# Mitigation options in the transportation sector

# Development drives car ownership

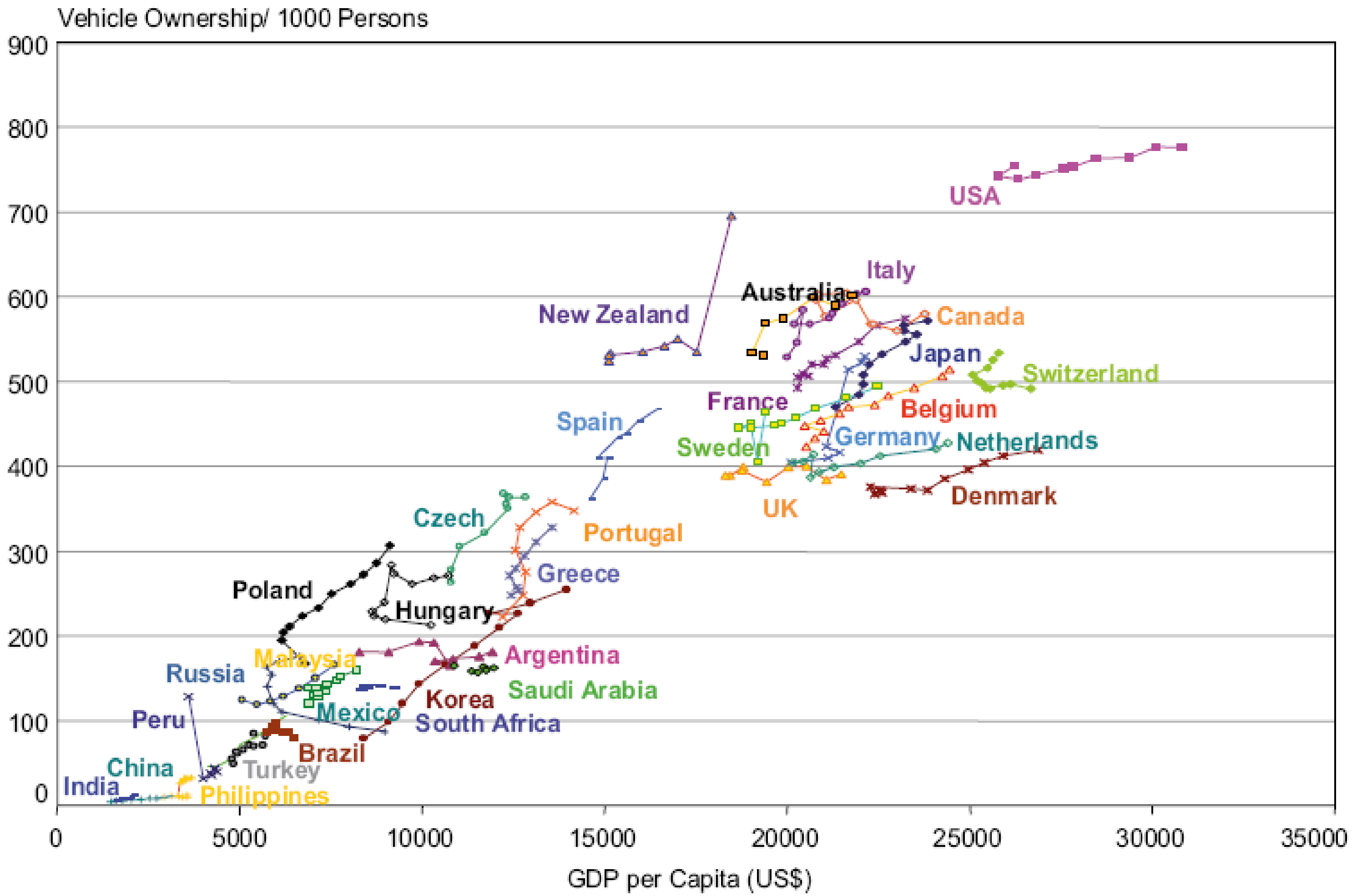



**Figure TS.14:** *Vehicle ownership and income per capita as a time line per country [Figure 5.2].*

Note: data are for 1900–2002, but the years plotted vary by country, depending on data availability.

