Energy and CO_2 Emissions in Transport

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Contents

1. Introduction

Basic principle:

$$S=f(E, \eta\ (Tc), \eta\ (Tis))$$

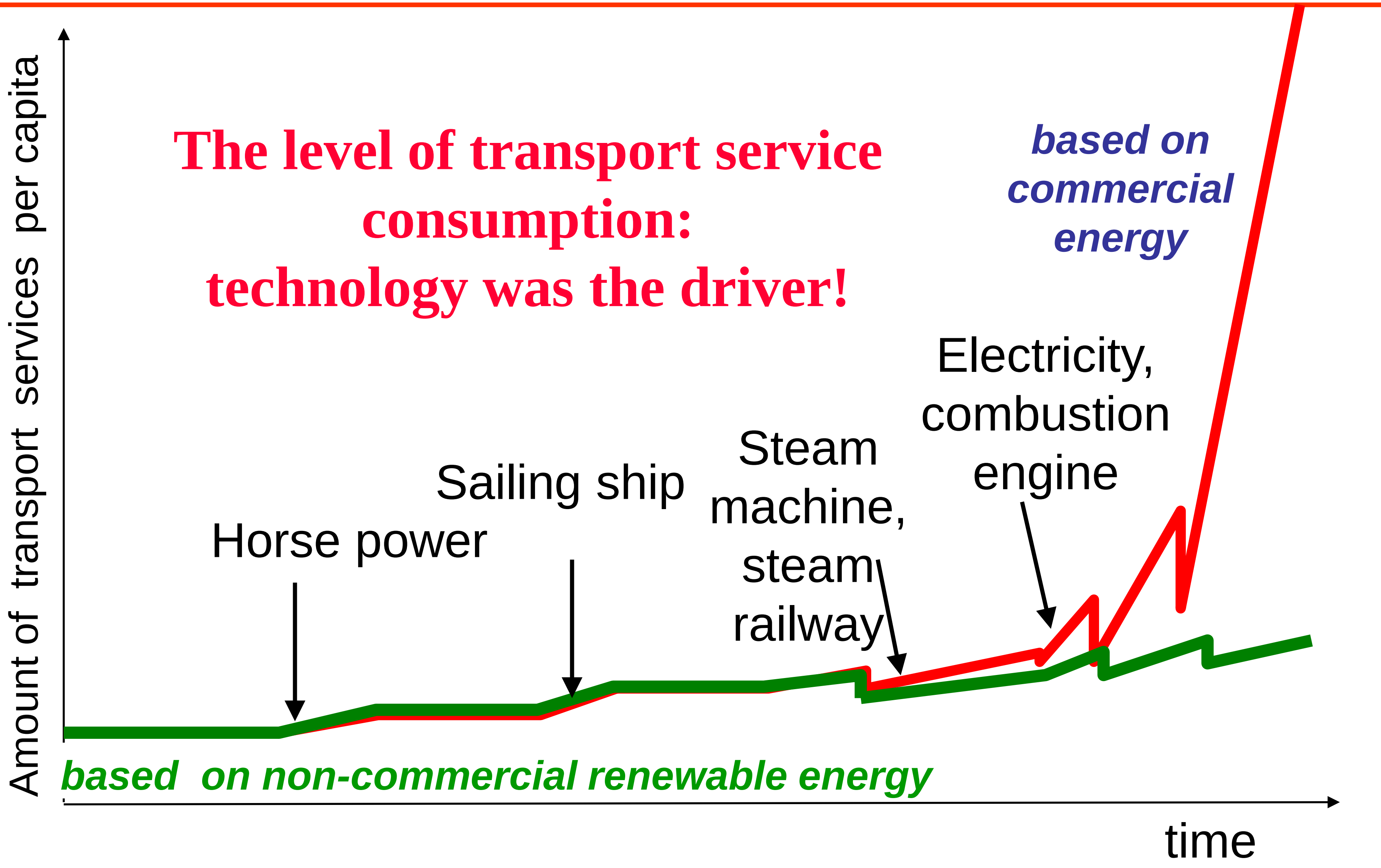
Infrastructur

Service:
km driven

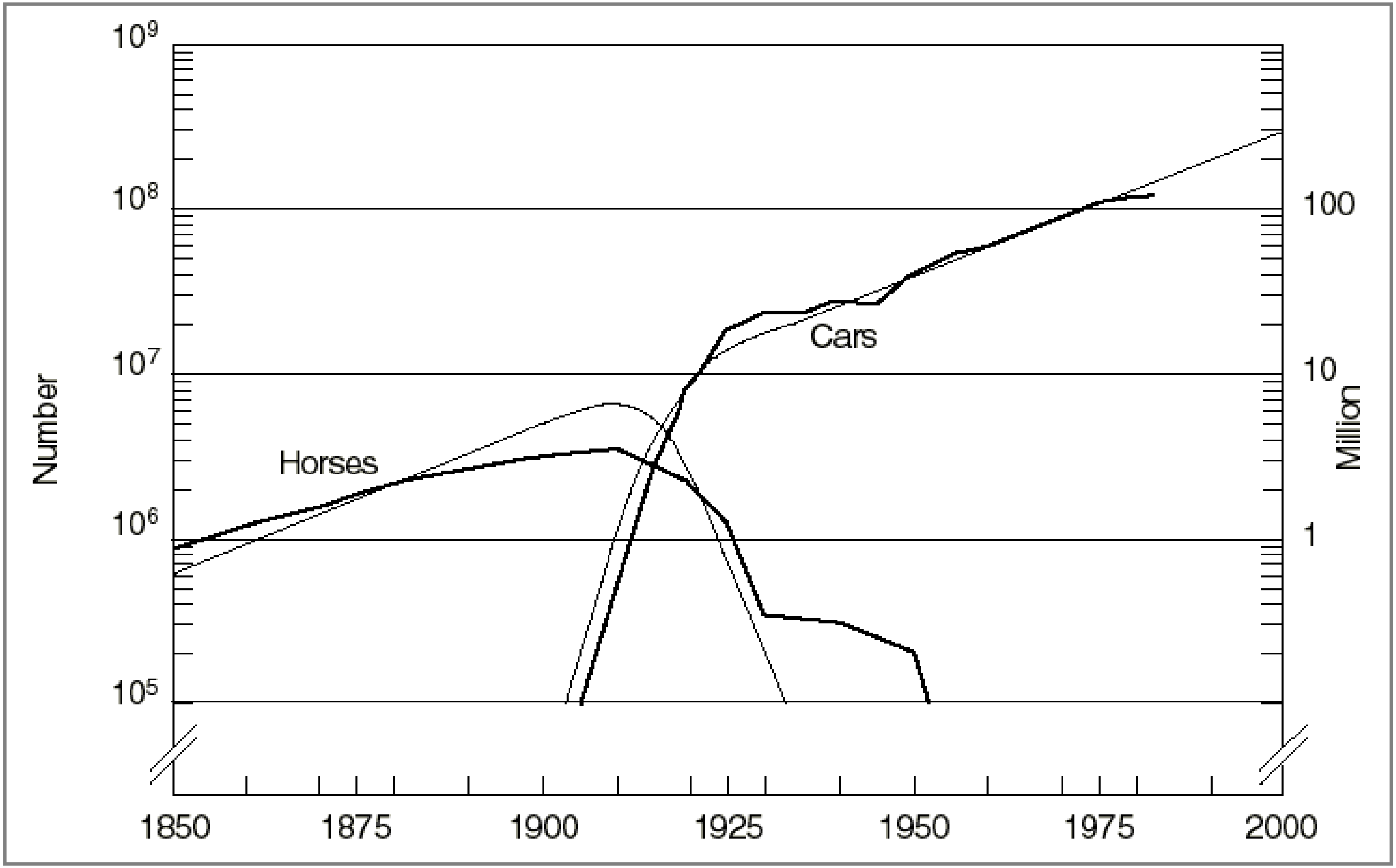
Fuel mix

Efficiency:
Liter/100 km

2. Historical developments

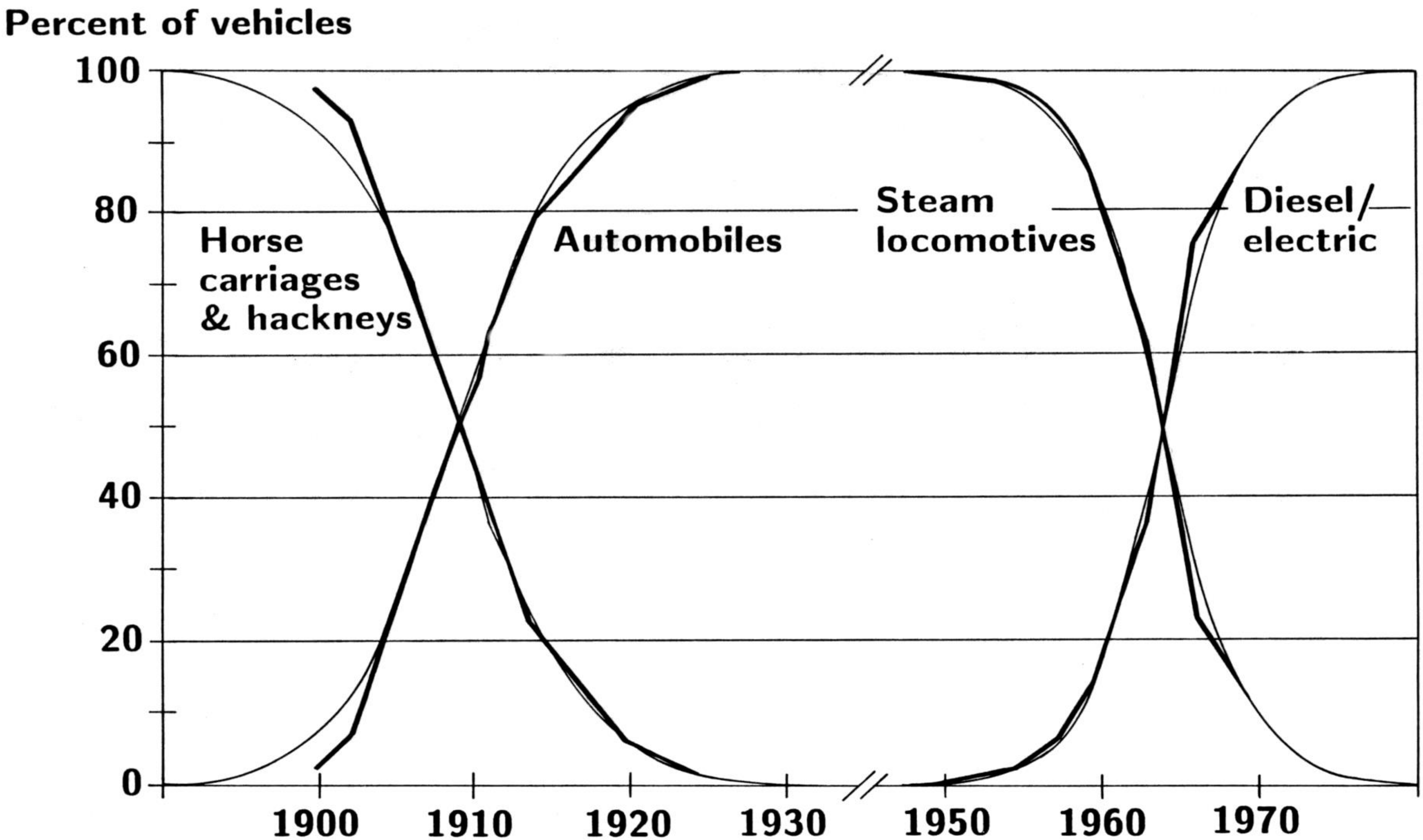

The level of transport service consumption:
technology was the driver!
based on commercial energy
Electricity, combustion engine
Steam machine, steam railway
Sailing ship
Horse power
Amount of transport services per capita
based on non-commercial renewable energy
time

USA – Number of Horses and Cars

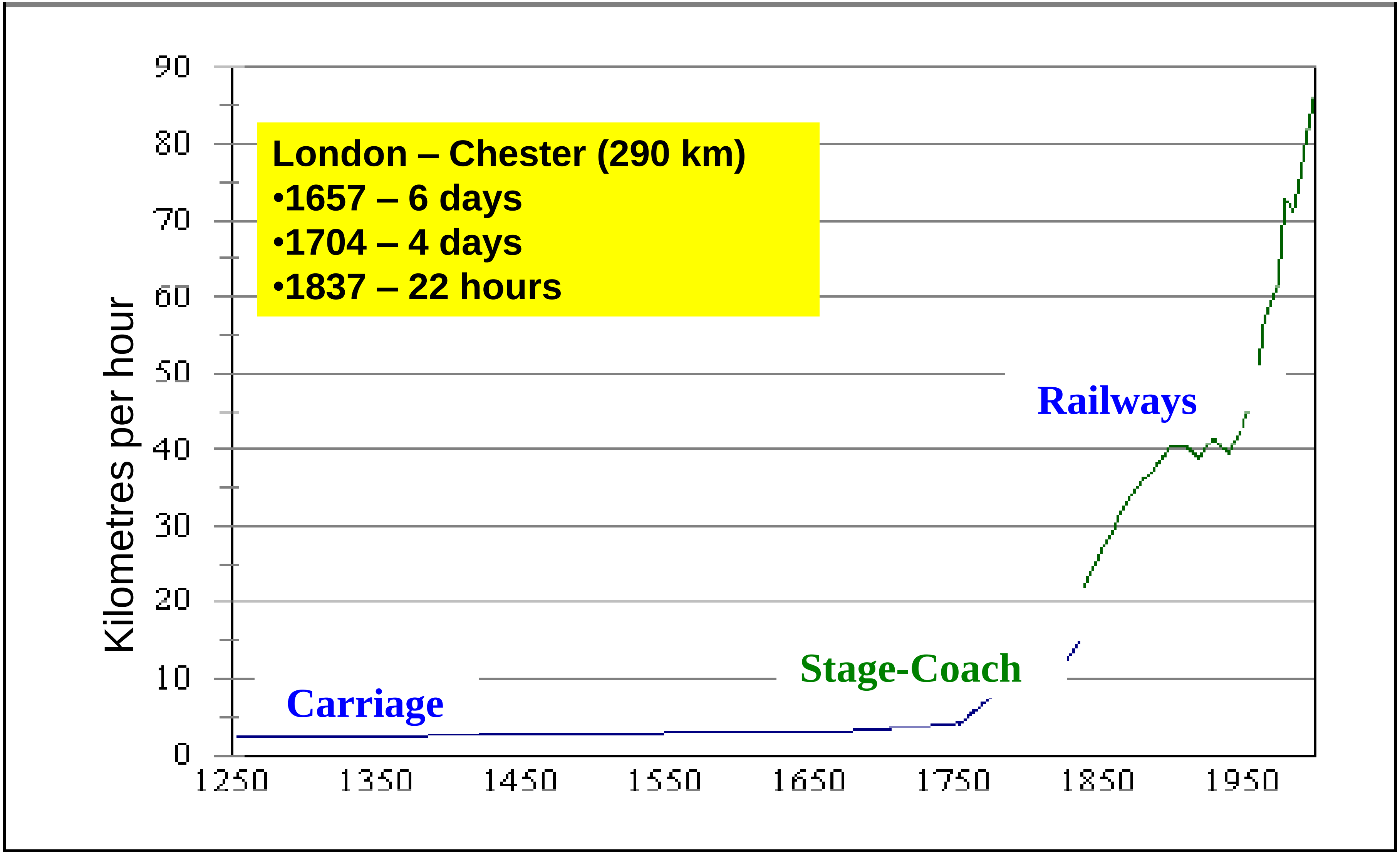


Source: Nakicenovic, 1984.

UK – Replacement within Vehicle Fleets



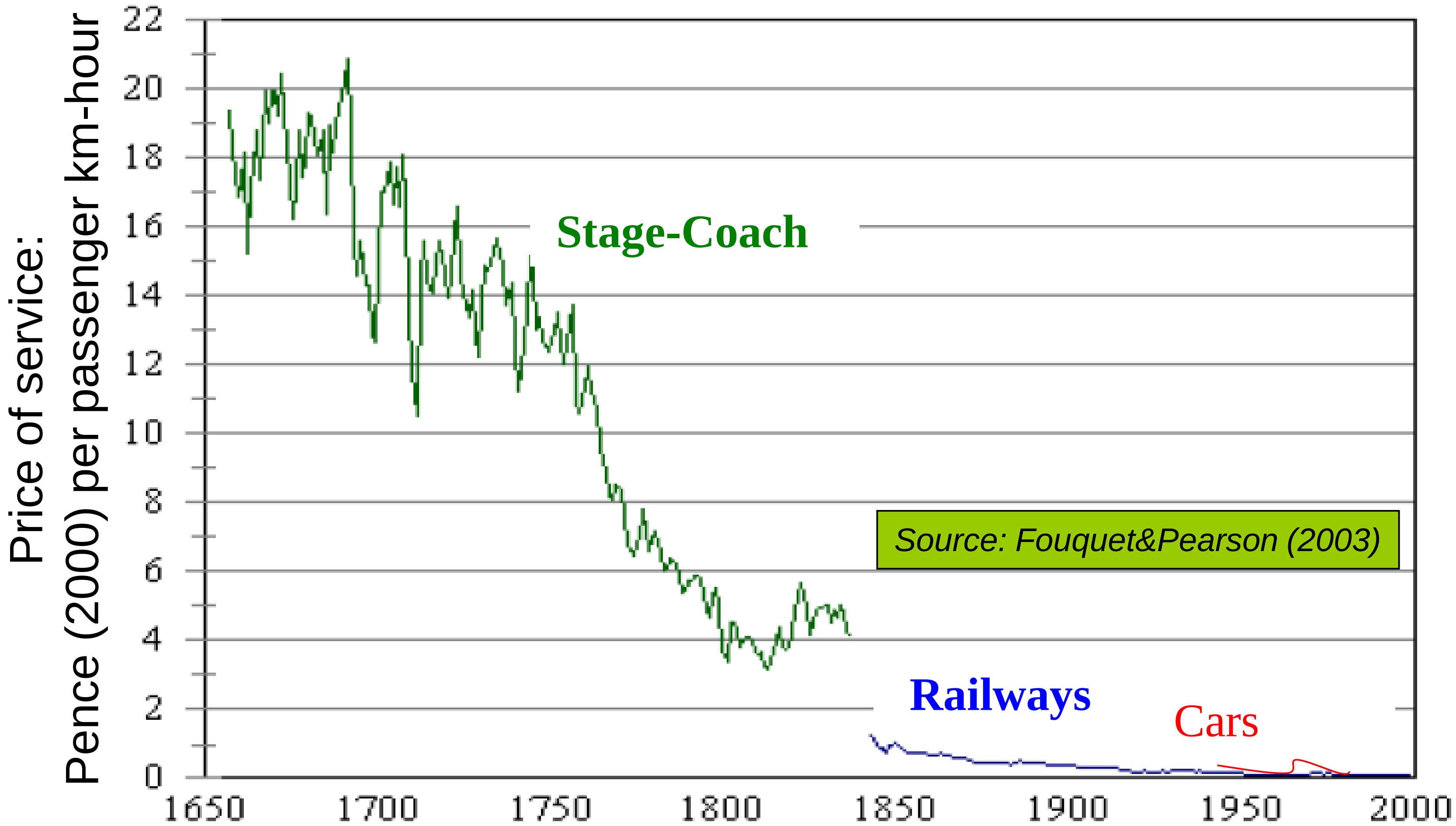
The Speed of Transport (Kilometres per Hour)



Source: Fouquet,2003

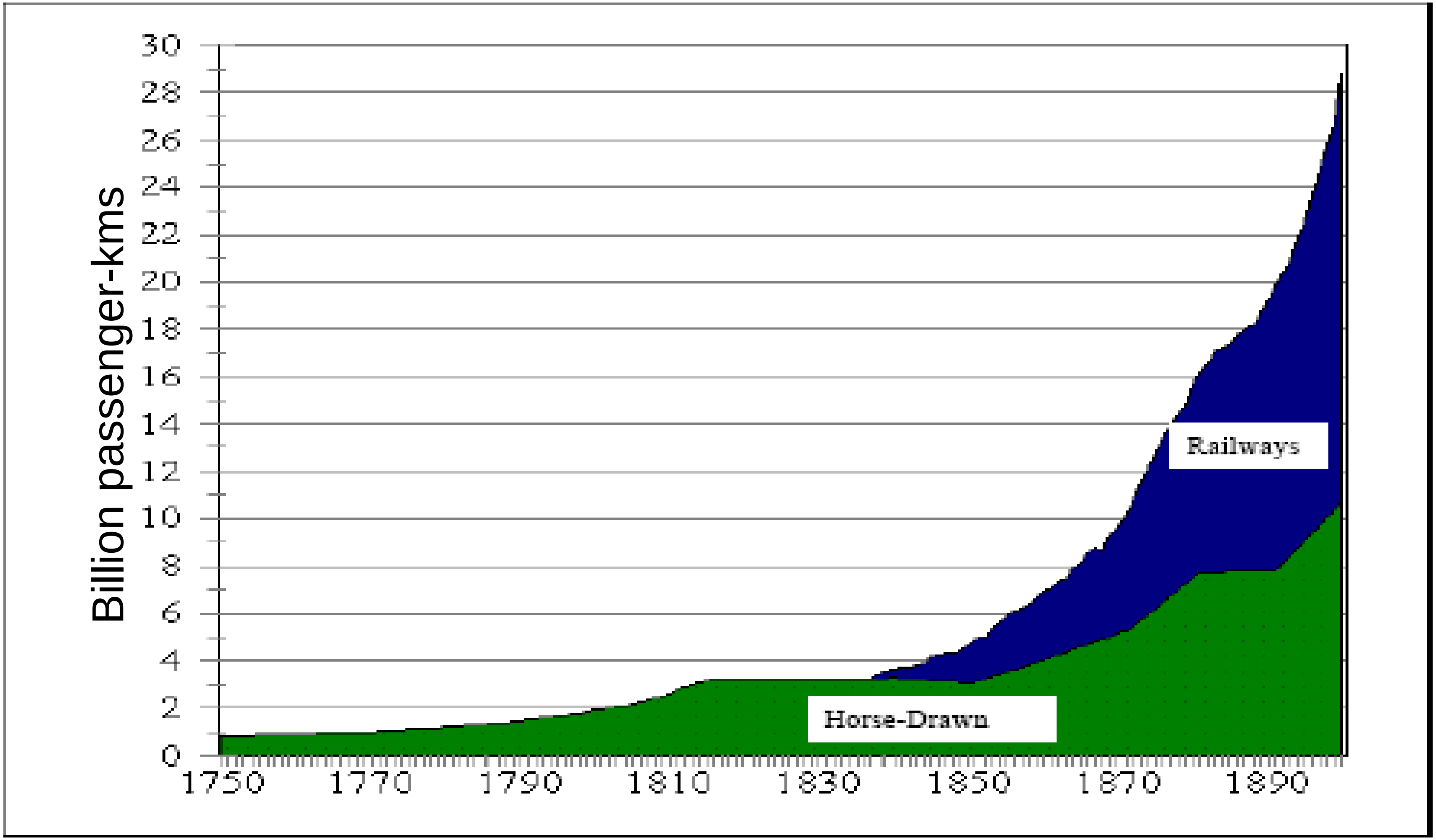
Price of Passenger Transport (per passenger-kilometer-hour)

The price of service dropped dramatically!



