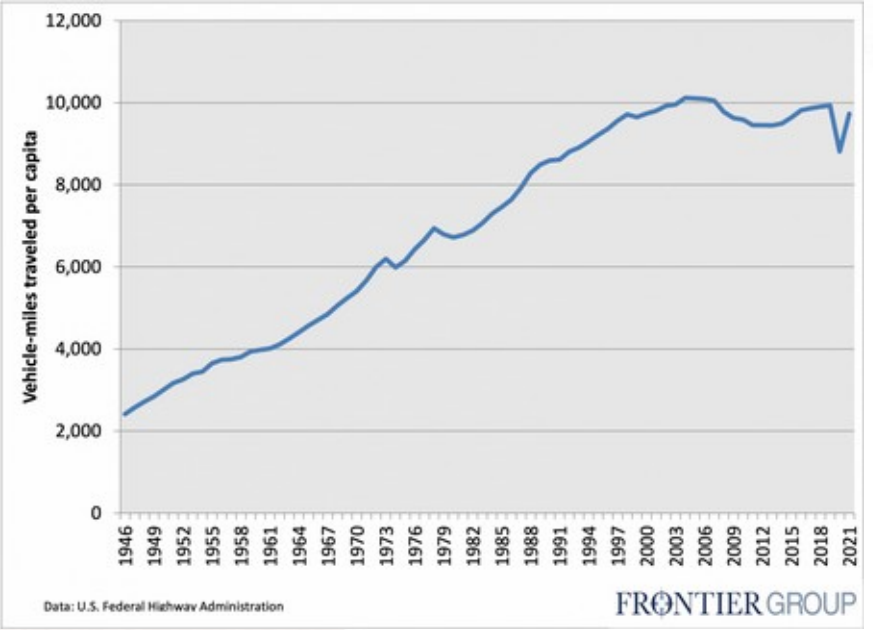
Source: Kenworthy & Laube, 2002.

Driving levels respond to cost

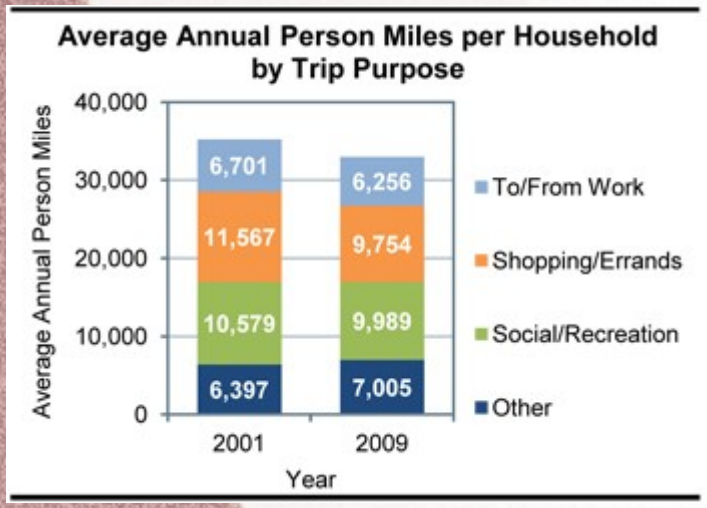
Table 5.15: *Impact of a permanent increase in real fuel prices by 10%*