Source: IPCC AR4 WG 3, ch 5

# Future transport energy consumption

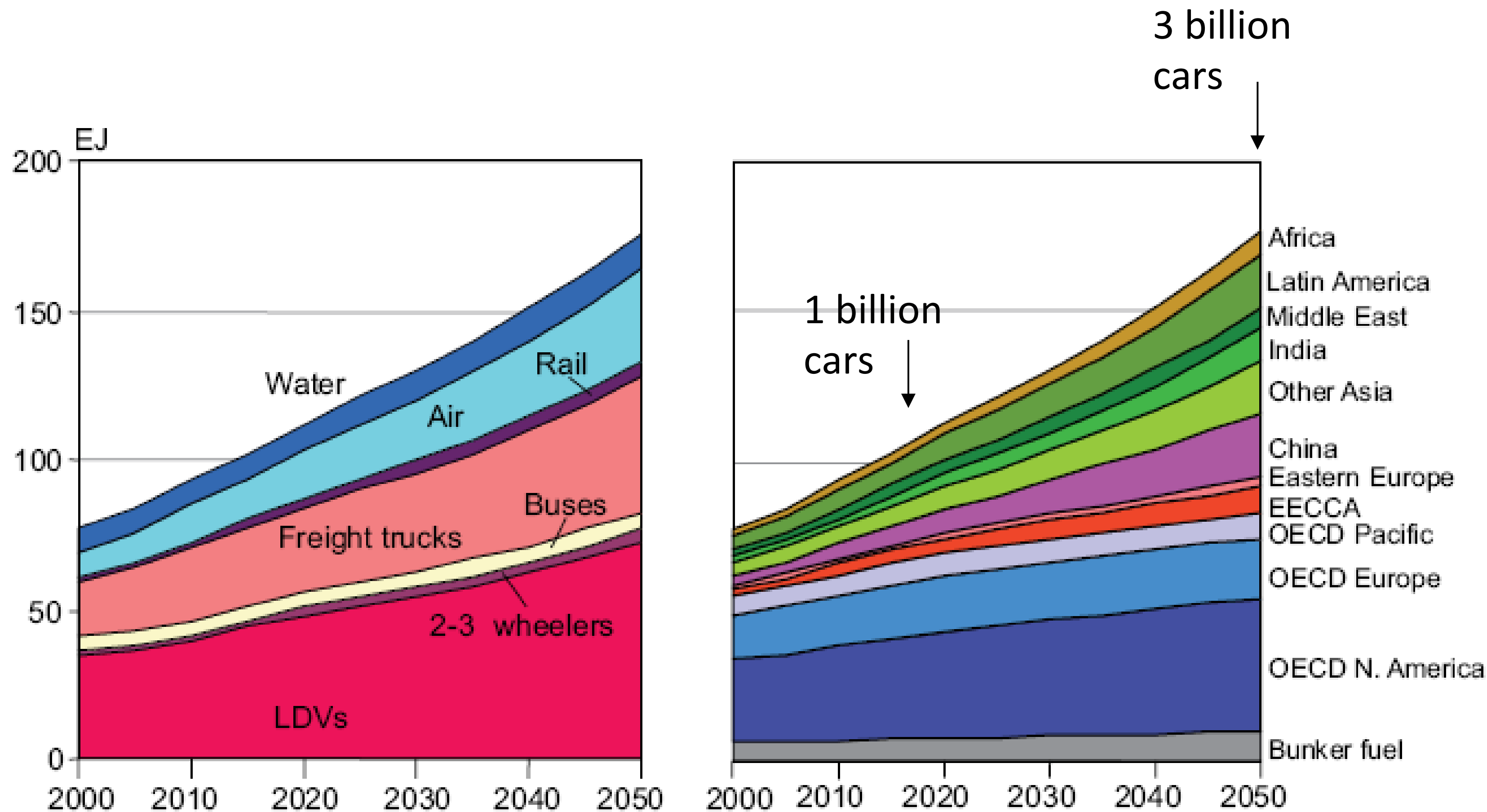



**Figure 5.3:** *Projection of transport energy consumption by region and mode*

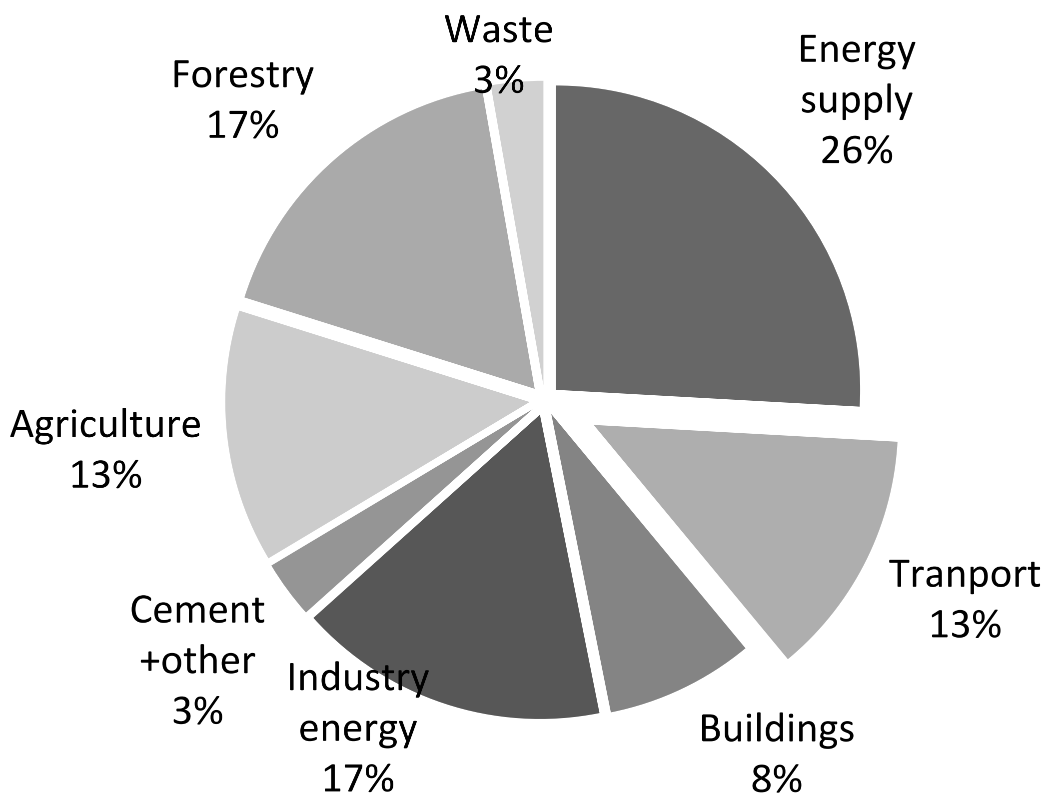
*Source: WBCSD, 2004a.*

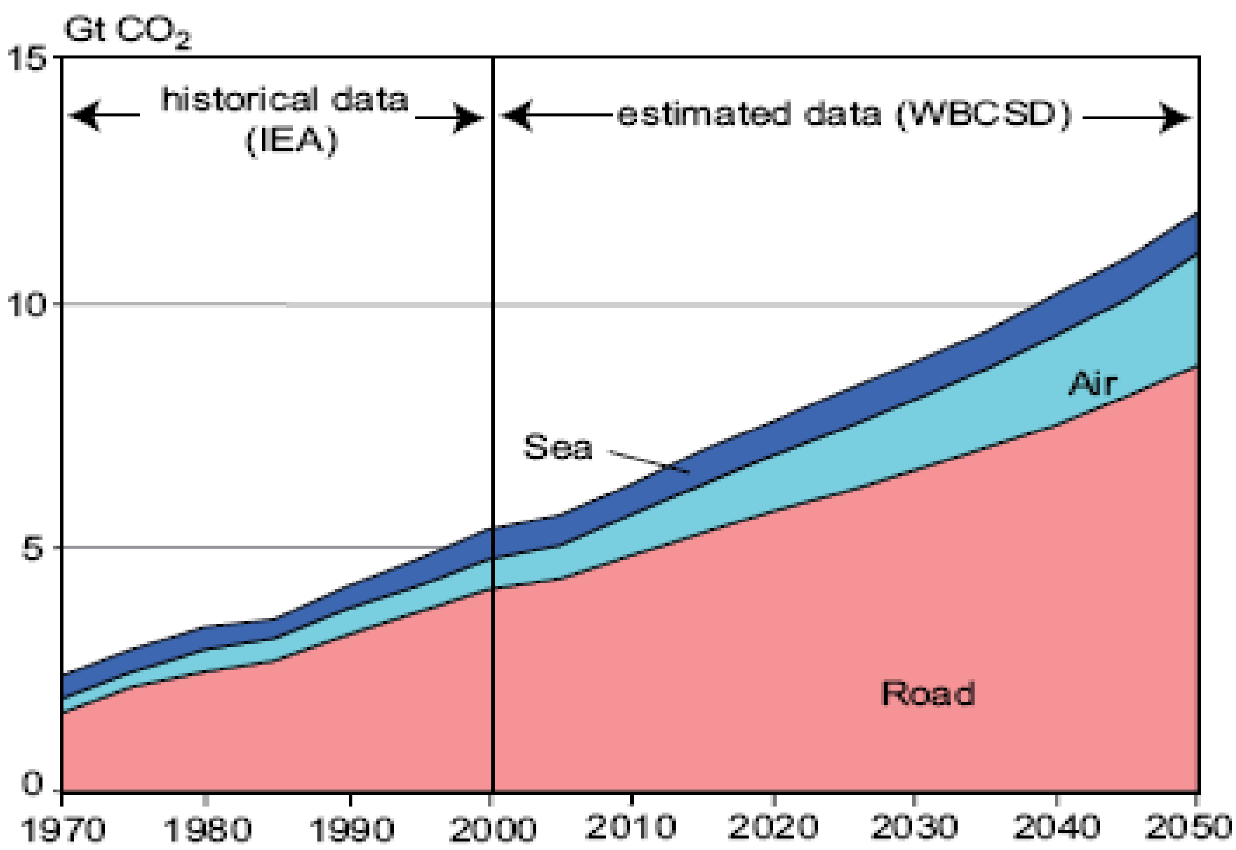
Source: IPCC AR4 WG 3, ch 5

# Oil import dependency

| Country | Oil import as % of consumption 2007 | Expected Oil import as % of consumption 2030 |
|---|---|---|
| USA | 65 | 62 |
| EU-27 | 82 | 92 |
| Australia/Nw Zealand | 92 | 89 |
| China | 51 | 74 |
| India | 72 | 92 |