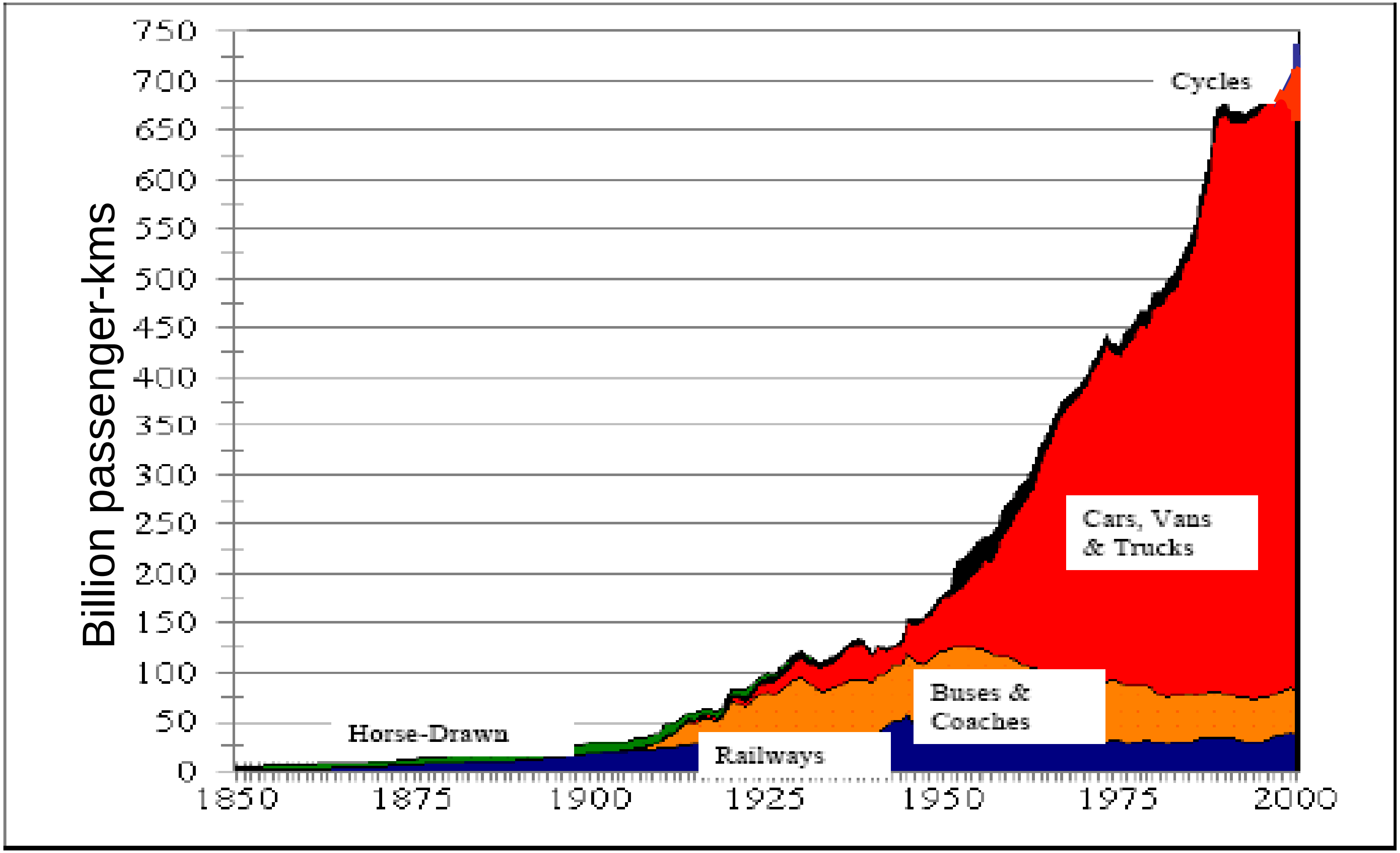
UK: The Use of Passenger Transport (per Passenger-Kilometre), 1750-1900

The demand for service



Source: Fouquet,2003

UK: The Use of Passenger Transport (per Passenger-Kilometre), 1850-2000

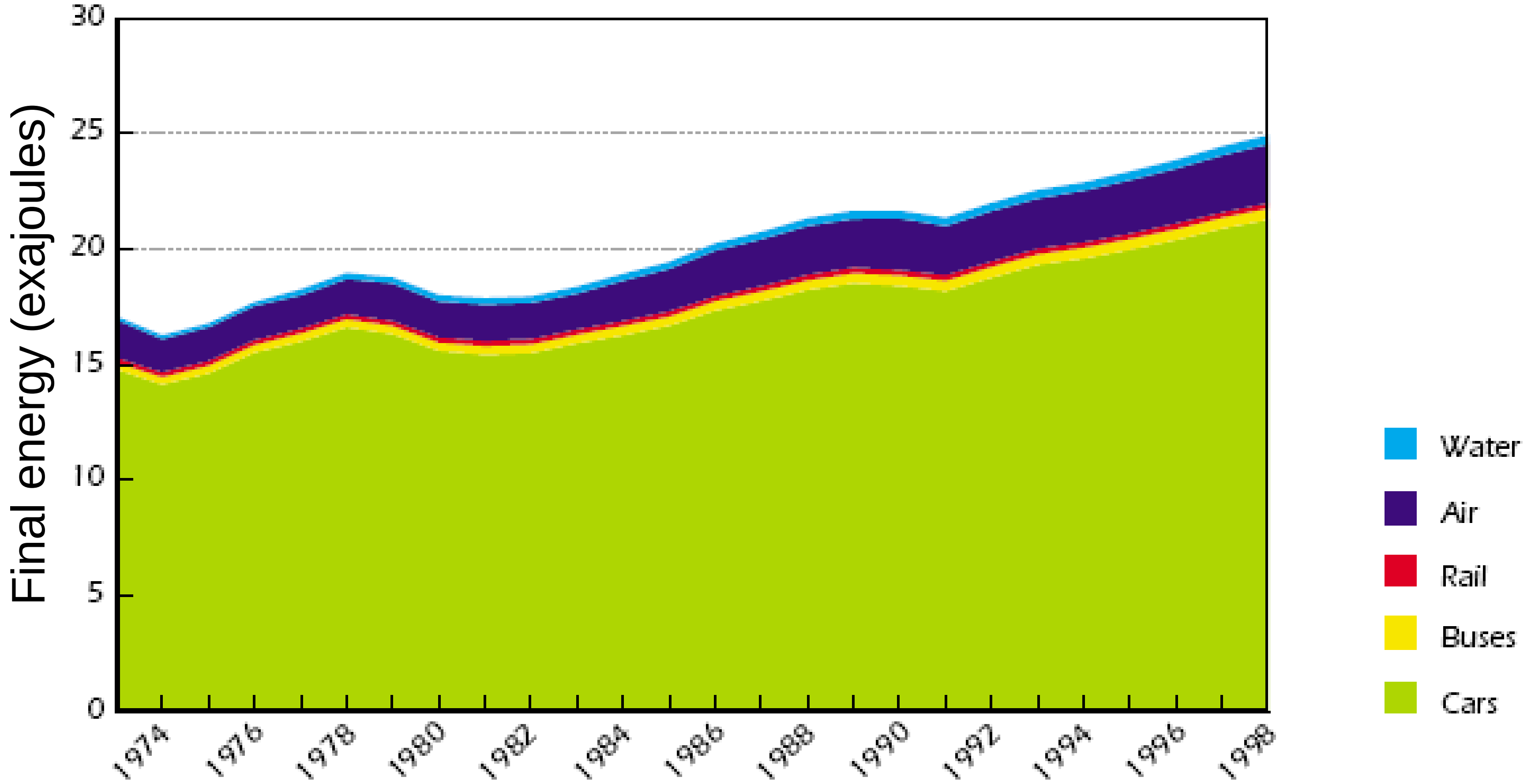


Source: Fouquet,2003

3. Indicators of recent developments, current situation

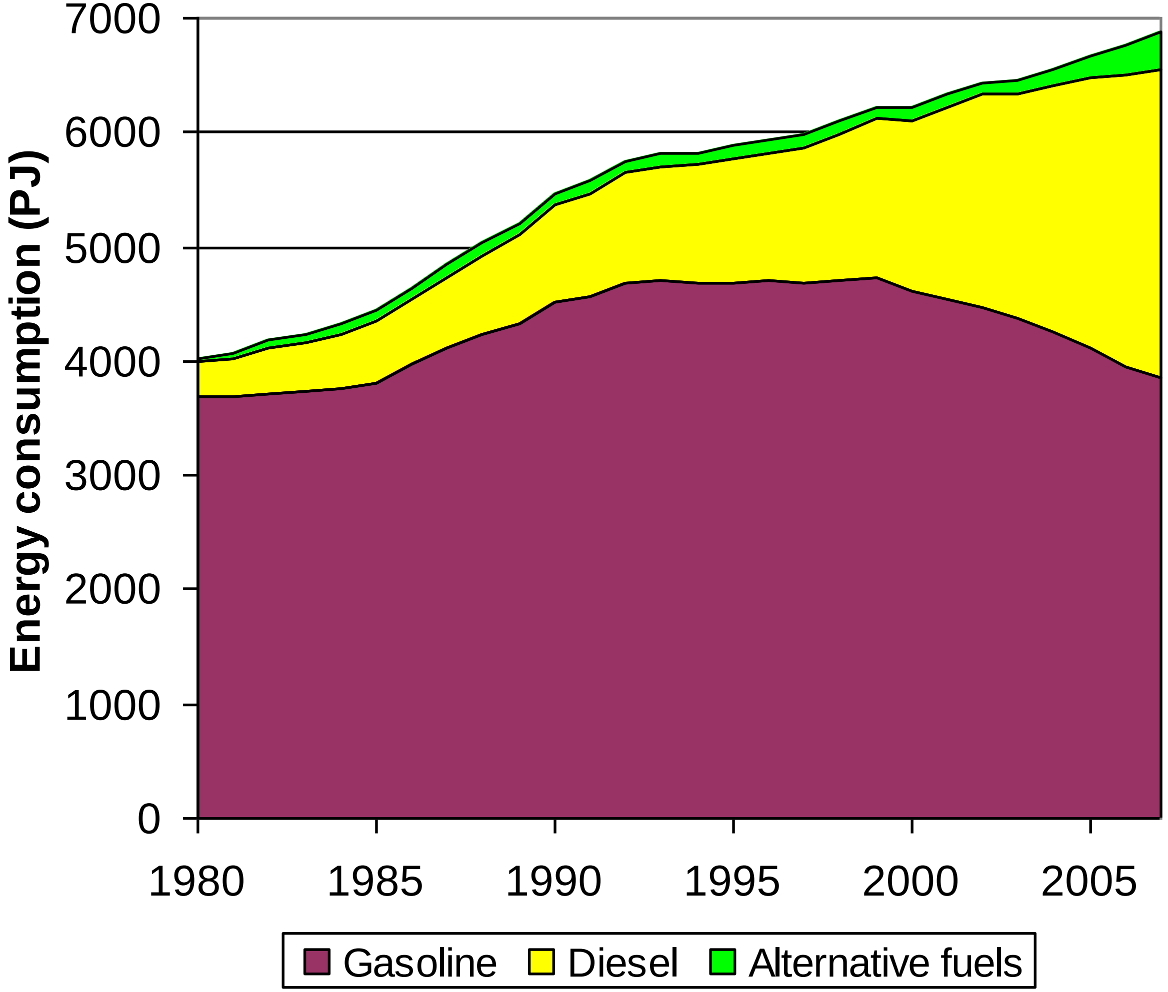
Energy Use in Passenger Transport by Mode

Energy used to move people was 45% higher in 1998 than in 1973



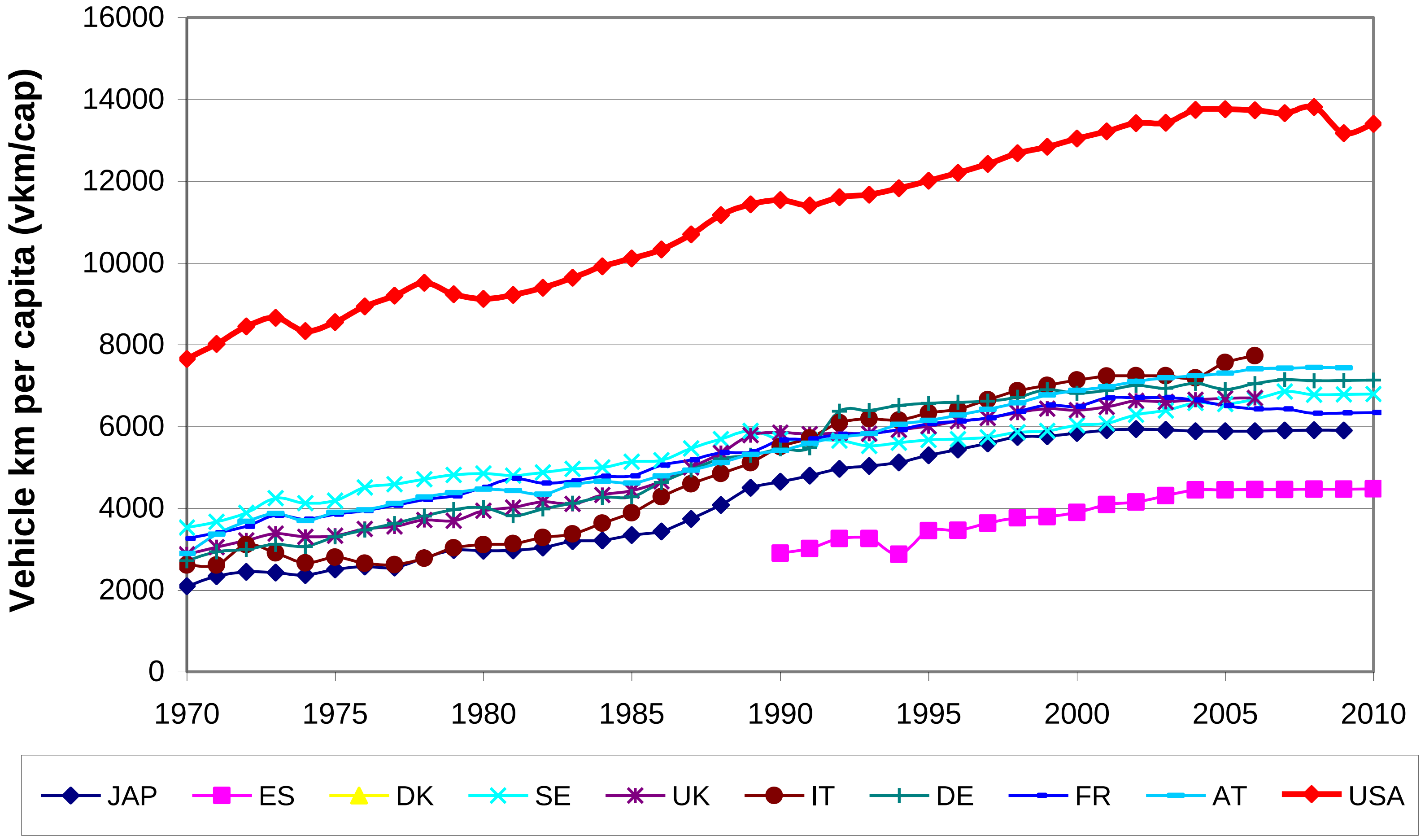
Source: IEA, 2004

Energy consumption in car passenger transport in EU-15 by fuel, 1980 – 2007



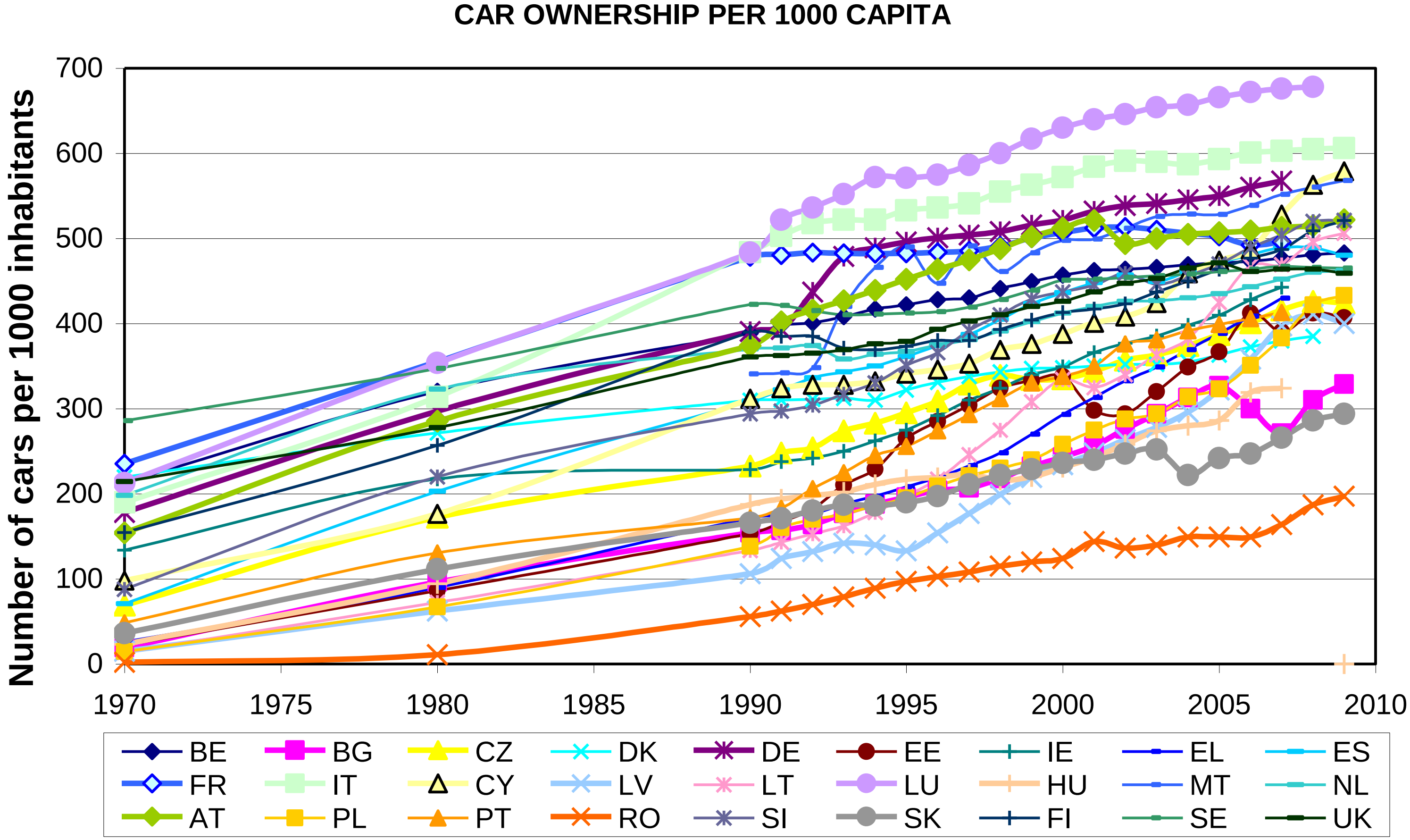
Source: ALTER-MOTIVE, 2009

Travel activity



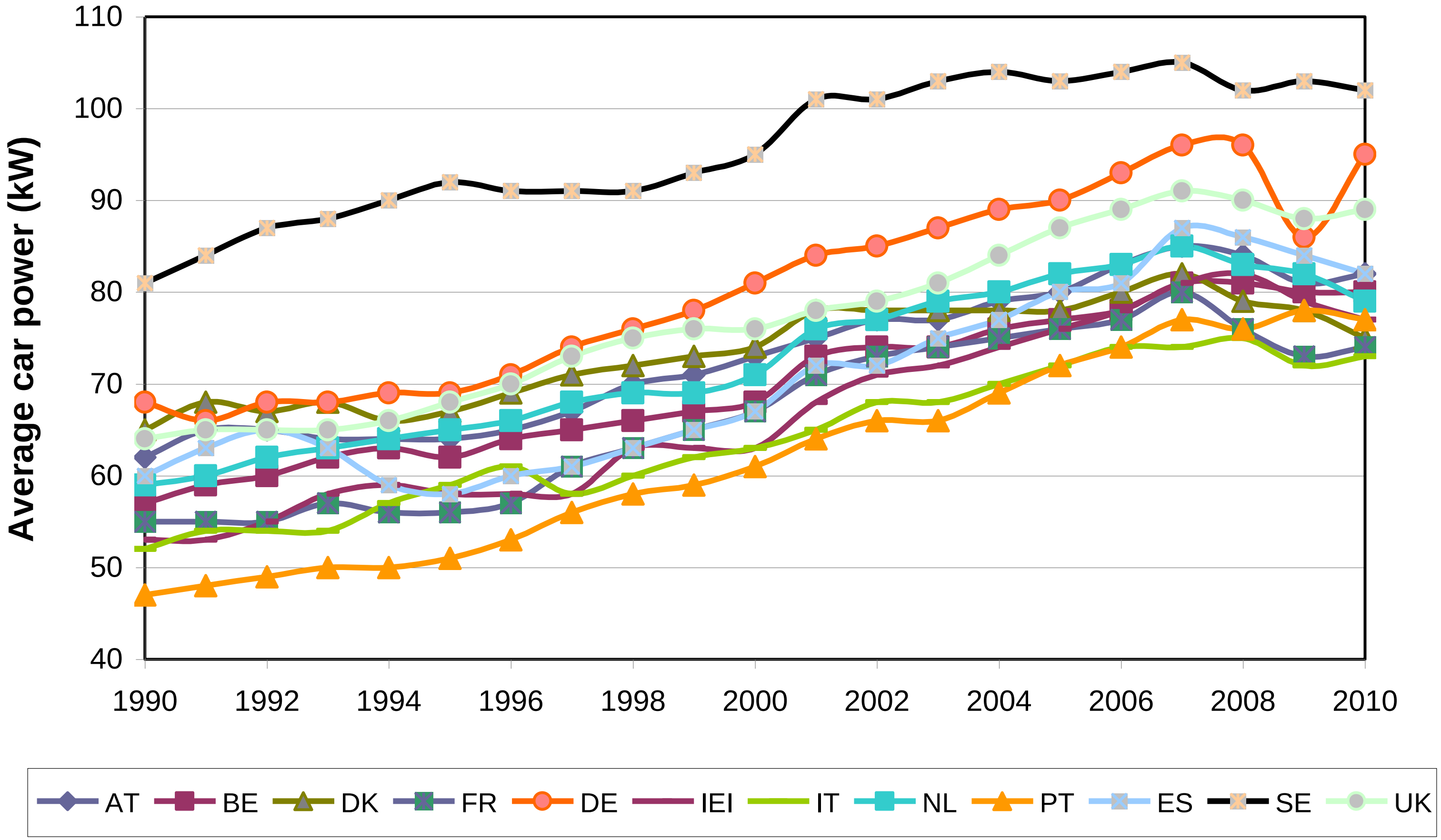
Development of vehicle kilometer per capita

Development of car stock



Car ownership per 1000 capita in EU-27 countries 1970 – 2009

Increases in power of cars

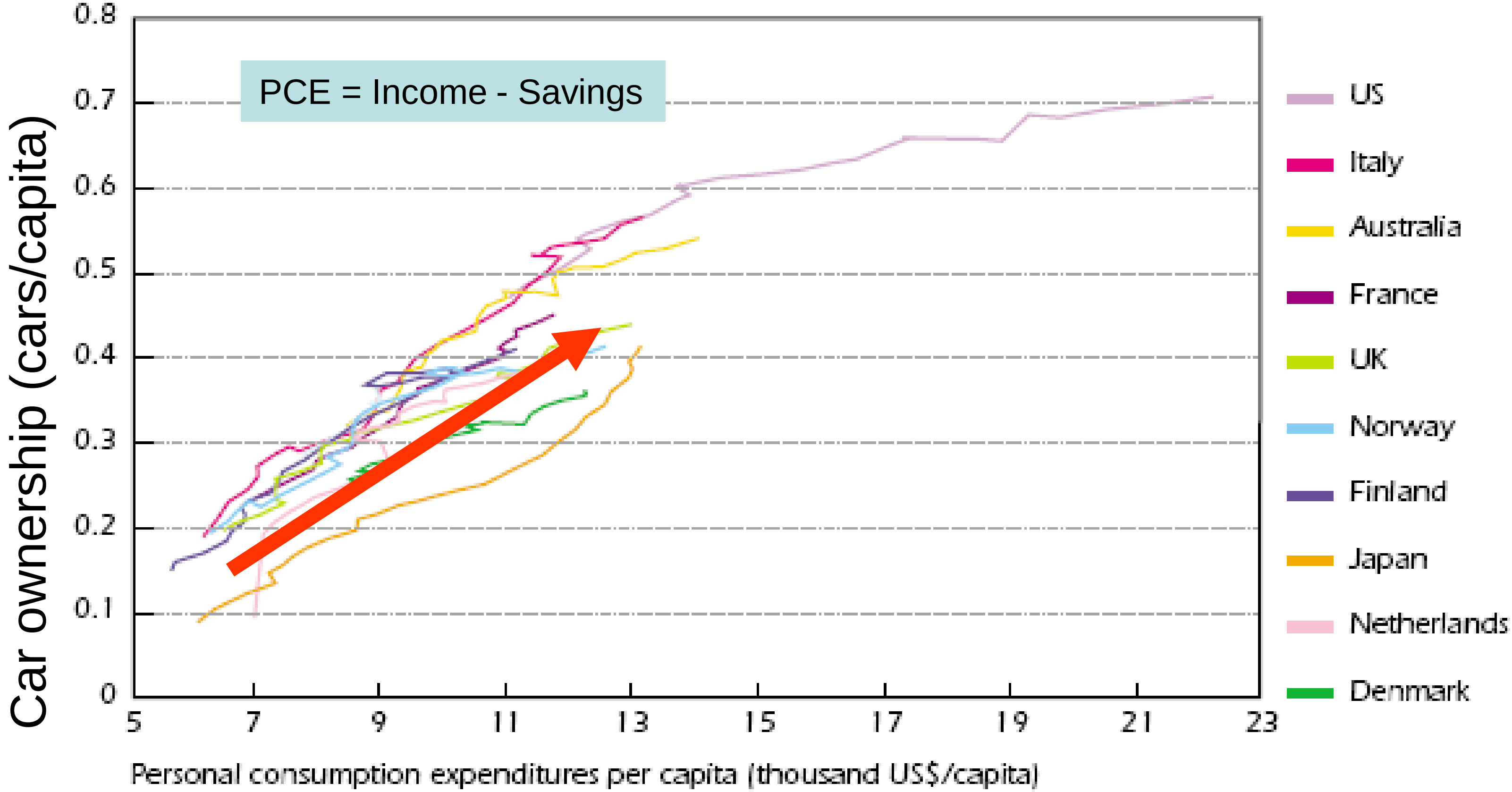


Average developments of car power (kW) of new cars in various EU-15 countries from 1990 to 2010

