# Introduction:
# Energy Economics in Transport

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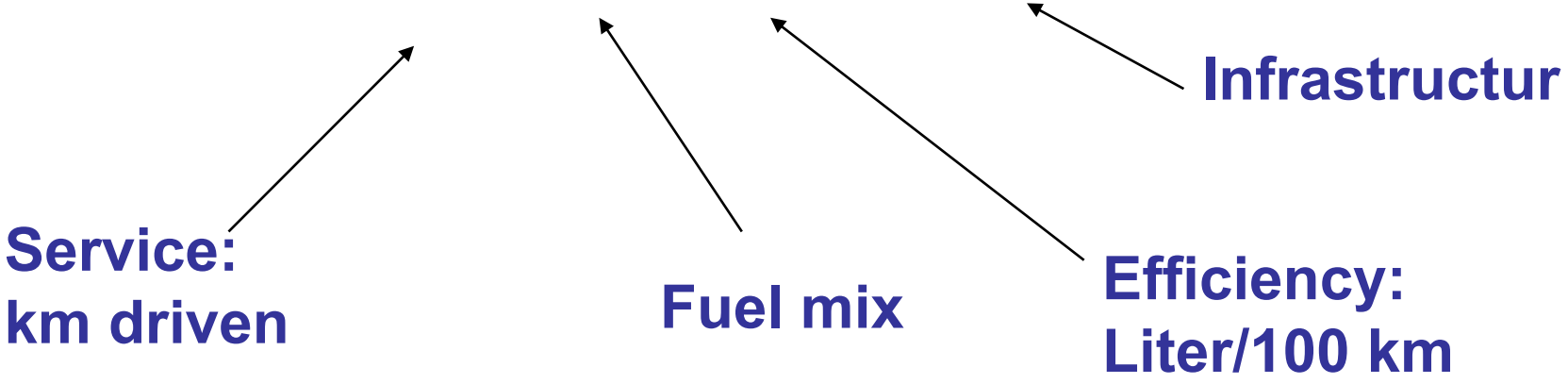
# Contents

1. *Introduction*
2. *Historical developments*
3. *Alternative fuels and technologies*
   - *Biofuels*
   - *Electric vehicles*
4. *Energy policies*

# 1. Introduction

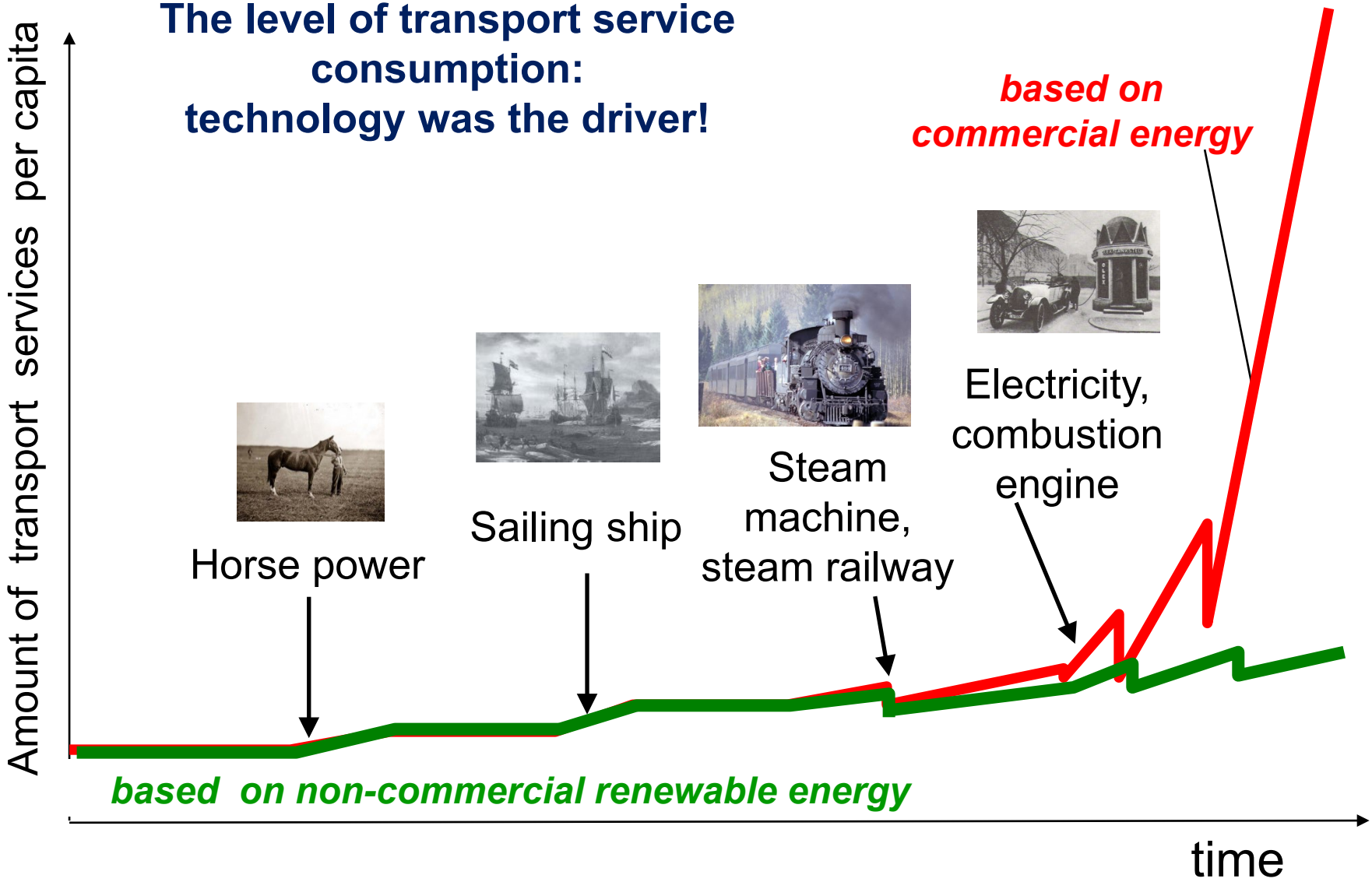
## Basic principle:

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



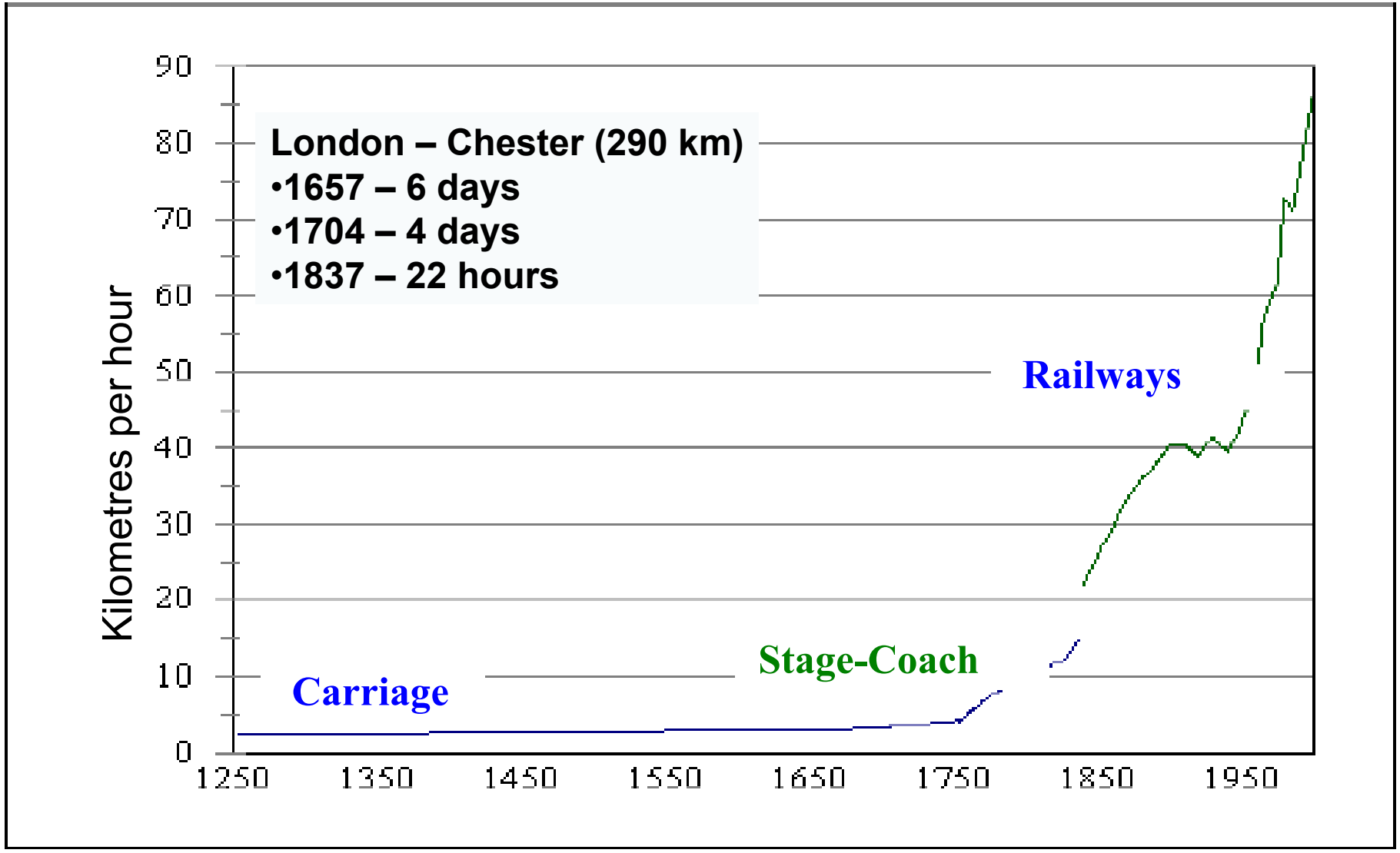
# *2. Historical developments*

# Introduction



# The Speed of Transport

*(Kilometres per Hour)*

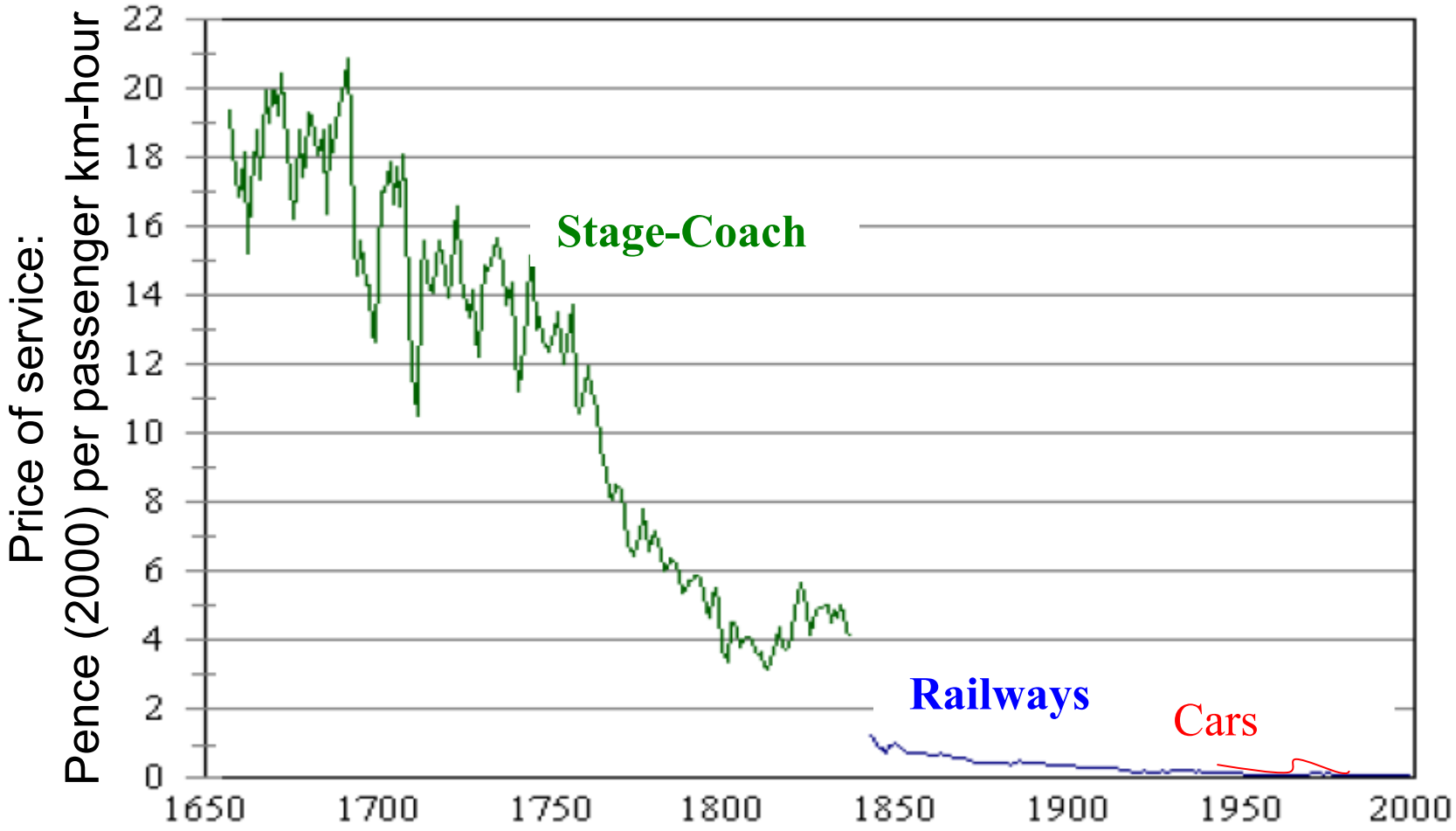



Source: Fouquet,2003

# Price of Passenger Transport

*(per passenger-kilometer-hour)*

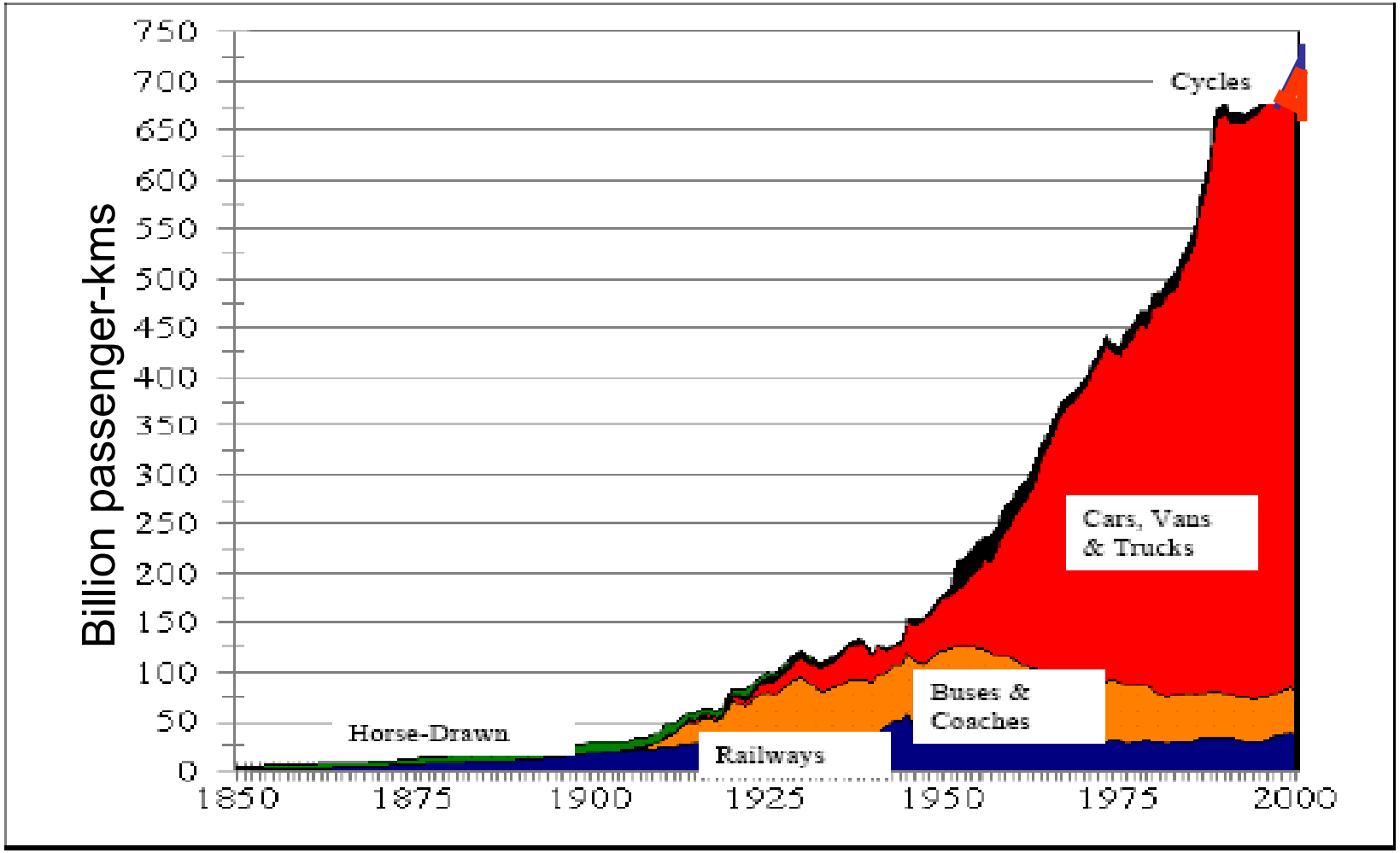
**The price of service dropped dramatically!**