# Share of transportation in global GHG emissions





Gt $CO_2$
15
10
5
0
historical data (IEA)
estimated data (WBCSD)
Sea
Air
Road
1970
1980
1990
2000
2010
2020
2030
2040
2050

# How transport emissions can be reduced

- Reduce demand
- Shift mode of transport
- Improve efficiency
- Change fuel

# Transportation demand reduction

- Build compact cities
- Create livable city centres
- Increase price of transportation
- Telecommuting
- Provide recreational areas in/close to city

# Commercial transport mitigation technologies

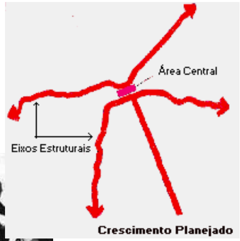
NOW 2030











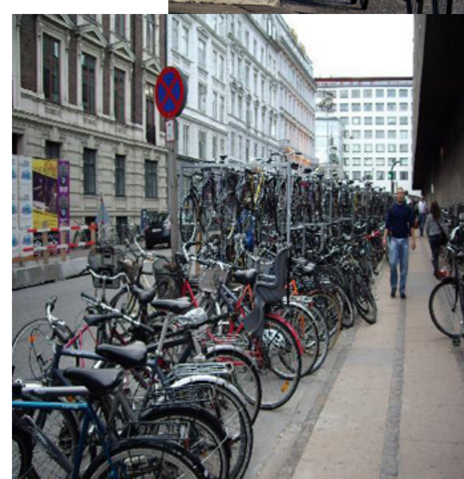



# Transport modes

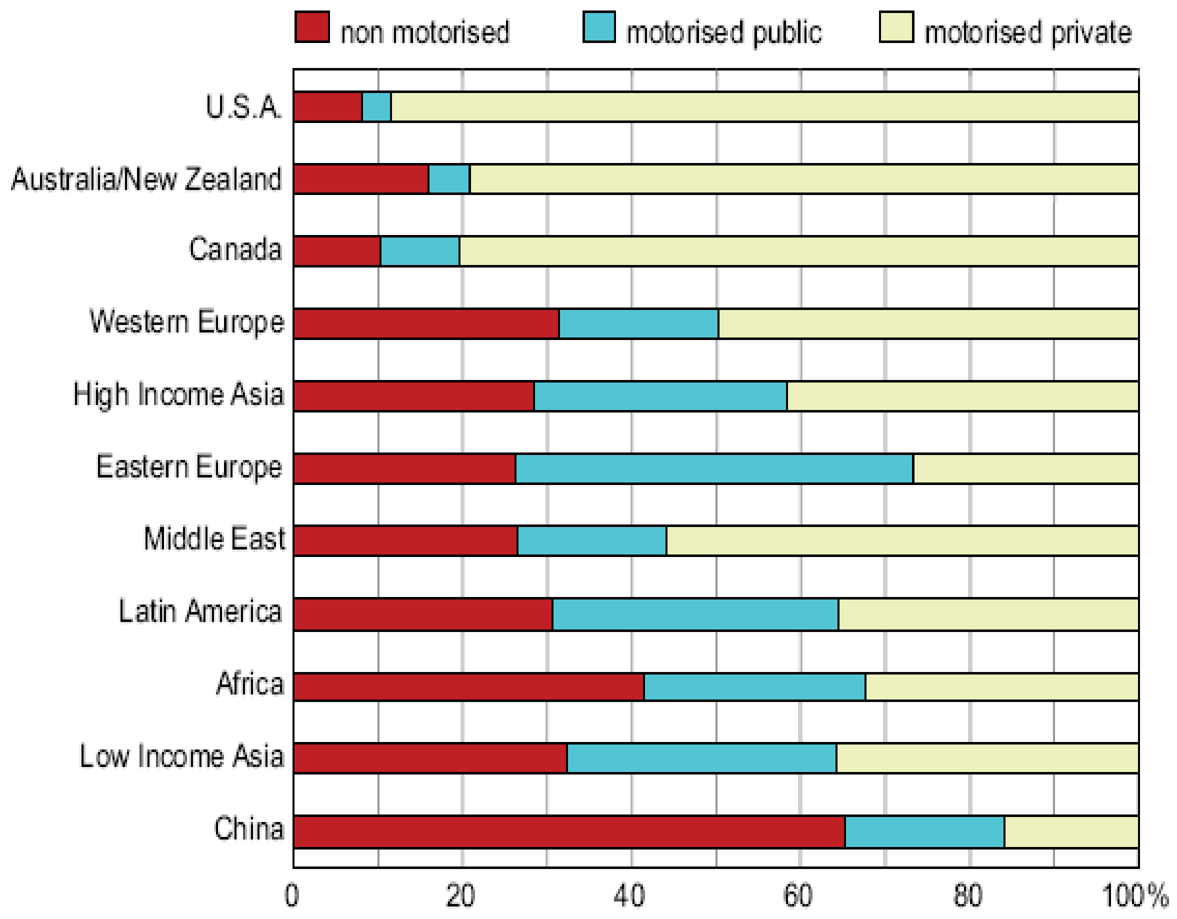
# Bus Rapid Transit Systems are a success in developing country mega cities

# Copenhagen bicycle programme

- Convert streets into pedestrian area
- Reduce traffic parking gradually
- Turn parking lots into public spaces
- Keep  buildings dense and low
- Maintain human scale
- Create residential buildings in city centre
- Encourage student  city living
- Make city attractive in all seasons
- Good bike infrastructure
- Provide easy rental bikes



# City transportation, 1995 (% of trips)



# CO2 intensity of transport modes (developing countries)

| | Load factor (average occupancy) | $CO_2$-eq emissions per passenger-km (full energy cycle) |
|---|---|---|
| Car (gasoline) | 2.5 | 130-170 |
| Car (diesel) | 2.5 | 85-120 |
| Car (natural gas) | 2.5 | 100-135 |
| Car (electric)[a)] | 2.0 | 30-100 |
| Scooter (two-stroke) | 1.5 | 60-90 |
| Scooter (four-stroke) | 1.5 | 40-60 |
| Minibus (gasoline) | 12.0 | 50-70 |
| Minibus (diesel) | 12.0 | 40-60 |
| Bus (diesel) | 40.0 | 20-30 |
| Bus (natural gas) | 40.0 | 25-35 |
| Bus (hydrogen fuel cell)[b)] | 40.0 | 15-25 |
| Rail Transit[c)] | 75% full | 20-50 |

Note: All numbers in this table are estimates and approximations and are best treated as illustrative.

a) Ranges are due largely to varying mixes of carbon and non-carbon energy sources (ranging from about 20–80% coal), and also the assumption that the battery electric vehicle will tend to be somewhat smaller than conventional cars.
b) Hydrogen is assumed to be made from natural gas.
c) Assumes heavy urban rail technology ('Metro') powered by electricity generated from a mix of coal, natural gas and hydropower, with high passenger use (75% of seats filled on average).

