

Introduction: Energy Economics in Transport

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Contents

- *Historical developments*
- *Alternative fuels and technologies*
 - *Biofuels*
 - *Electric vehicles*
- *Energy policies*

Introduction

Basic principle:

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

Service:
km driven

Fuel mix

Efficiency:
Liter/100 km

Infrastructur

Introduction

The level of transport service consumption:
technology was the driver!

based on commercial energy



Electricity,
combustion
engine



Steam
machine,
steam railway



Sailing ship

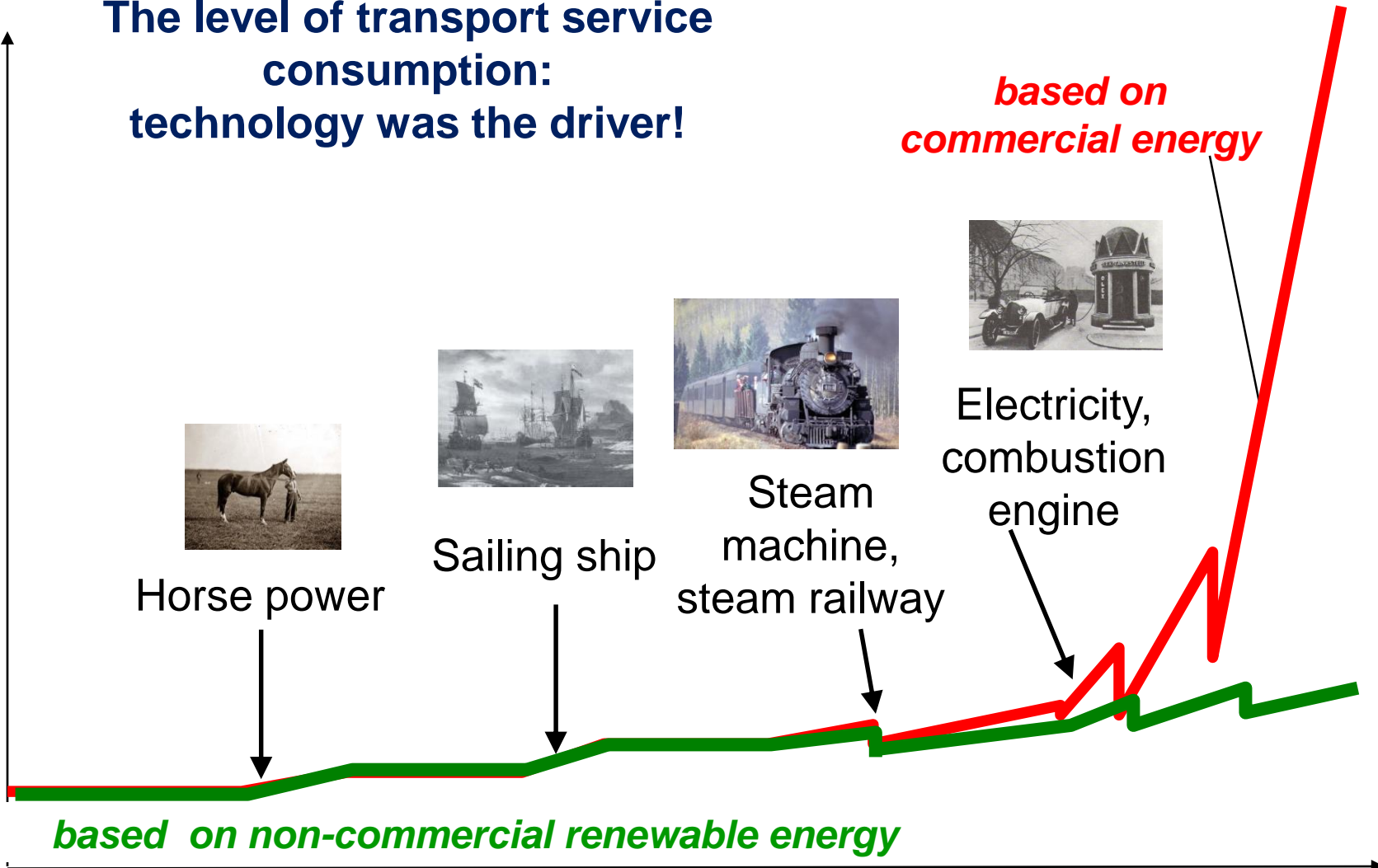


Horse power

based on non-commercial renewable energy

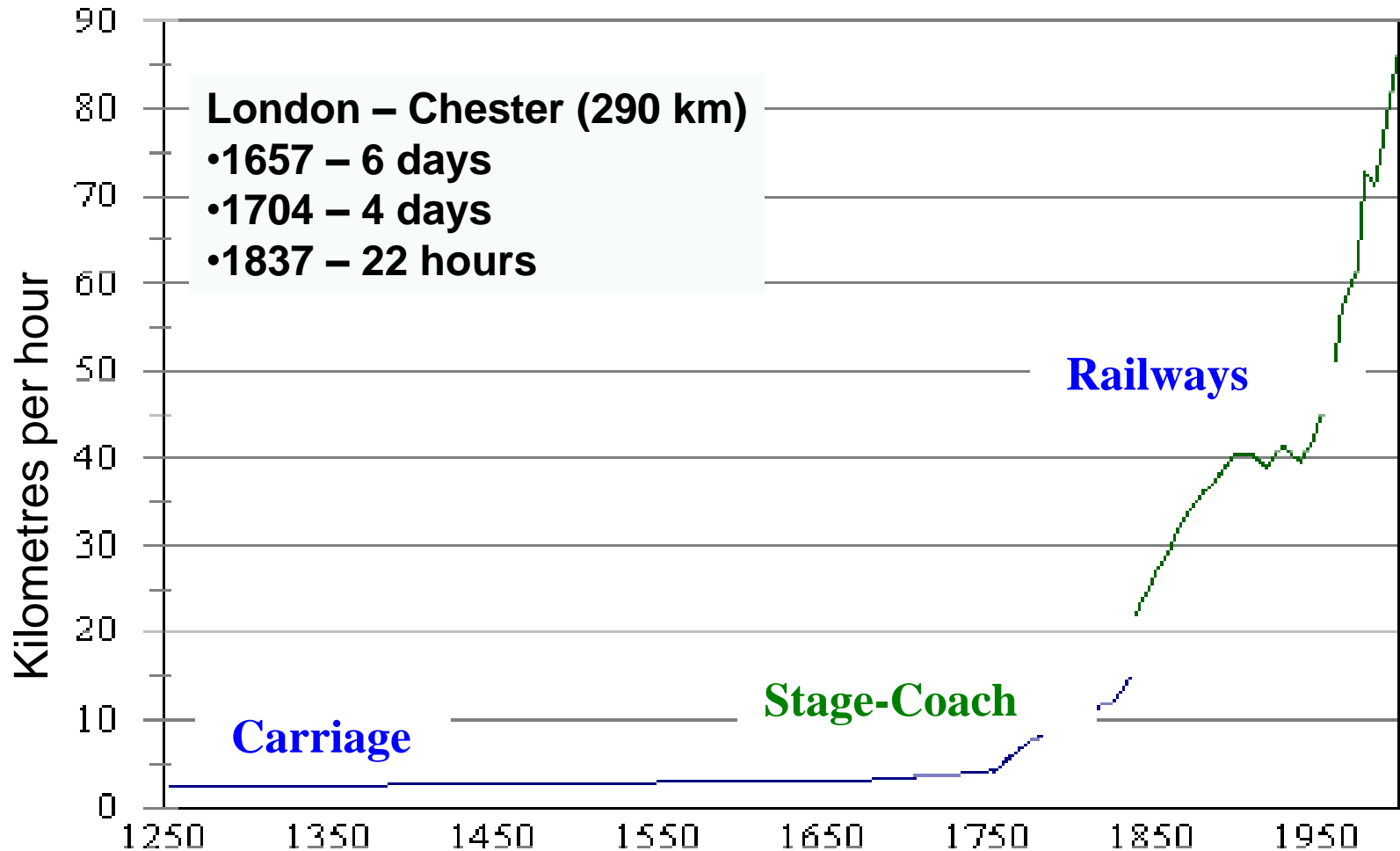
time

Amount of transport services per capita



The Speed of Transport

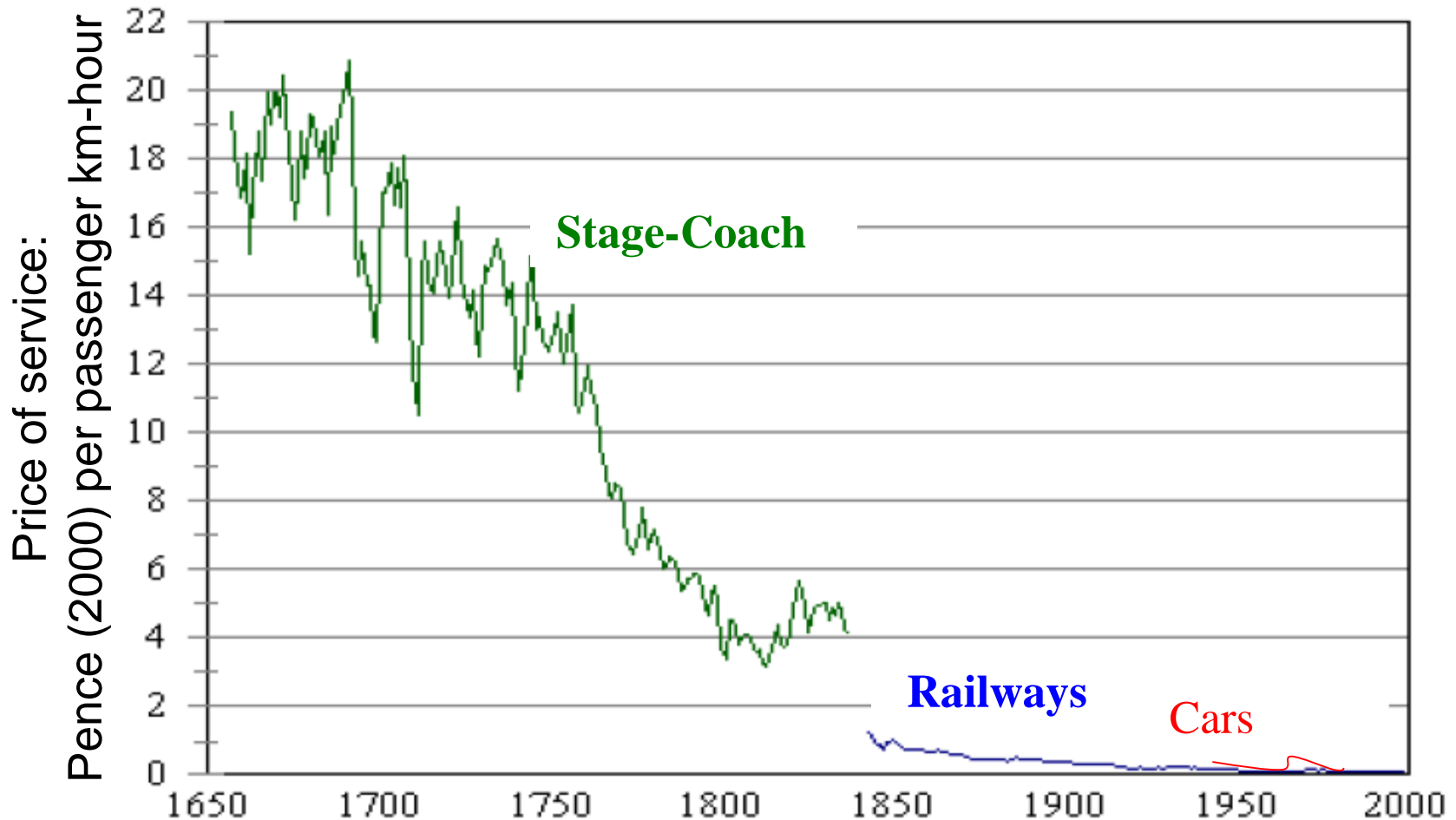
(Kilometres per Hour)