*Source: Fouquet&Pearson (2003)*

# UK: The Use of Passenger Transport

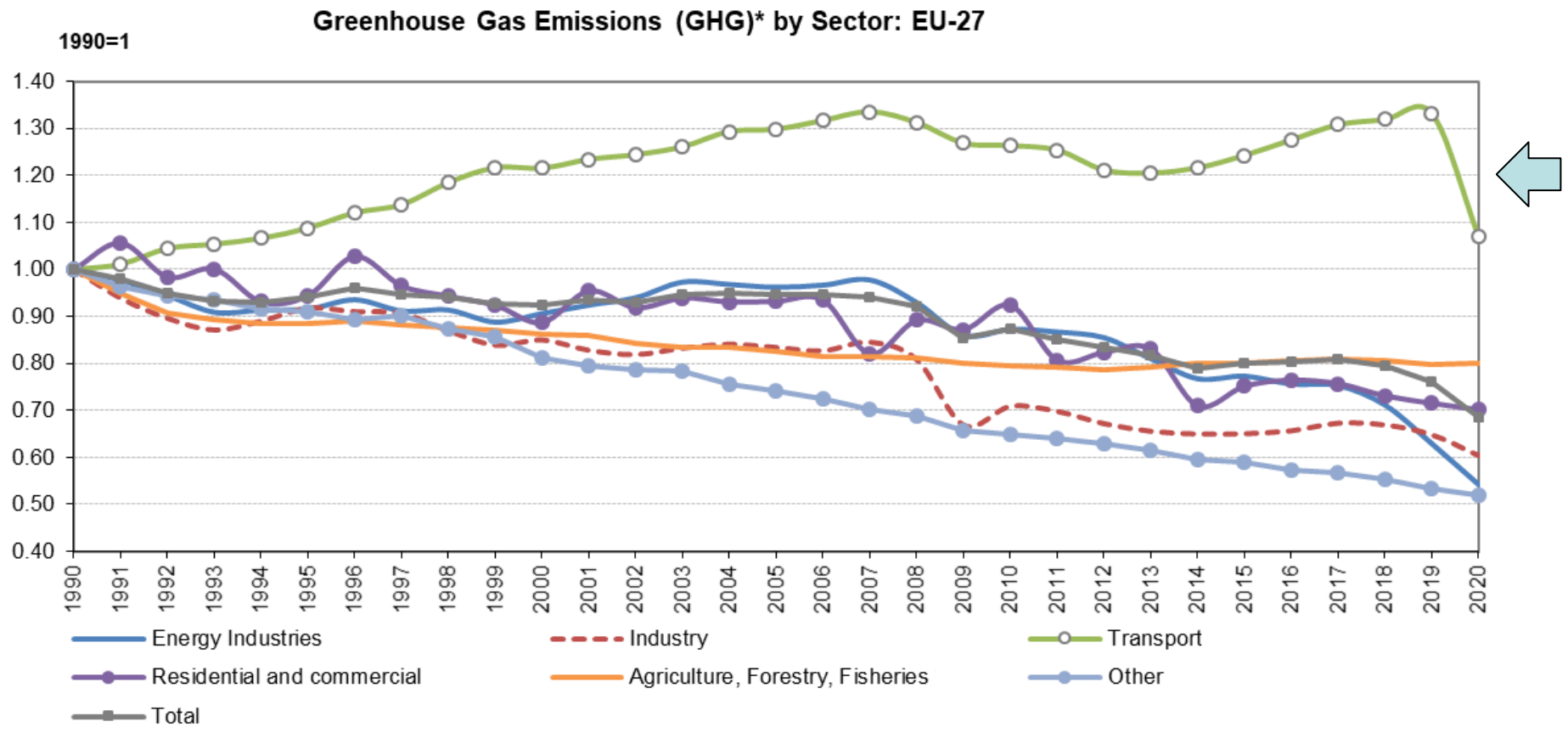
## (per Passenger-Kilometre), 1850-2000



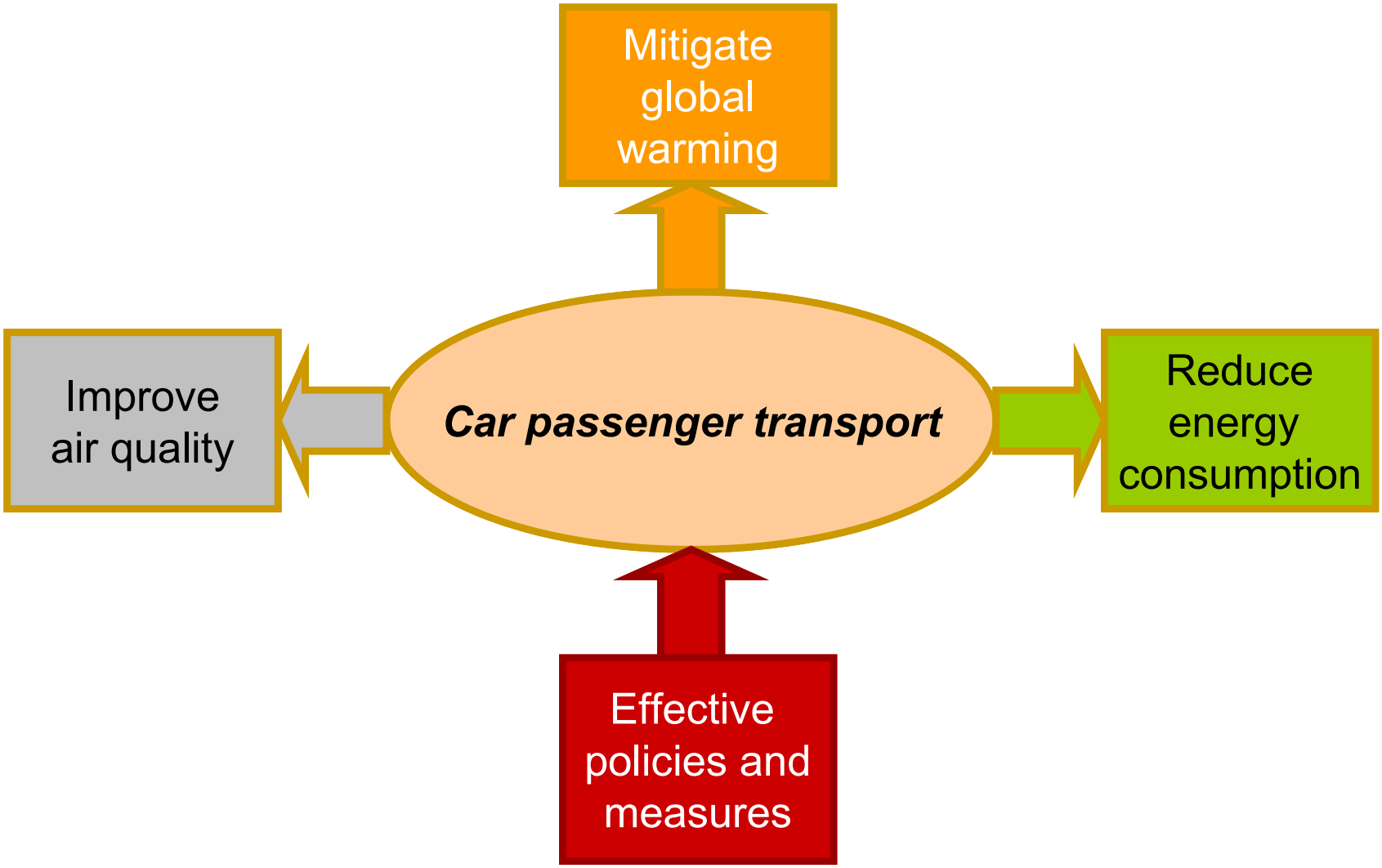

Source: Fouquet,2003

# *3. Alternative fuels and technologies*

# GHG


Greenhouse Gas Emissions (GHG)* by Sector: EU-27
1990=1
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Energy Industries
Industry
Transport
Residential and commercial
Agriculture, Forestry, Fisheries
Other
Total

# The challenges for EU climate and energy policies



# EU targets

EU - the first climate-neutral continent by 2050

European Green Deal

55-42.5-36

**2030 climate & energy framework**

40-32-32,5

14%

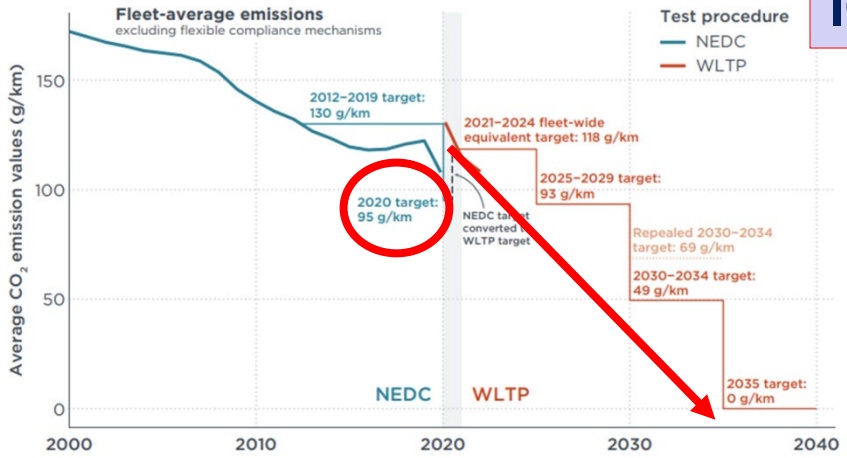
RED III: at least 29% renewables in the final energy consumption in the transport sector by 2030

**Sustainable and Smart Mobility Strategy**

at least 30 million zero-emission cars will be in operation on European roads

nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission.

2009 2010 2015 2020 2025 2030 2050




**ICE -50% in city**

20% GHG (2008)

**No ICE in city**

60% GHG (1990)

**Transport White Paper**

# Biofuels

- **Liquid or gaseous fuels for transport produced from biomass**

# Biofuels

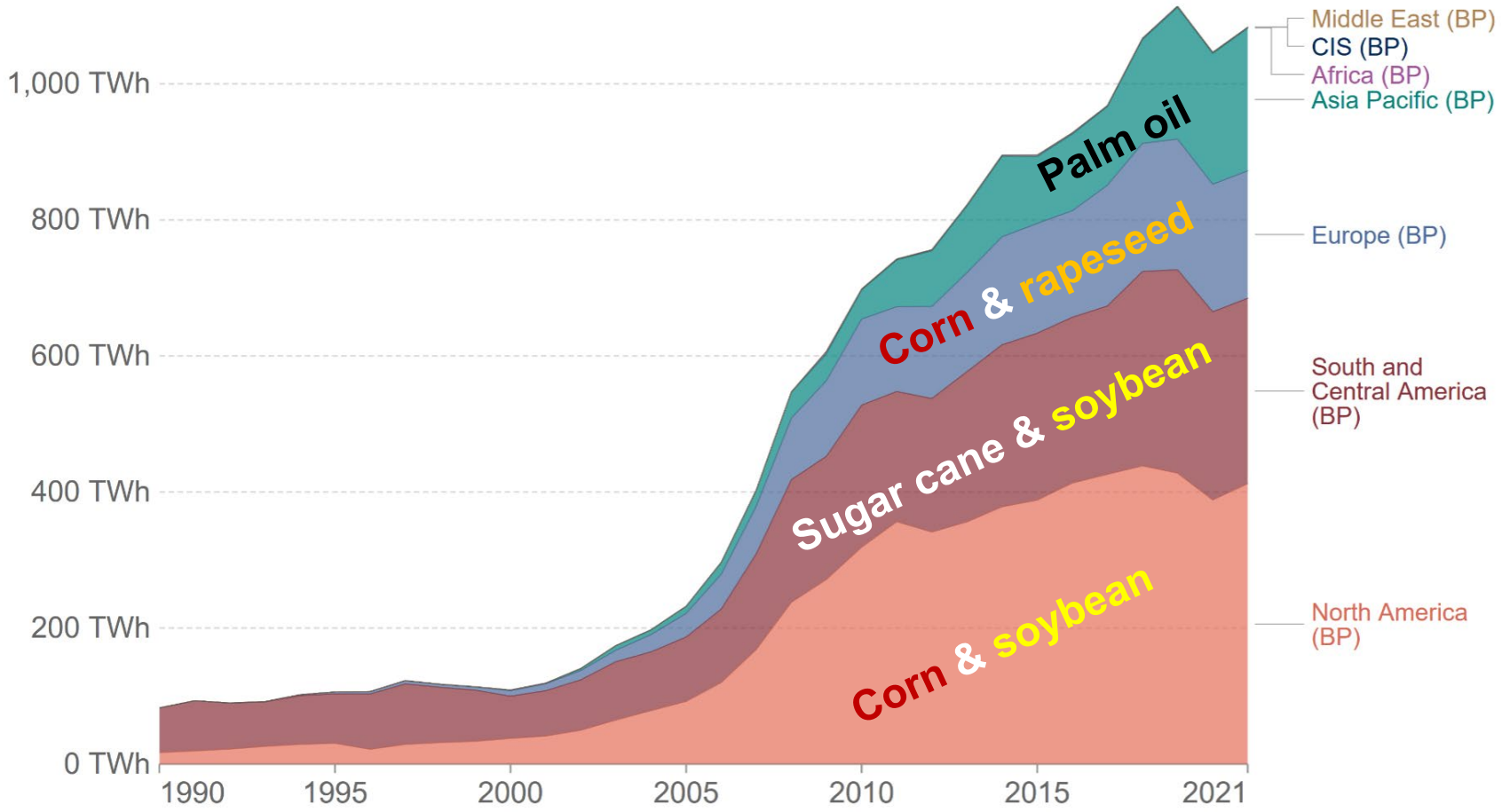
**Mature biofuels**
***1st generation biofuels***

**Immature biofuels**
***2nd generation biofuels***
***(from lignocellulose)***

**Biofuels in labour stage**
***3rd generation biofuels***
***(from algae)***

**Long term possibility**
***4th generation biofuels***
***(from genetically manipulated feedstocks)***

# Biofuel production by region

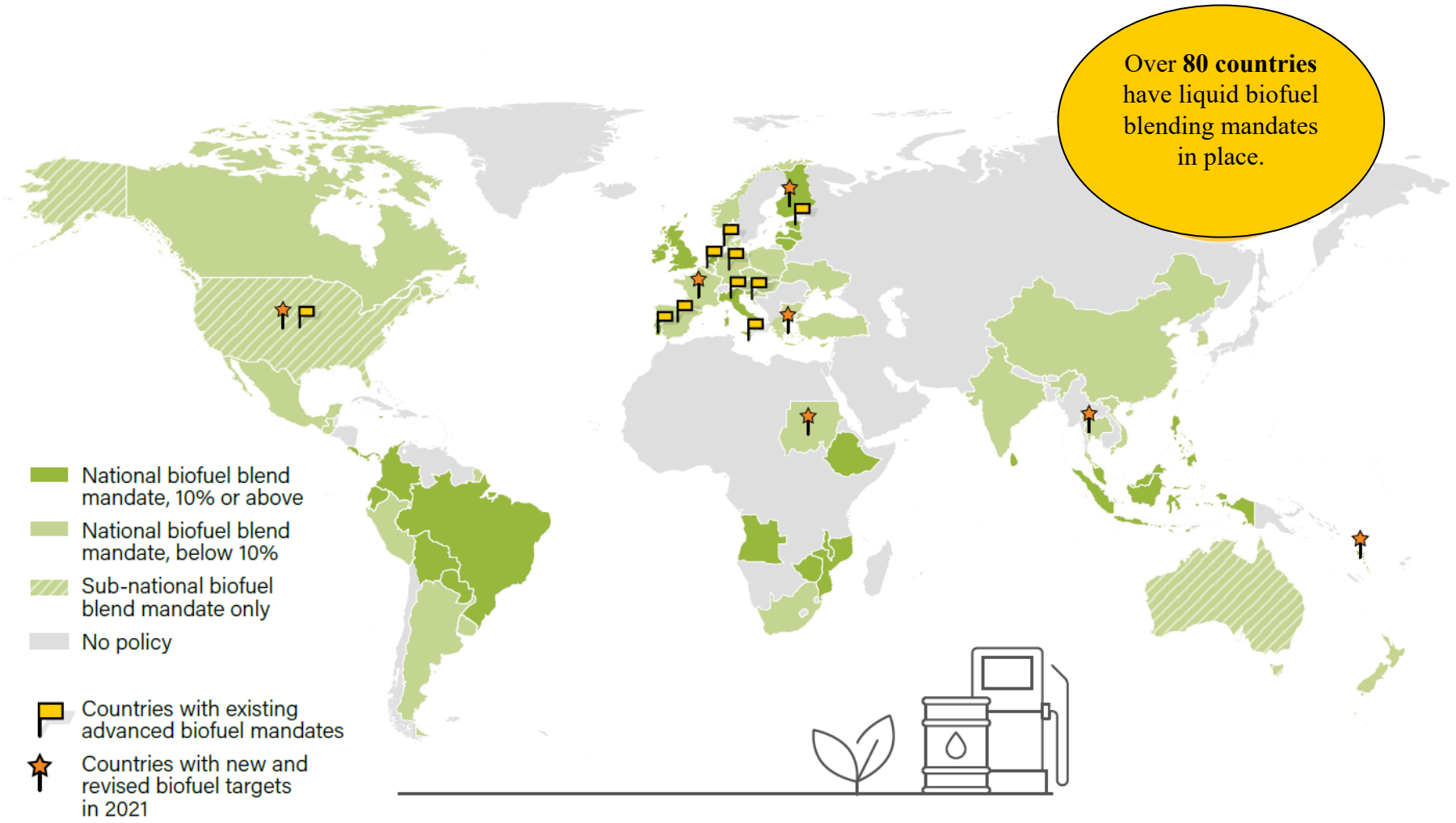



Source: Statistical Review of World Energy - BP (2022)

OurWorldInData.org/renewable-energy • CC BY

Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.