Car Ownership and Income

Car Ownership per Capita and Personal Consumption Expenditures, 1970 - 2000

The United States leads the way in both car ownership and income

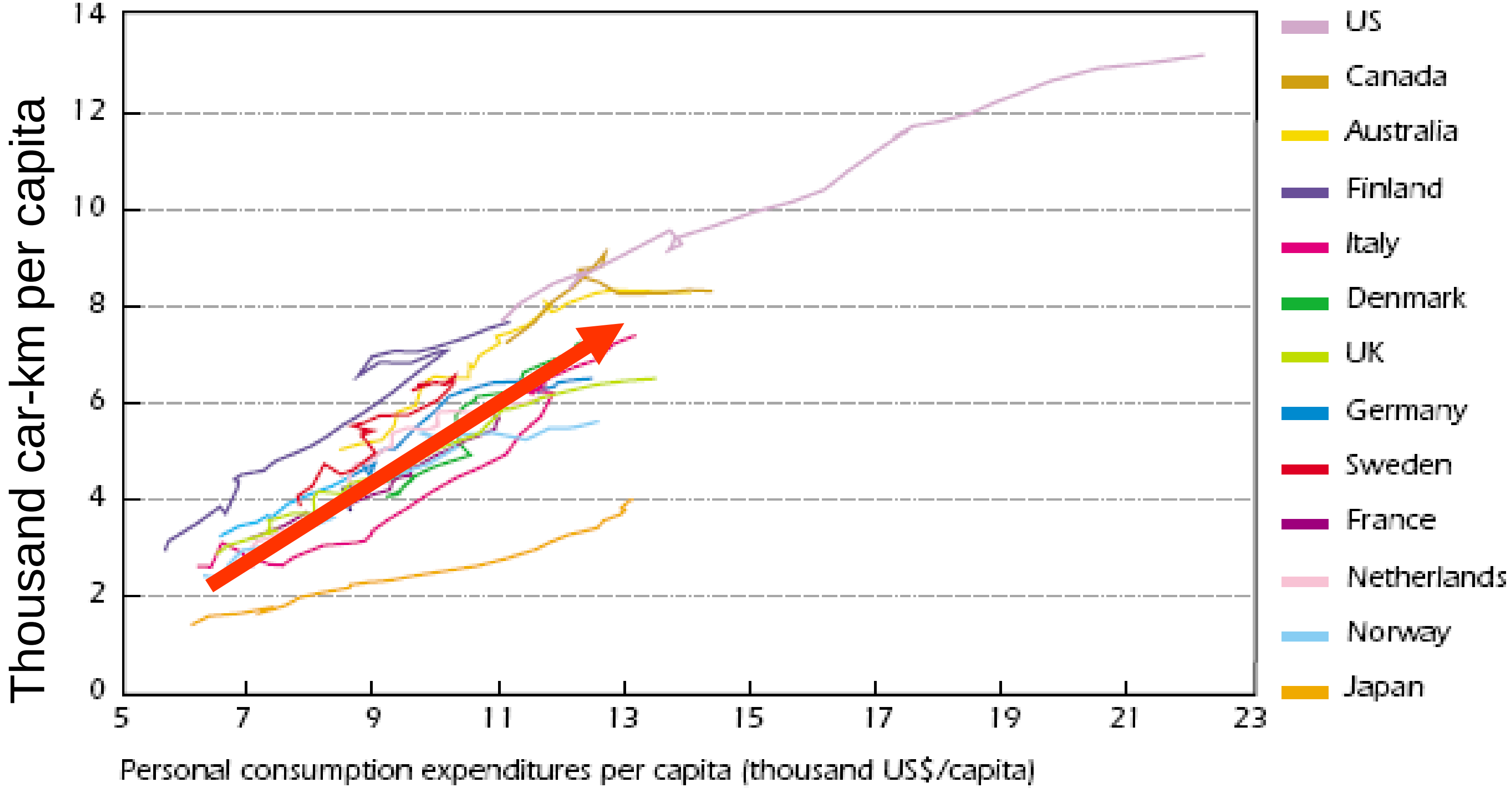


Source: IEA, 2004

Car Travel and Income

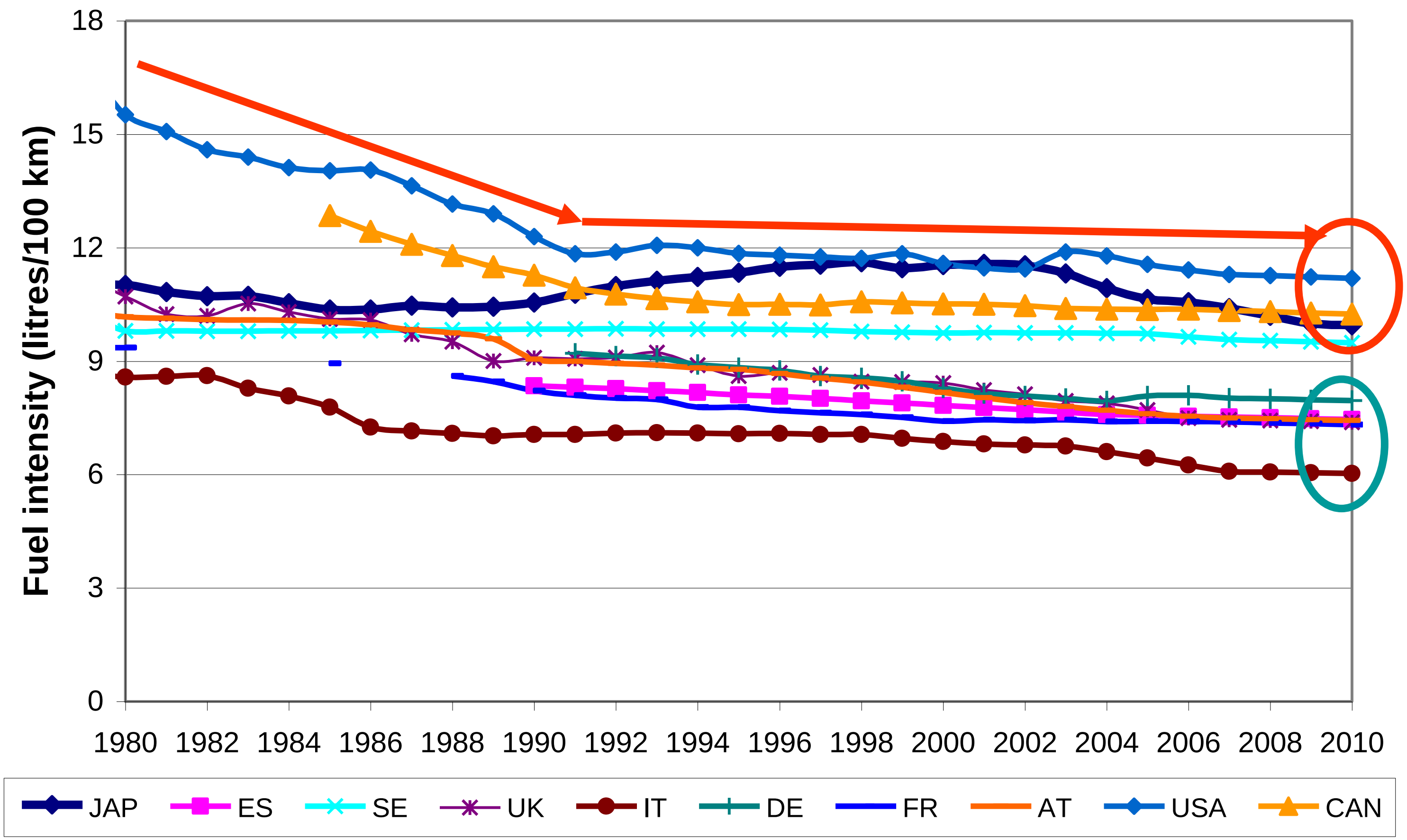
Car-kilometres per Capita and Personal Consumption Expenditures, 1970-2000

The trend for car travel is quite similar to car ownership



Source: IEA, 2004

Fuel intensity

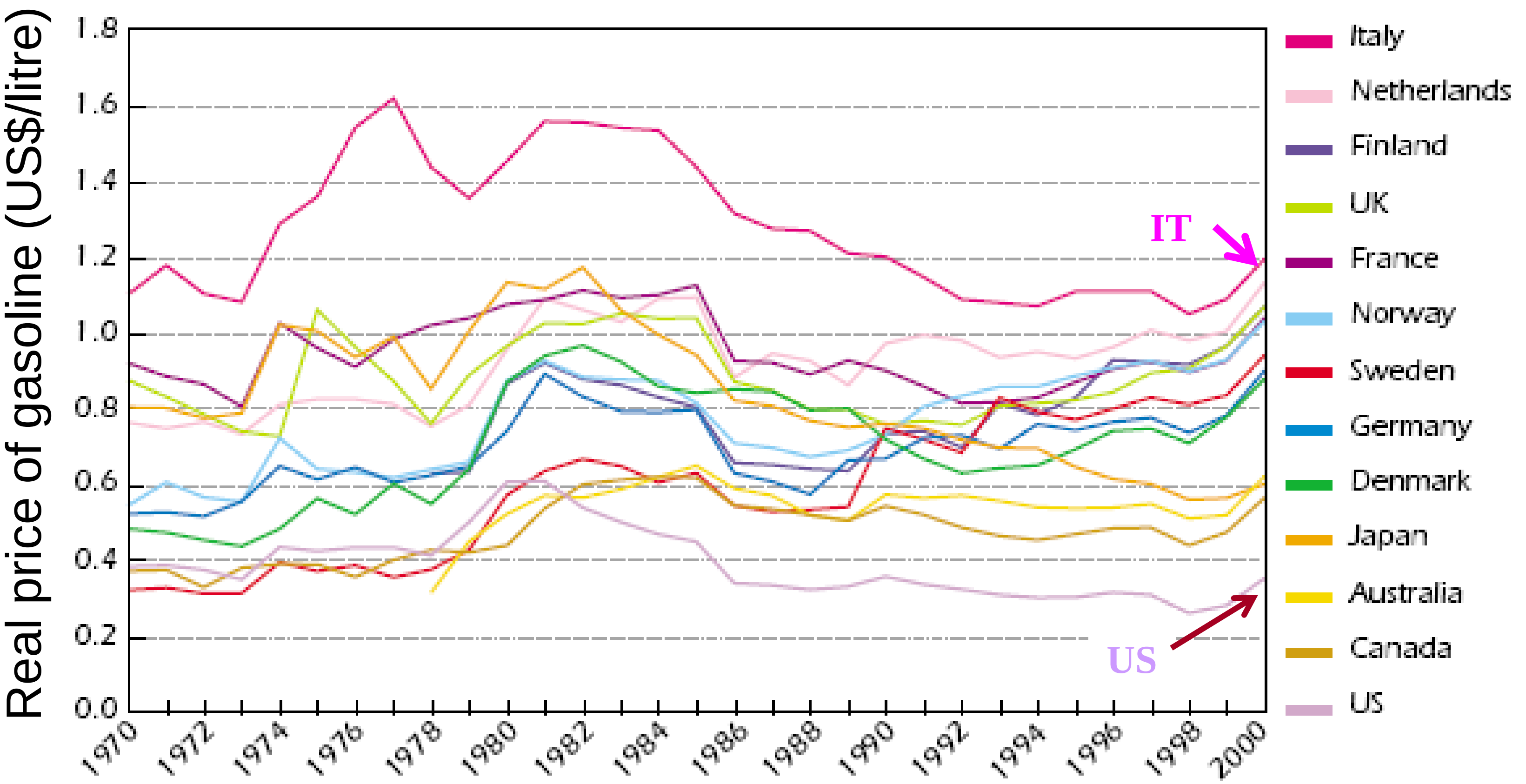


Average on road fuel intensity of stock of cars and household light truck fleet, gasoline equivalent (Diesel and LPG are converted to liters of gasoline at their energy content.
1 litre diesel = 1.12 litre gasoline)

Gasoline Prices

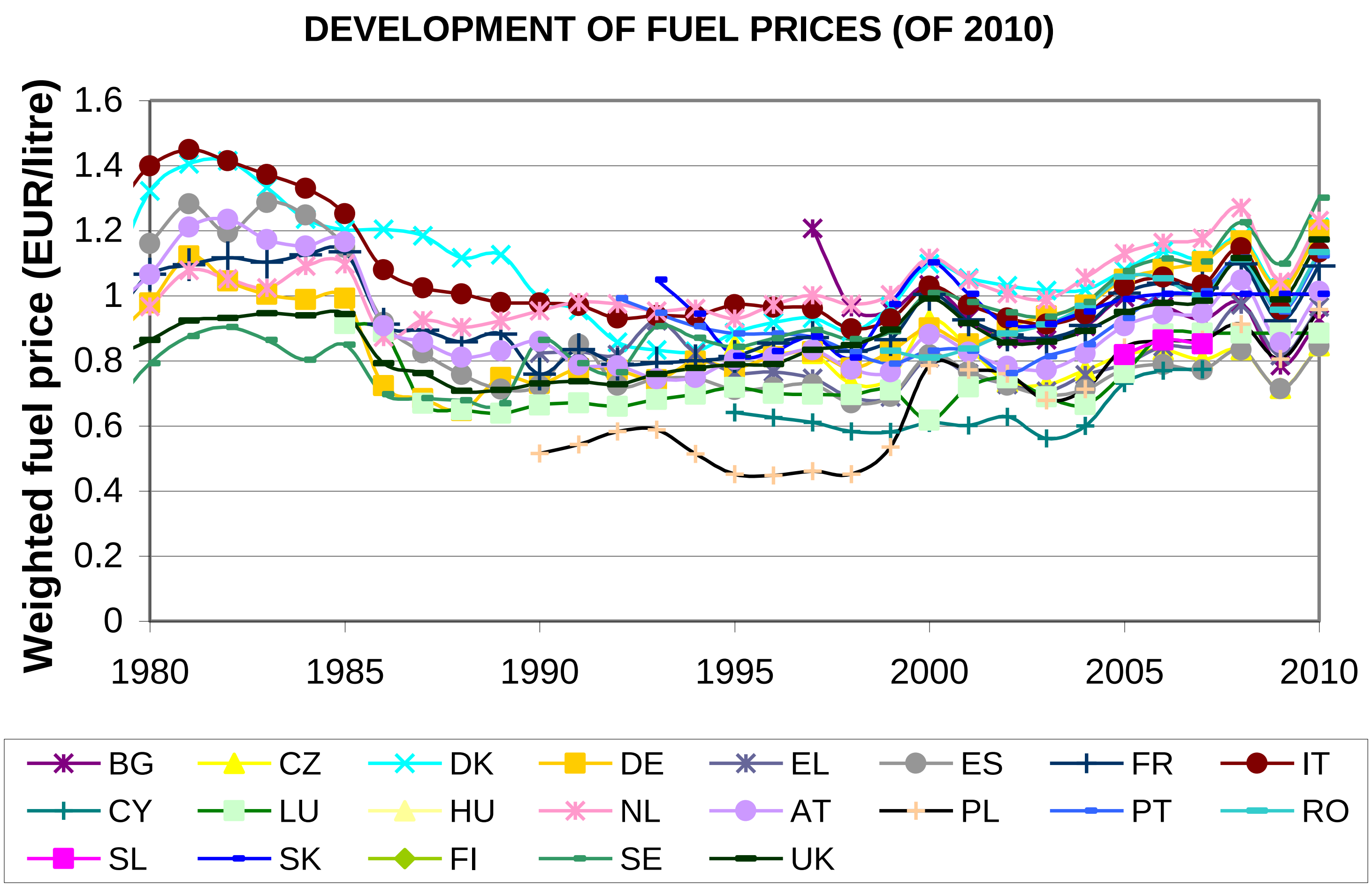
Trends in Retail Gasoline Prices in Real Terms, Including Taxes

Gasoline prices have varied considerably both over time and across IEA countries



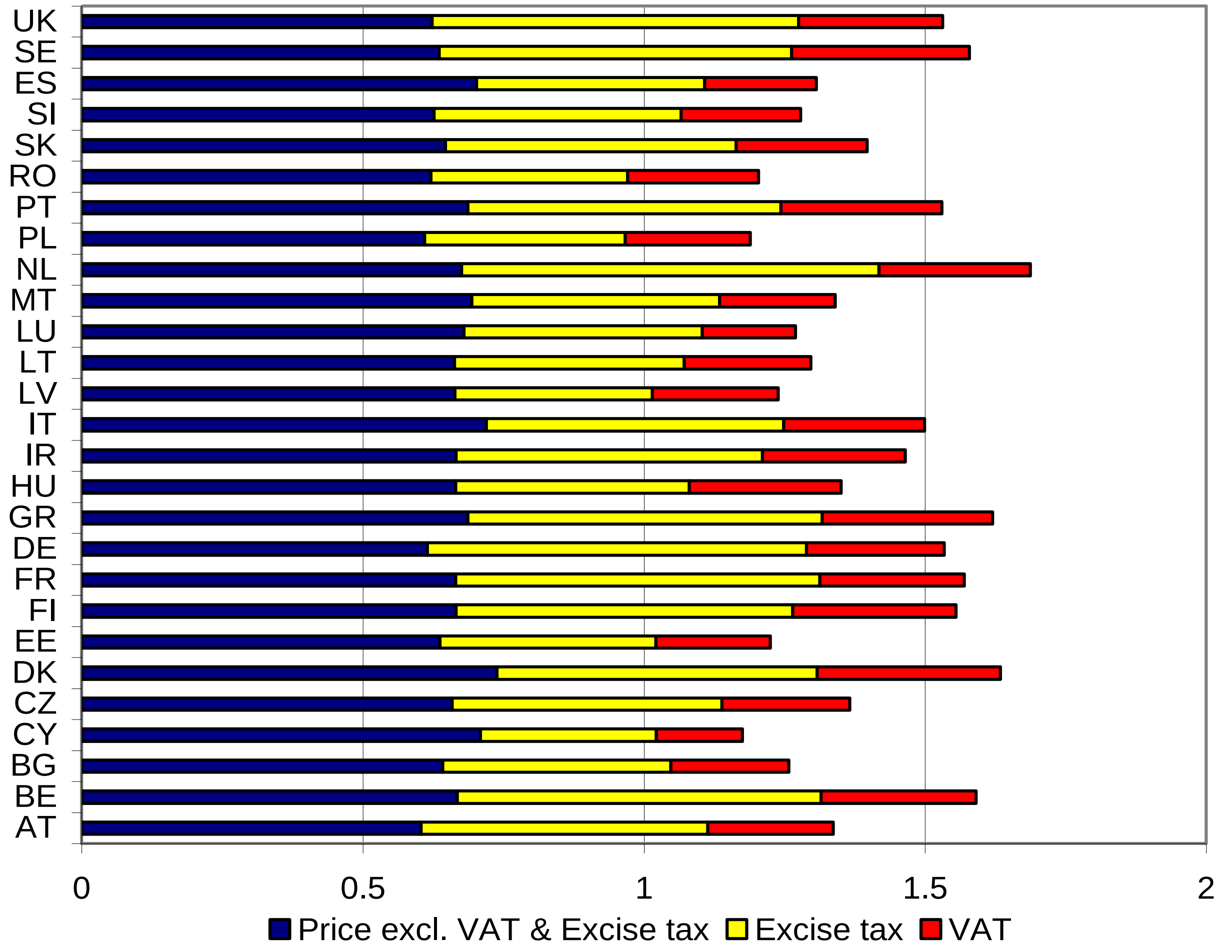
Source: IEA, 2004

Development of fuel prices



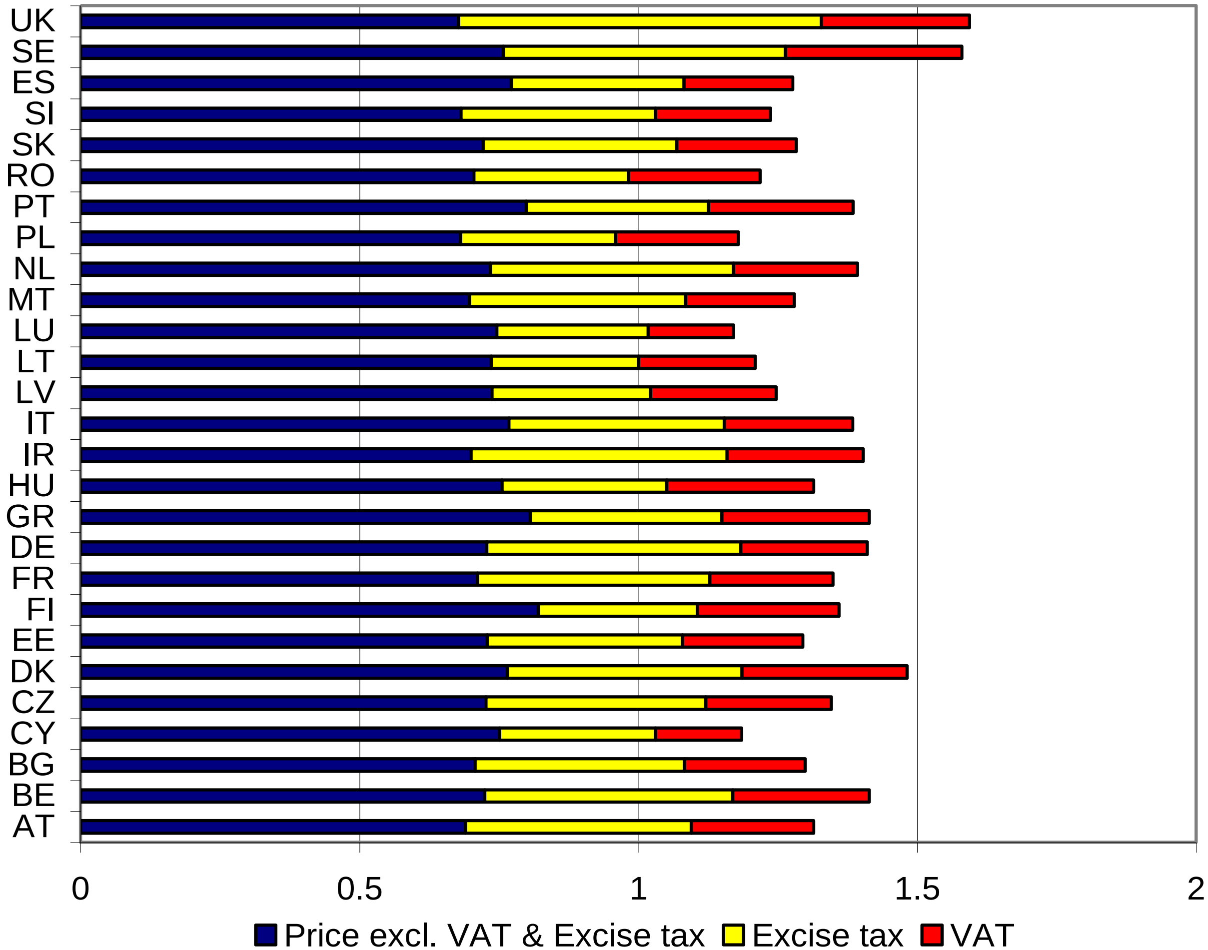
Weighted fuel prices (including all taxes) for EU countries 1980 – 2010 (in prices of 2010, numbers for 2010 preliminary) (Source: EEP; IEA, 2010)

Price structure of gasoline



Price structure of gasoline in EU-27 (data source: EEP, 2011 - effective March 2, 2011)

Price structure of diesel

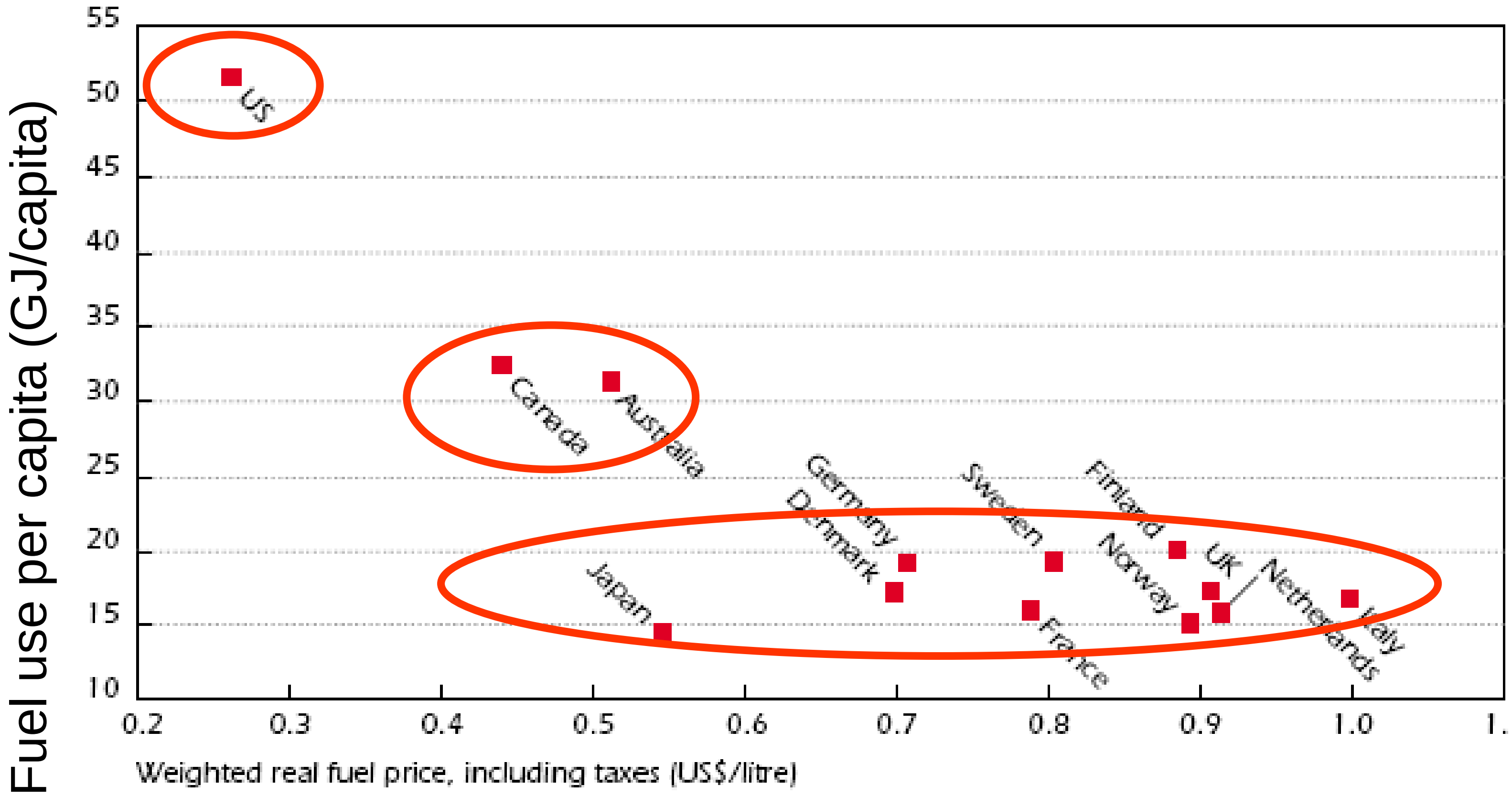


Diesel prices in 2011 for EU-27 (data source: EEP, 2011 - effective March 2, 2011)