# Fuel efficiency of current new cars

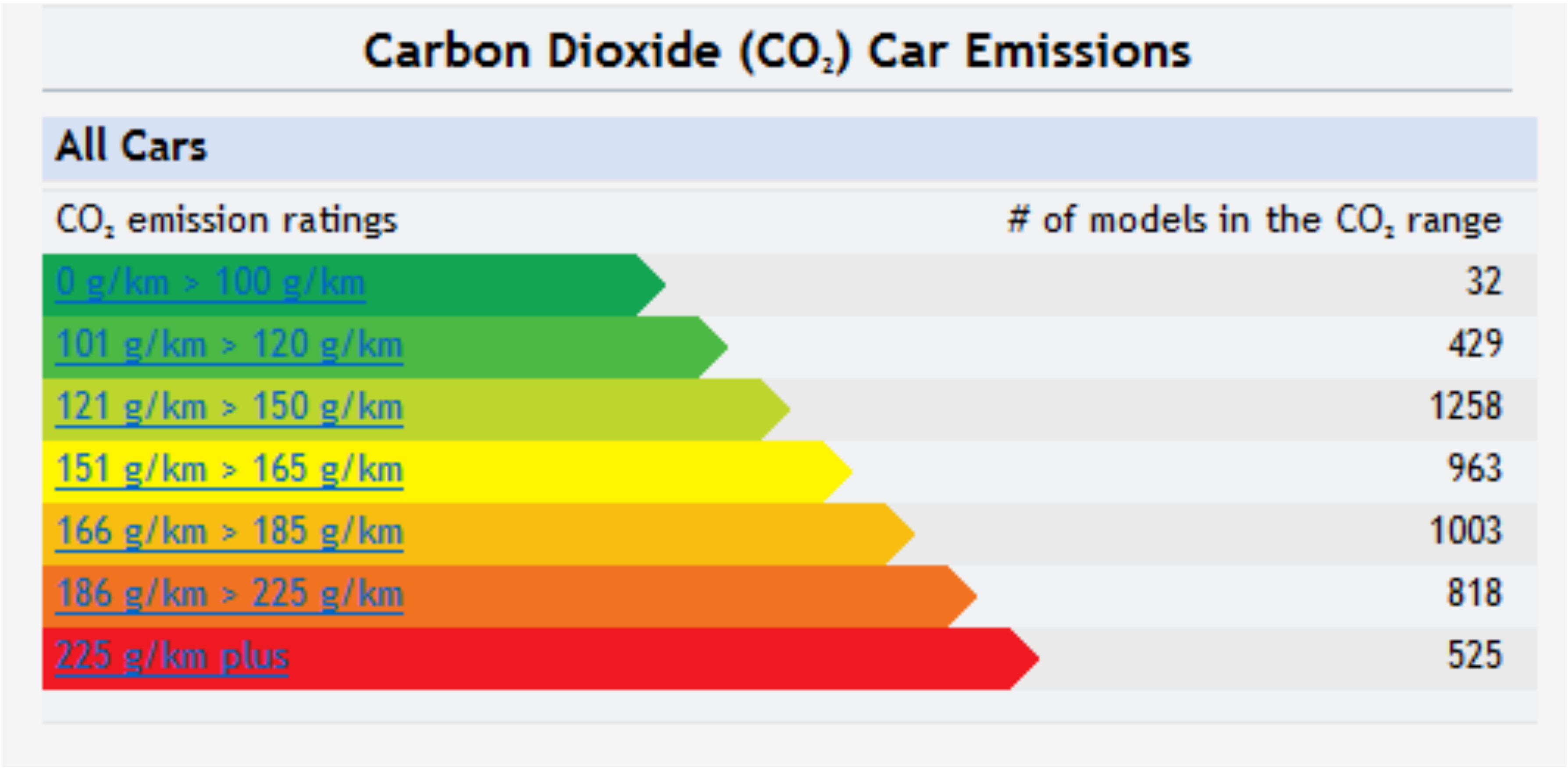
88 g CO2/km (best)


104 g CO2/km

197 g CO2/km

495 g CO2/km (worst)

# But the average is still high ….



**Carbon Dioxide ($CO_2$) Car Emissions**

**All Cars**

| $CO_2$ emission ratings | # of models in the $CO_2$ range |
|---|---|
| 0 g/km > 100 g/km | 32 |
| 101 g/km > 120 g/km | 429 |
| 121 g/km > 150 g/km | 1258 |
| 151 g/km > 165 g/km | 963 |
| 166 g/km > 185 g/km | 1003 |
| 186 g/km > 225 g/km | 818 |
| 225 g/km plus | 525 |

http://www.carpages.co.uk/co2/

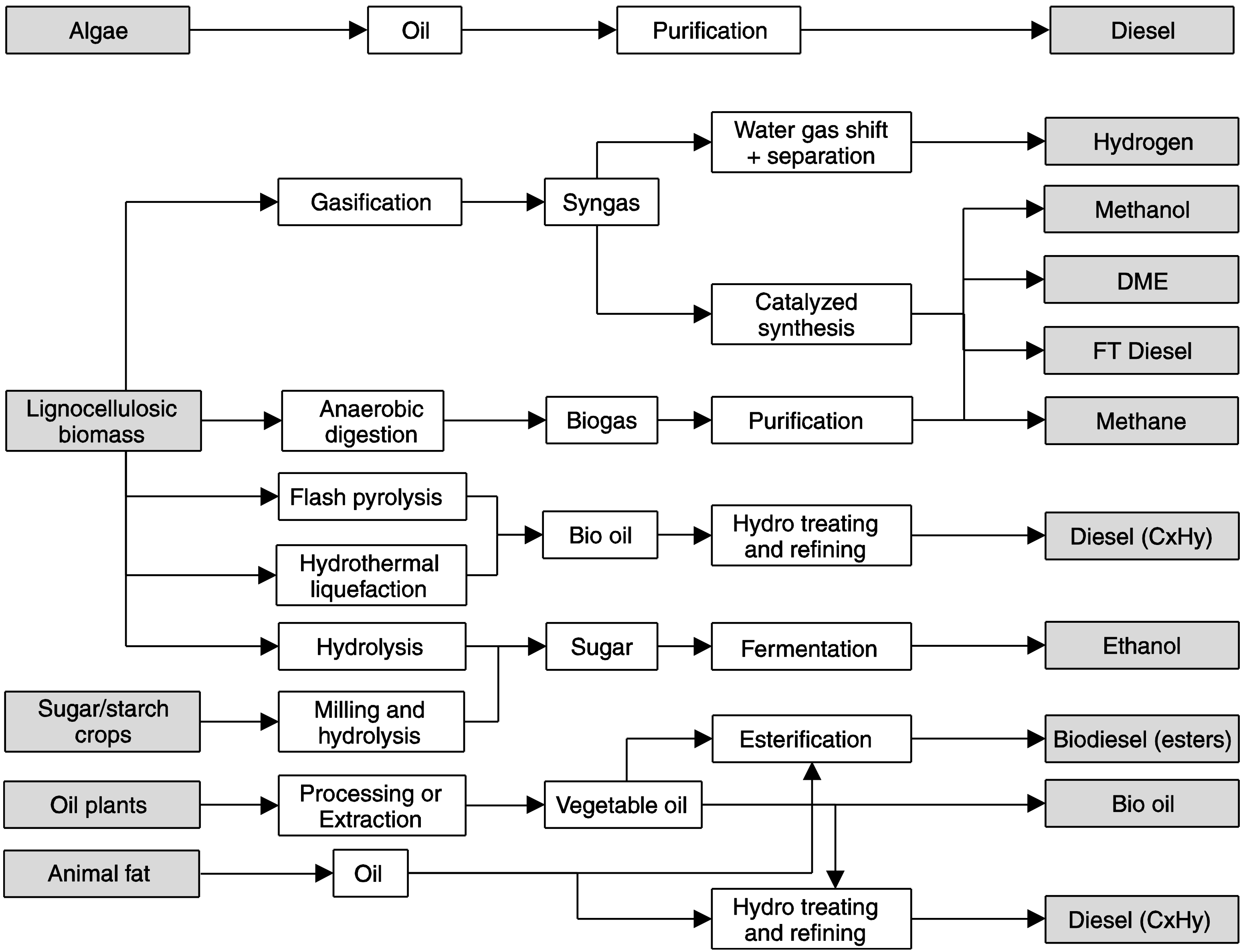
# How to improve fuel efficiency?