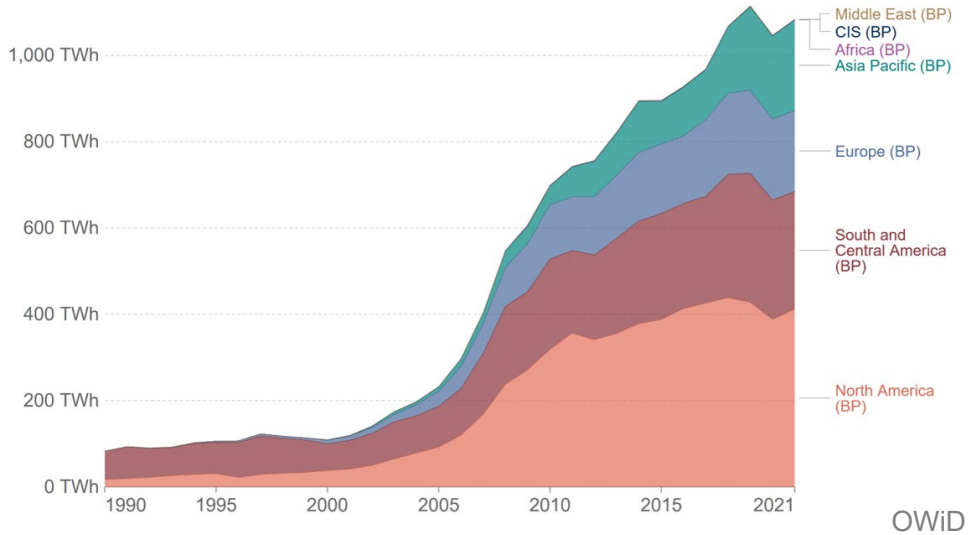
# Biofuel Mandates and Targets



# COVID 19

- ✓ 11 March 2020 – global pandemic
  - ✓ partial or total lockdowns….
- ✓ Impact on mobility
  - ✓ Change in modal split
    - ✓ Walking and cycling
    - ✓ Private cars
  - ✓ New working/living habits
    - ✓ Home-working
    - ✓ Video conferences

**11.6% drop in global BF production**




OWiD

# *The Russia-Ukraine war*

- ✓ …disrupted the chance of global economic recovery from the COVID-19 pandemic
- ✓ …one of the primary reasons for the rapid increase in global energy prices
- ✓ both Russia and Ukraine play key roles in the energy, food and fertilizers markets
- ✓ Russia
  - ✓ the world's largest exporter of wheat
  - ✓ the second largest exporter of sunflower oil
  - ✓ the largest exporter of fertilizers
- ✓ Ukraine
  - ✓ the largest exporter of sunflower oil
  - ✓ the fourth largest exporter of corn
  - ✓ the fifth largest exporter of wheat

# *The Russia-Ukraine war*

- ✓ …increase in feedstock and energy costs…biofuels prices
- ✓ …vegetable oil export losses from Ukraine and weather-related supply disruptions (drought in Latin America)….

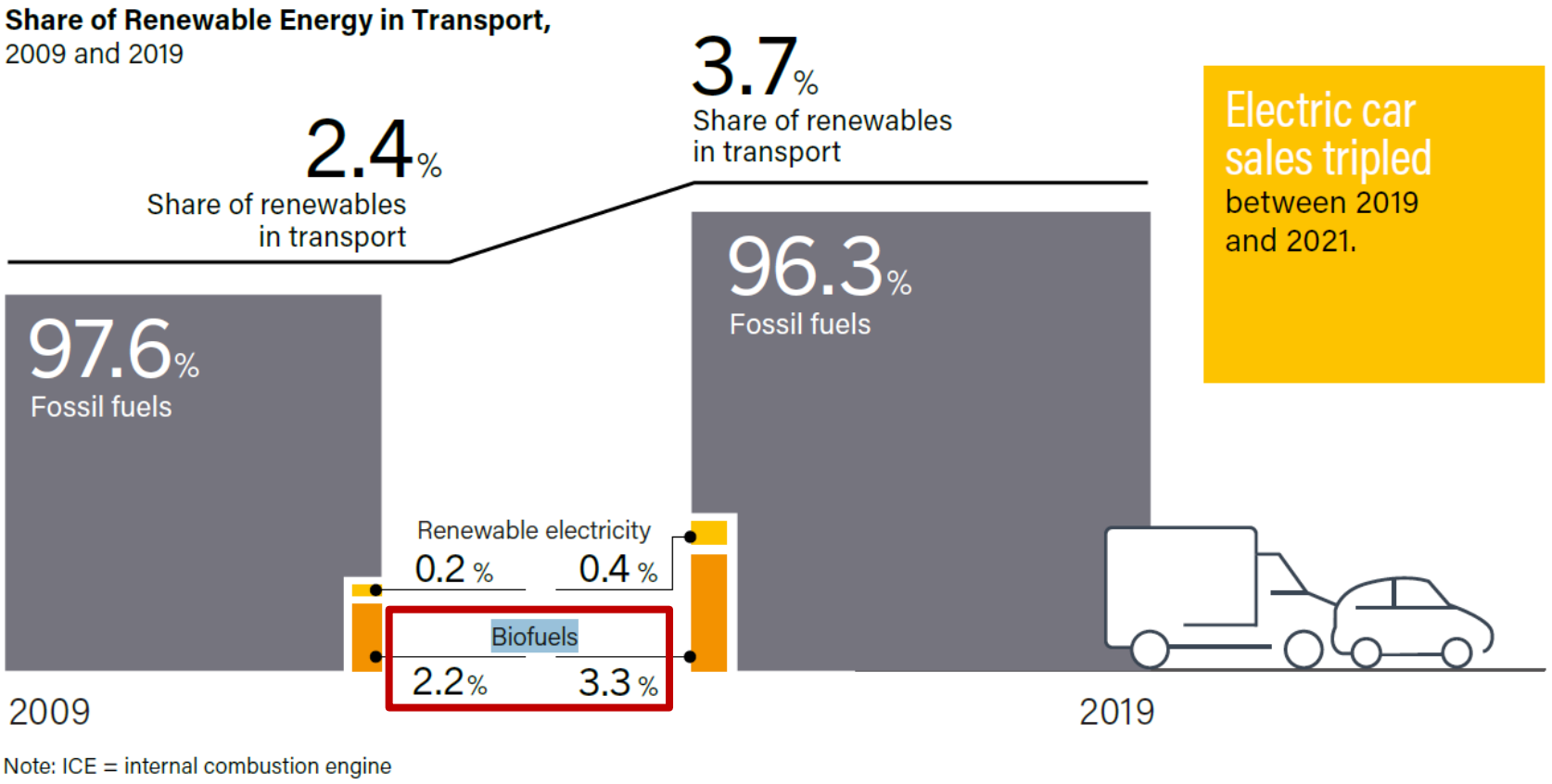
**Food vs fuel**

- ✓ **…** about 10% of all grain …biofuel production.. could be used to reduce food insecurity in many parts of the world
- ✓ calls …to change biofuel production mandates in favour of food production

# *Policy reactions to high prices: some policy proposals and changes*

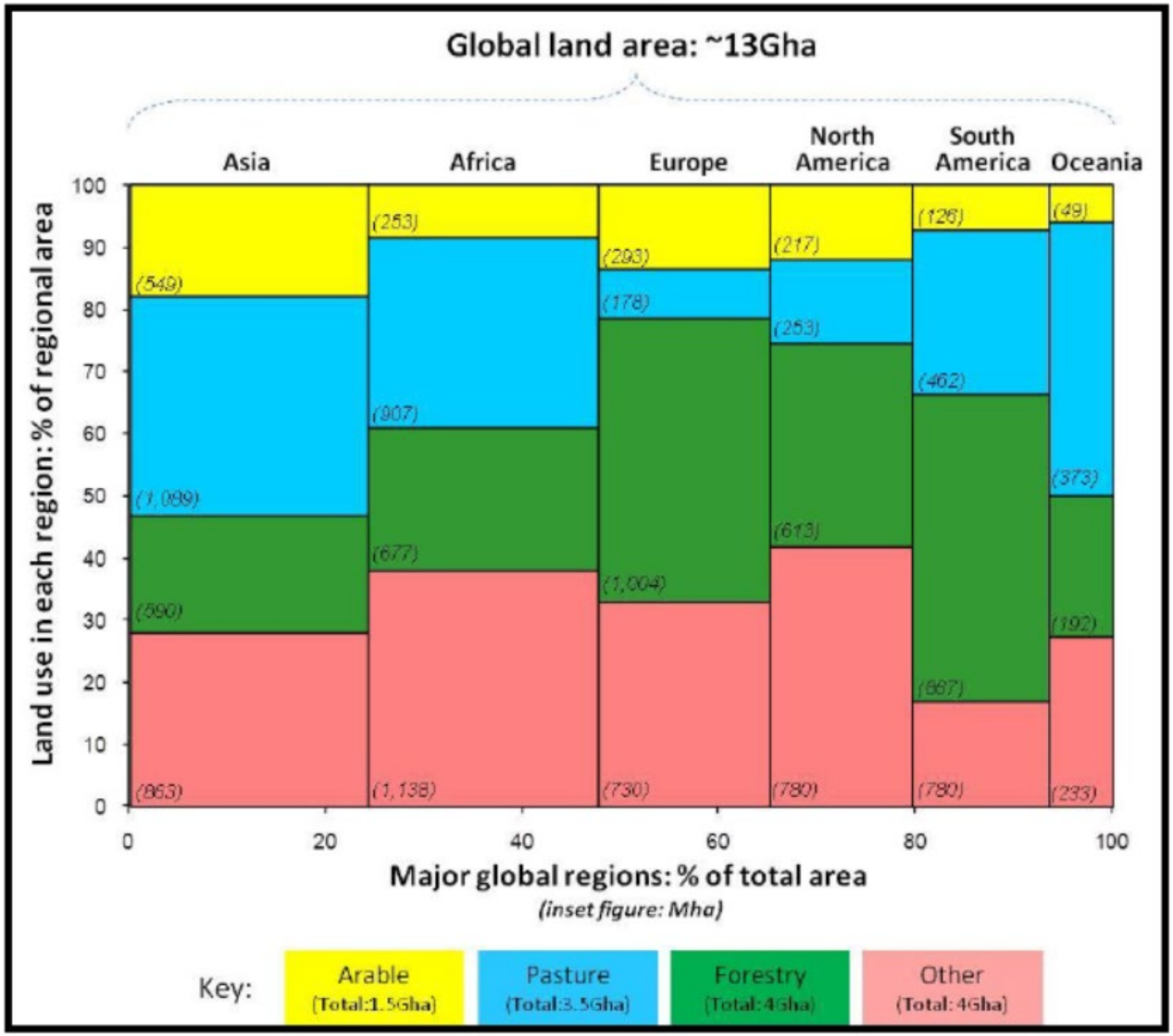
- ✓ **Argentina** passed a law to reduce the biodiesel blend rate from the original **10% to 5%** because of high crop costs.
- ✓ **Brazil** will maintain its biodiesel blending mandate at **10%**, from an intended **15%** target for 2022.
- ✓ The **Colombian** government reduced its ethanol blending mandate from **10% to 4%** in 2021.
- ✓ **Belgium**'s green coalition has proposed **to remove current biofuel mandates** temporarily to reduce fuel and food costs and then slowly fade out crop-based fuels by 2030.
- ✓ The **Czech** government has proposed **removing** blending targets.
- ✓ **Finland** reduced its renewable energy requirement to **12% from 20%** for 2022.
- ✓ **Croatia** will **remove penalties** on blenders that miss their targets.

# Share of biofuels

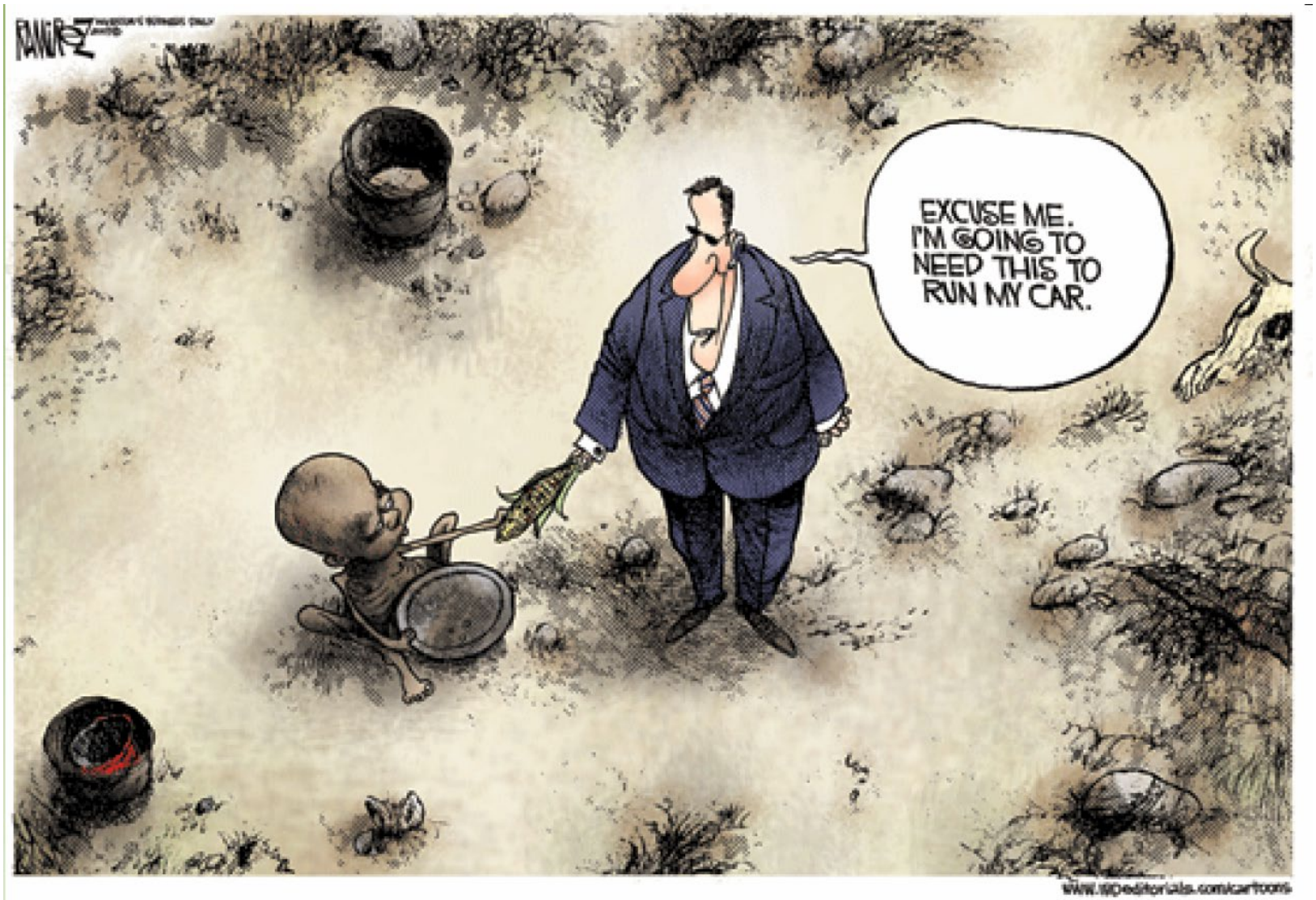



Note: ICE = internal combustion engine

# World land use




Source: (Slade *et al.*, 2011; based on FAO database).


EXCUSE ME. I'M GOING TO NEED THIS TO RUN MY CAR.


BIO-FUELS

# EU targets

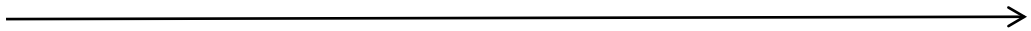
## European Green Deal

EU - the first climate-neutral continent by 2050

**Sustainable and Smart Mobility Strategy**

at least 30 million zero-emission cars will be in operation on European roads

nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission.