Fuel Use per Capita versus Fuel Prices

Car Fuel Use per Capita versus Average Fuel Price, 1998

Energy use for cars is much higher in countries with low fuel prices

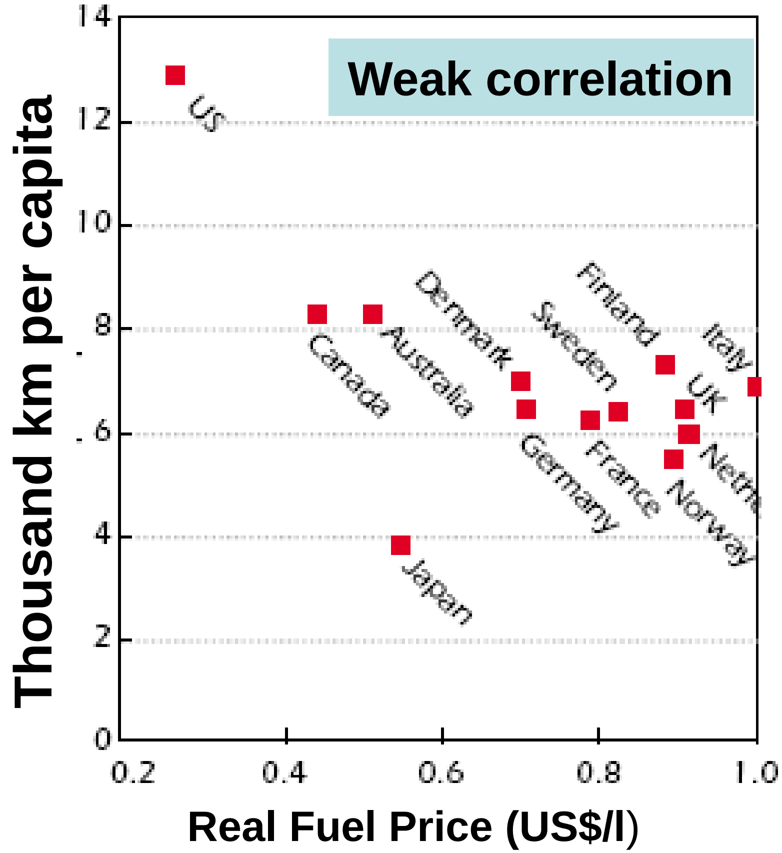


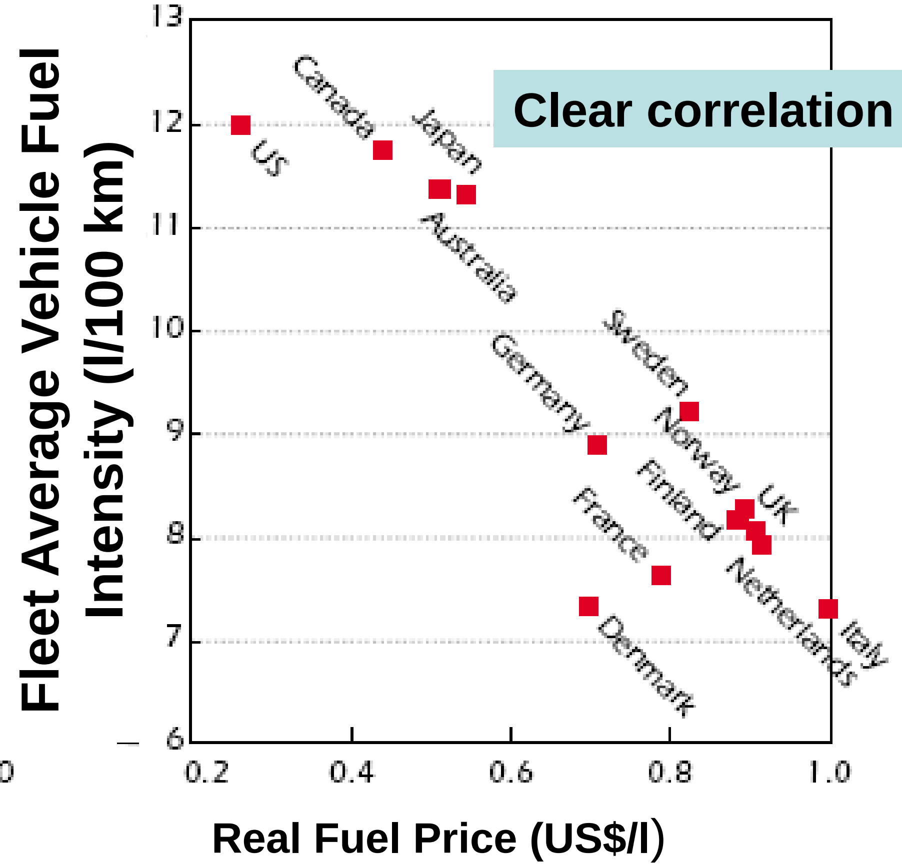
Source: IEA, 2004

Vehicle Travel and Intensities vs. Fuel Prices

Passenger Car Travel per Capita and Car Fuel Intensity versus Average Fuel Price, 1998

Higher fuel prices correlate with lower vehicle fuel intensity and lower travel per capita, though the travel effect is fairly weak

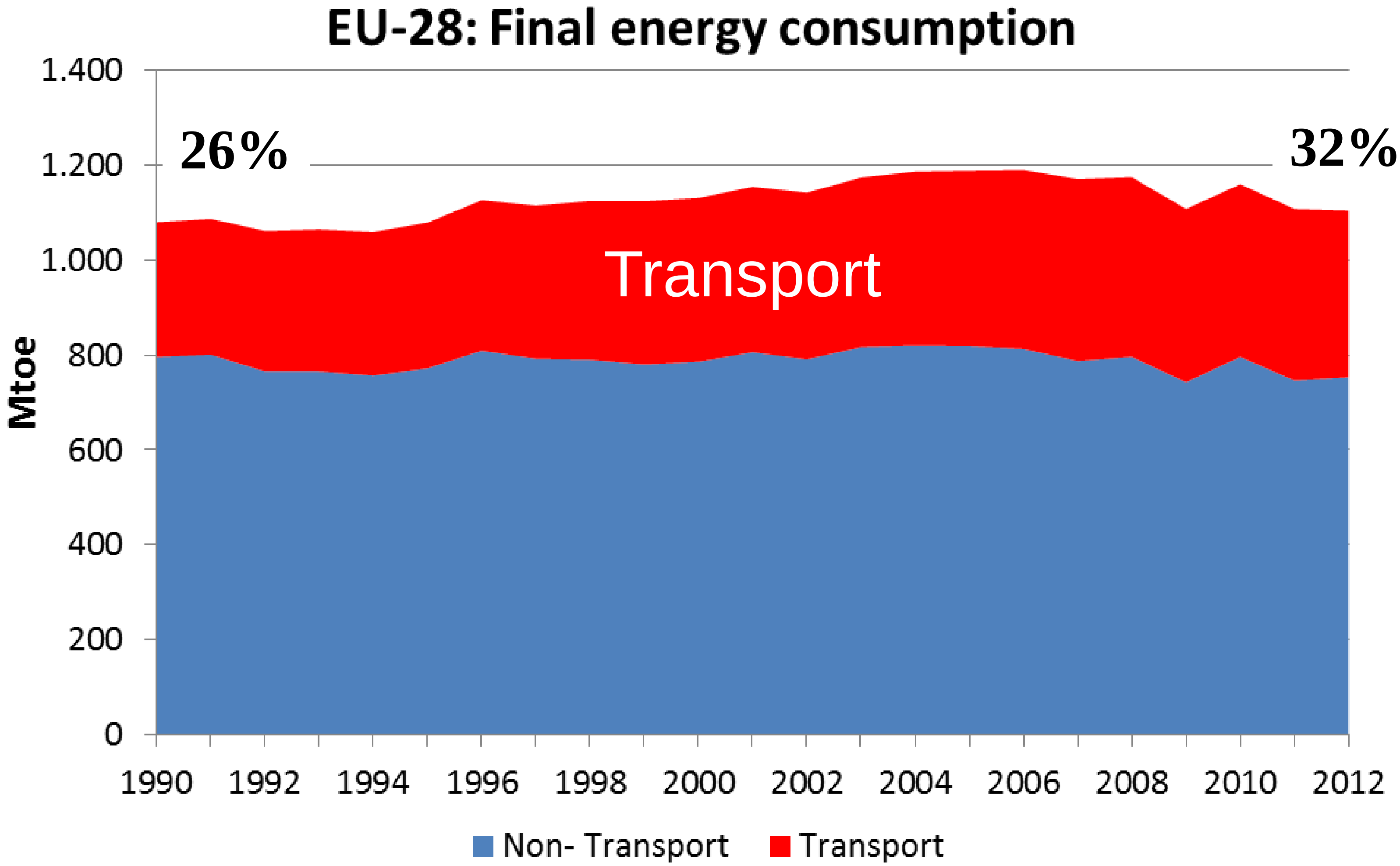




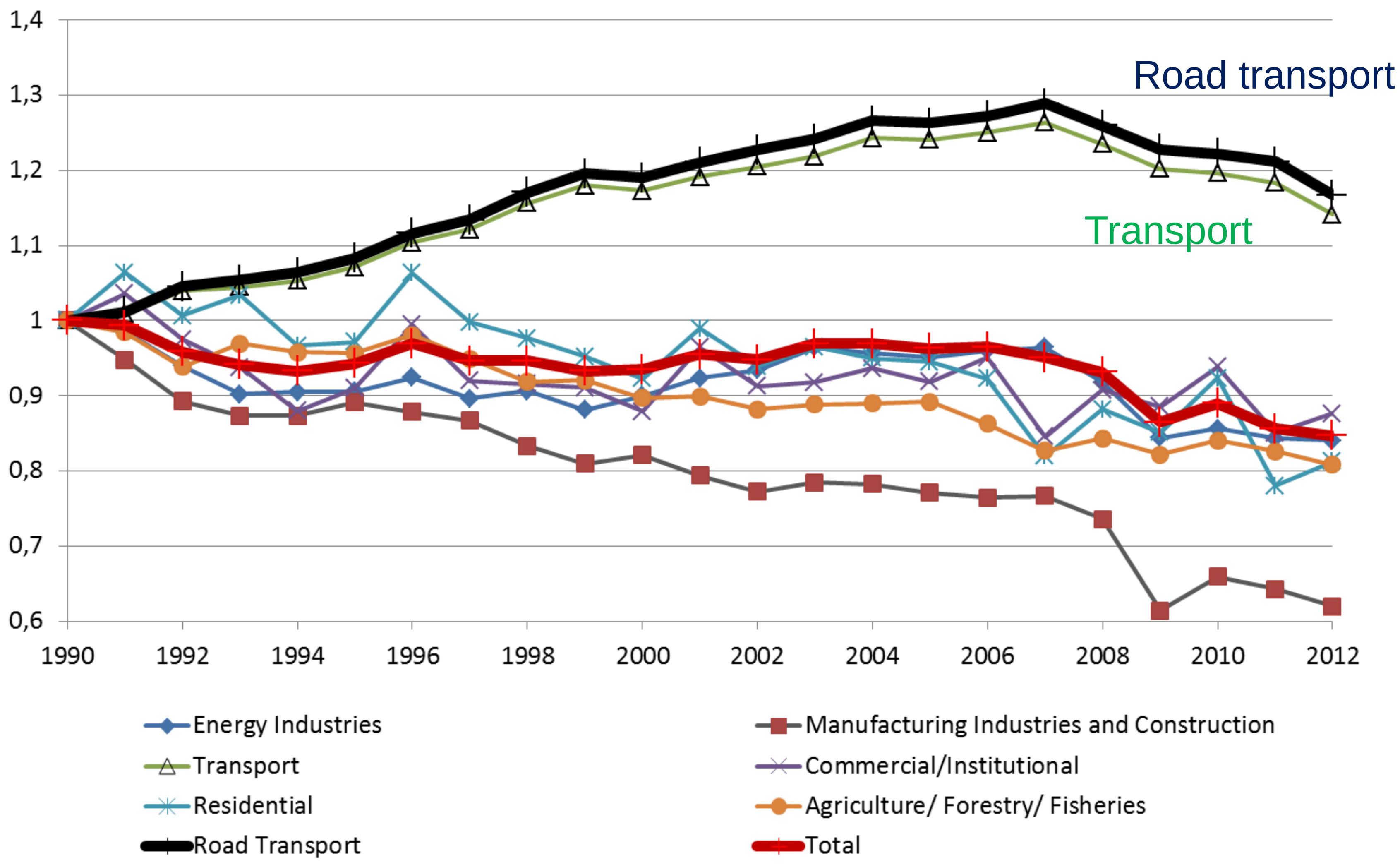
Source: IEA, 2004

- Passenger transport is almost exclusively based on petroleum products. Growth in passenger travel has been the biggest contributor to increased oil demand.
- Changes in passenger transport energy use, as well as its components (travel activity and energy intensity), are related to income growth and changes in fuel prices, among other factors.
- Countries with relatively high fuel prices tend to have lower average vehicle energy intensities and fuel use than countries where fuel prices are low.
- Increases in car ownership and travel levels are closely related to income growth. Together, these relationships help account for large differences in transport energy use per capita among countries.

4. Comparison of technical, economic, and ecological aspects


EU-28: Final energy consumption
Mtoe
1.400
1.200
1.000
800
600
400
200
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
26%
32%
Transport
Non- Transport
Transport

GHG emissions by sector



Alternative fuels

Mature AEC
Electricity
1st gen. biofuels:
Bioethanol
Biodiesel

Biofuel	Liquid or gaseous fuel for transport produced from biomass

* **Bioethanol** produced from wheat, sugar beet and sugar cane, it is
as a substitute of conventional

it kinds of vegetable oil (e.g. rape
mix of different methyl esters. It is
titute for conventional fossil diesel.