Price of Passenger Transport

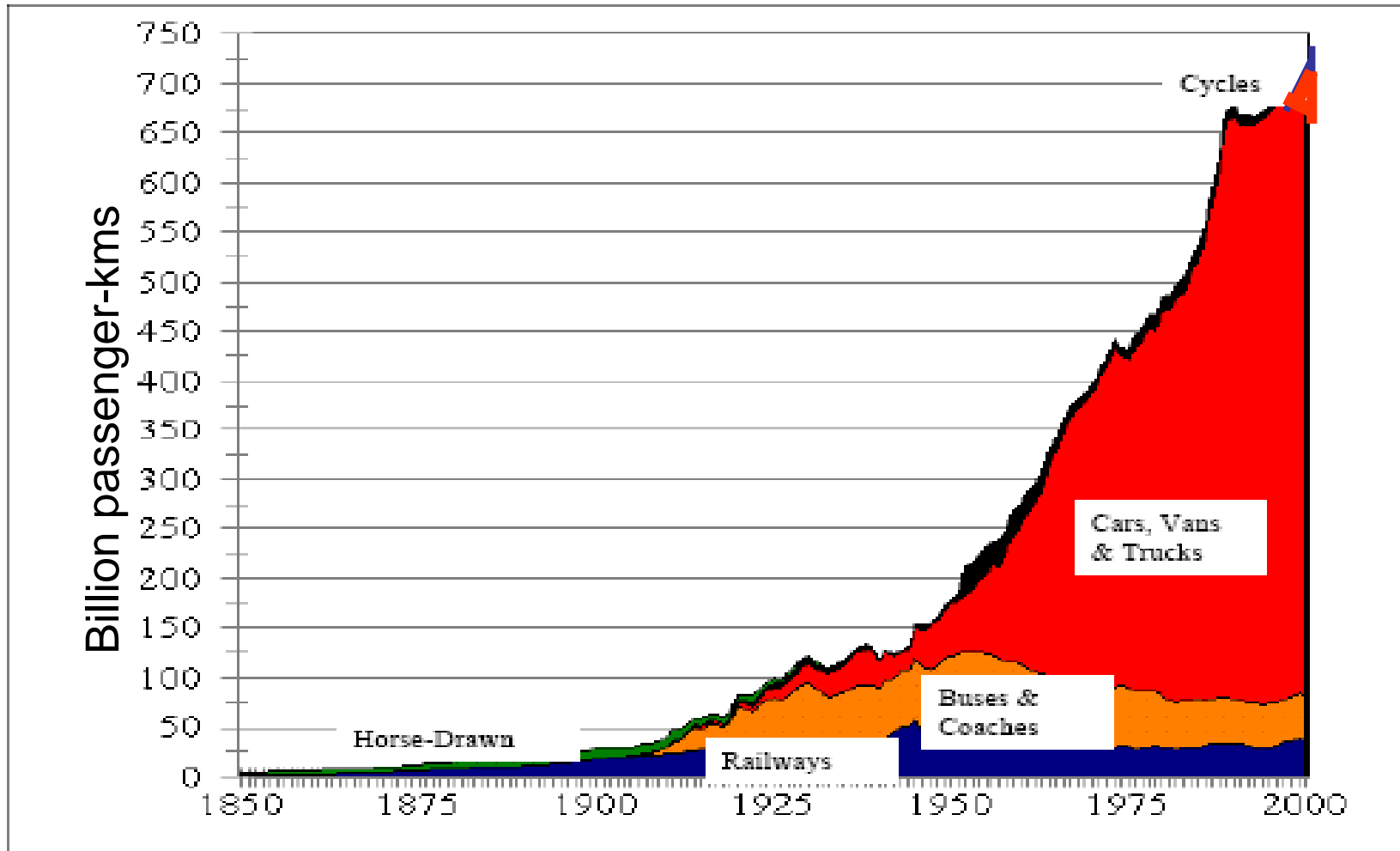
(per passenger-kilometer-hour)

The price of service dropped dramatically!