2030

2050

# Announced 100% ZEV sales targets and bans on ICE vehicle sales

| | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|
| Costa Rica | | | | | | ● |
| Denmark | | ● | | | | |
| France | | | | ● | | |
| Iceland | | ● | | | | |
| Ireland | | ● | | | | |
| Israel* | | ● | | | | |
| Netherlands | | | | | ● | |
| Norway | ● | | | | | |
| Portugal | | | | ● | | |
| Slovenia | | ● | | | | |
| Spain | | | | ● | | ● |
| Sri Lanka | | | | ● | | |
| United Kingdom | | | | ● | | |

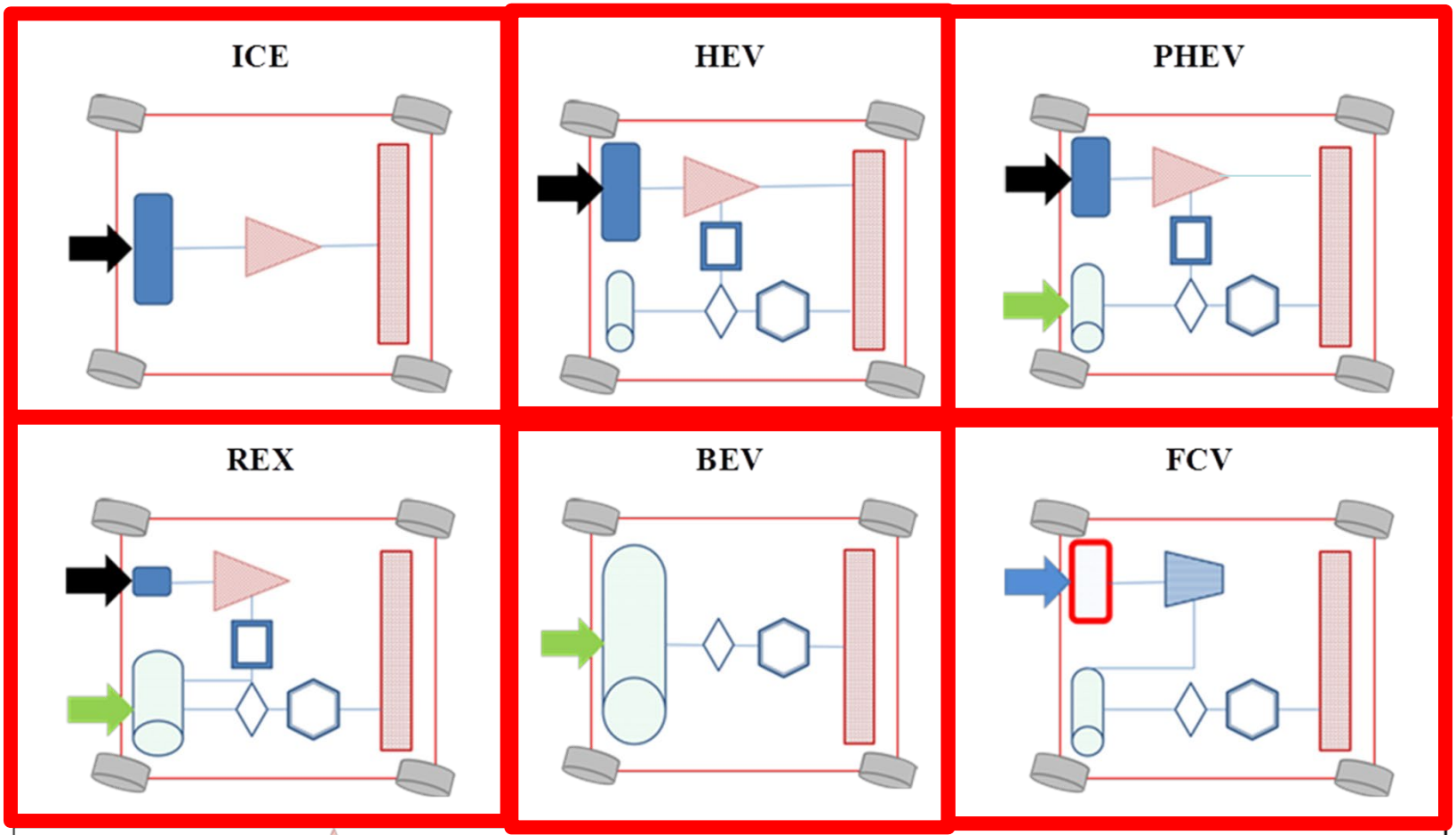
EU - 2035

● ICE sales ban or 100% ZEV sales target ● Fleet without ICEs

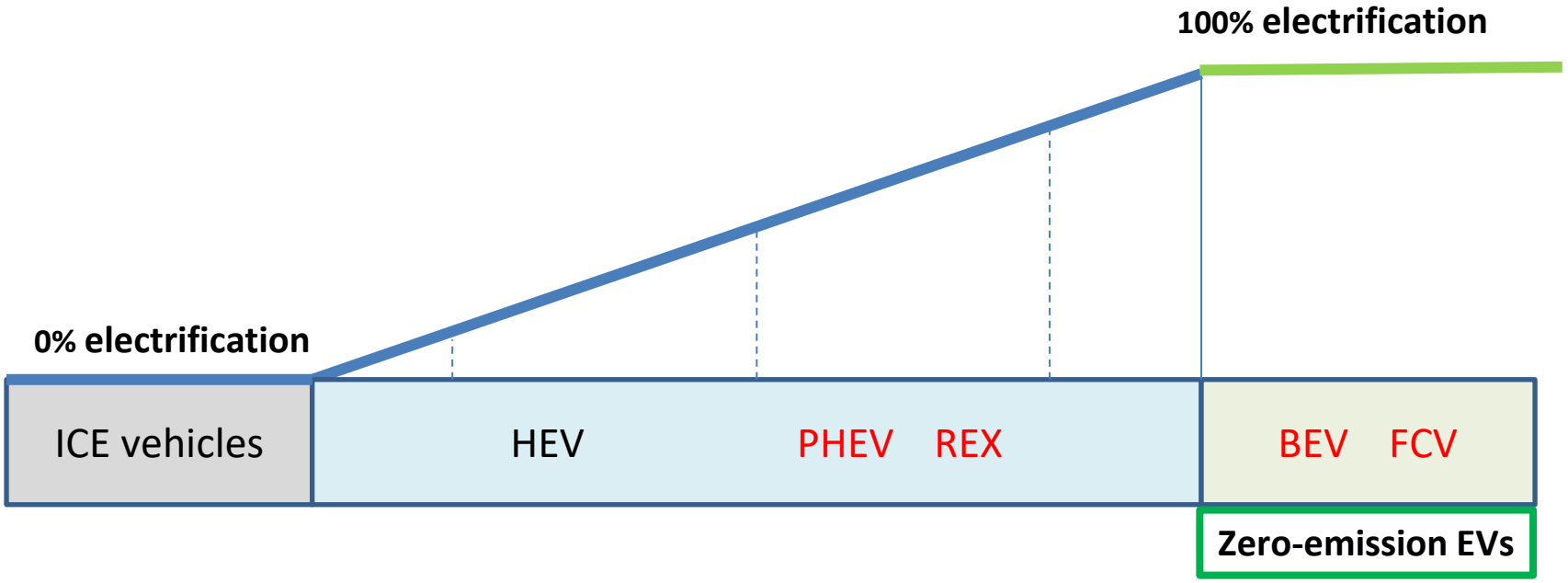
# Perspectives for biofuels

- Optimistic estimates – biofuels contribute ca. one-third of global fuel supply in 2050
  - 2nd generation and 3rd generation –commercially available by 2030
- Incentives for the development of 2 gen. biofuels…especially from wastes and residues
- Biofuel – dependent on markets created by government policy
- Biofuels…in aviation, shipping and heavy goods vehicles

# Electric vehicles

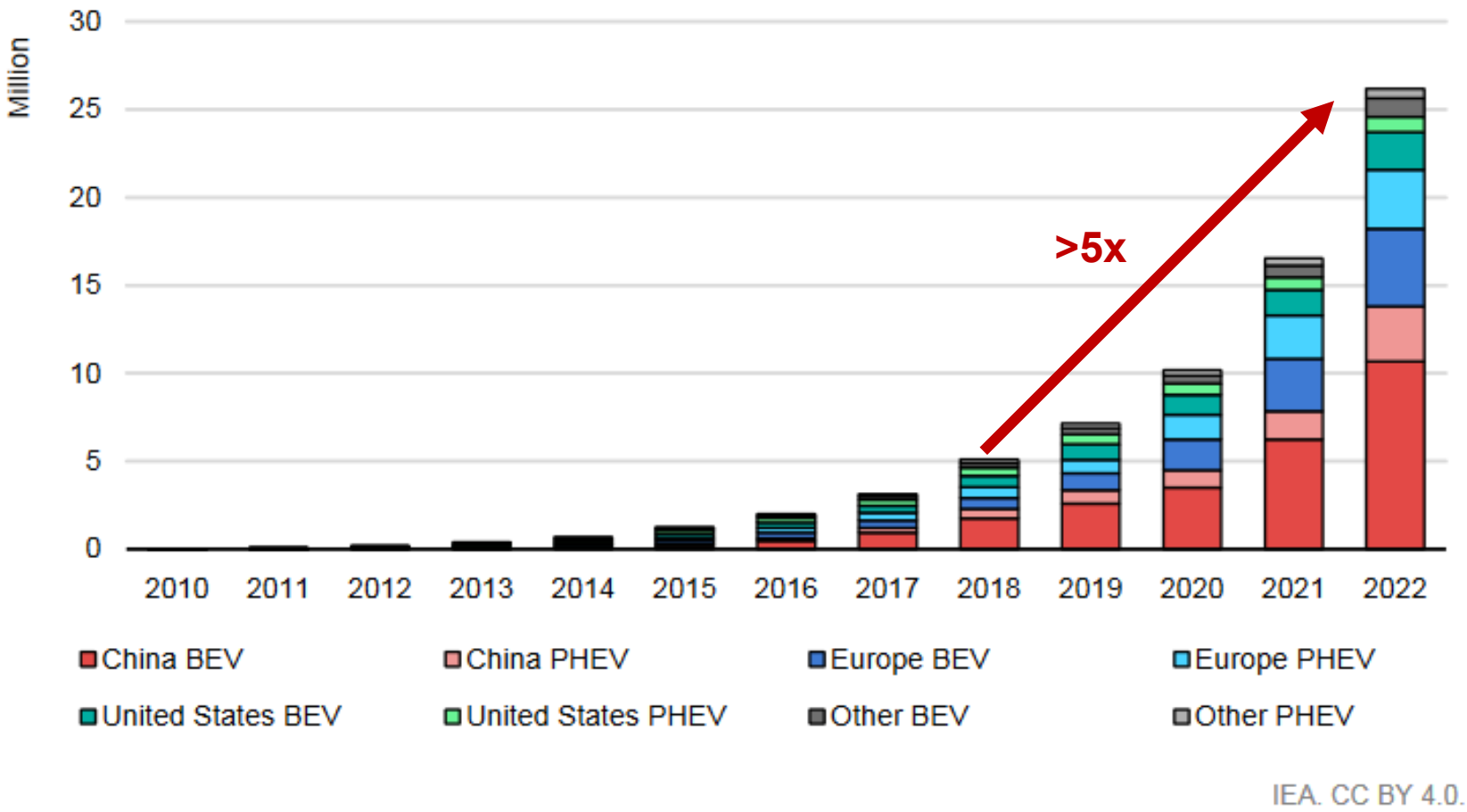


# Electric vehicles




Level of electrification of electric vehicles

# Electric vehicles




Over 26 million electric cars were on the road in 2022

# *Targets*

Paris Declaration on Electro-Mobility and Climate Change & Call to Action:

- more than 100 million EVs
- 400 million two and three-wheelers

# Economic assessment

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

$$C_{km} = \frac{IC \cdot \alpha}{skm} + P_f \cdot FI + \frac{C_{O\&M}}{skm}$$

[€/100 km driven]

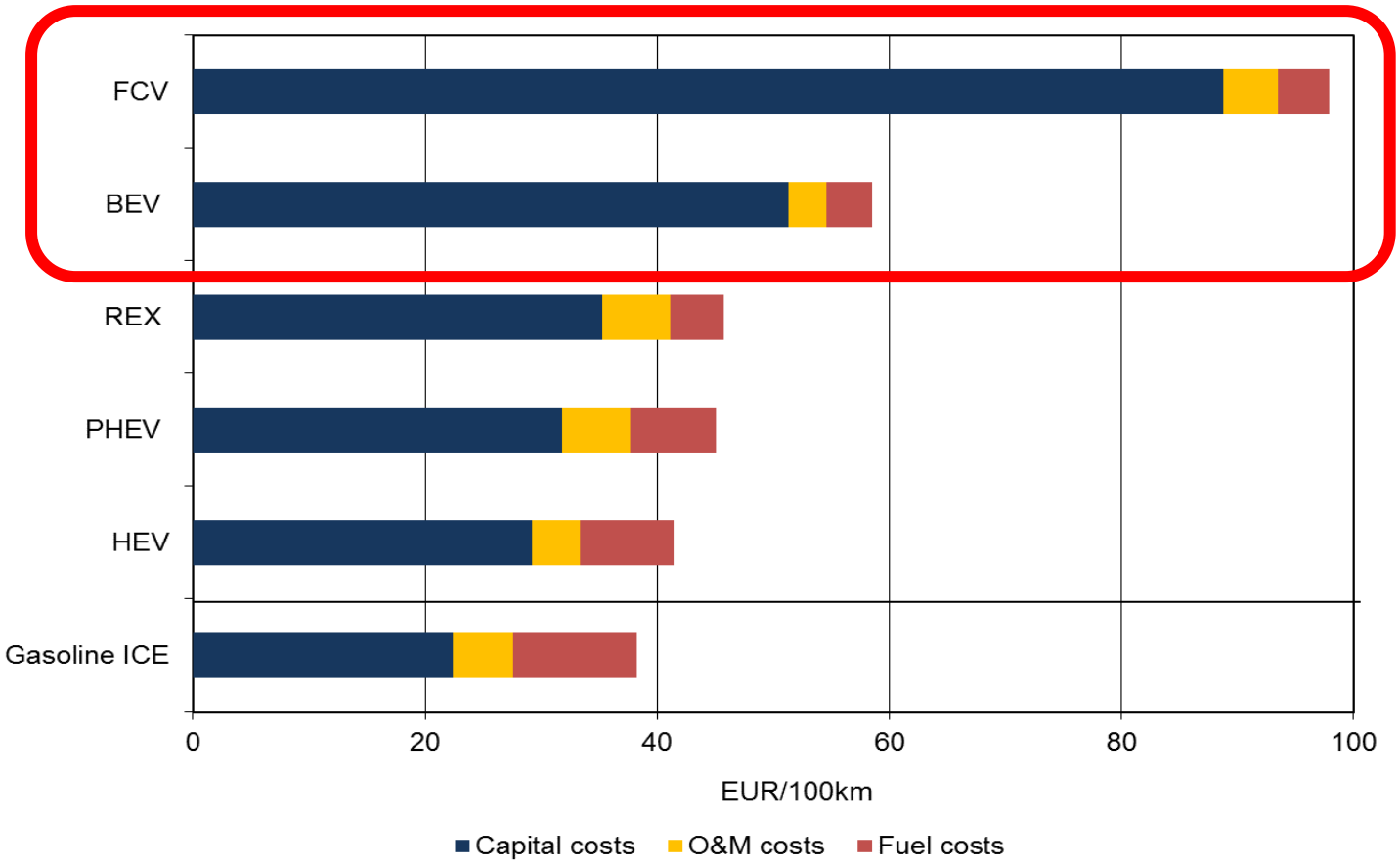
IC……investment costs [€/car]
α……..capital recovery factor
skm…..specific km driven per car per year [km/(car.yr)]
Pf……fuel price incl. taxes [€/litre]
$C_{O\&M}$…operating and maintenance costs
FI……..fuel intensity [litre/100 km]

A capital recovery factor (α) is the ratio of a constant annuity to the present value of receiving that annuity for a given length of time. Using an interest rate (z), the capital recovery factor is:

$$\alpha = \frac{z(1+z)^n}{(1+z)^n - 1}$$

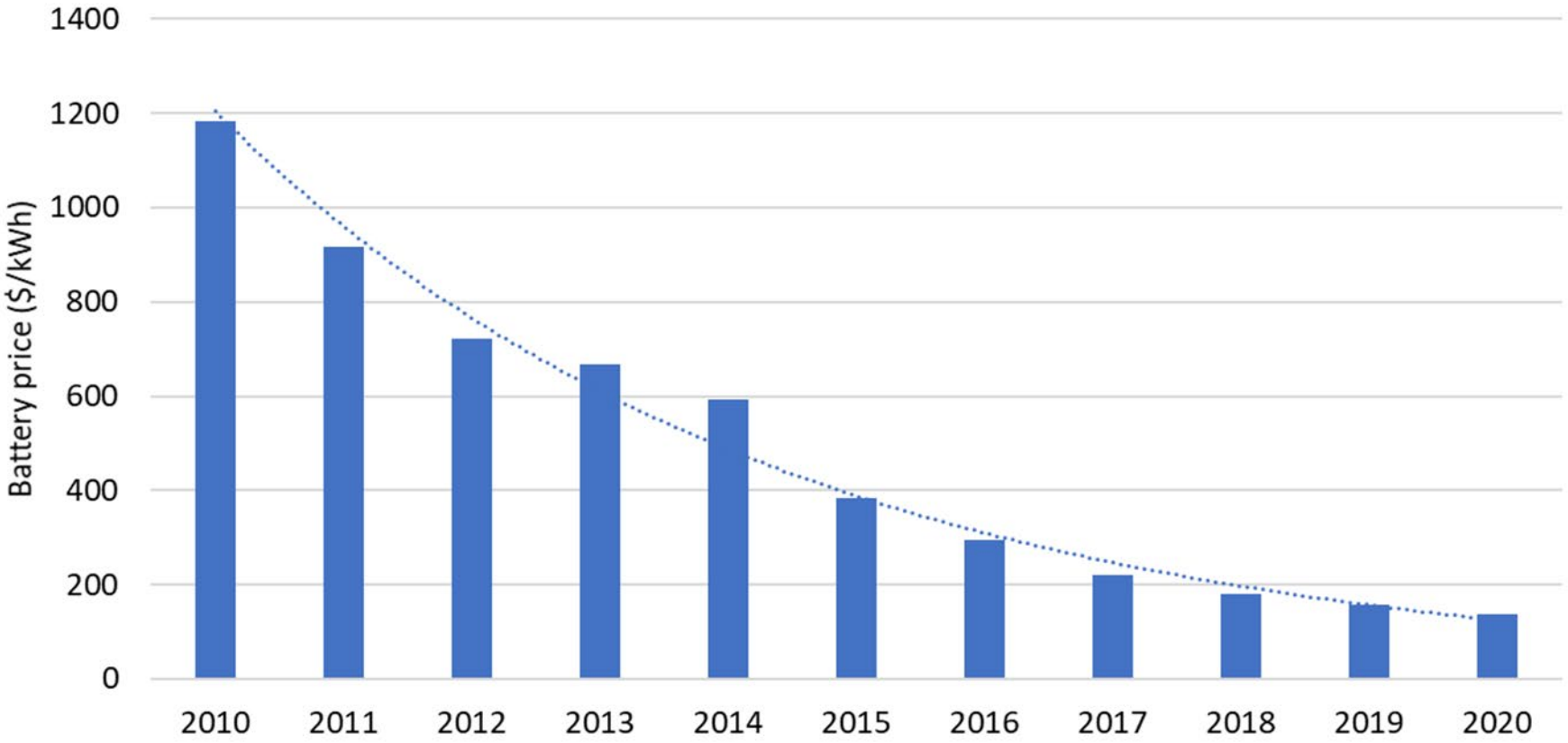
n…..the number of annuities received.