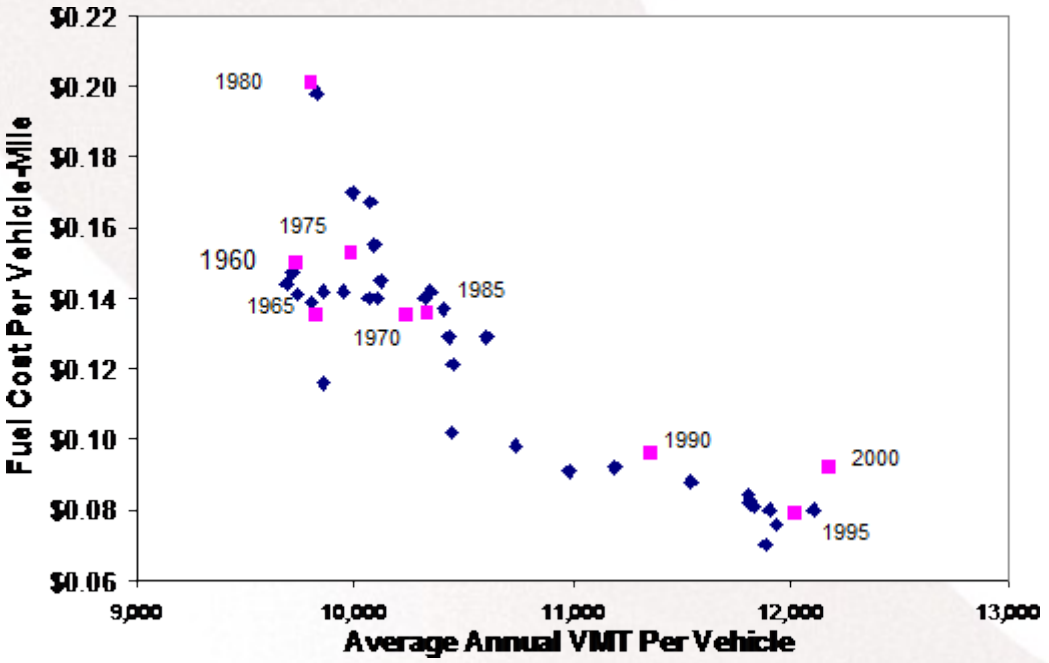
	Short run/within 1 year (%)	Long run/5 years (%)
Traffic volume	-1	-3
Fuel consumption	-2.5	-6
Vehicle fuel efficiency	-1.5	-4
Vehicle ownership	Less than -1	-2.5

Source: Goodwin et al. 2004.