- Lighter cars
- Smaller cars
- Better aerodynamics
- Hybrid electric
- More rapid penetration of new cars
- Scrapping gaz guzzlers
- ????

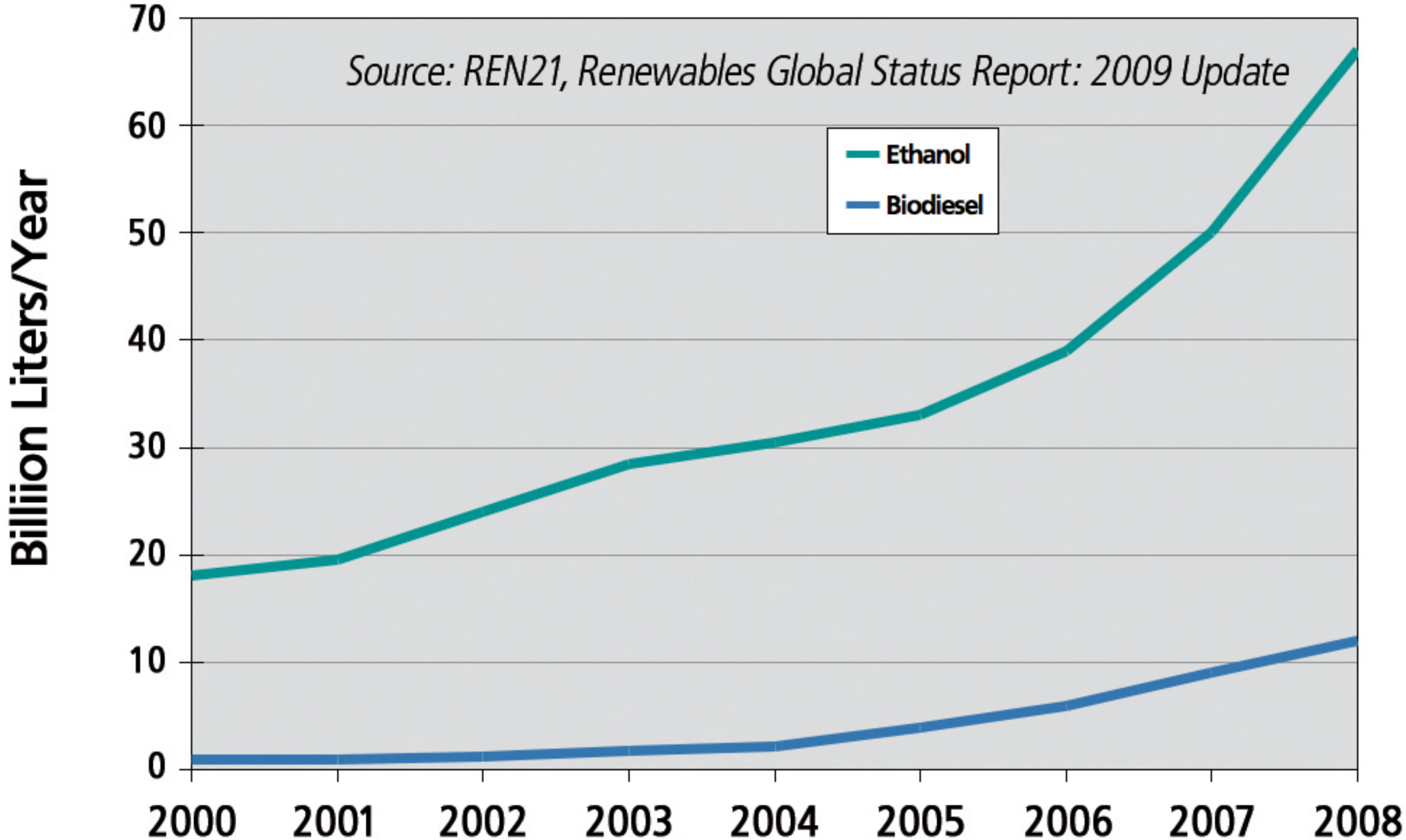
# CO2 intensity of freight transport modes

| **Freight transport mode** | **Average CO2 emissions (grams per ton-kilometre)** | **Remarks** |
|---|---|---|
| Inland shipping | 31 | |
| Ocean shipping | 14 | Varies from 8 for bulk tankers to 25 for container ships and 124 for refrigerated cargo ships |
| Rail | 23 | Mix of electric and diesel trains |
| Road | 123 | Varies from 92 for heavy trucks to 400 for light trucks |