# Economic aspects

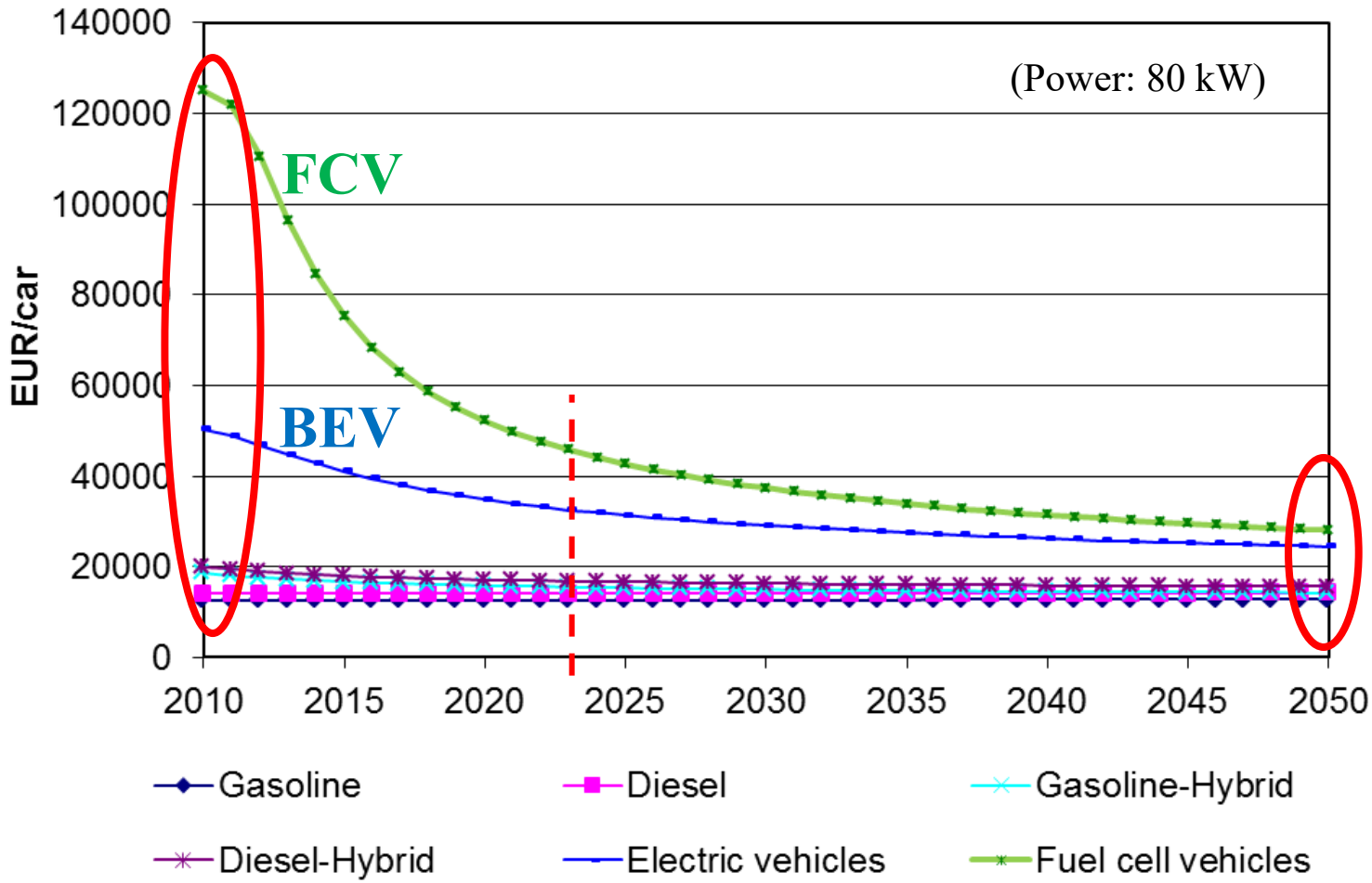



Total costs of service mobility of various types of EV in comparison to ICE cars

# Technological learning – Battery



# Scenario for development of investment costs



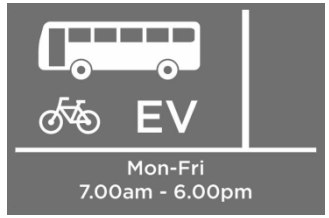
# *Monetary measures*

The most commonly used monetary measures are subsidies and exemptions (or reductions) from:

- road taxes
- annual circulation tax
- company car tax
- registration tax
- fuel consumption tax
- congestion charges

# Non-monetary measures

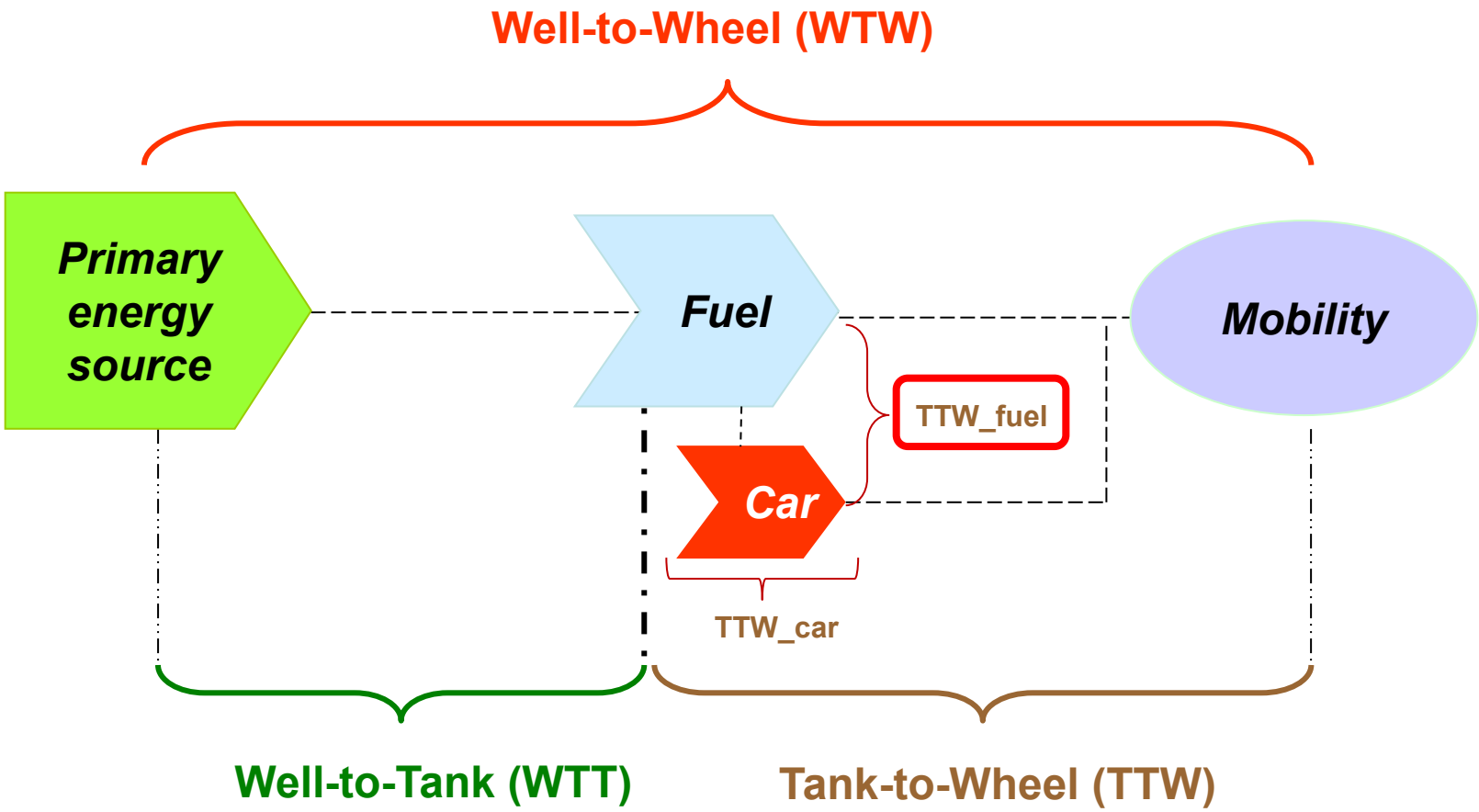
- free parking spaces,

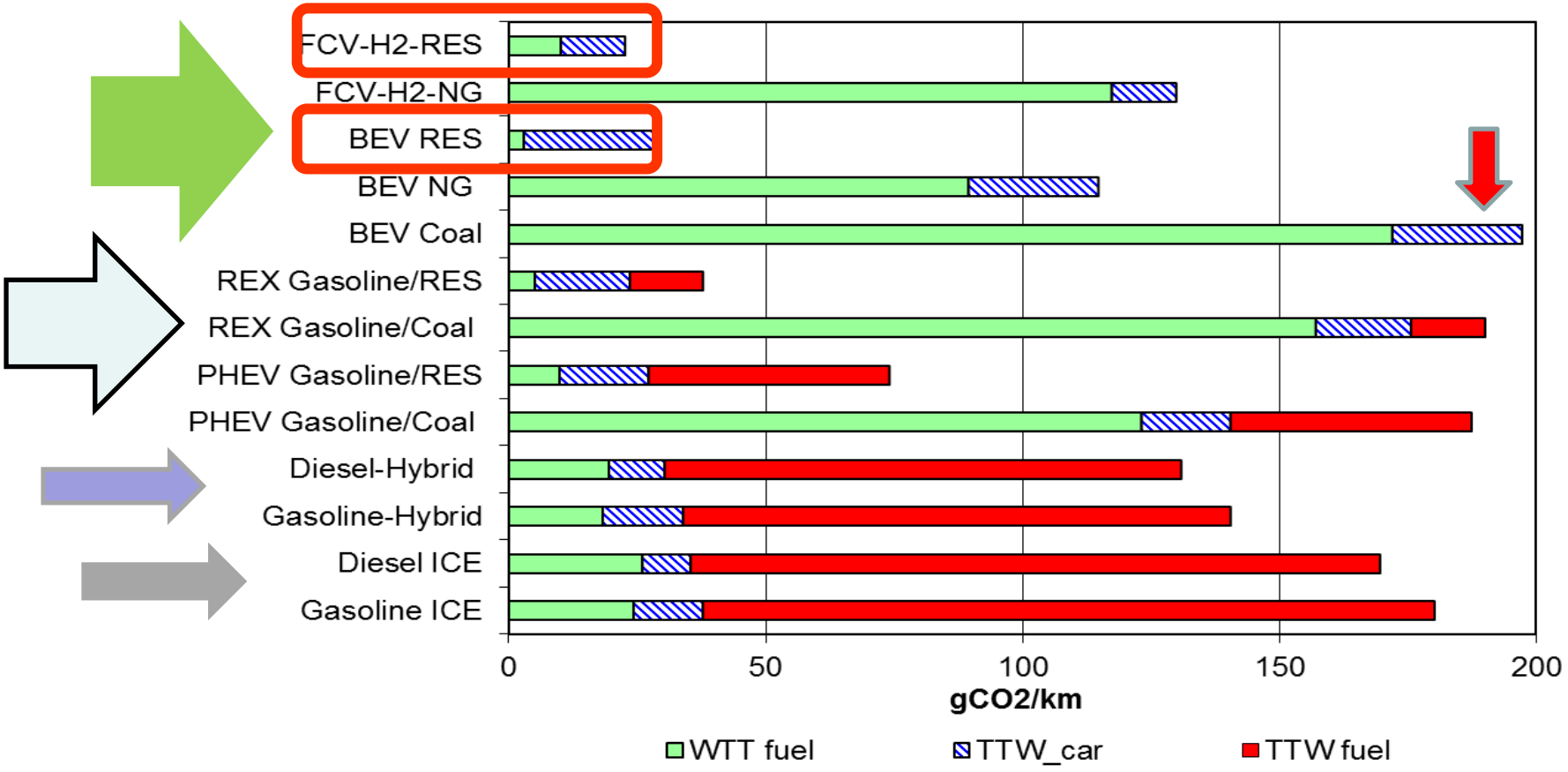

- possibility for EVs drivers to use bus lanes,
- wide availability of charging stations,


- permission for EVs to enter city centers and zero emission zones.

# Environmental assessment

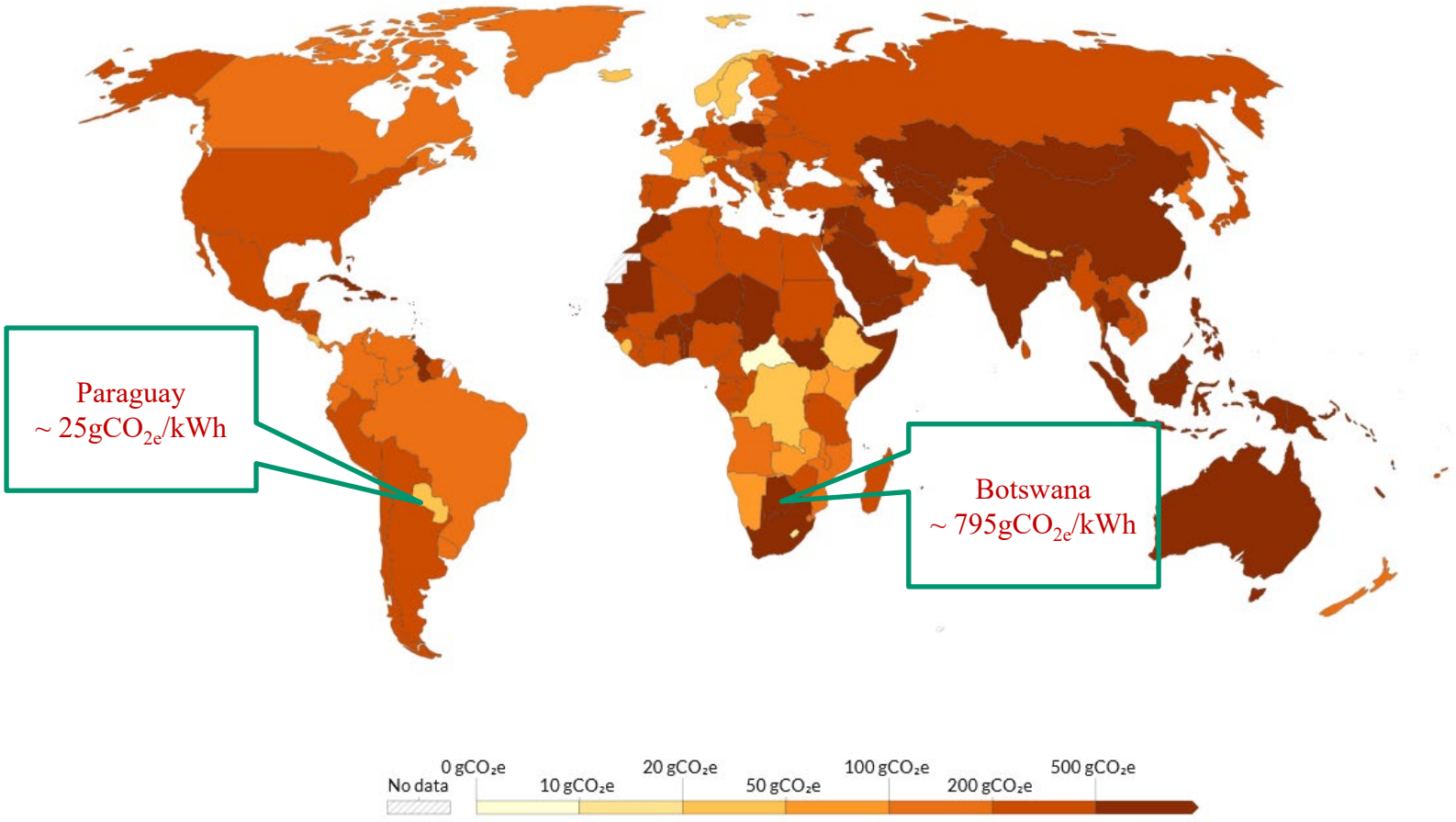


# Environmental assessment



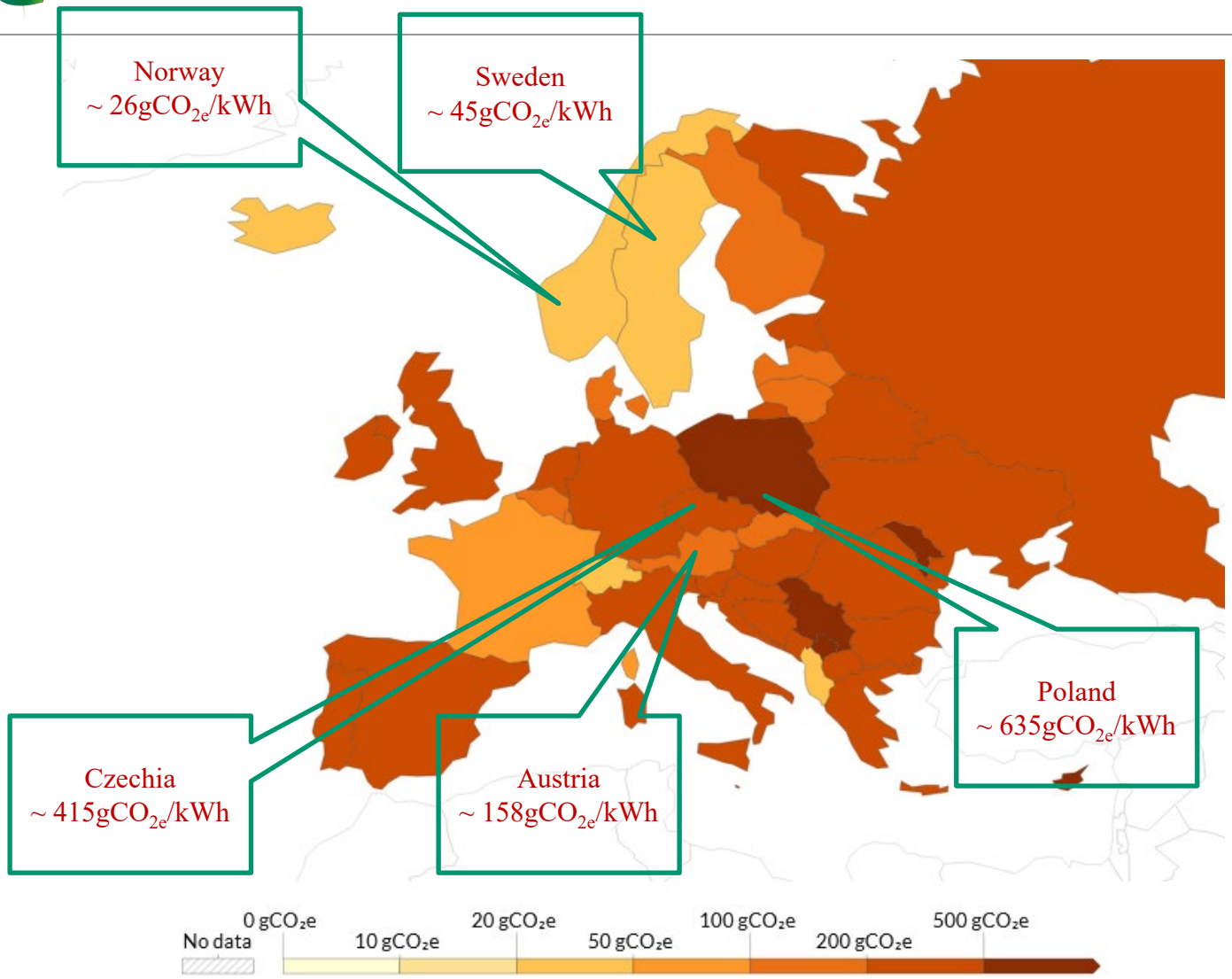

$CO_2$ emissions per km driven for various types of EV in comparison to conventional cars (power of car: 80kW)