USA vehicle miles per capita





Slowing down traffic

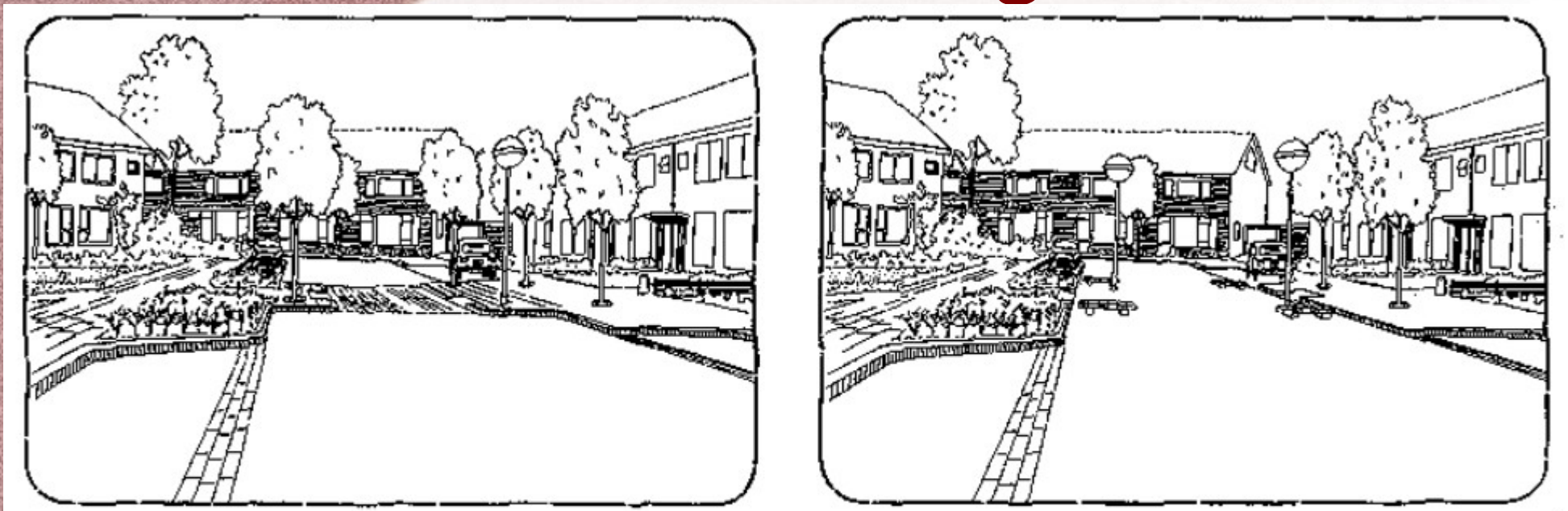
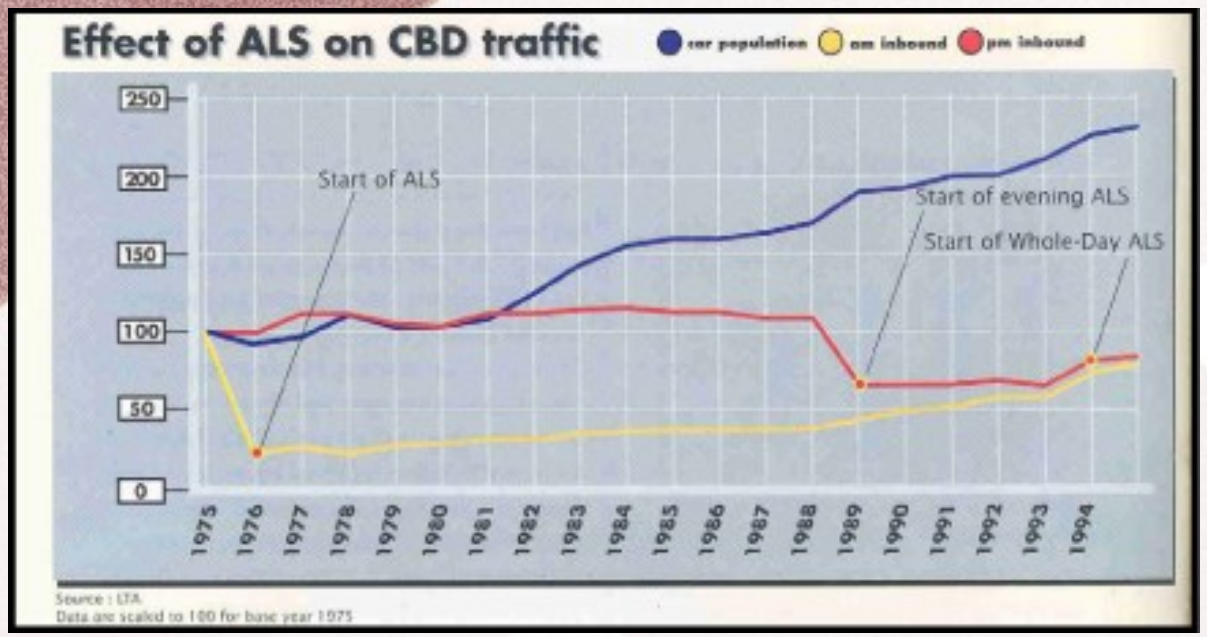


Figure 3. An example of road constriction (narrowing) in firstly a lavish design version (l) and in a cheaper design (r)

Teun de Wit & Hillie Talens, Traffic Calming in The Netherlands

- Narrow roads can improve safety and ambiance by reducing speed (30 kph) – resulted from grass-roots action
- Slowly being applied in NYC (Vision Zero)

Congestion pricing



- Singapore since 1970s: charge for driving in central city during rush hours – increased speeds substantially
- Combined with funding for good public transit
- Adopted in London, Stockholm, …, NYC?

Car-free central cities

- Make cities safe for walkers, cyclists, and breathers
- Cf. Venice, Mackinac Island, Roosevelt Island
- At least on small scale, a central component of recent urban renewal initiatives
- Could use small, slow electric vehicles for cargo and people who can't walk
- *“We experience that those areas in Oslo that are already car free are the most popular areas for all people; both inhabitants, tourists and also for business,” the Vice Mayor says. "We are improving the public transport system with cheaper prices, more departures, new trams and new metro lines.”* (2019)