Inmature AEC
2nd gen. biofuels:
Bioethanol from Lignocellulose

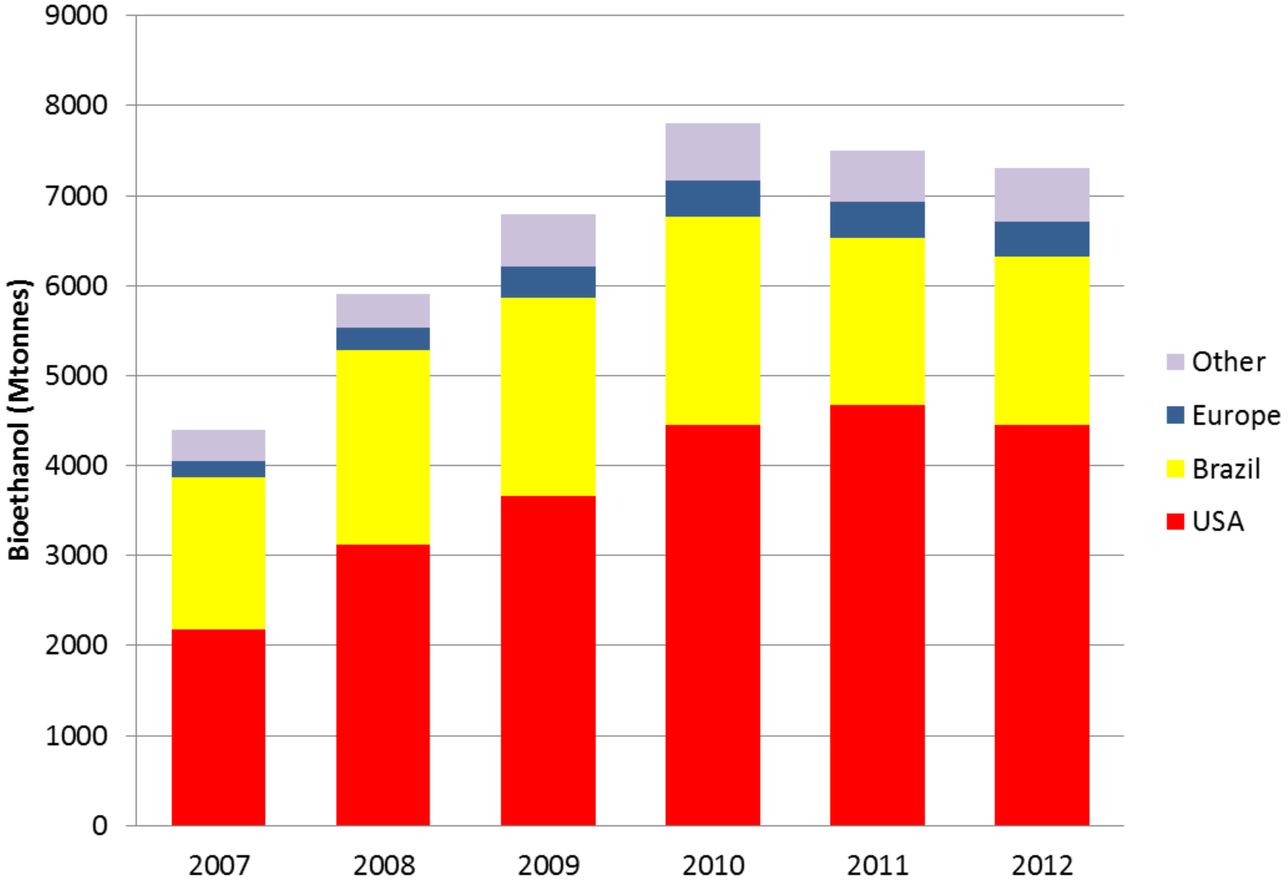
Hydrogen

AEC in labour stage
3td gen. biofuels:
Ethanol from algae
…

Technology suprise
4th gen.biofuels
…

Bioethanol

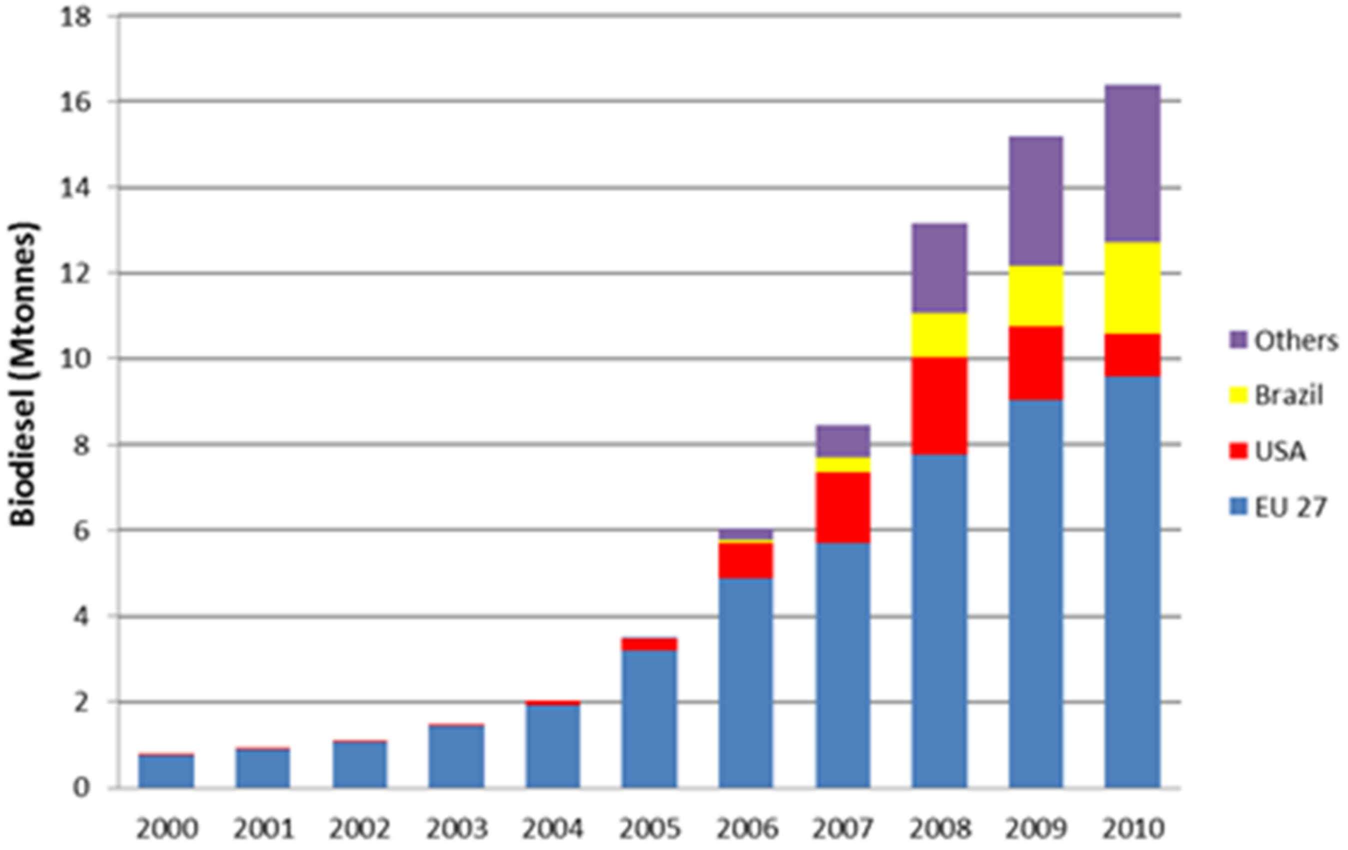
Recent Trends in Ethanol Production



Source: F.O.Licht

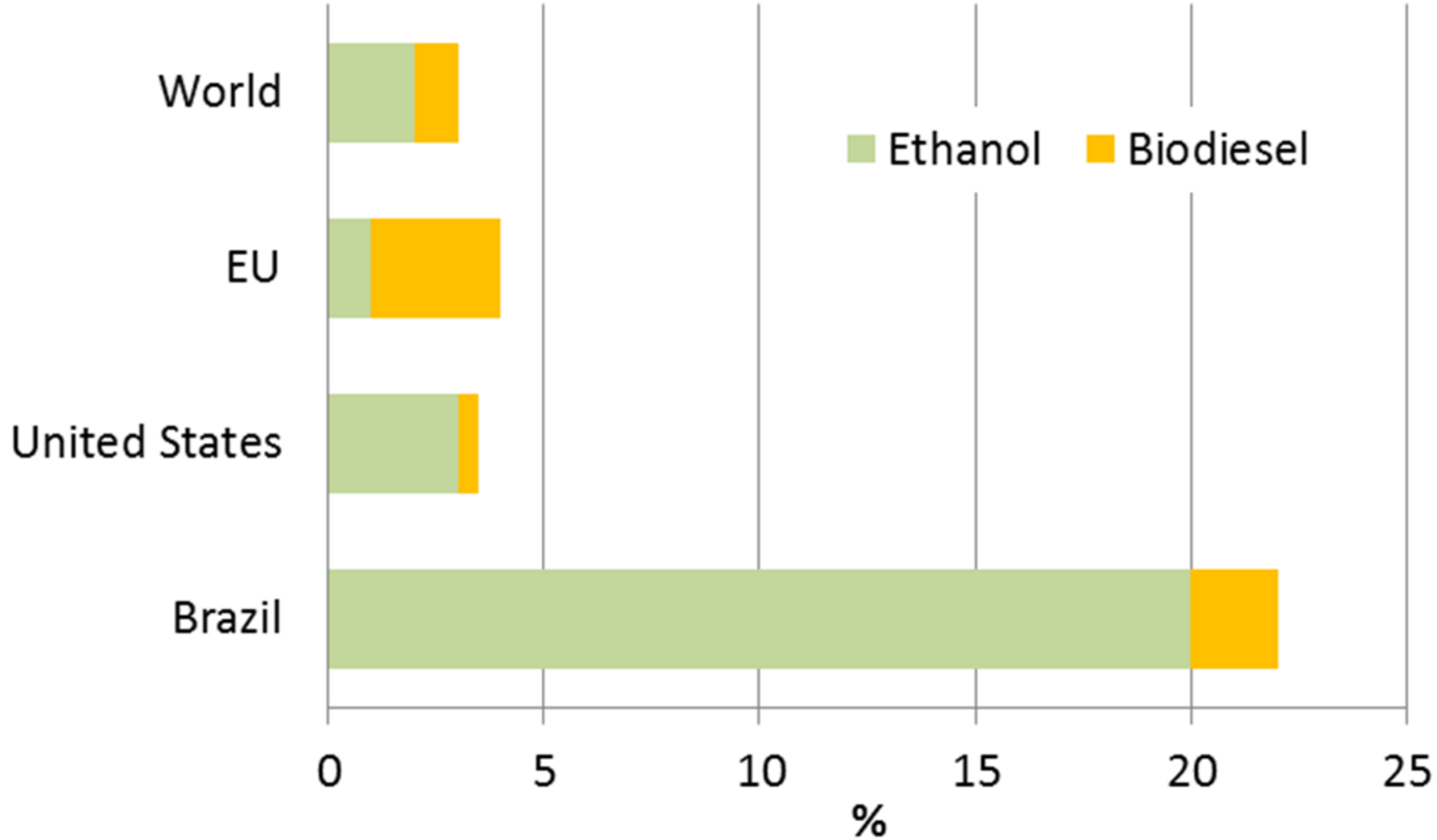
Biodiesel

Recent Trends in Biodiesel Production



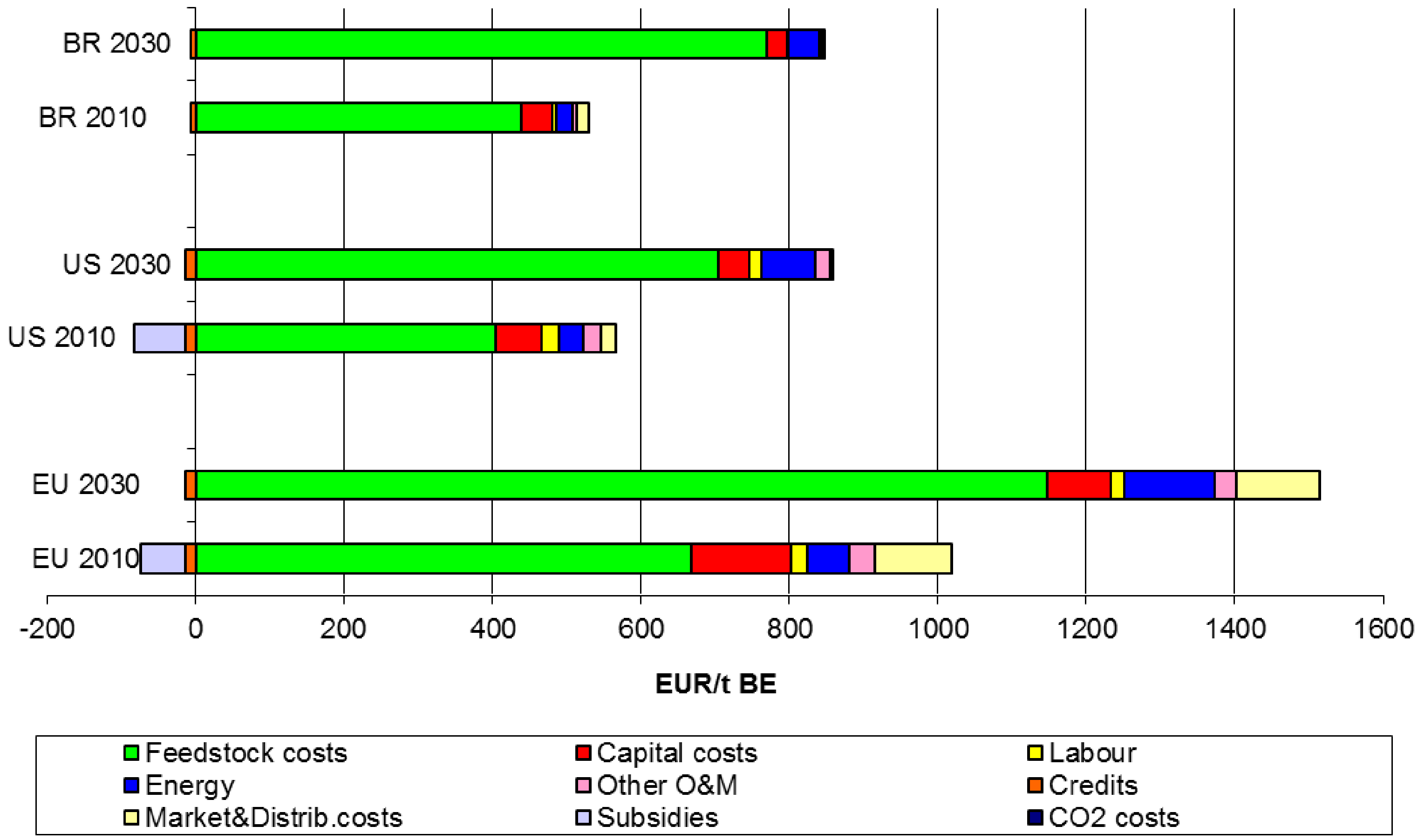
Source: UFOP

Share of biofuels in total road-fuel consumption in energy terms, 2009



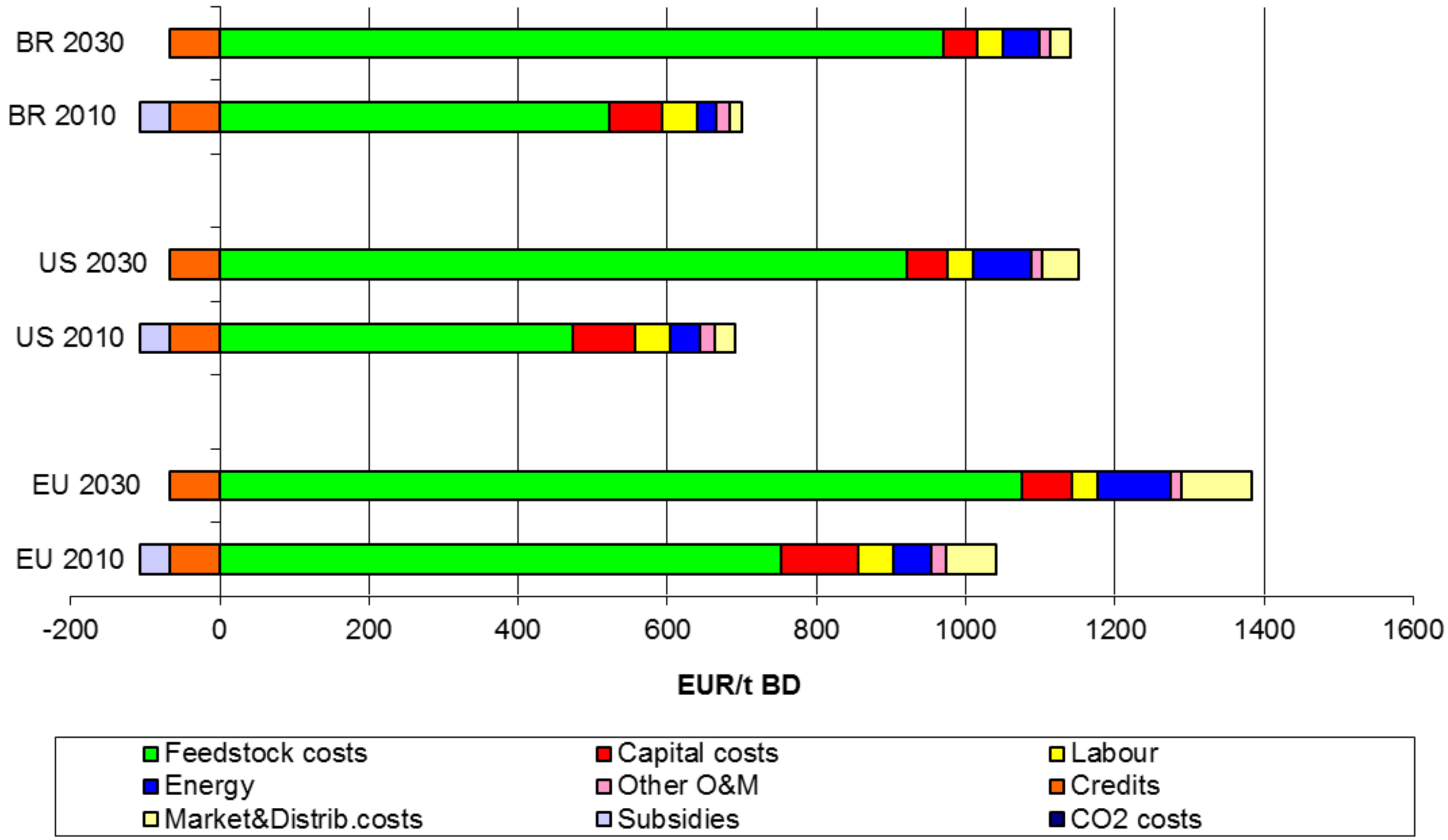
Source: F.O.Licht,IEA

Bioethanol production costs



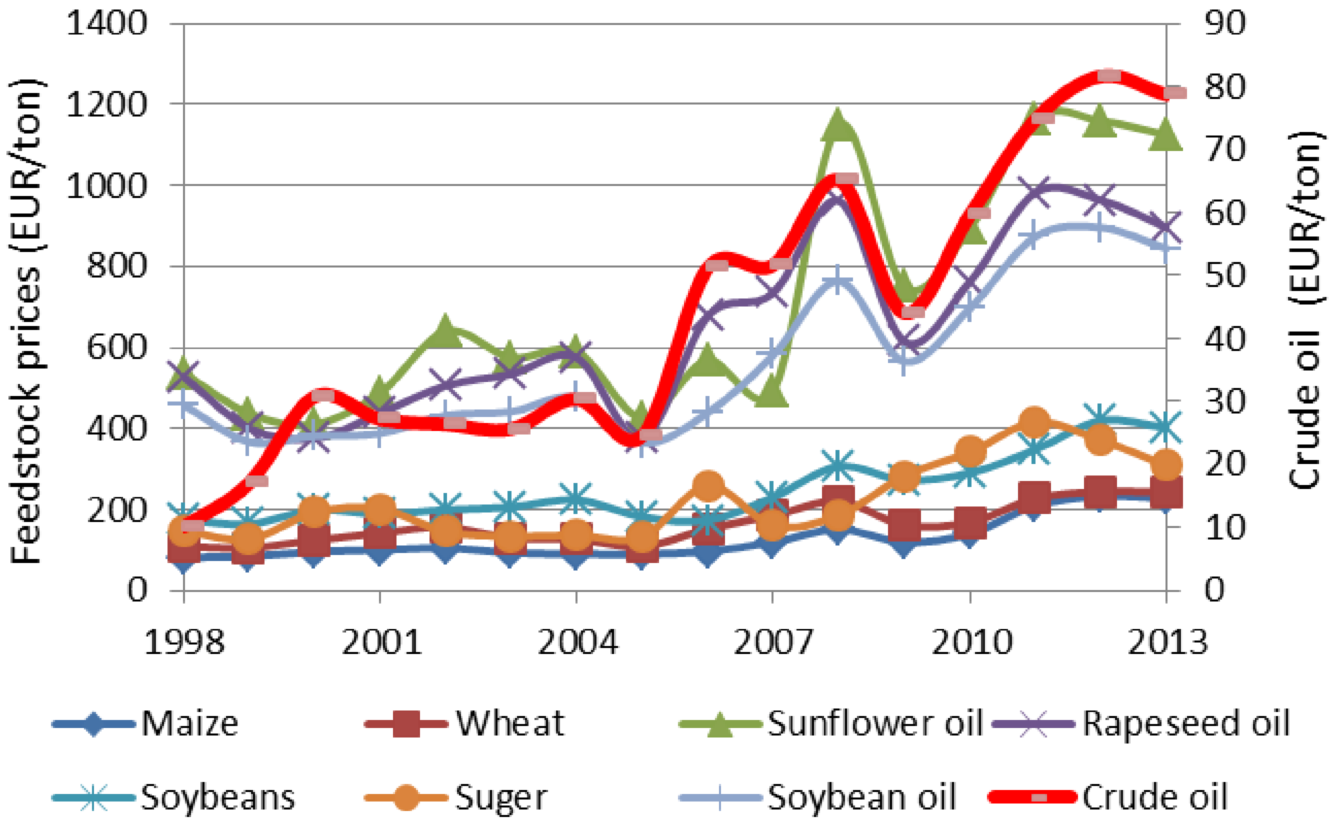
Comparison of bioethanol production costs in the US, Brazil and the EU (average) in 2010 and 2030 (prices of 2010)

Biodiesel production costs



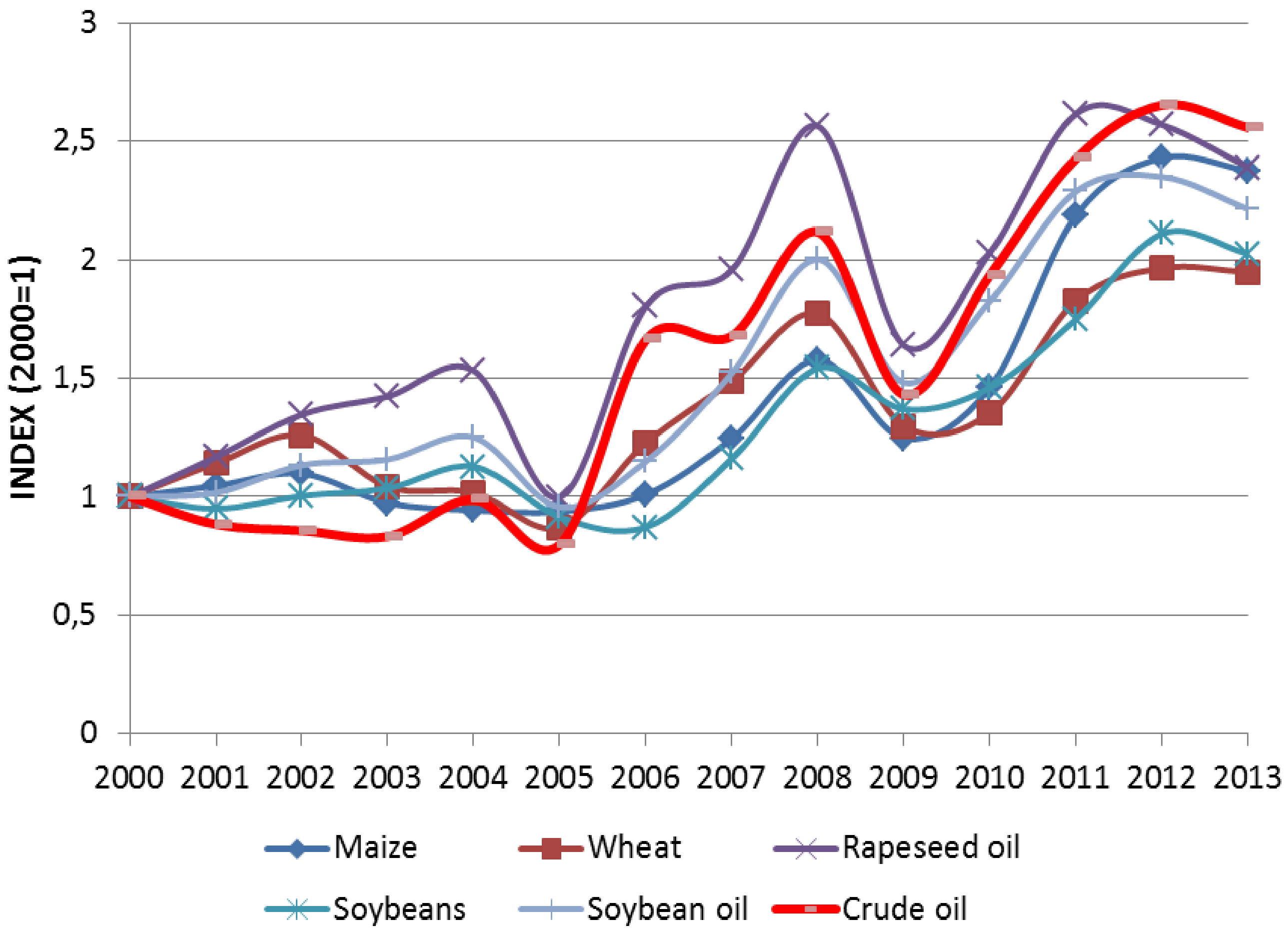
Comparison of biodiesel production costs in the US, Brazil and the EU (average) in 2010 and 2030 (prices of 2010)

Feedstock prices



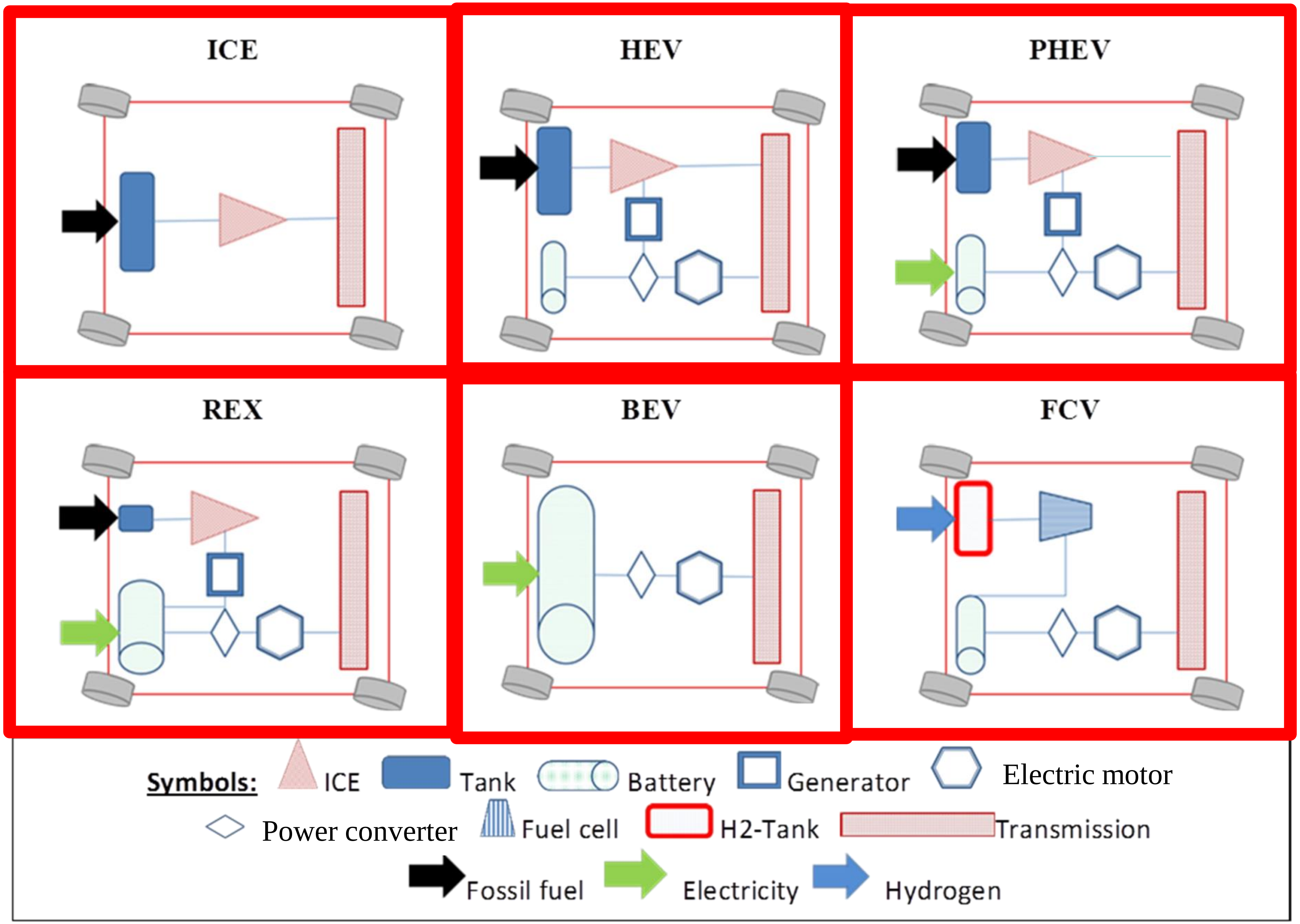
Feedstock and crude oil prices for the period 1998-2013

Feedstock prices

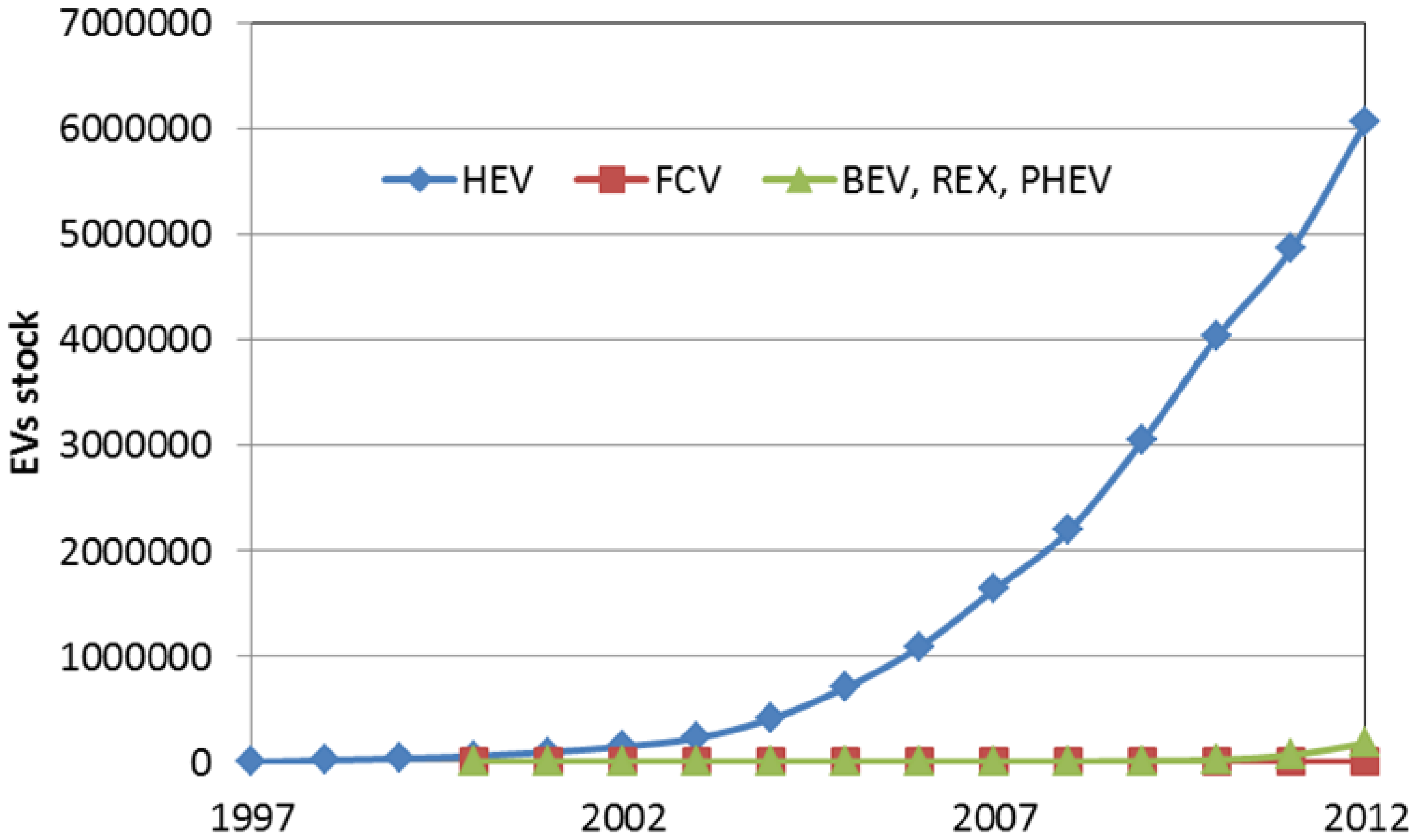


Normalized development of feedstock and crude oil prices for the period 2000-2013 (Index 2000=1)