# Carbon intensity of electricity, 2022



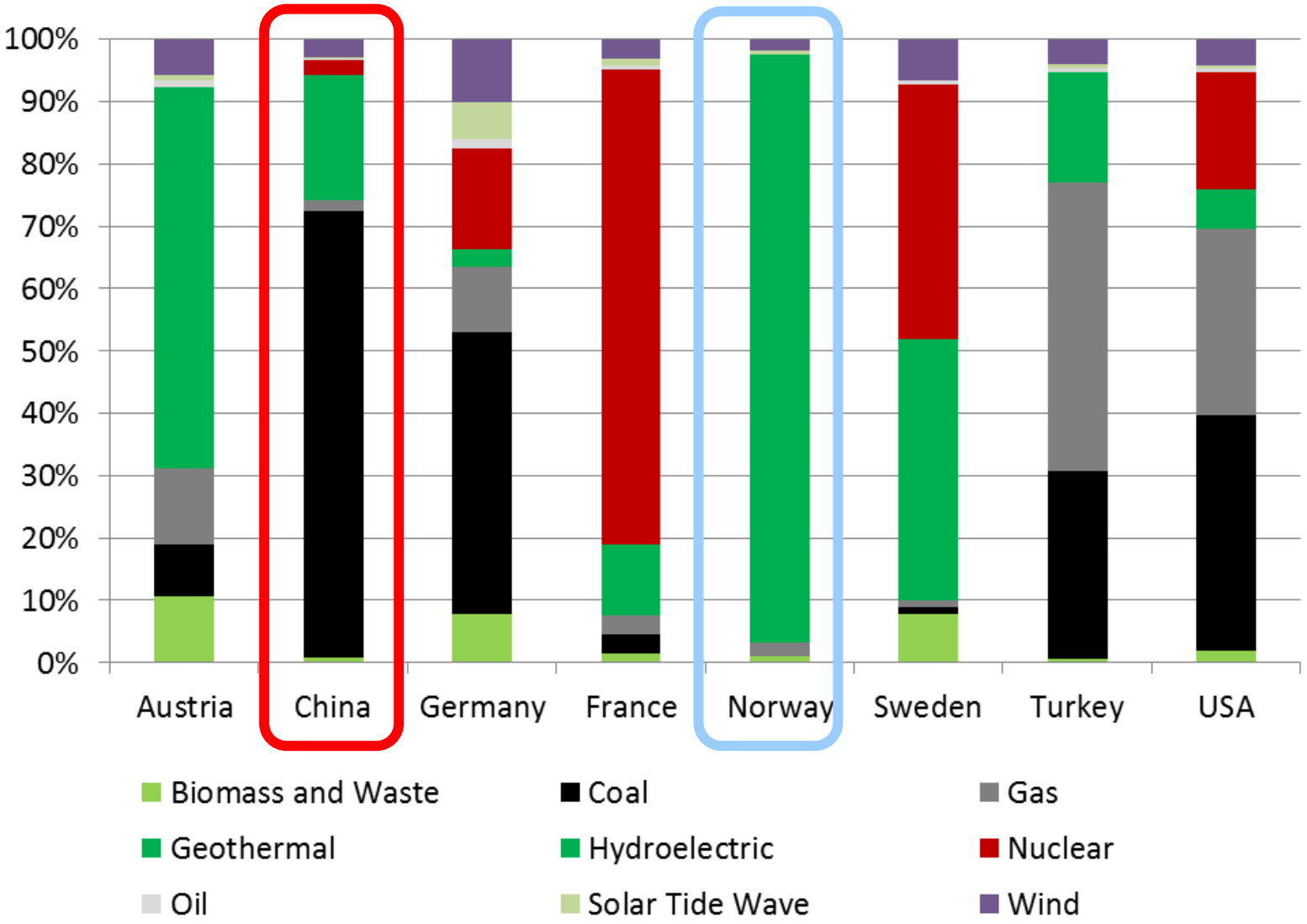

Carbon intensity is measured in grams of carbon dioxide-equivalents emitted per kilowatt-hour of electricity.

# Carbon intensity of electricity, 2022



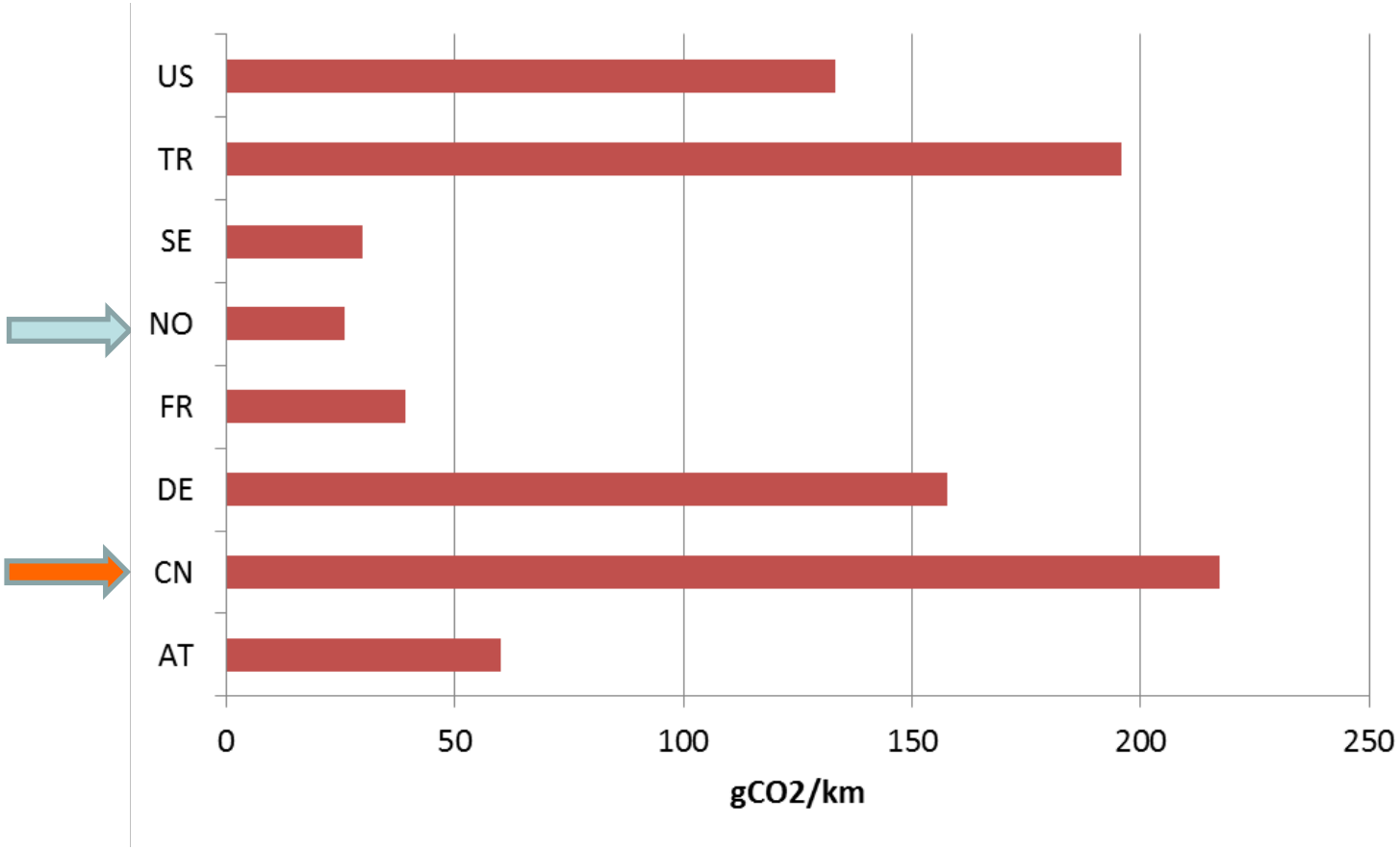

Carbon intensity is measured in grams of carbon dioxide-equivalents emitted per kilowatt-hour of electricity.

# Electricity mix



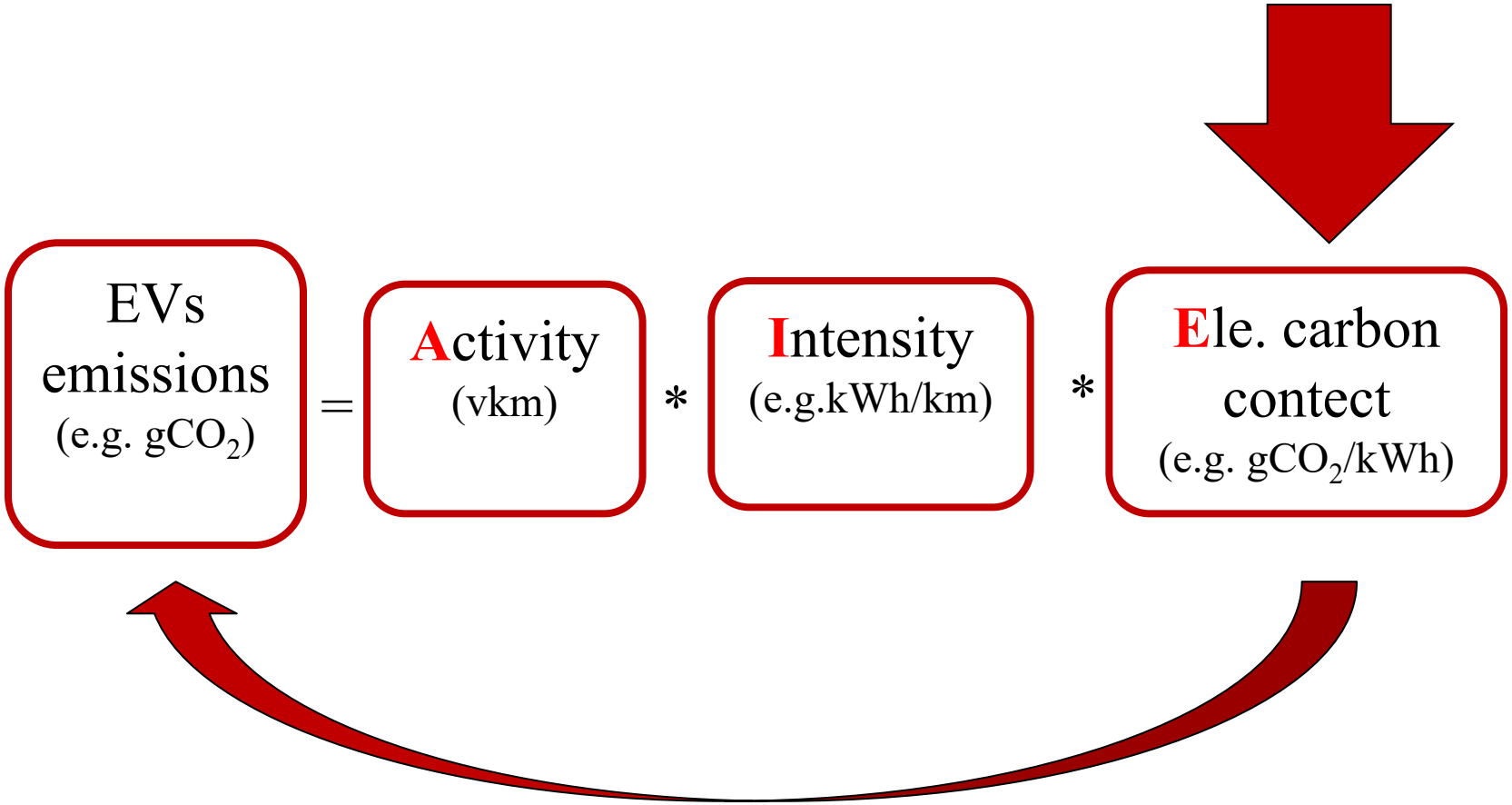

Data source: tsp,2014

# Environmental assessment




$CO_2$ emissions per km driven for BEVs powered by grid electricity in different countries

# Car emissions

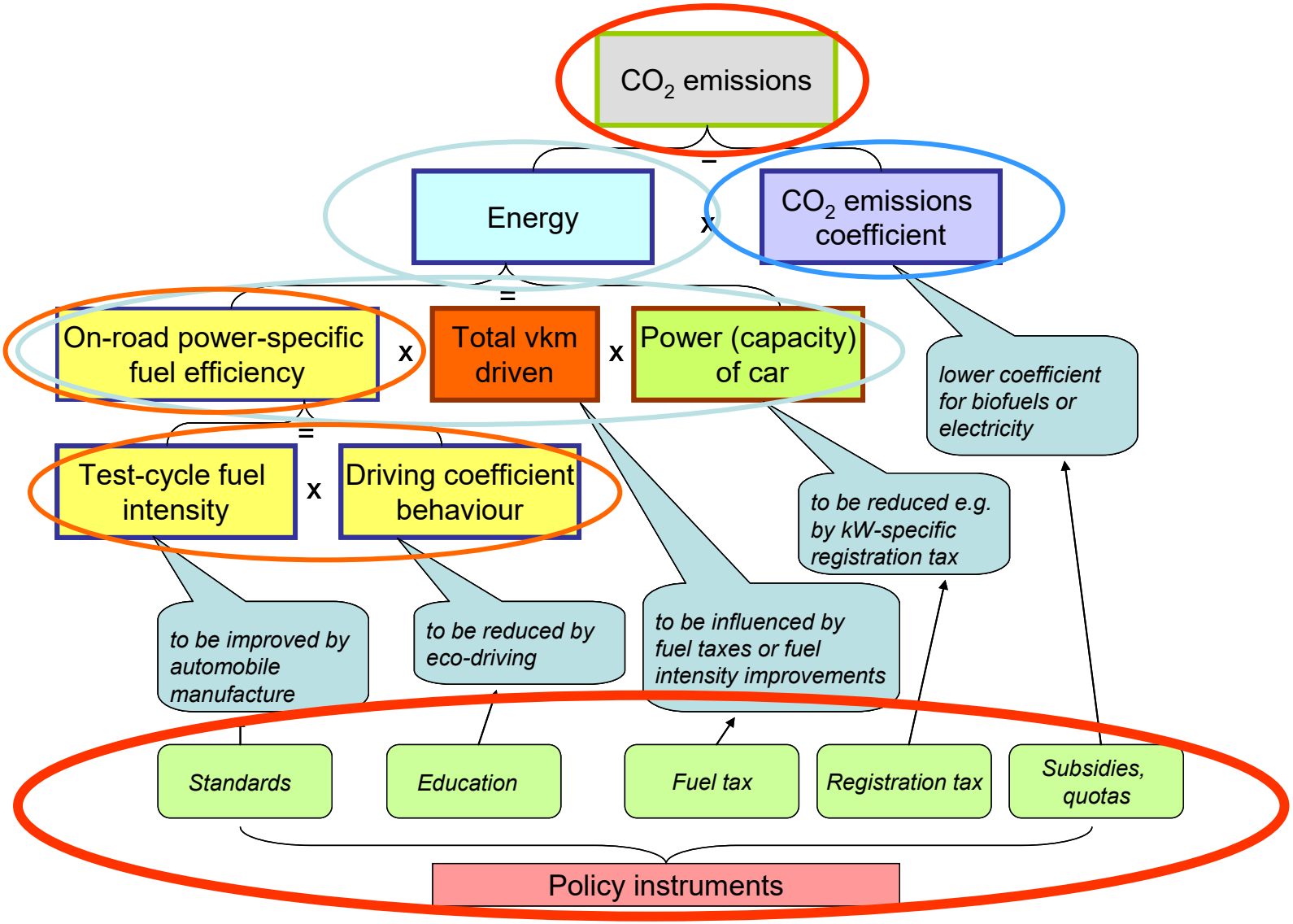


# *4. Energy policies*

# Policy instruments

| Regulation | Monetary incentives | Information |
|---|---|---|
| • Fuel efficiency standards | • Energy efficiency or CO2 emission based element in the annual circulation tax | • Car labelling based on fuel use or emissions |
| • Pollutant emission regulations | • Tax incentives for the purchase/first registration of efficient vehicles | • Eco driving campaigns |
| • Speed limits | • Inclusion/exclusion in/for road pricing/congestion charging schemes | |