# Biofuels production



# Ethanol and Biodiesel Production, 2000–2008



# How much does biofuel really reduce CO2?

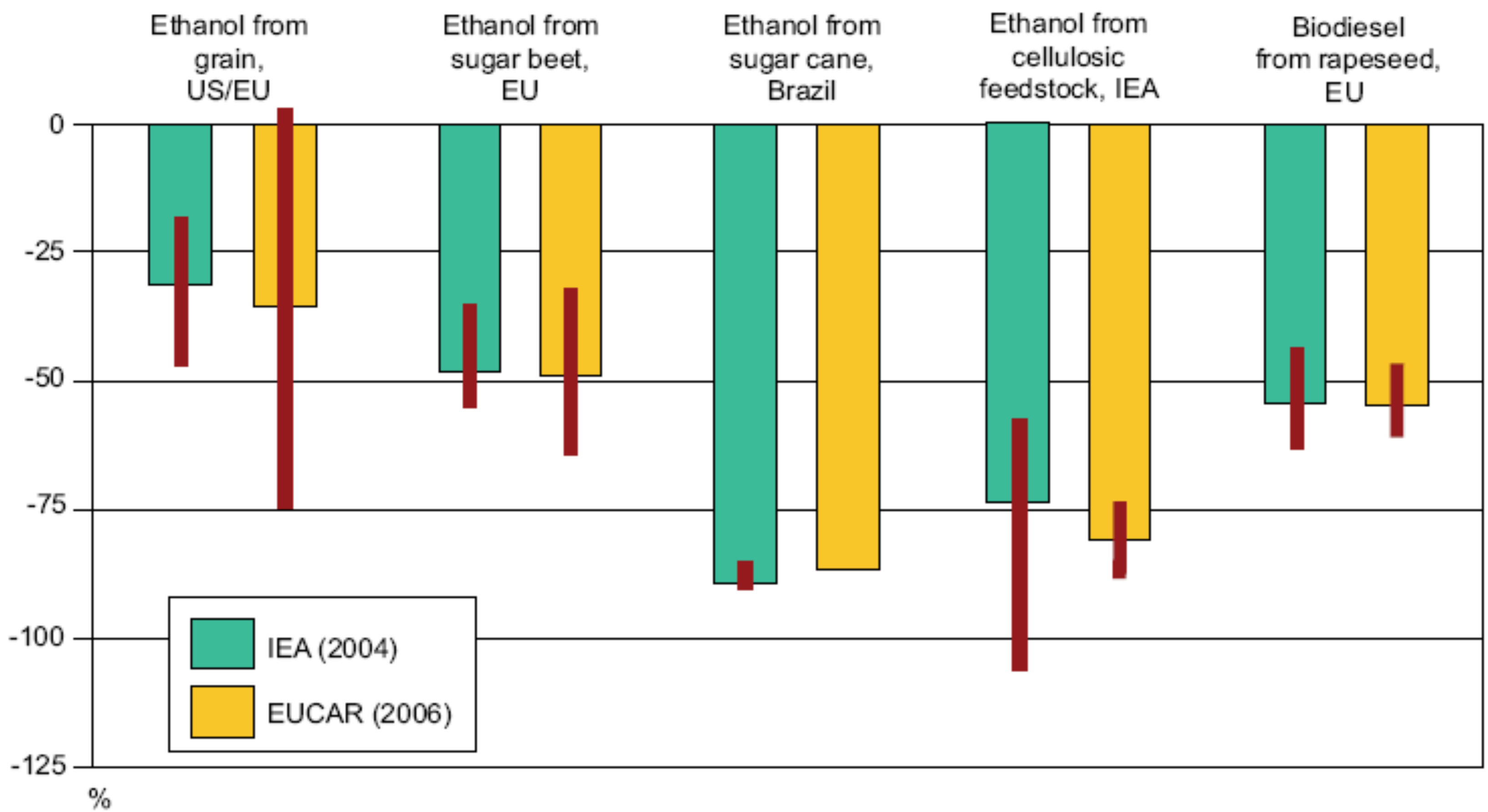



**Figure 5.10:** *Reduction of well-to-wheels GHG emissions compared to conventionally fuelled vehicles*

Note: bars indicate range of estimates.

*Source: IEA, 2004c; EUCAR/CONCAWE/JRC, 2006.*

Source: IPCC AR4 WG 3, ch 5

# Biofuel costs

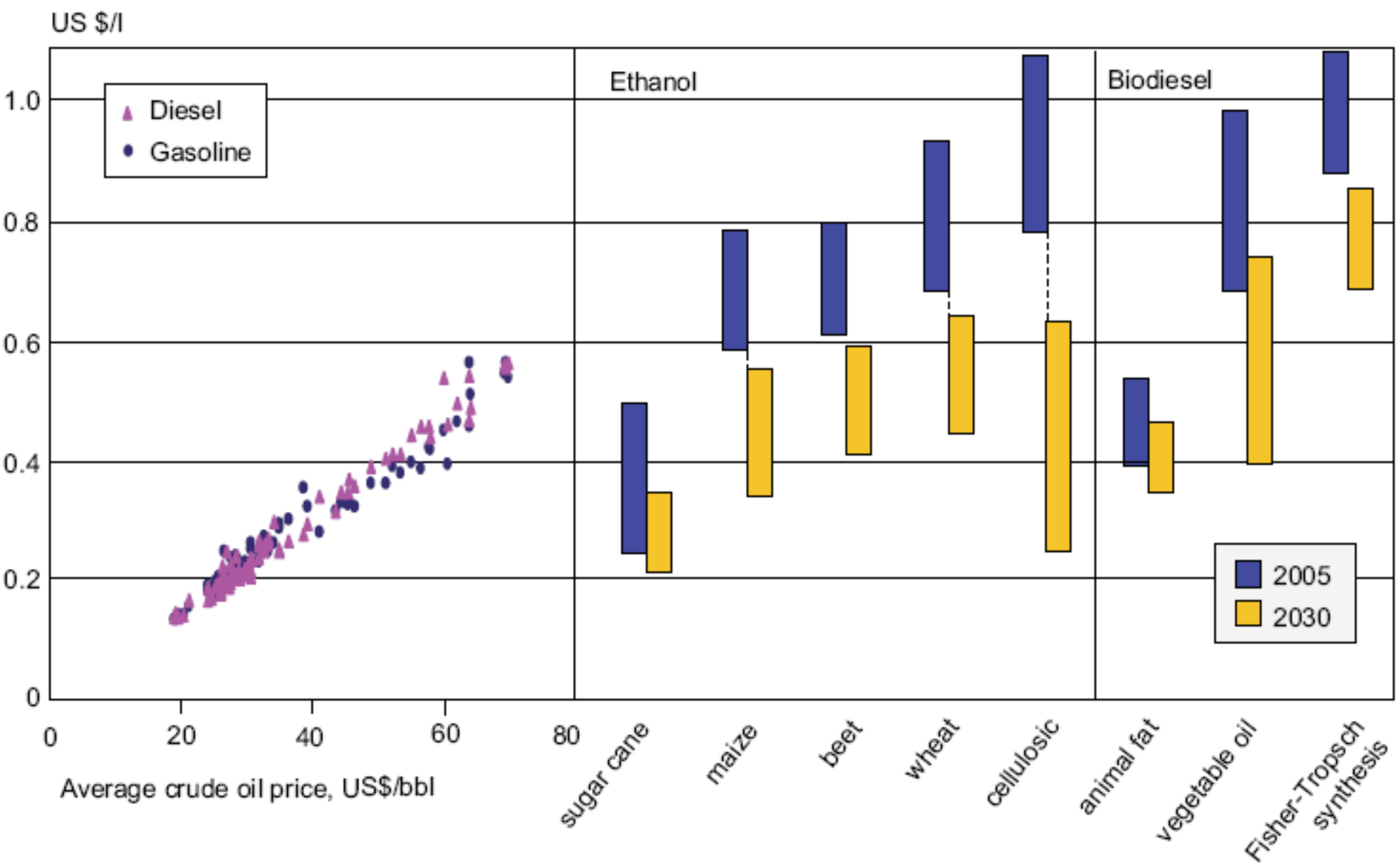
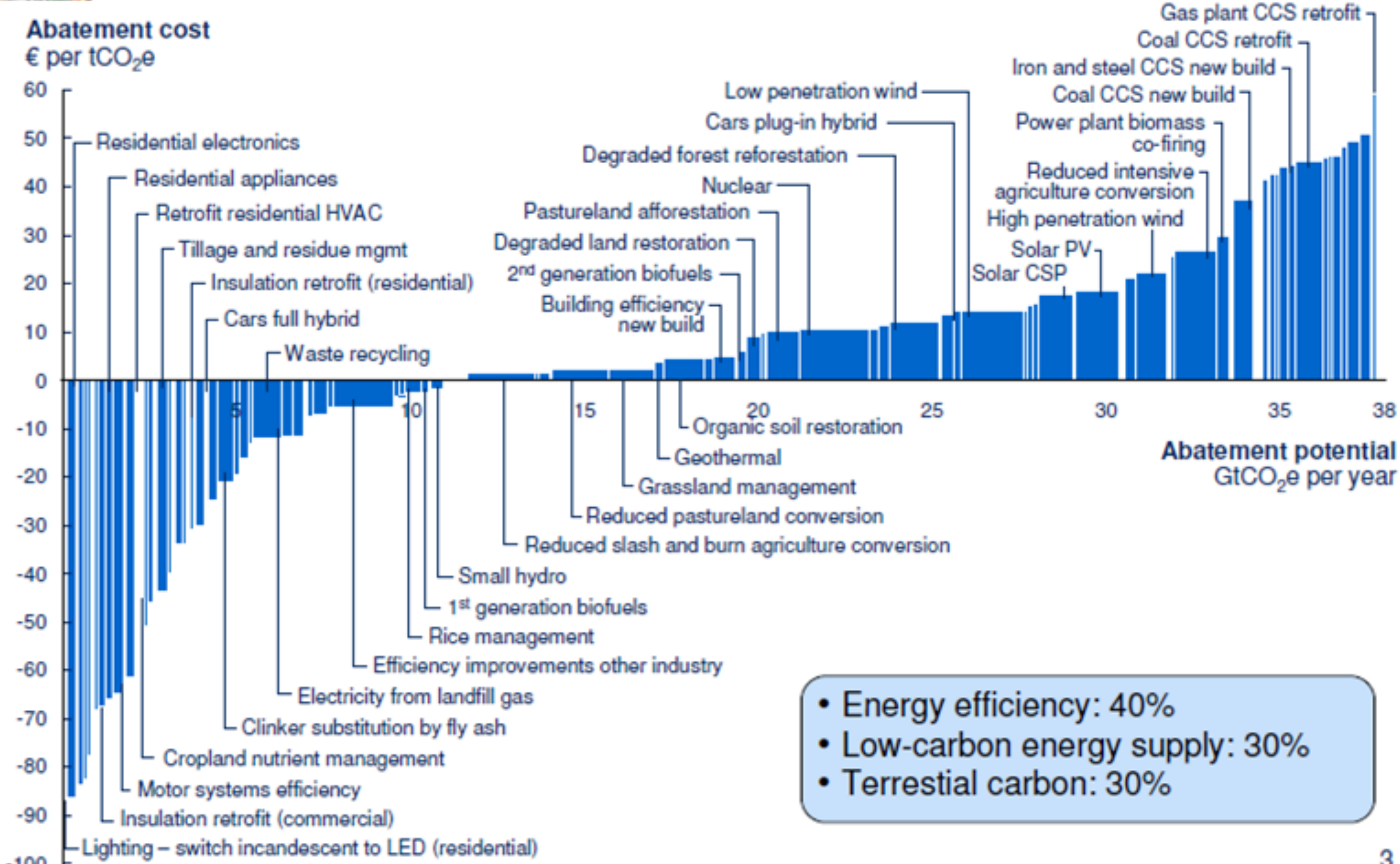