Electric vehicles

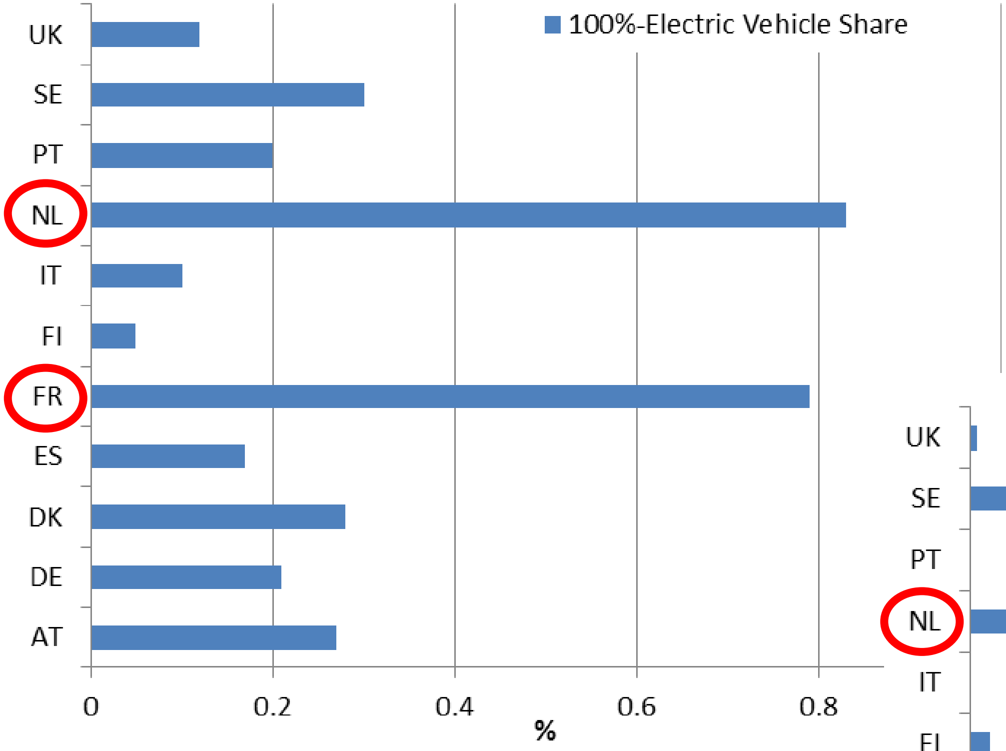


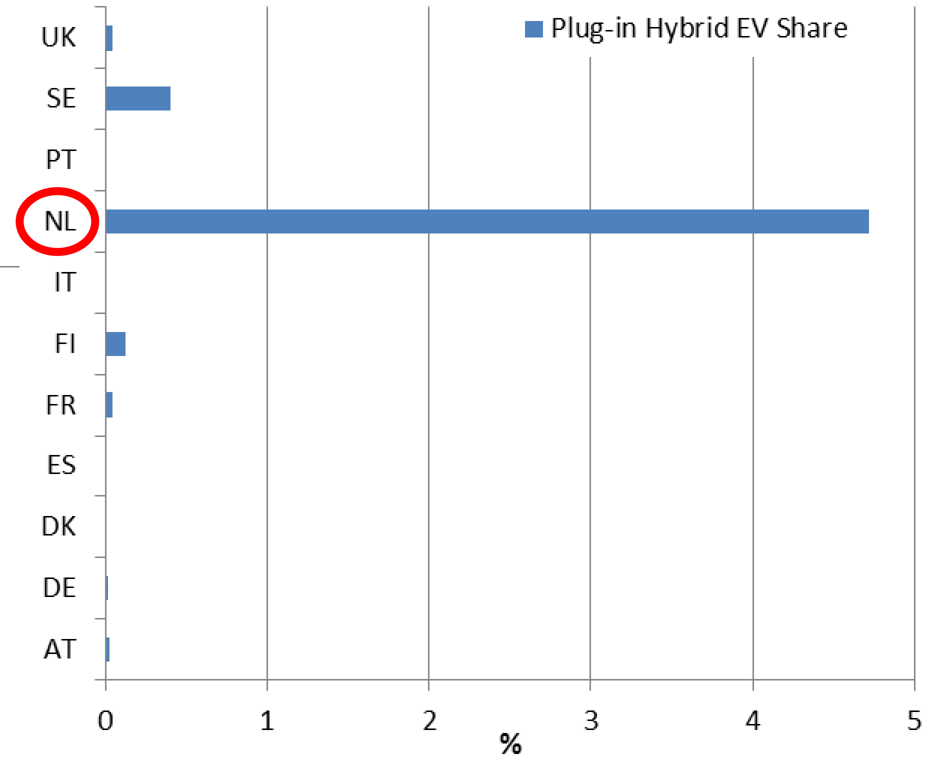
Global stock of EVs



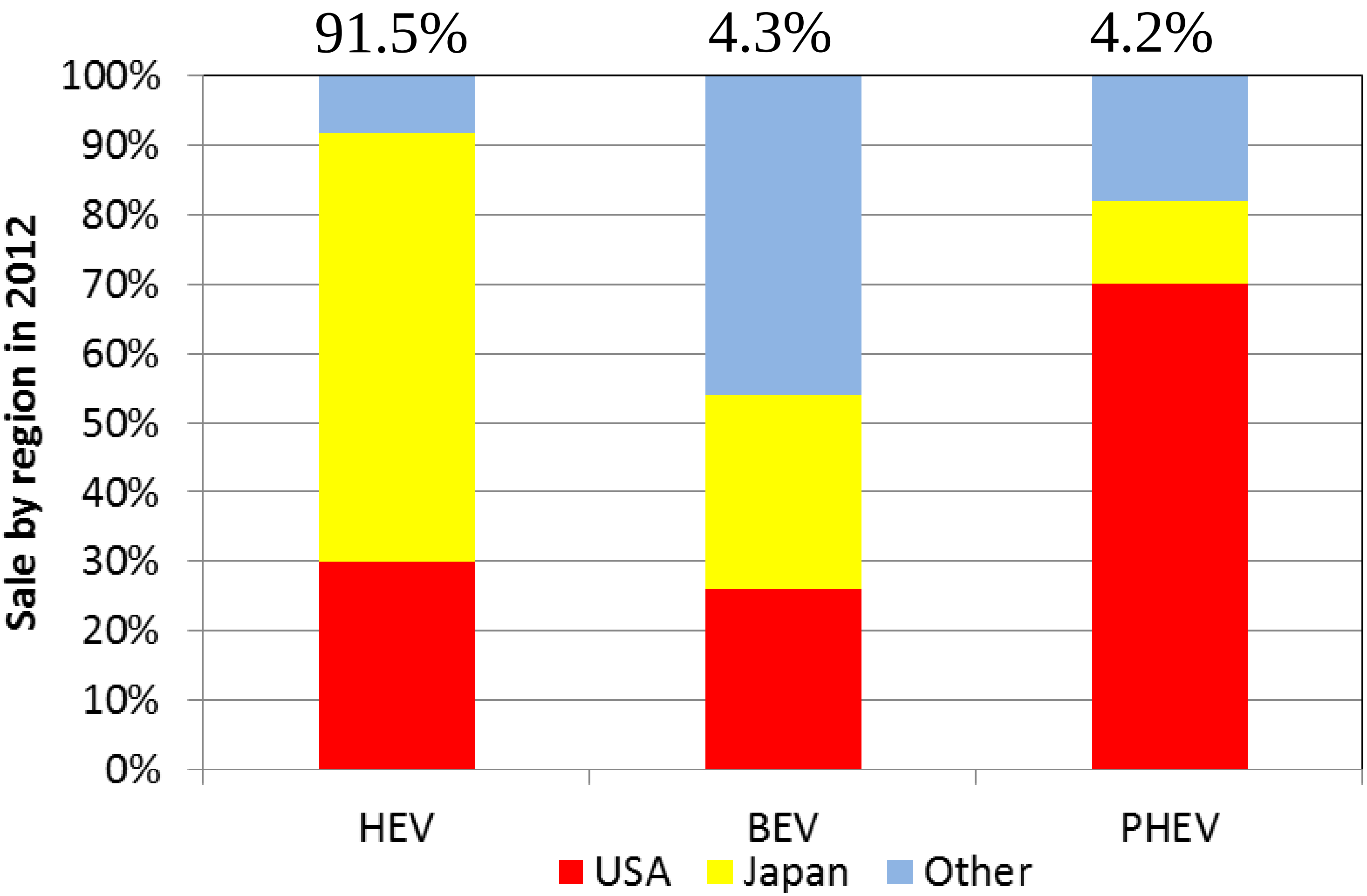
Development of the global stock of EVs

Share of electric vehicles

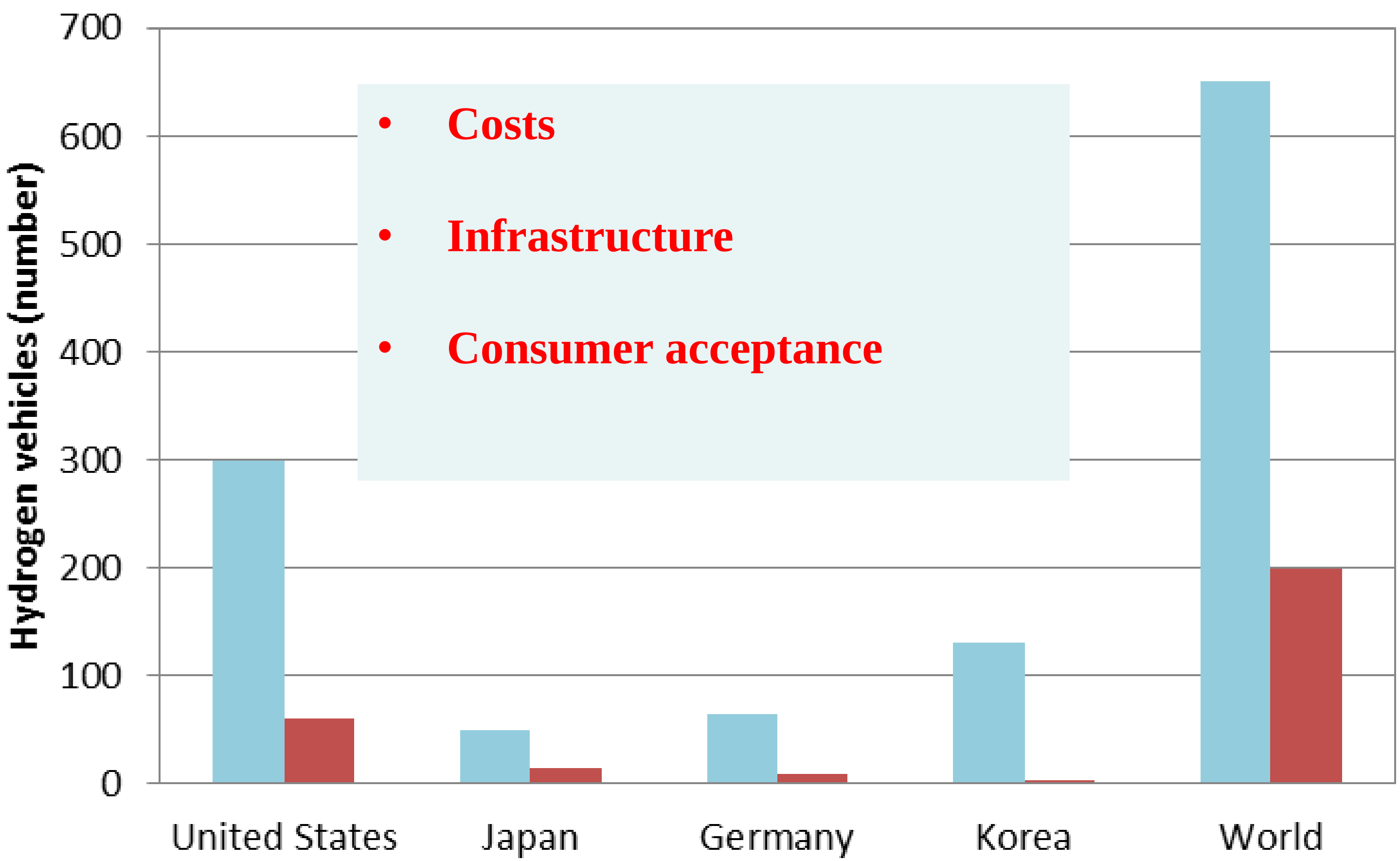




Sale of EVs in 2012

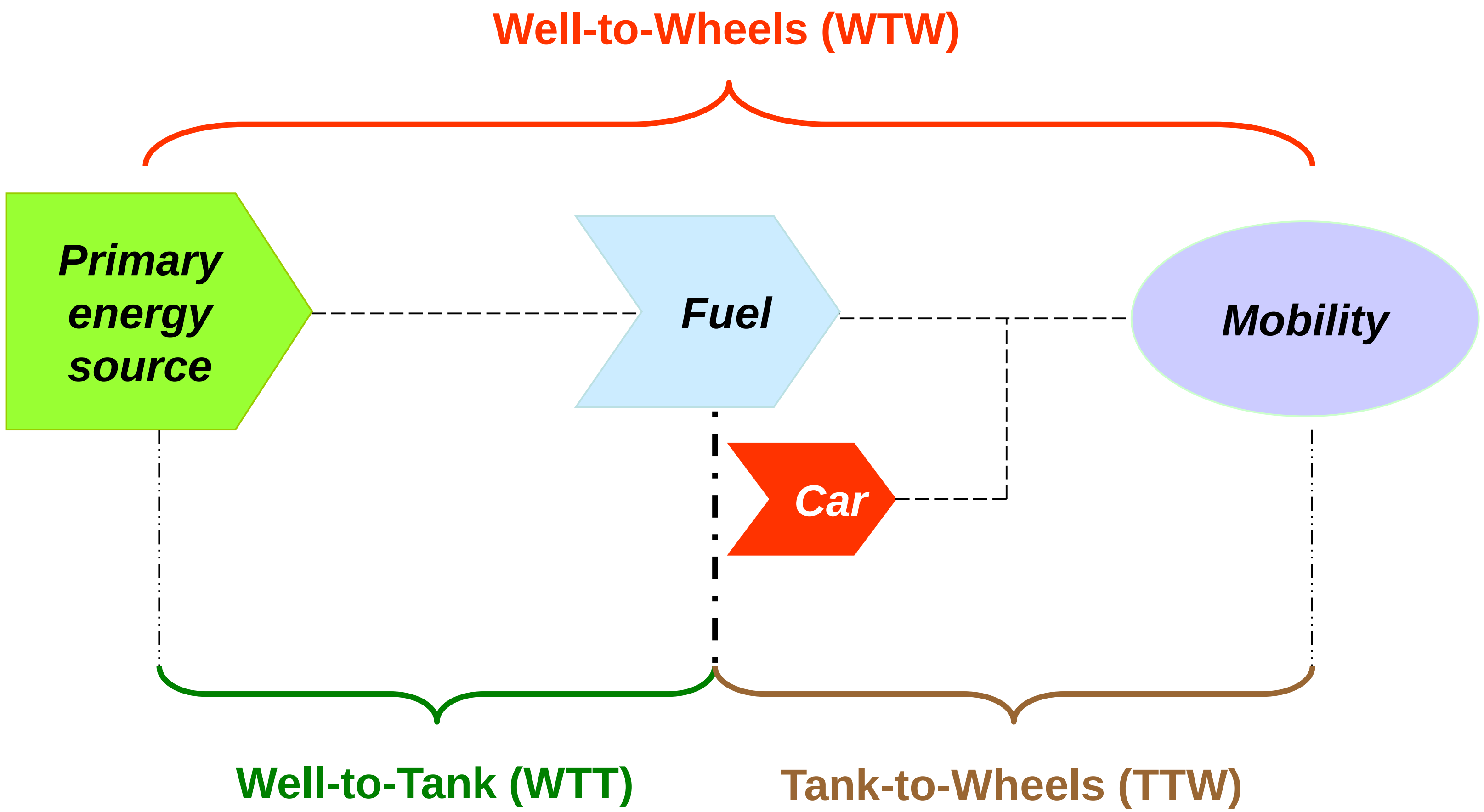


Fuel cell vehicles

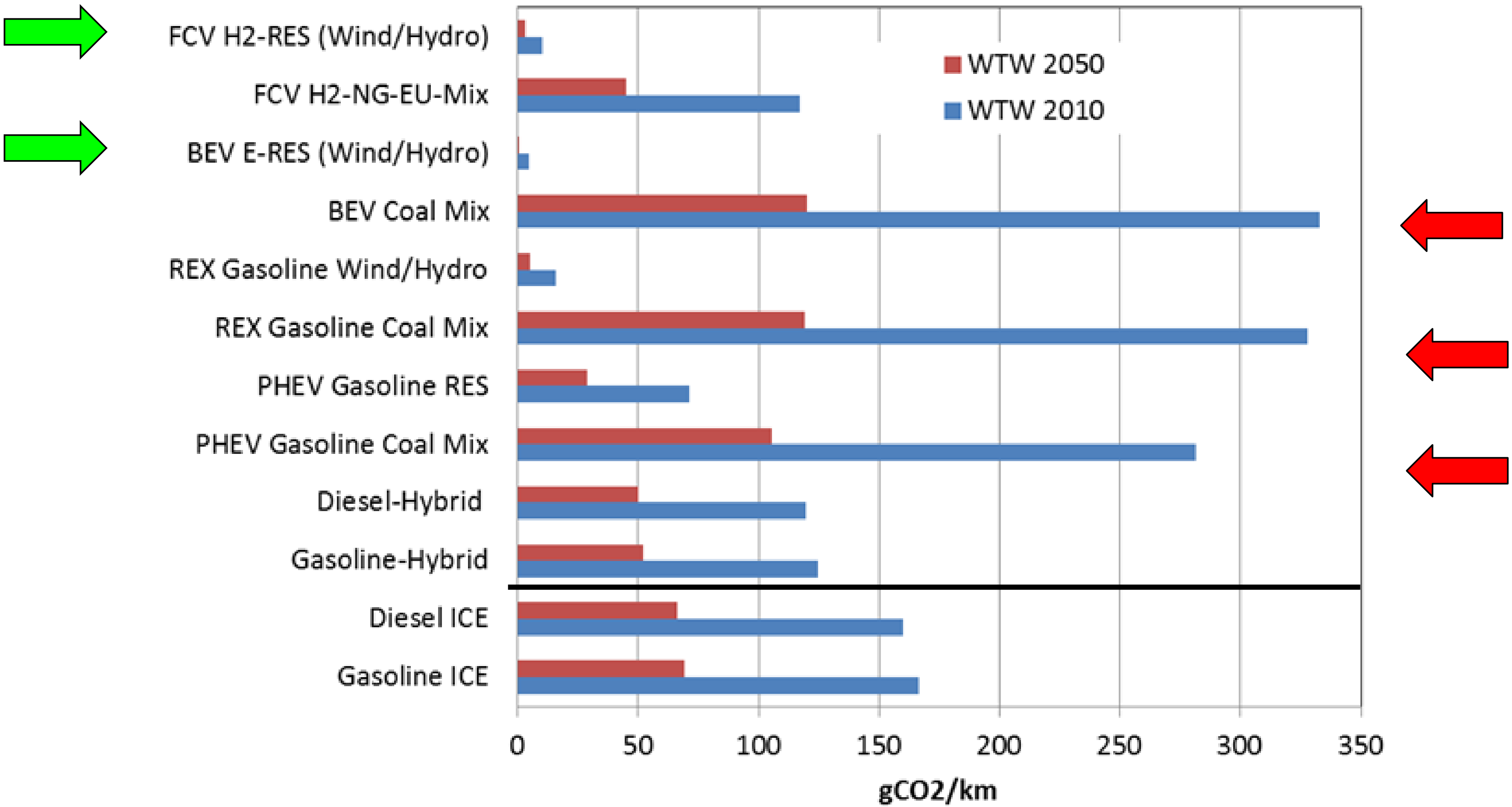


Total stock of hydrogen FCV in today's leading countries and worldwide

Energy chain for providing mobility



Ecological assessment



WTW-balance of CO_2 emissions per 100 km driven for various types of EVs in comparison to gasoline and diesel cars, 2010 vs. 2050 (Power of car: 80 kW)

Economic assessment

The costs per km driven C_{km} are calculated as:

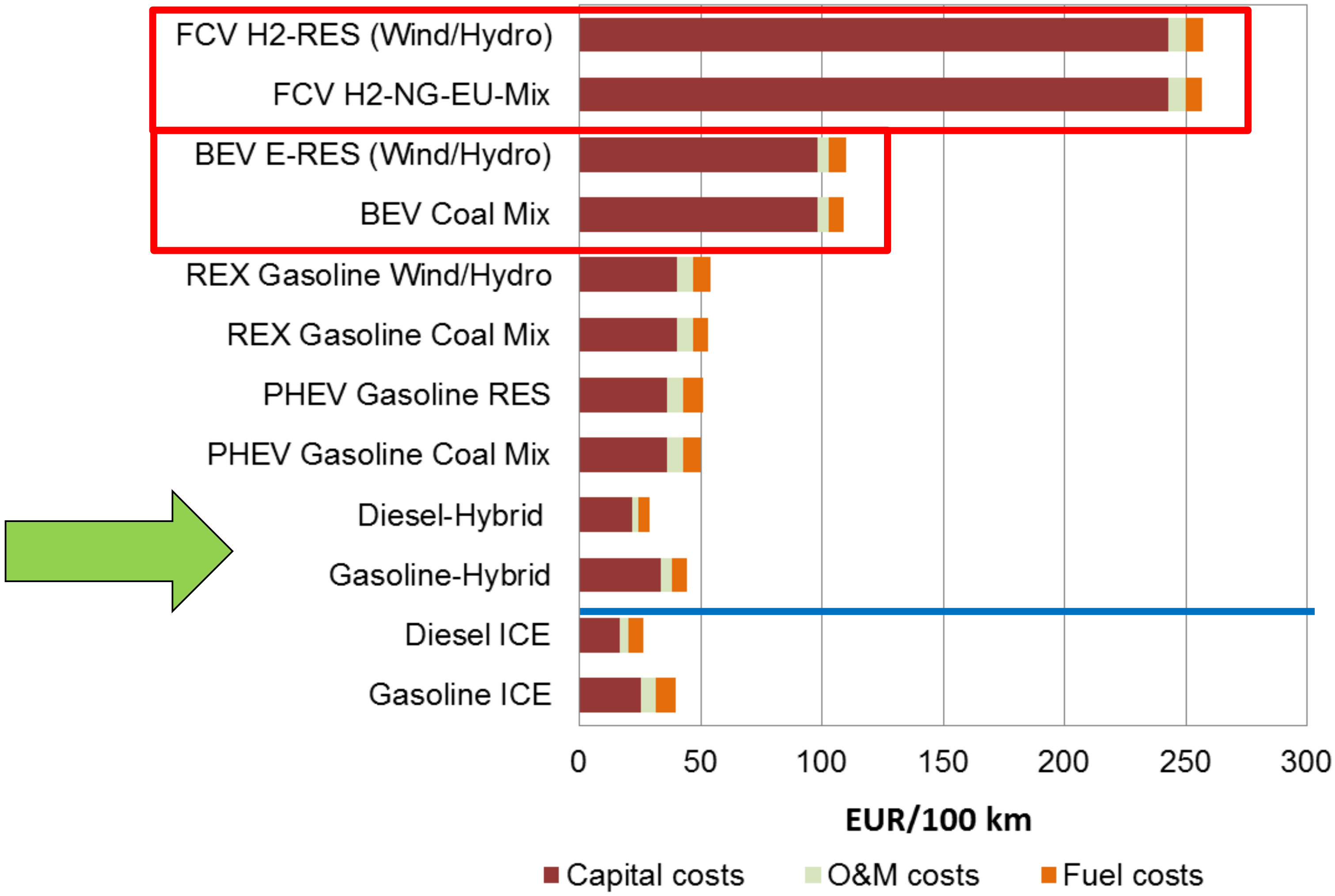
$$C_{km} = \frac{IC \cdot CRF}{skm} + P_f \cdot FI + \frac{C_{O\&M}}{skm}$$ [€/100 km driven]

IC……investment costs [€/car]
CRF……..capital recovery factor
skm…..specific km driven per car per year [km/(car.yr)]
Pf……..fuel price incl. taxes [€/litre]
$C_{O\&M}$…operating and maintenance costs
FI……..fuel intensity [litre/100 km]

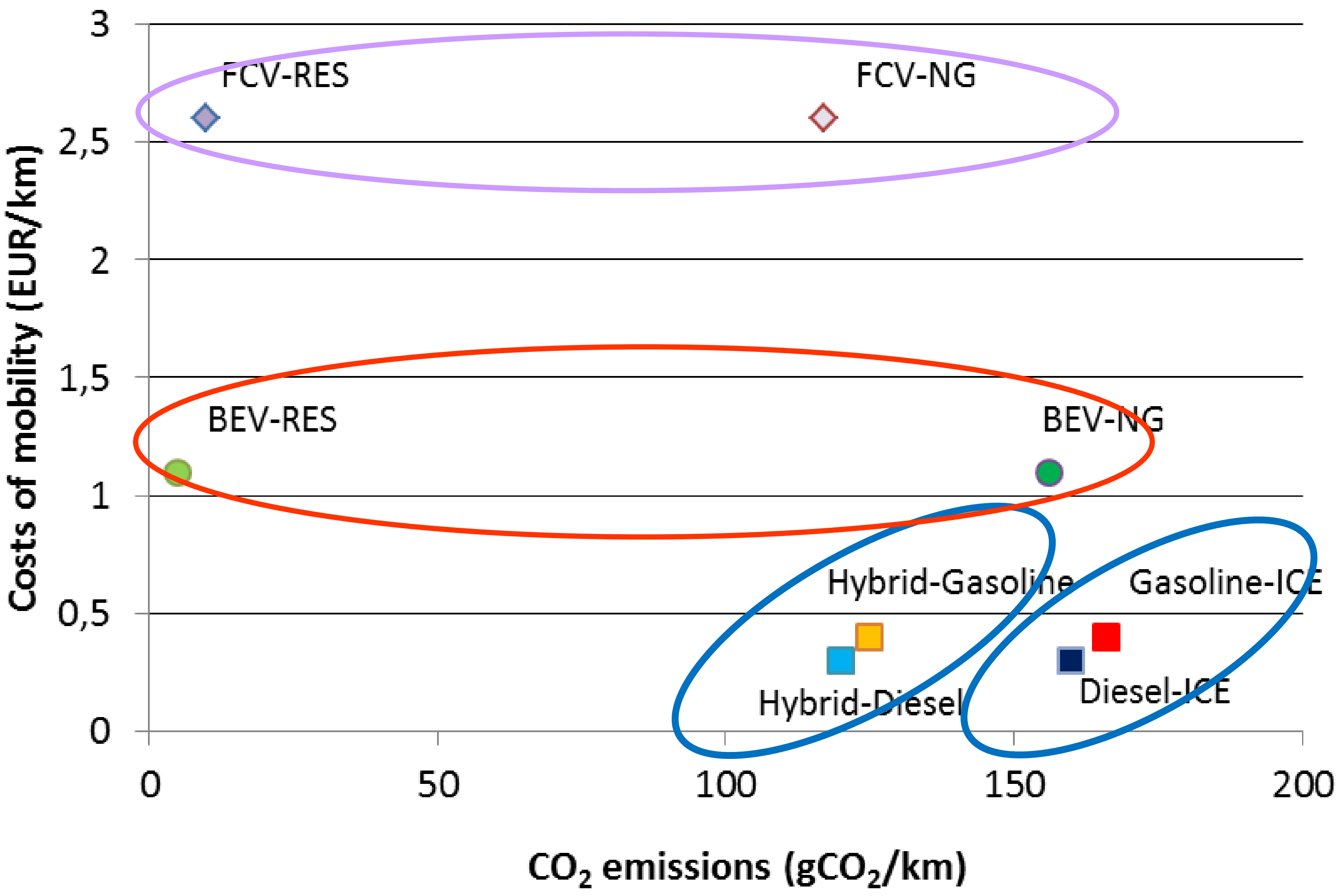
The fuel price depends on the cost of fuel C_f, and possible taxes τ:

$$P_f = C_f + \sum_{i=1}^{n} \tau_i$$

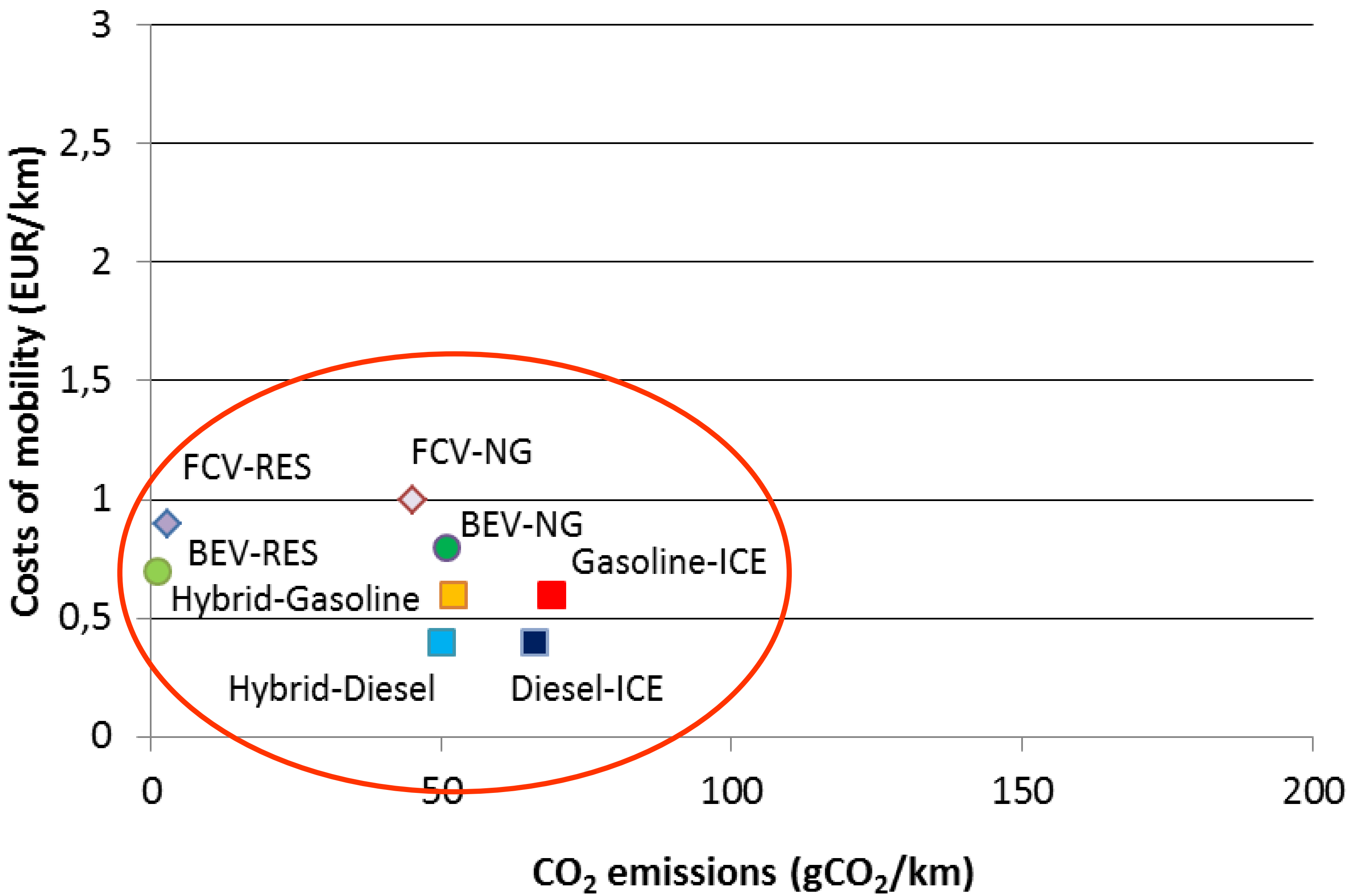
Total costs of service mobility



CO_2 emissions vs. driving costs: 2010

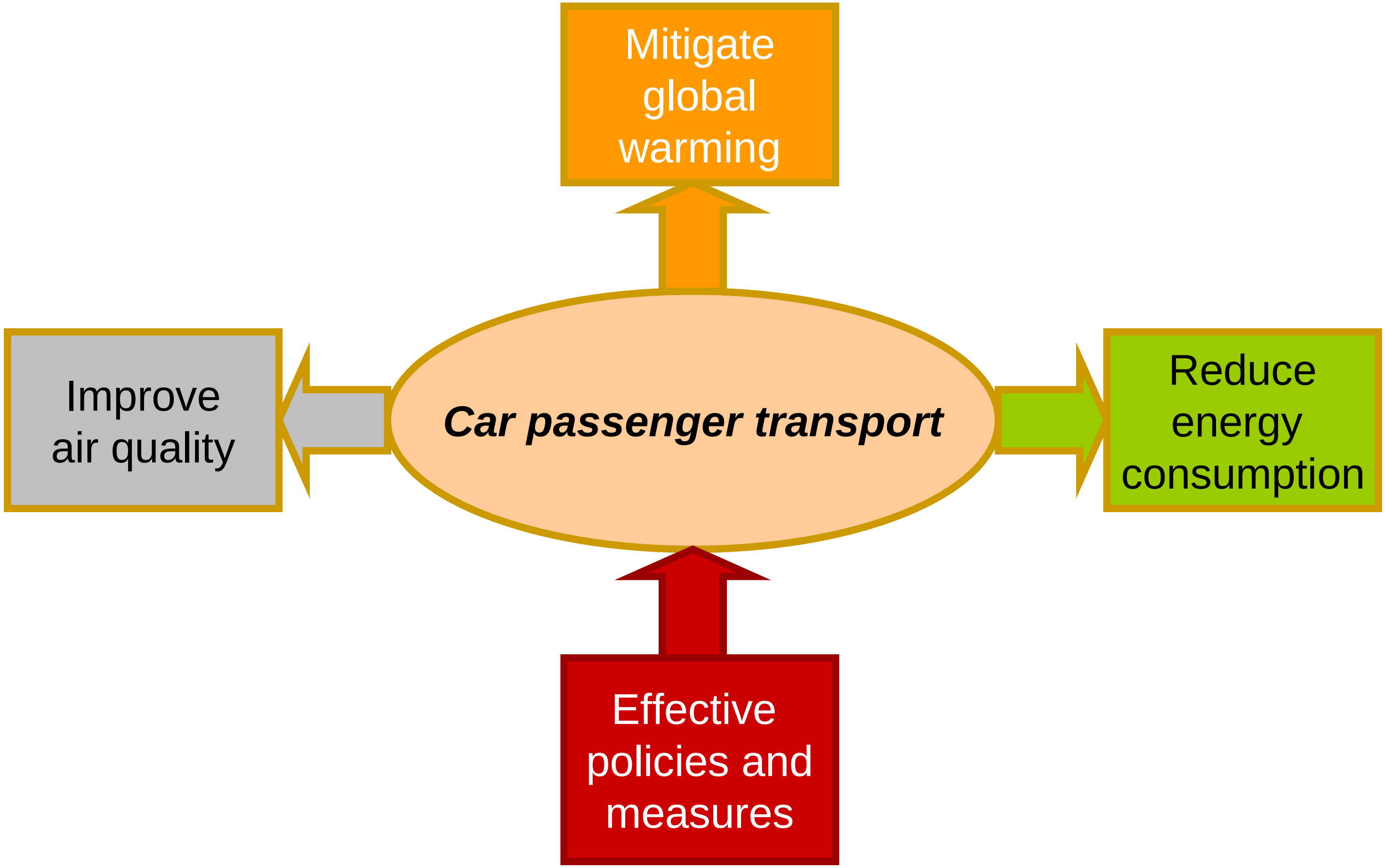


CO_2 emissions vs. driving costs: 2050



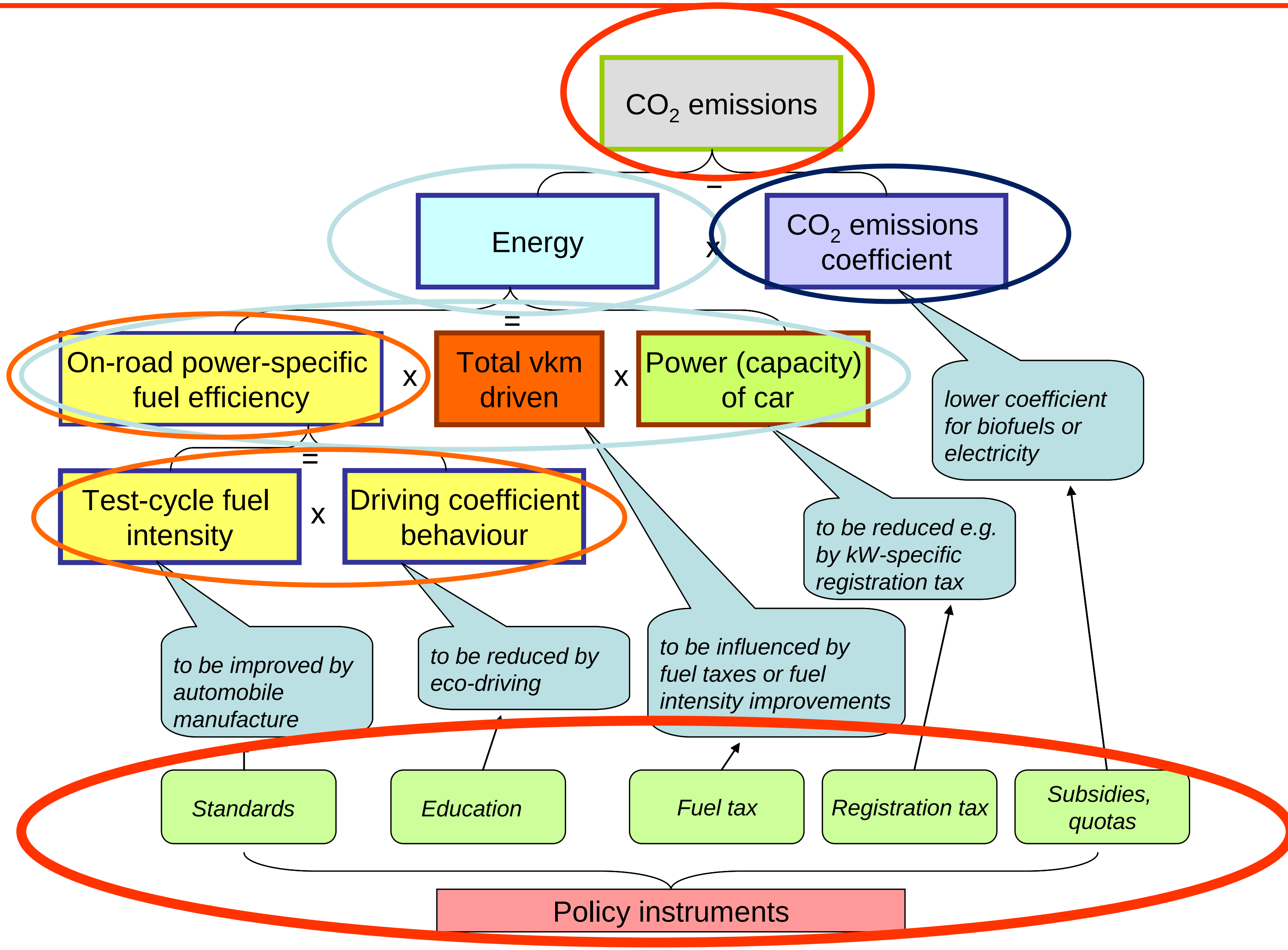
5. Energy policies

Energy policy



The challenges for EU climate and energy policies

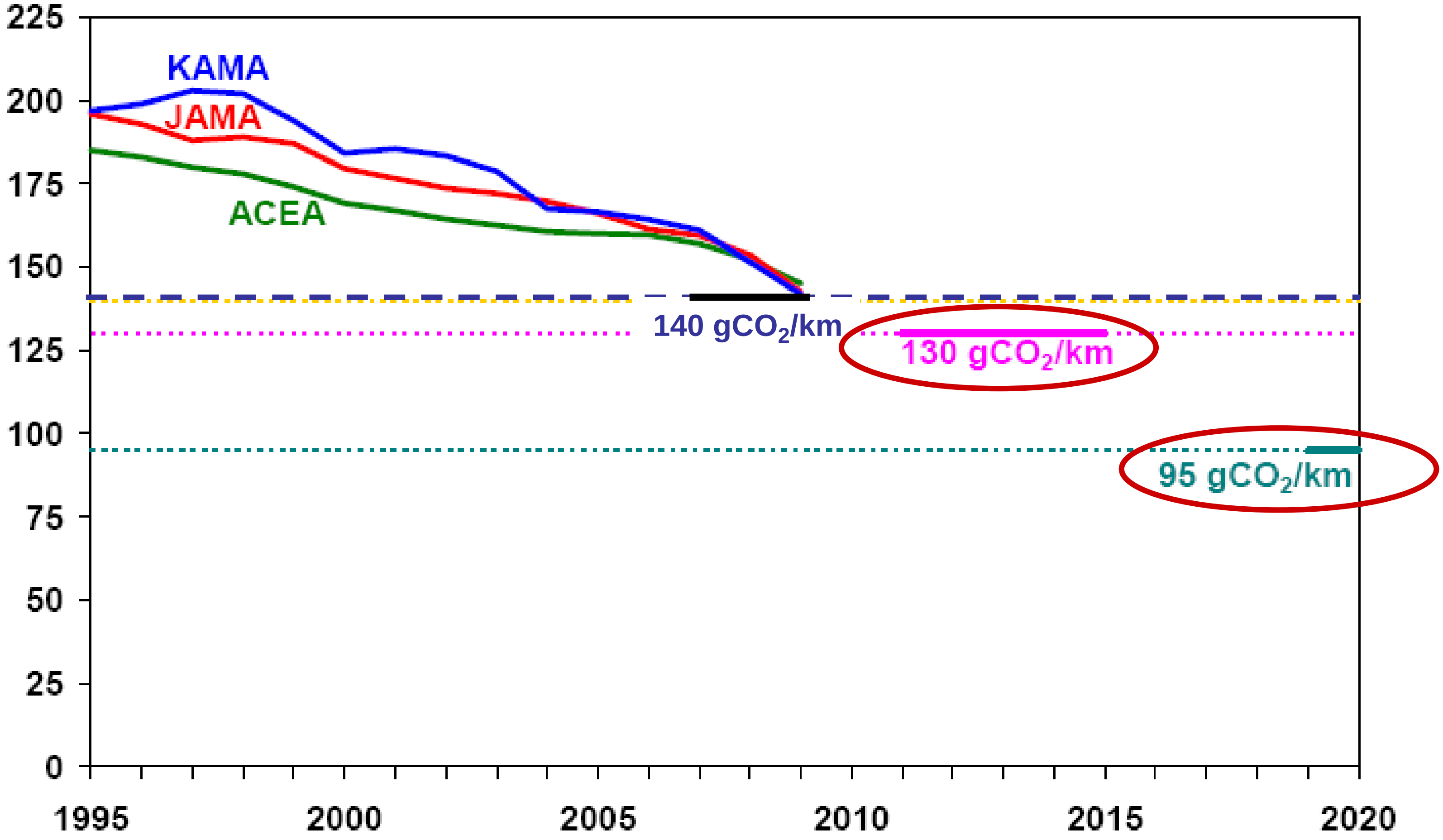
Energy policy



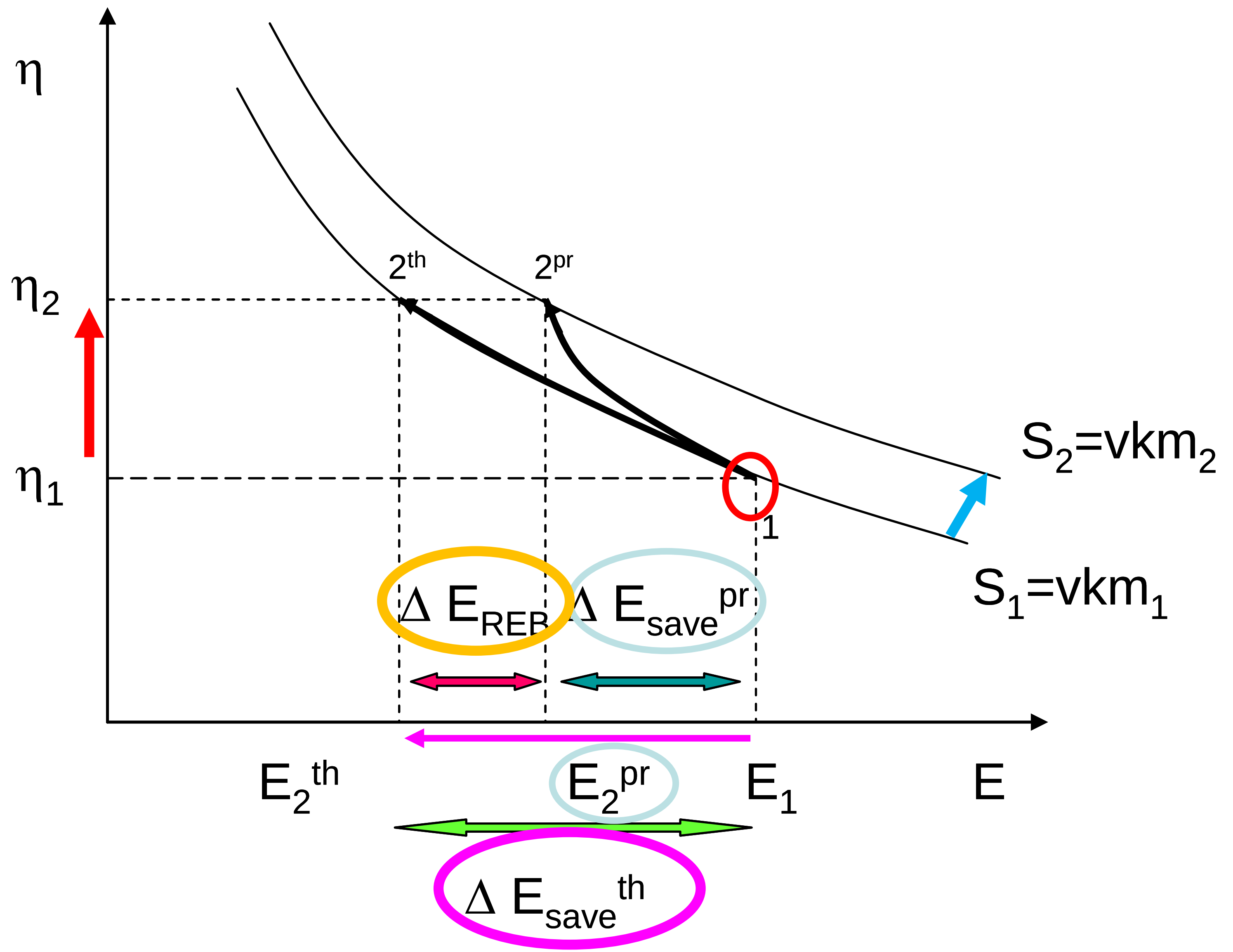
Impact factors on CO_2 emissions in the car passenger transport sector

Energy Policy

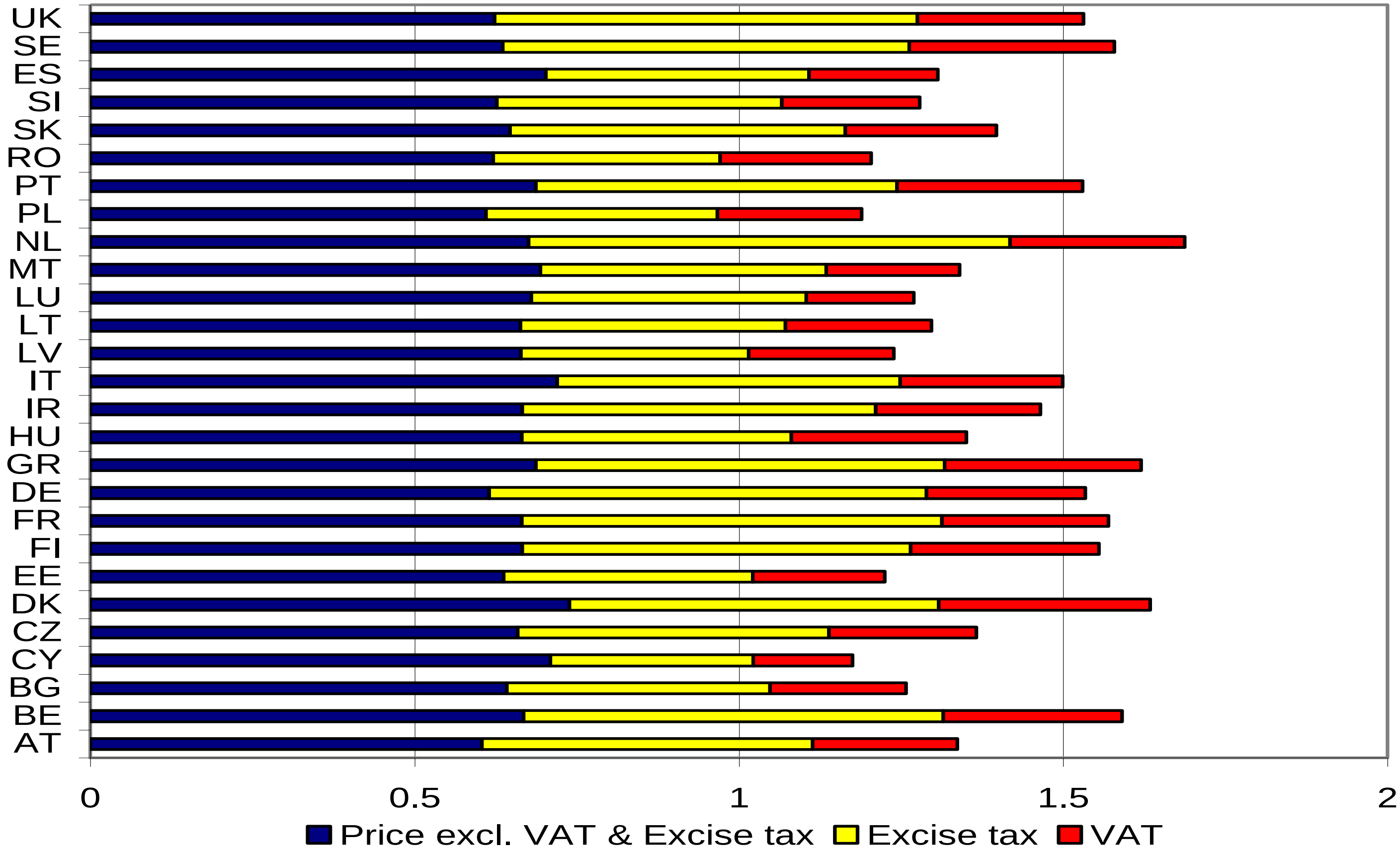
Evolution of CO2 emissions from new passenger cars by the European (ACEA), Japanese (JAMA) and Korean (KAMA) car manufacturer associations



Rebound effect



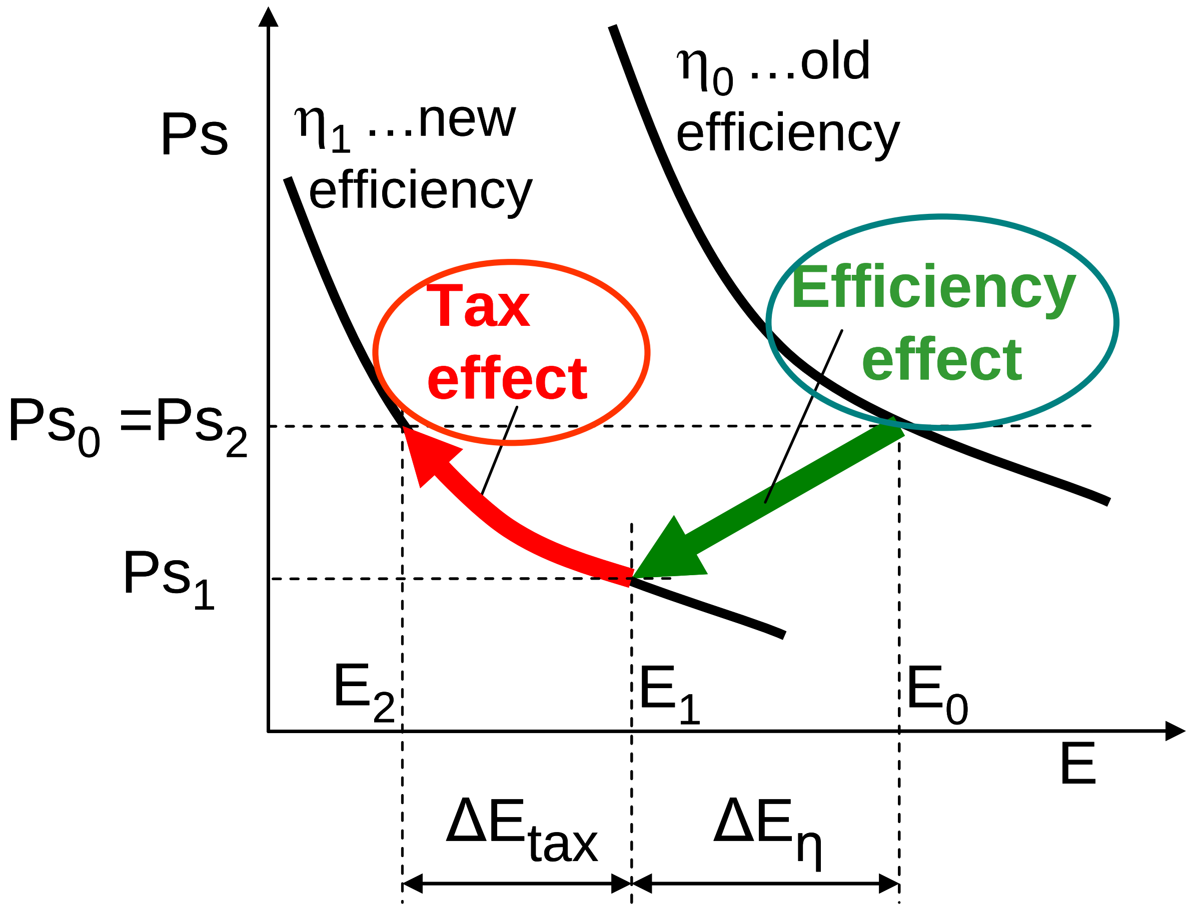
Energy Policy



Price structure of gasoline in EU-27

(data source: EEP, 2011 - effective March 2, 2011)

Standards & taxes



How taxes and standards interact and how they can be implemented in a combined optimal way for society

Brazil

- 1975 – Brazil‘s Proalcool program
- ‚neat‘ (pure) ethanol cars
- Subsidies for sugar production
- Flexible-fuel vehicles

EVs - Monetary measures

- Tax exemptions and reductions (e.g. registration and ownership tax)
- Direct subsidies (e.g. in Sweden)
- One-time bonus upon purchase of an EV (e.g. UK)

EVs - on-monetary measures

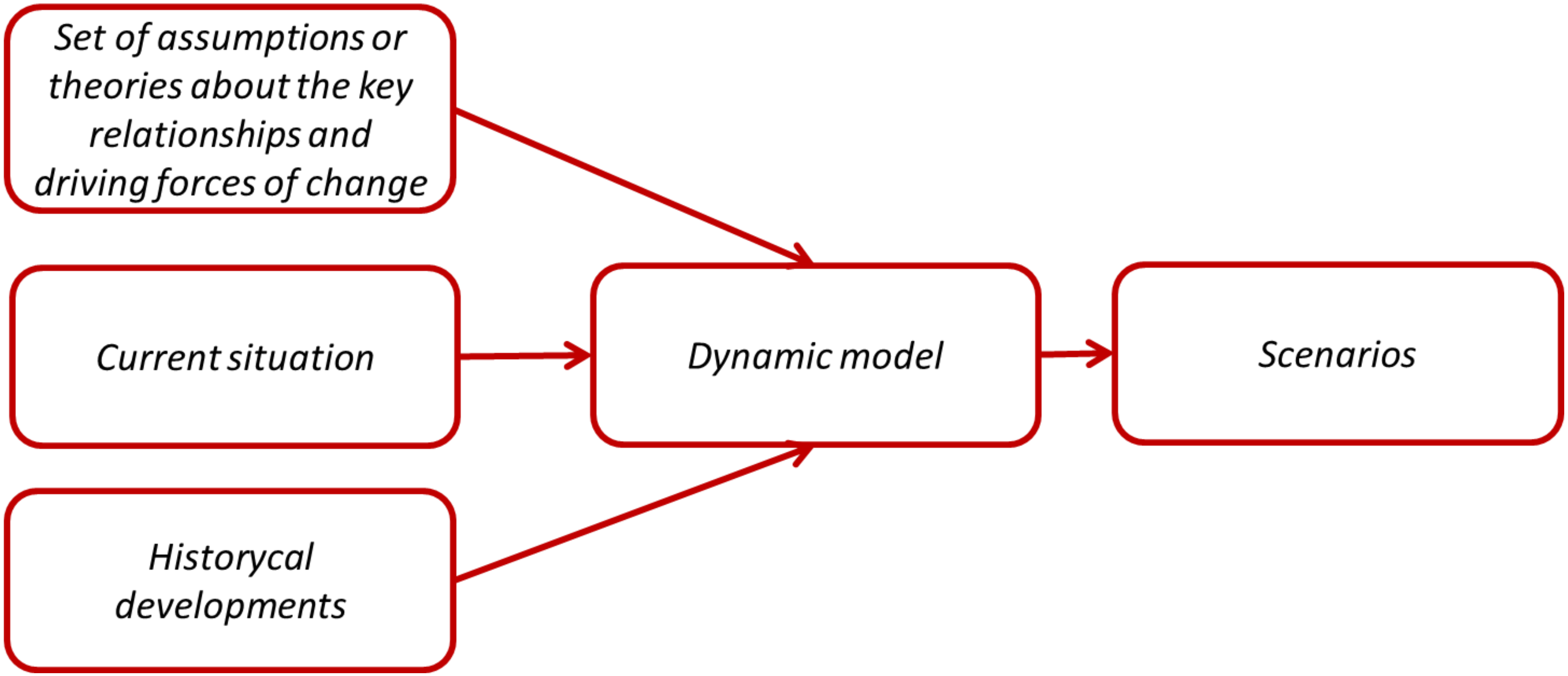
The most important non-monetary measures are:

- free parking spaces,
- possibility for EVs drivers to use bus lanes,
- wide availability of fast charging stations,
- permission for EVs to enter city centers and zero emission zones.