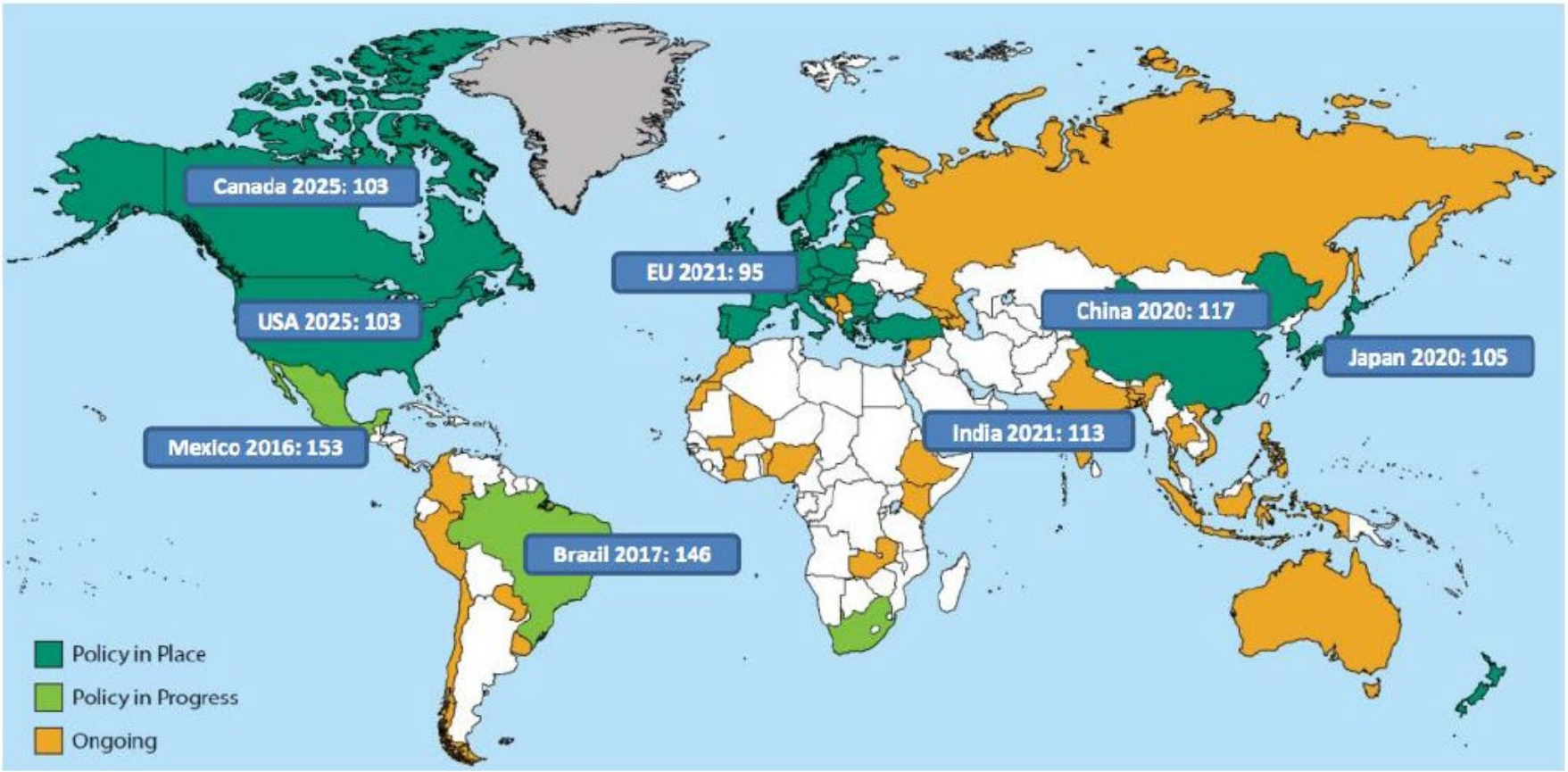
# $CO_2$ emissions in passenger car transport