**Figure 5.9:** *Comparison of cost for various biofuels with those for gasoline and diesel*

*Source: IEA, 2006b.*

Source: IPCC AR4 WG 3, ch 5

# Global GHG abatement cost curve beyond business-as-usual – 2030




- Energy efficiency: 40%
- Low-carbon energy supply: 30%
- Terrestial carbon: 30%

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60/$tCO_2e$ if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

# 2030 biofuel potential

- Baseline:  3% of total road transport energy (92 Mtoe = ~4 EJ)
- Policy case: 5-10% (150-300 MToe= ~6-12 EJ)
- Technology scenarios: 13-25% *by 2050*
- Sustainability criteria

Source: IPCC AR4 WG 3, ch 5

# Biofuel, help or hindrance?

**Pro**

- Oil import reduction
- New cash crop
- Rural fuel source
- Some $CO_2$ reduction

**Con**

- First generation poor $CO_2$ reduction
- High cost per tonne of $CO_2$ avoided
- Can compete with food production
- Can lead to additional deforestation
- Huge subsidies

# China: >120 million e-bikes and e-scooters in use


(a)


(b)

# Electric cars you can buy now




# CO2 intensity of transport modes (developing countries)

| | Load factor (average occupancy) | $CO_2$-eq emissions per passenger-km (full energy cycle) |
|---|---|---|
| Car (gasoline) | 2.5 | 130-170 |
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Note: All numbers in this table are estimates and approximations and are best treated as illustrative.

a) Ranges are due largely to varying mixes of carbon and non-carbon energy sources (ranging from about 20–80% coal), and also the assumption that the battery electric vehicle will tend to be somewhat smaller than conventional cars.
b) Hydrogen is assumed to be made from natural gas.
c) Assumes heavy urban rail technology ('Metro') powered by electricity generated from a mix of coal, natural gas and hydropower, with high passenger use (75% of seats filled on average).

USA: 60-130 gCO2/km

# Costs of plug-in hybrid electric vehicles

| | CONVENTIONAL HYBRID | PLUG-IN HYBRID (with a 40-mile all-electricity range) |
|---|---|---|
| **Near-term incremental costs** | | |
| Battery | $2,000 | $17,500 |
| Other | $1,500 | $1,500 |
| Annual fuel savings | $480 | $705 |
| Payback (years) | 7.3 | 27.0 |
| **Long-term incremental costs** | | |
| Battery | $600 | $3,500 |
| Other | $1,000 | $1,000 |
| Annual fuel savings | $480 | $705 |
| Payback (years) | 2.9 | 6.4 |

| Measure | Total oil consumption reduction (% from BaU) | CO2 emissions reduction compared to BaU (GtCO2/yr | Other benefits |
|---|---|---|---|
| Reduce demand | low | low | Congestion can benefit more |
| Modal shift passenger transport | moderate | moderate | Congestion can benefit considerably |
| Modal shift freight transport | negligible | negligible | |
| Efficiency passenger road transport | 10 | 0.75 | |
| Efficiency freight road transport | 2-5 | 0.1-0.4 | |
| Biofuel | 5-10 | 0.1-0.4 | Sustainability constraints could reduce this amount |
| Electricity | low | negligible | |
| Hydrogen | negligible | negligible | |
| More efficient airline transport | n/a | 0.28 | |
| Freight shipping | n/a | 0.3-0.4 | |
| Rail | negligible | low | |
| TOTAL | | 1.6-2.3 | |