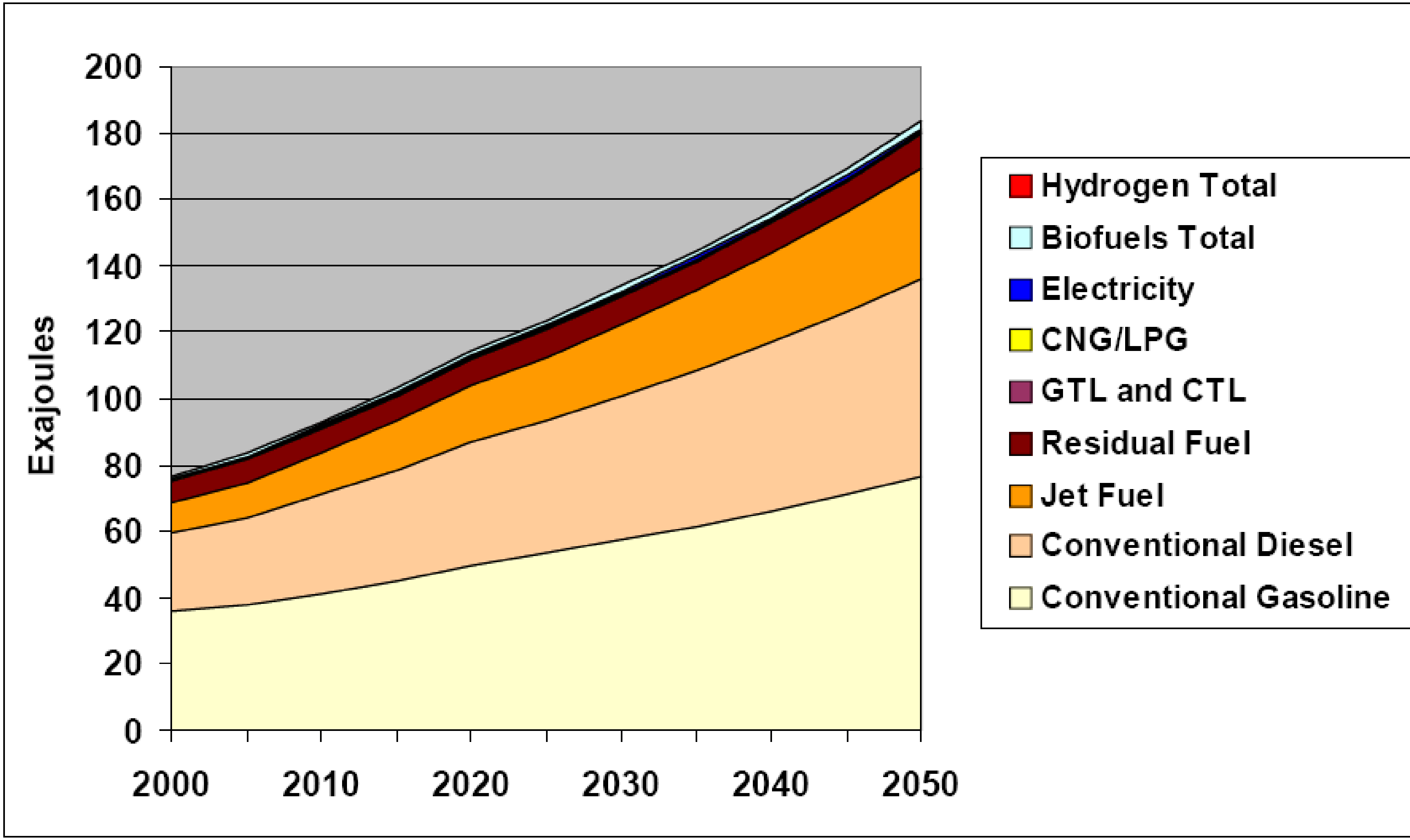
6. Future scenarios and perspectives

Scenarios

A scenario is a plausible description of how the future may develop, based on a coherent and internally consistent set of assumptions ("scenario logic") about key relationships and driving forces (e.g., rate of technology changes, prices). Note that scenarios are neither predictions nor forecasts. (SRES, 2000)

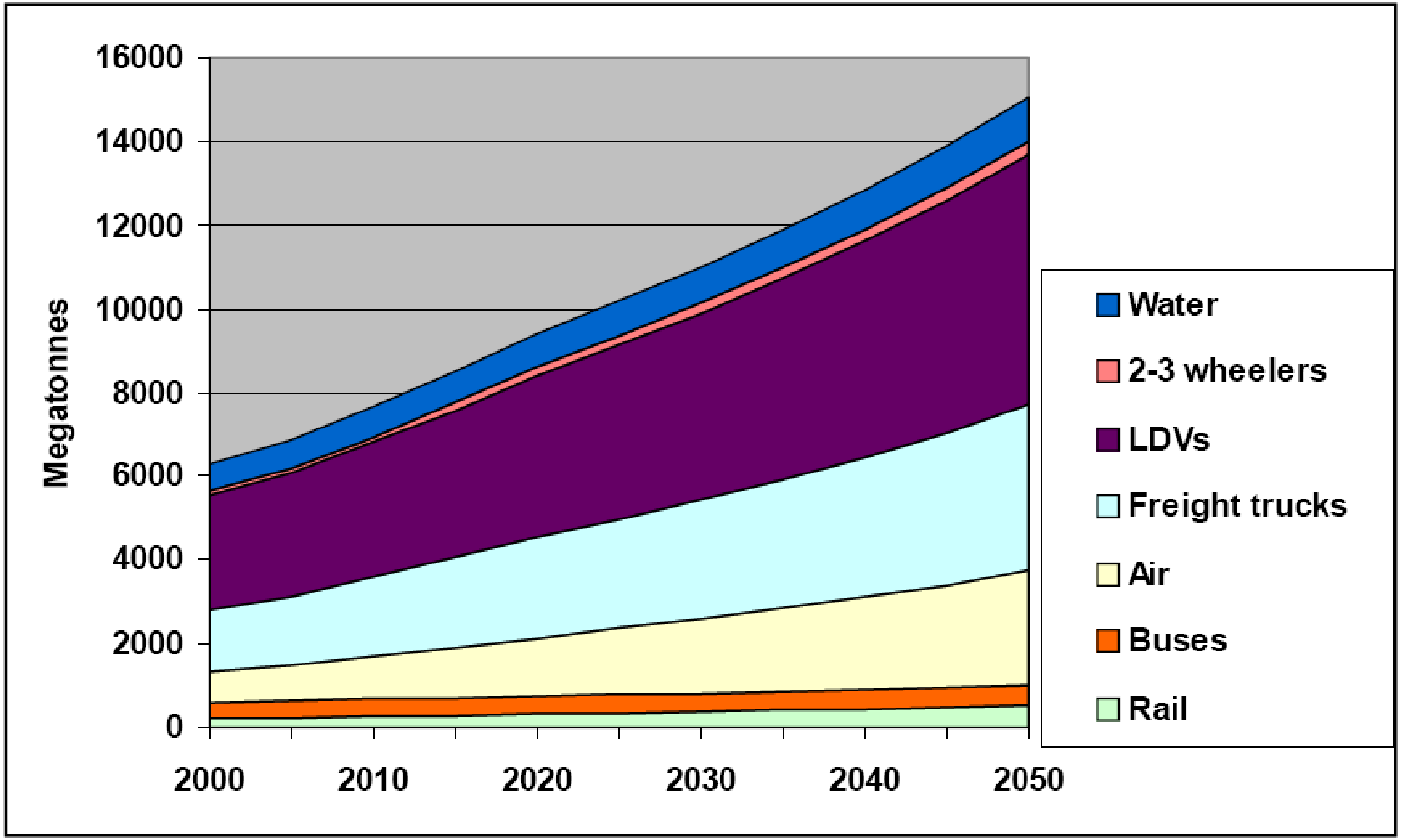


Ref. Case: Fuel Use



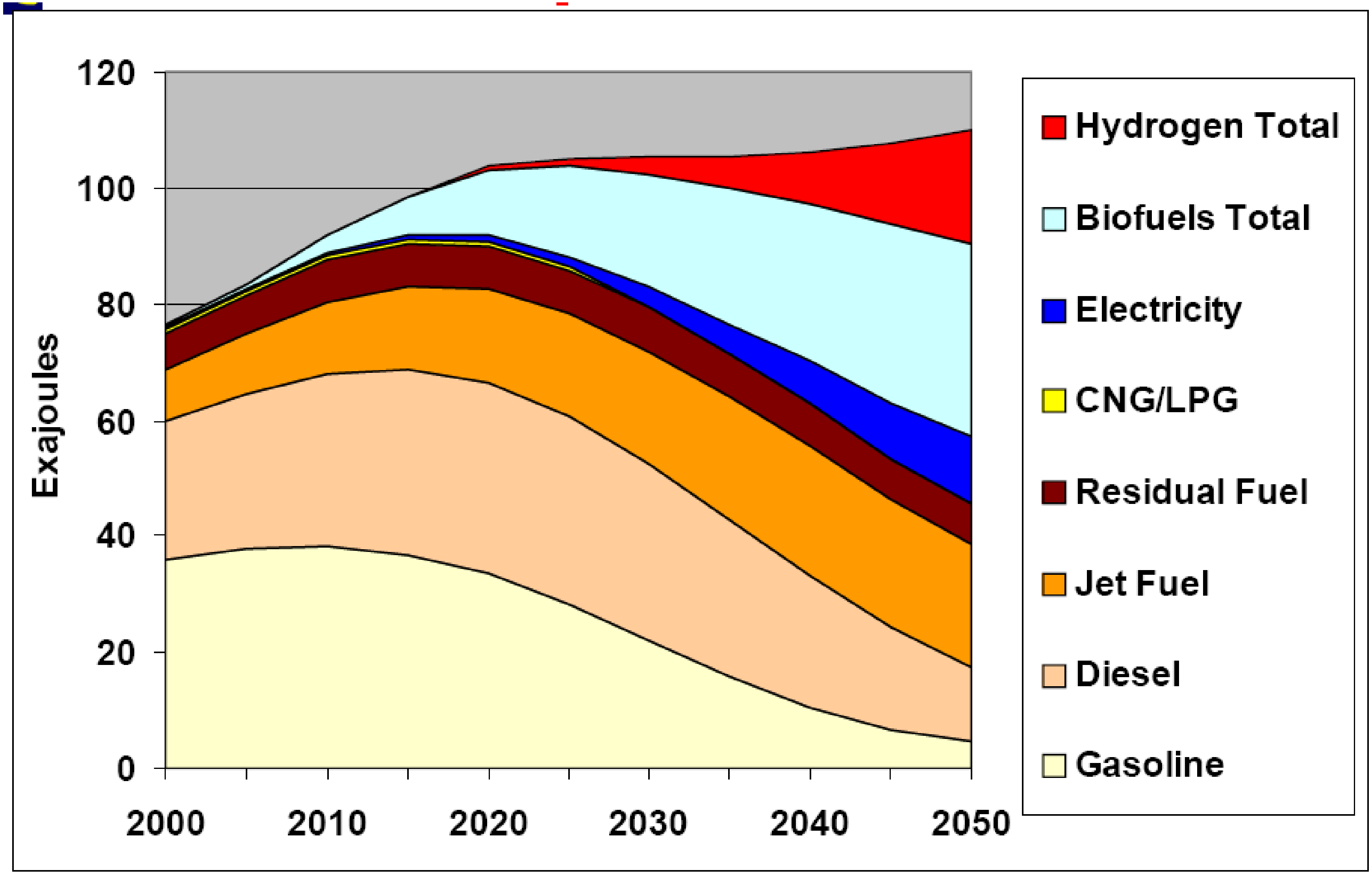
Souce: IEA, 2007

Ref. Case: Emissions by Mode (WTW)



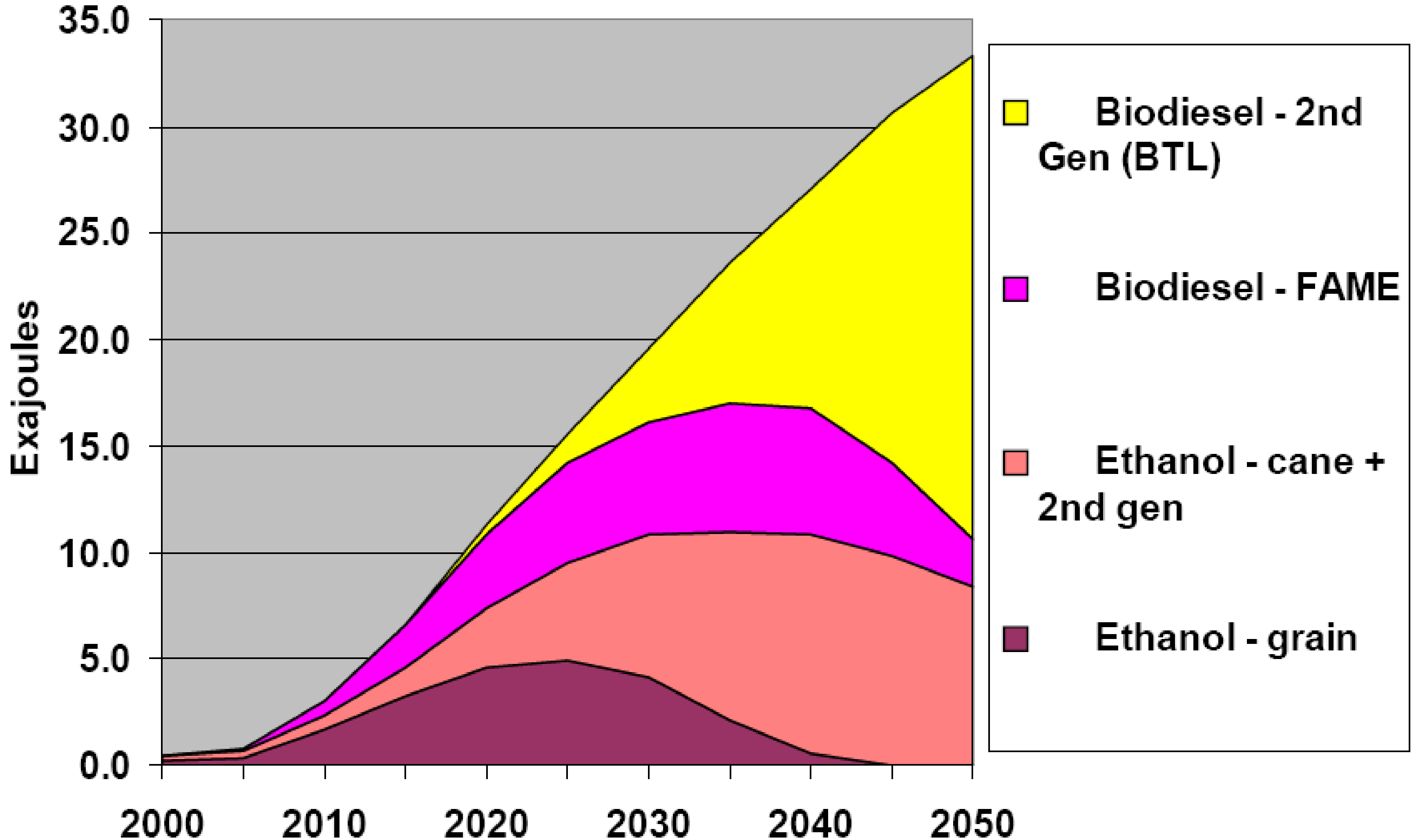
Souce: IEA, 2007

Alternative Scenario (AS): Transport Fuel Use

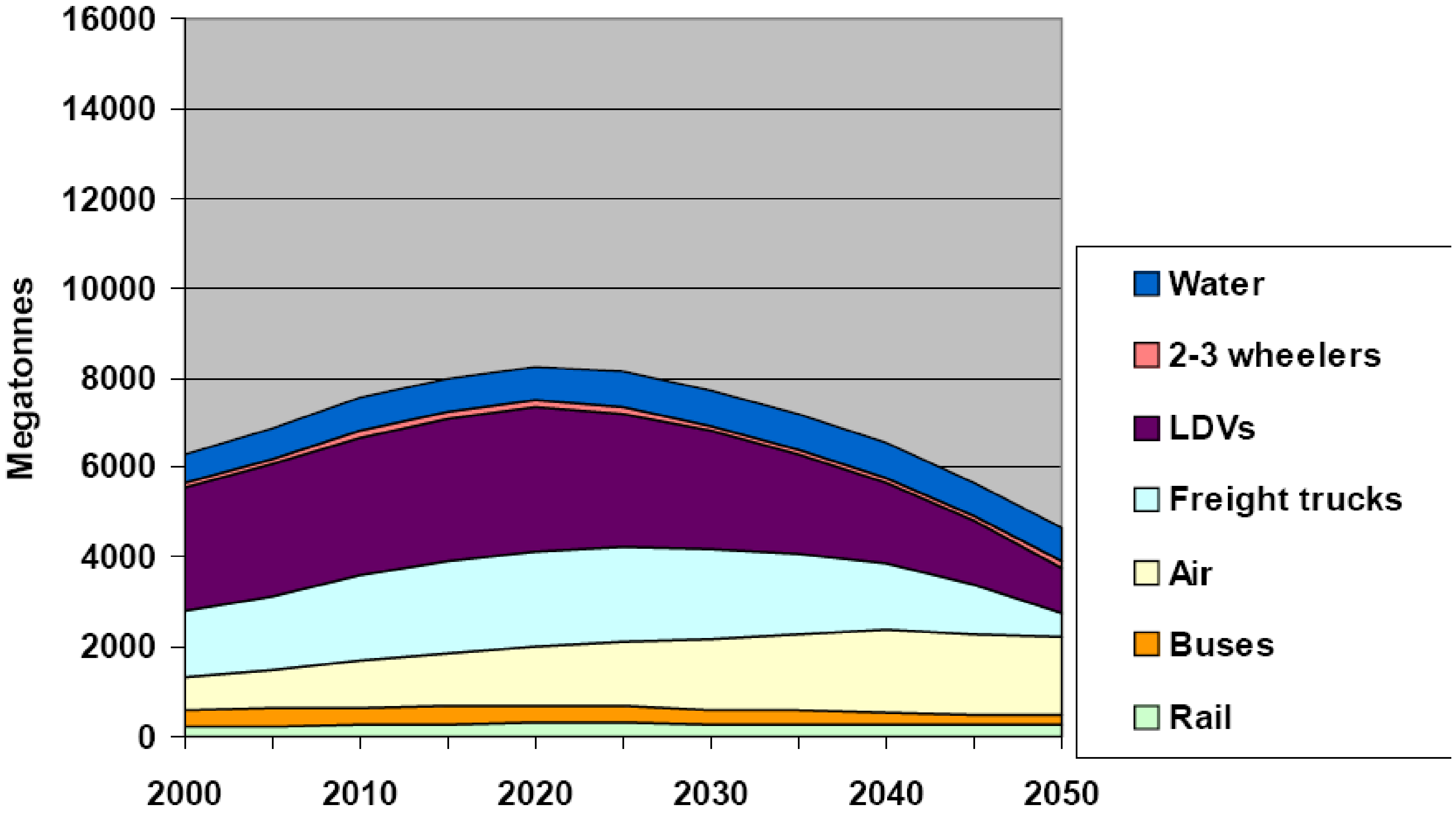


Souce: IEA, 2007

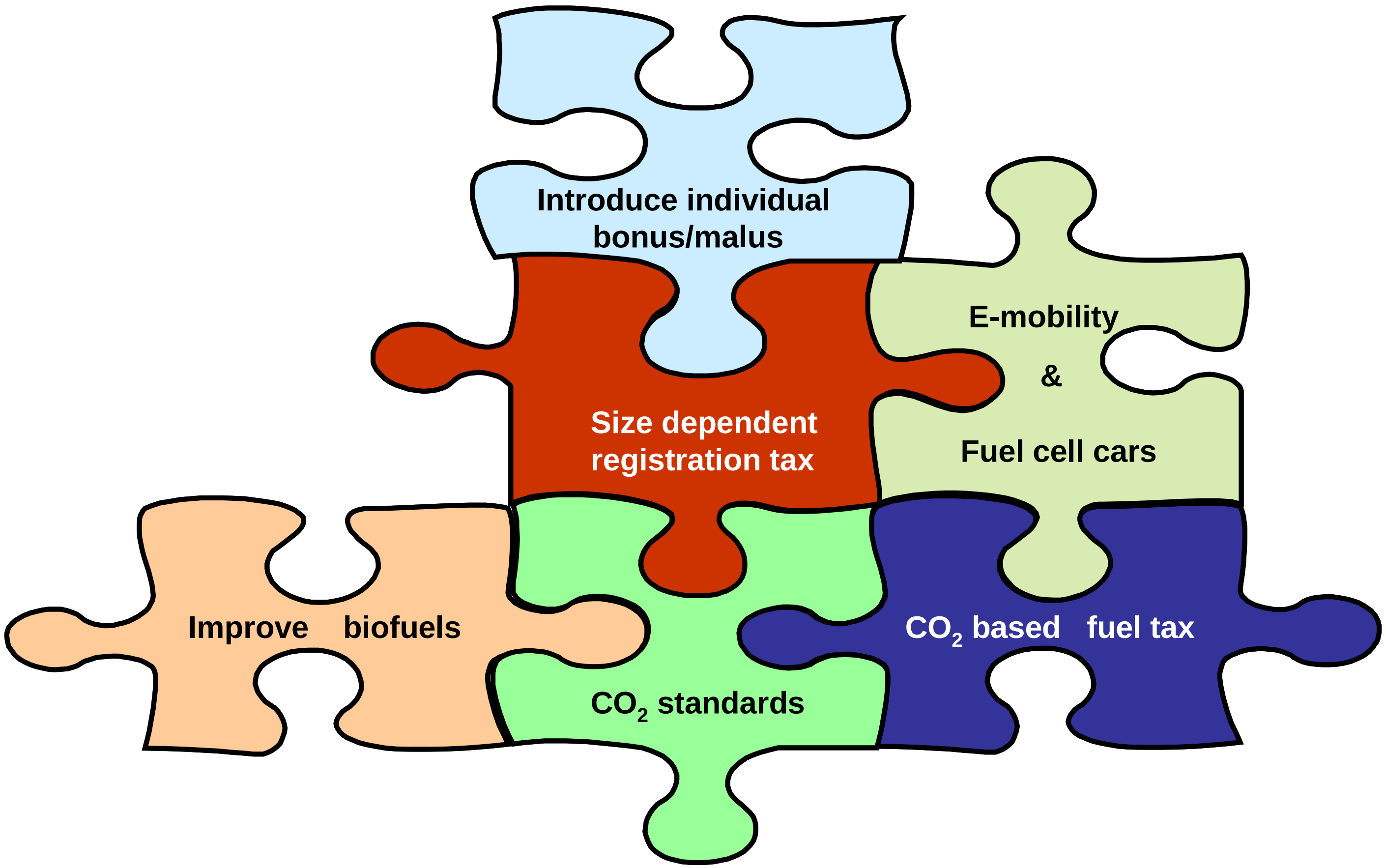
AS: Biofuels Breakdown



AS: GHG Emissions by Sector



Conclusions



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