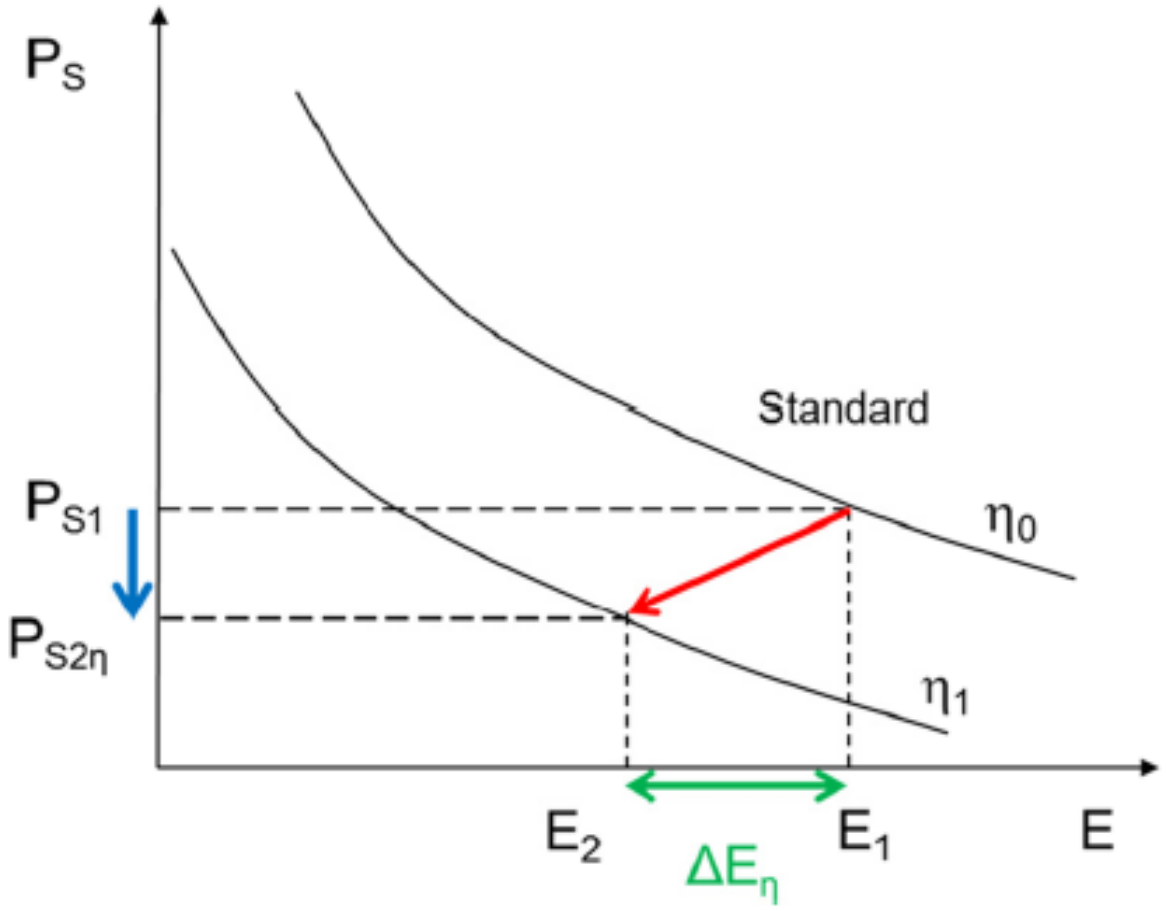

Impact factors on $CO_2$ emissions in the car passenger transport

# Standards

Fuel economy standards have been enforced in several countries

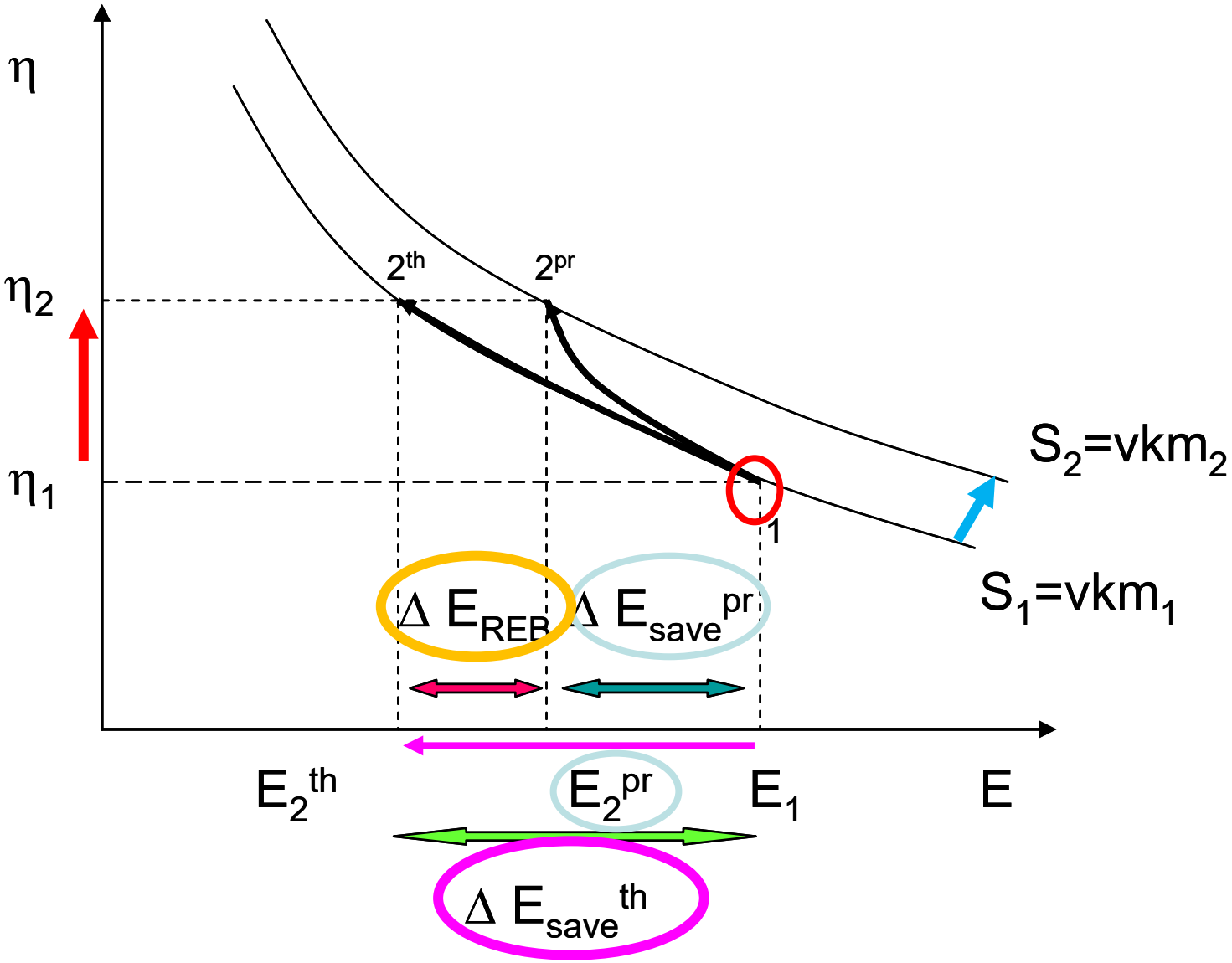


# Standards

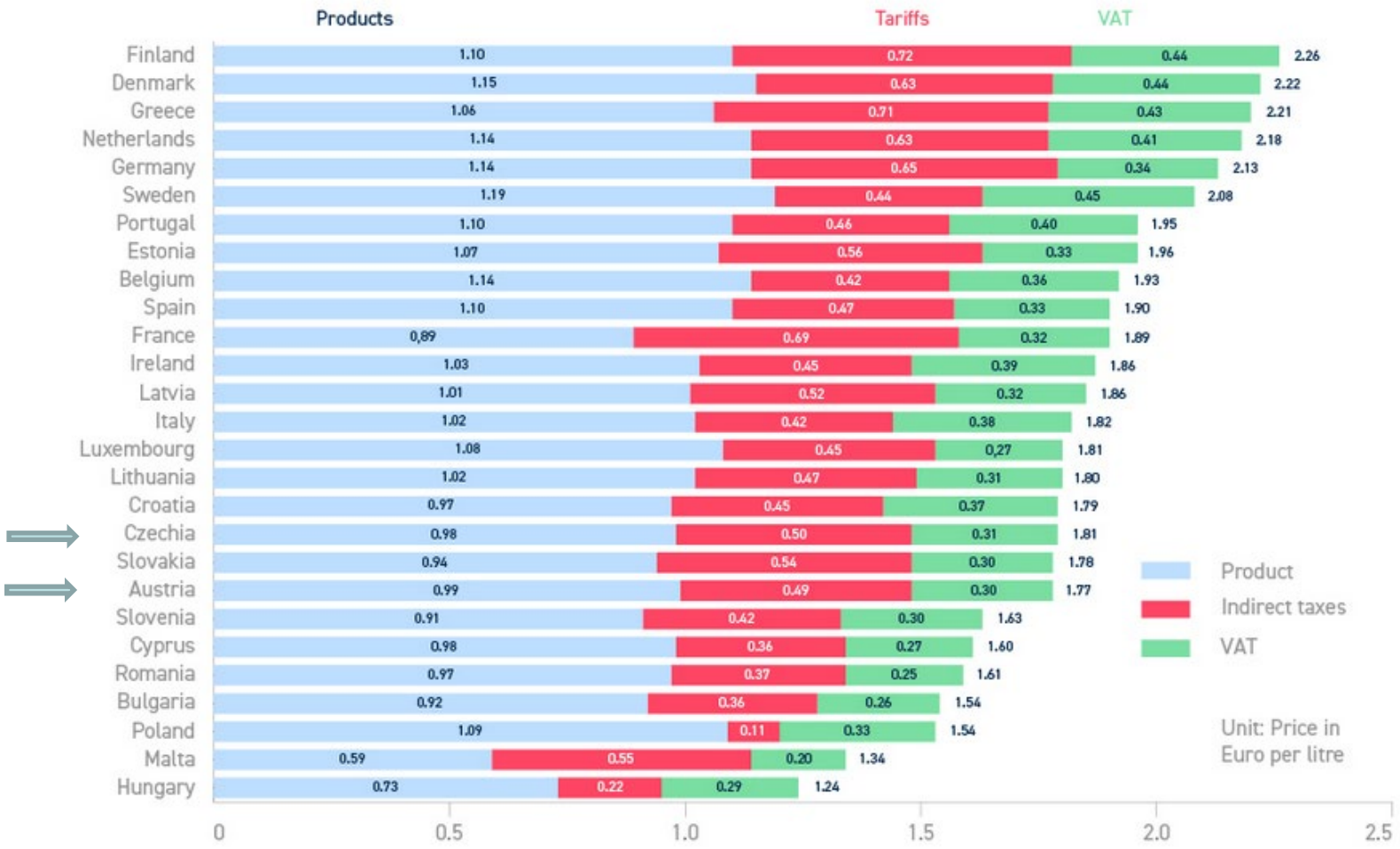



How a standard works

# Rebound effect



# Price structure of gasoline, May 2022



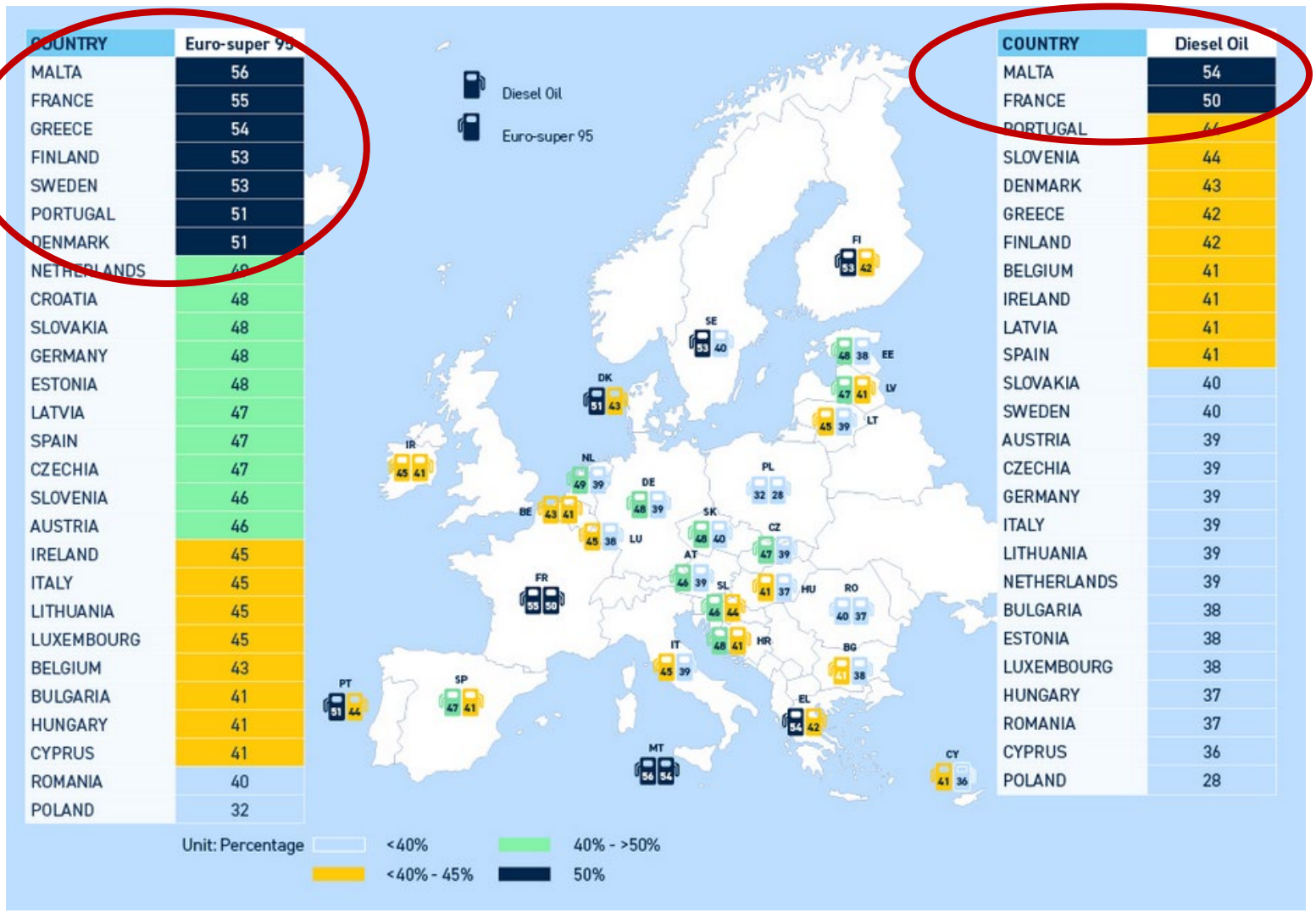

https://www.fuelseurope.eu/statistics

# Price structure of diesel, May 2022


https://www.fuelseurope.eu/statistics

# Total taxation share in the end consumer price

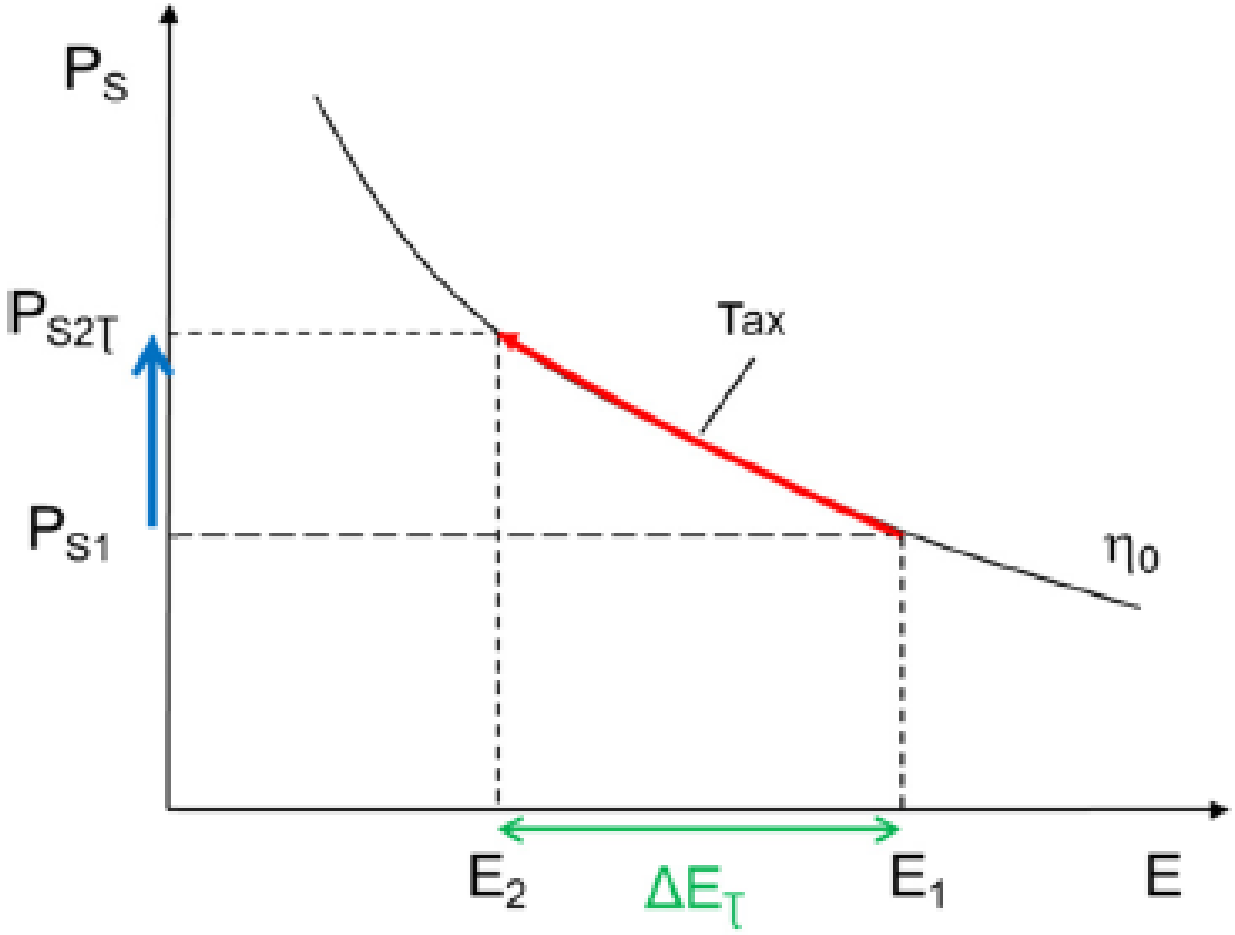
| COUNTRY | Euro-super 95 |
|---|---|
| MALTA | 56 |
| FRANCE | 55 |
| GREECE | 54 |
| FINLAND | 53 |
| SWEDEN | 53 |
| PORTUGAL | 51 |
| DENMARK | 51 |
| NETHERLANDS | 48 |
| CROATIA | 48 |
| SLOVAKIA | 48 |
| GERMANY | 48 |
| ESTONIA | 48 |
| LATVIA | 47 |
| SPAIN | 47 |
| CZECHIA | 47 |
| SLOVENIA | 46 |
| AUSTRIA | 46 |
| IRELAND | 45 |
| ITALY | 45 |
| LITHUANIA | 45 |
| LUXEMBOURG | 45 |
| BELGIUM | 43 |
| BULGARIA | 41 |
| HUNGARY | 41 |
| CYPRUS | 41 |
| ROMANIA | 40 |
| POLAND | 32 |




| COUNTRY | Diesel Oil |
|---|---|
| MALTA | 54 |
| FRANCE | 50 |
| PORTUGAL | 44 |
| SLOVENIA | 44 |
| DENMARK | 43 |
| GREECE | 42 |
| FINLAND | 42 |
| BELGIUM | 41 |
| IRELAND | 41 |
| LATVIA | 41 |
| SPAIN | 41 |
| SLOVAKIA | 40 |
| SWEDEN | 40 |
| AUSTRIA | 39 |
| CZECHIA | 39 |
| GERMANY | 39 |
| ITALY | 39 |
| LITHUANIA | 39 |
| NETHERLANDS | 39 |
| BULGARIA | 38 |
| ESTONIA | 38 |
| LUXEMBOURG | 38 |
| HUNGARY | 37 |
| ROMANIA | 37 |
| CYPRUS | 36 |
| POLAND | 28 |

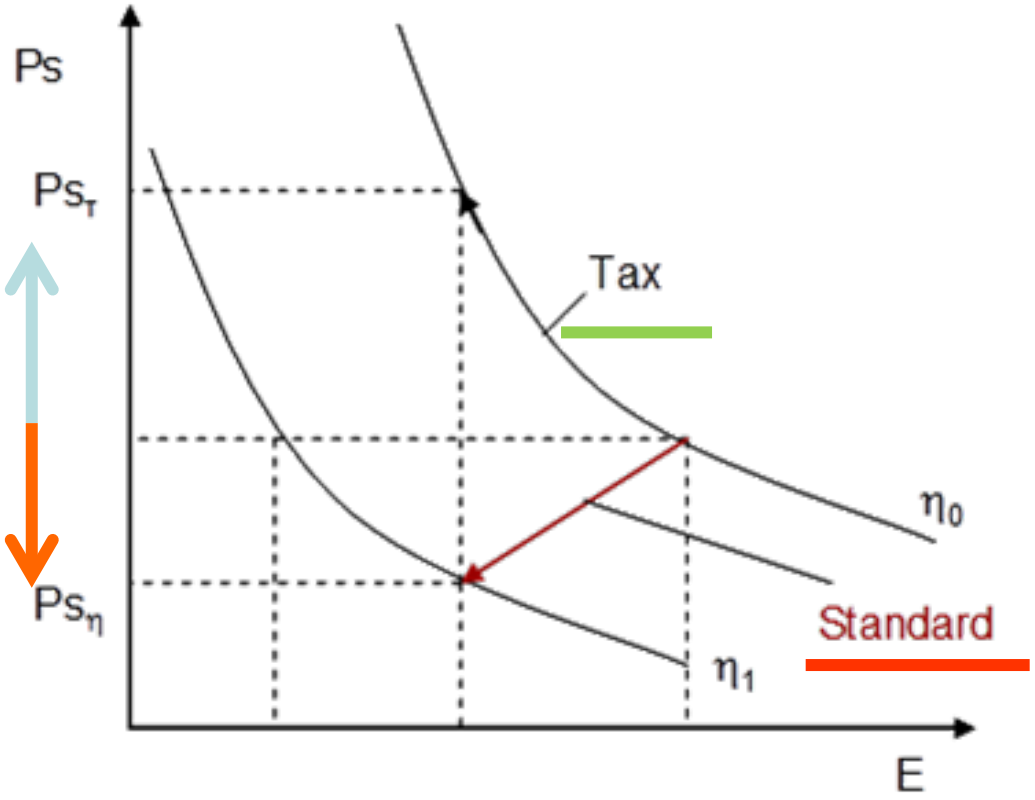
https://www.fuelseurope.eu/statistics

# Tax

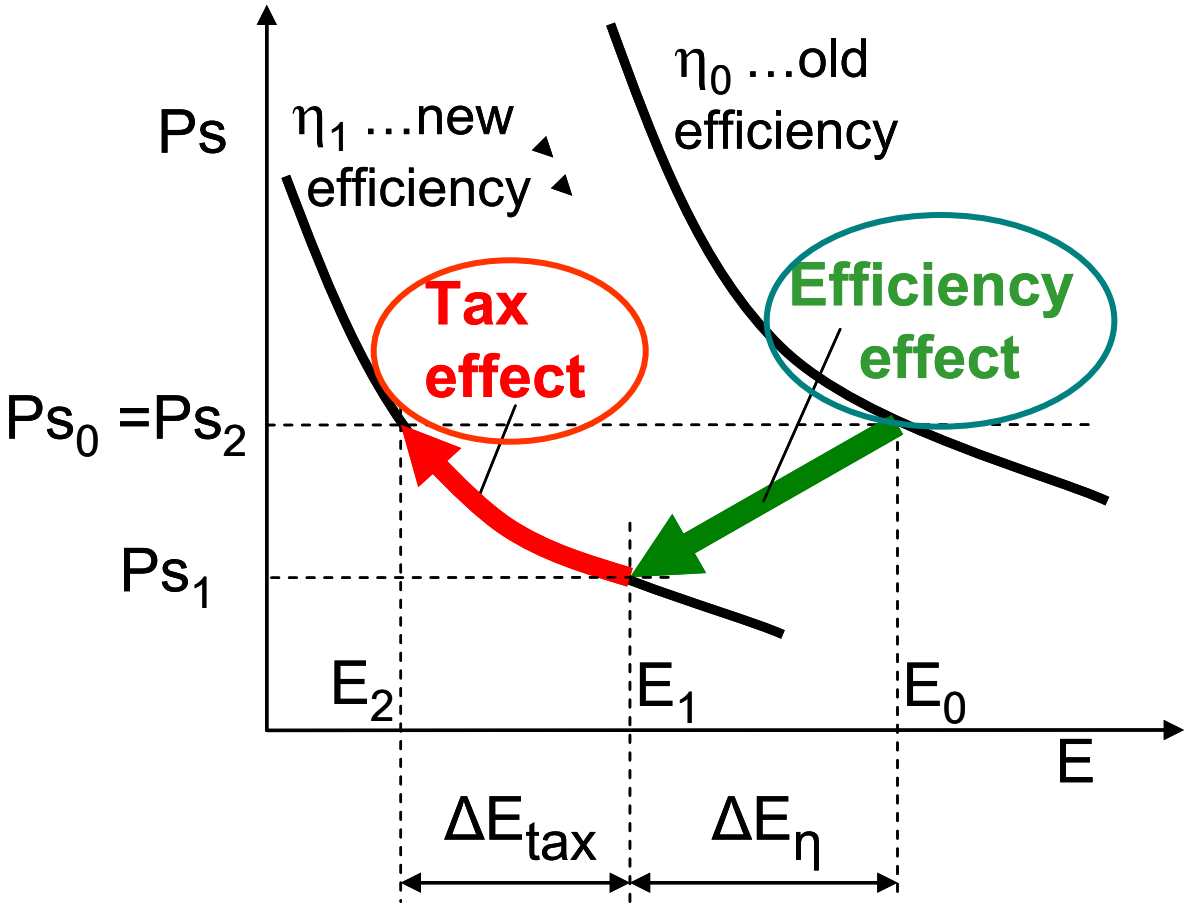



How a tax works

# How a tax vs a standard works

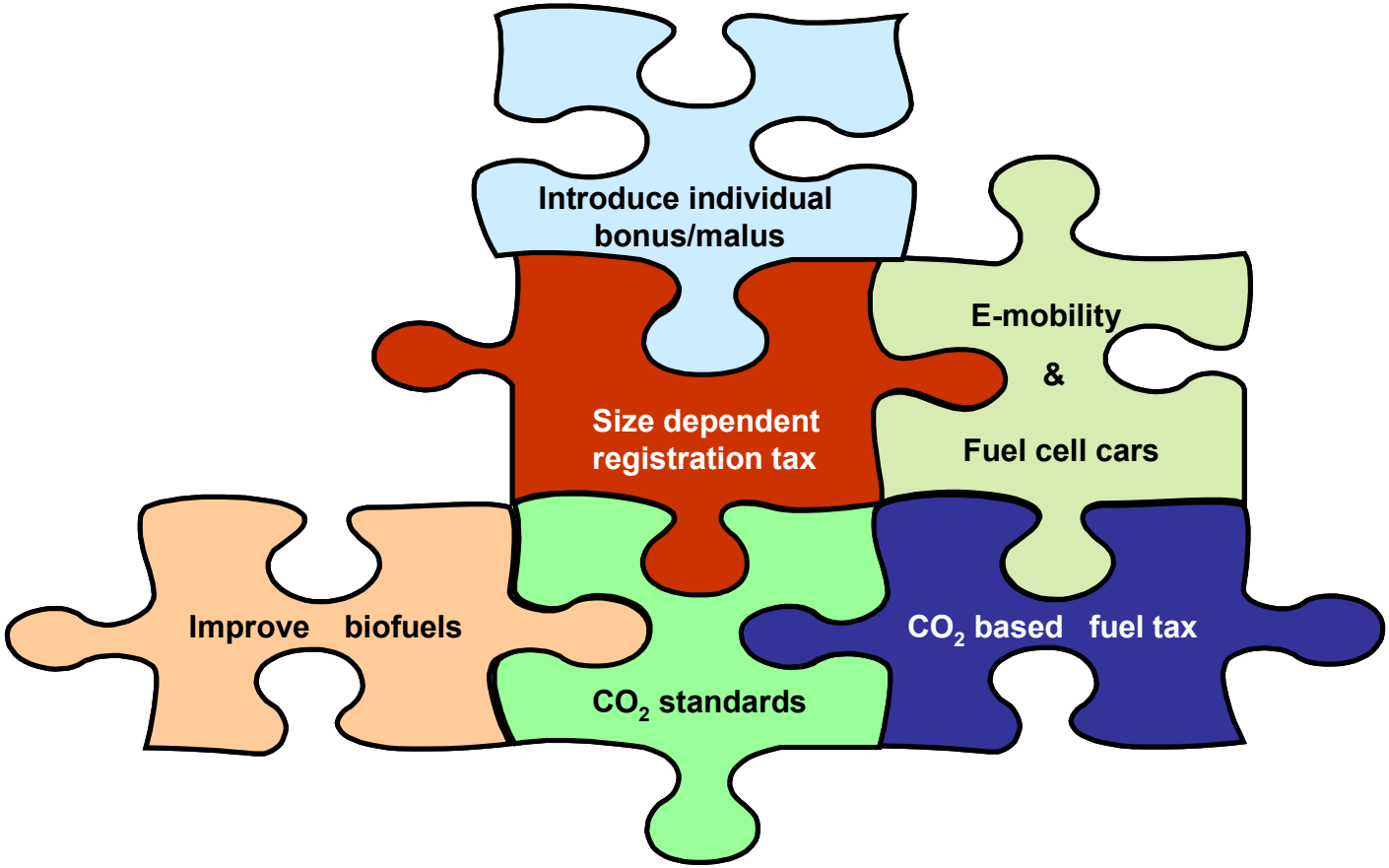


# Standards & taxes




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

# *Conclusions*



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