2030 contributions

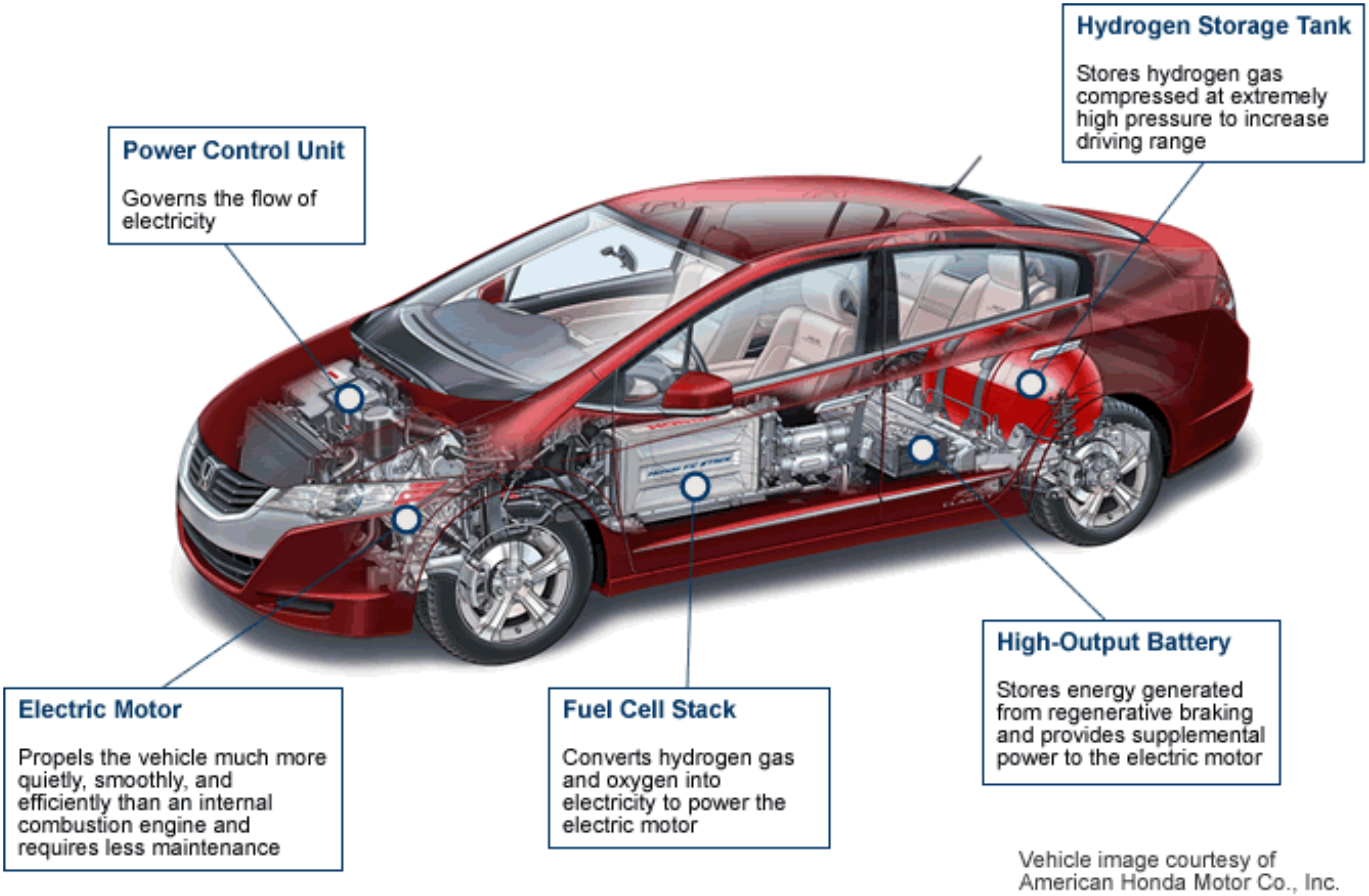
# Car fuel efficiency assumptions IPCC scenario

| Case | Average fuel efficiency new vehicle (mpg) | % improvement compared to 2001 |
|---|---|---|
| 2001 | 30.6 | |
| 2030 baseline | 43.2 | 40 |
| 2030 advanced | 49.2 | 60 |
| 2030 hybrid | 70.7 | 130 |
| 2030 diesel | 58.1 | 90 |
| 2030 diesel hybrid | 82.5 | 170 |

- New car sales in 2015: 20% hybrids; 2030: 75%
- Oil savings 2030: 6-11 EJ = 5-10% (from baseline)
- Costs (at oil price > $60/b): mostly negative

Source: IPCC AR4 WG 3, ch 5 and IEA WEO, 2006

# Hydrogen fuel cell vehicle



# Changes in lifestyle and behaviour patterns can contribute to climate change mitigation

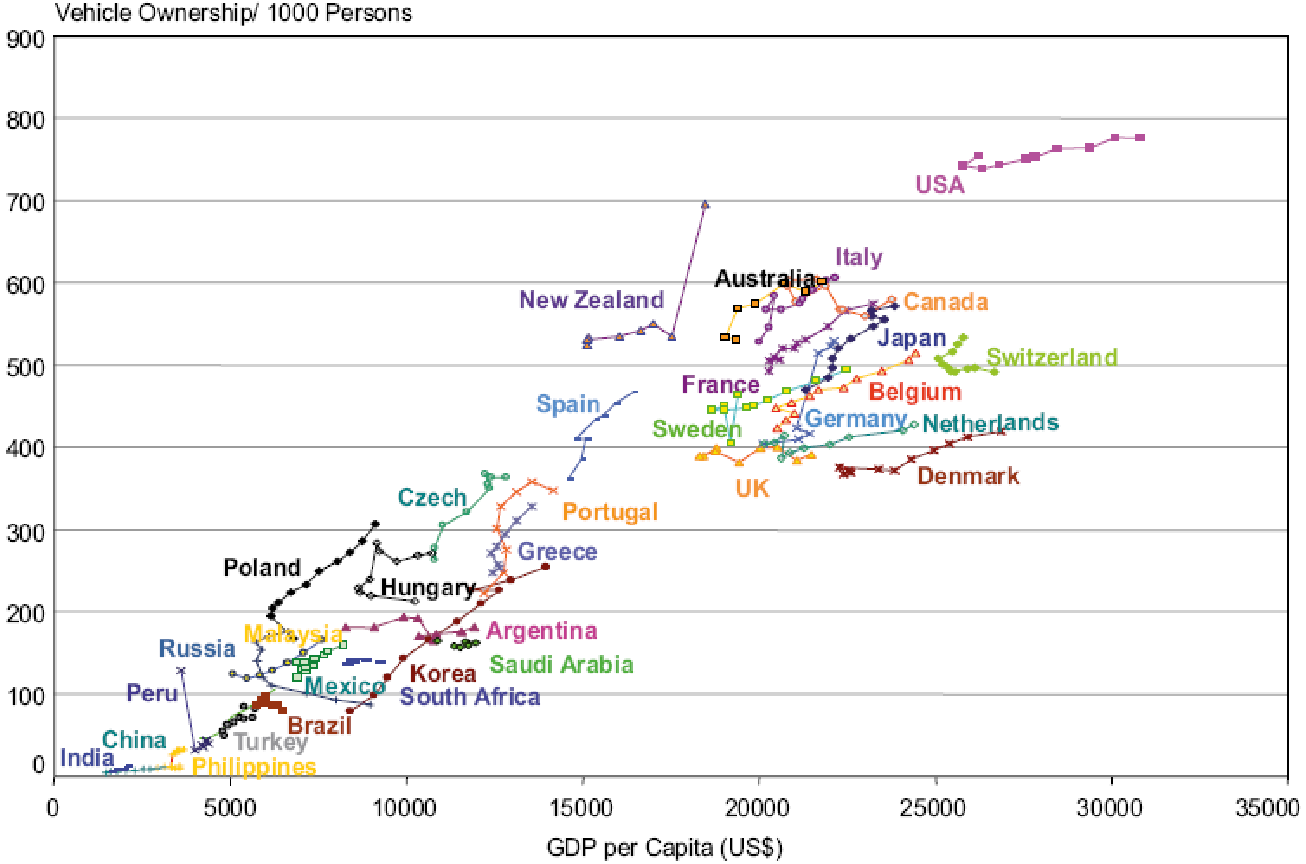



**Figure TS.14:** *Vehicle ownership and income per capita as a time line per country [Figure 5.2].*

Note: data are for 1900–2002, but the years plotted vary by country, depending on data availability.