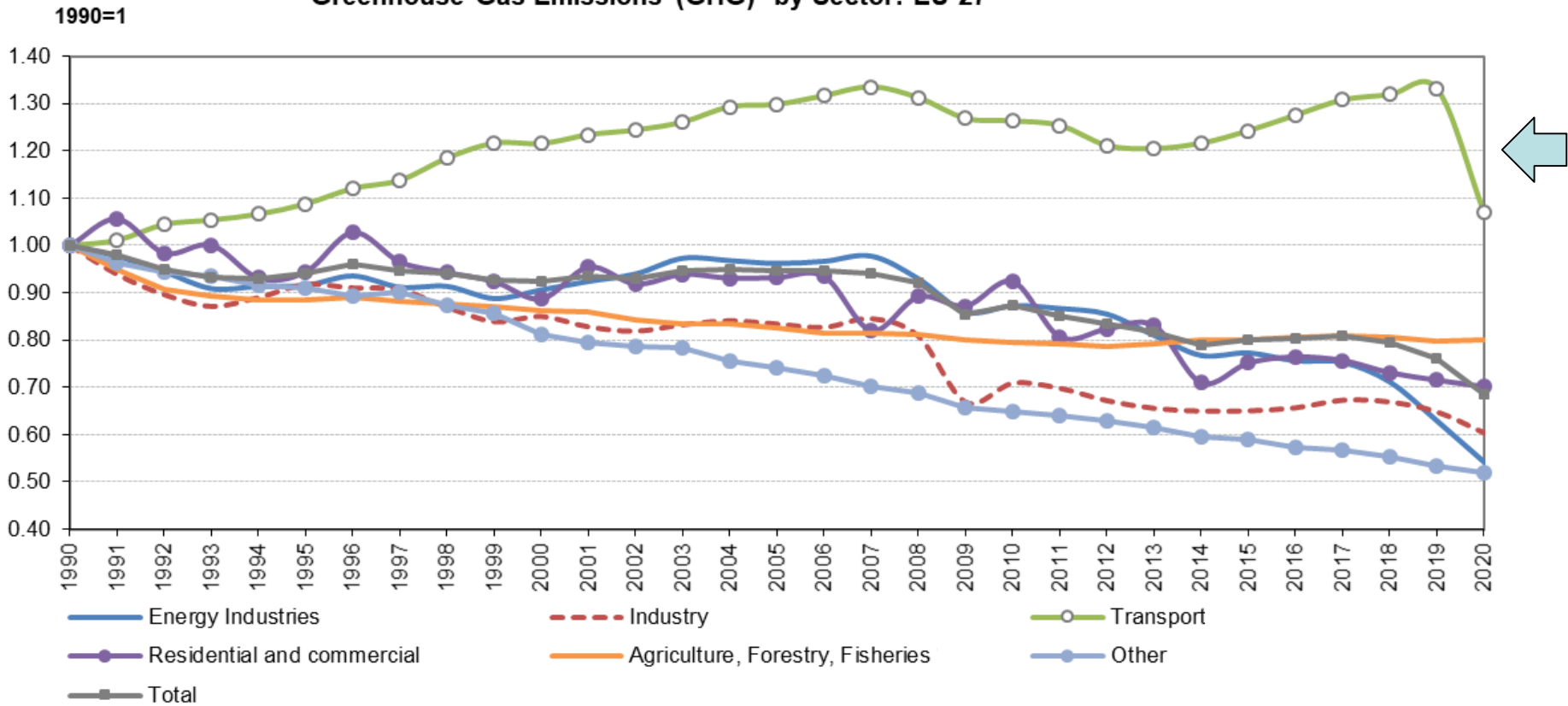
Source: Fouquet&Pearson (2003)

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

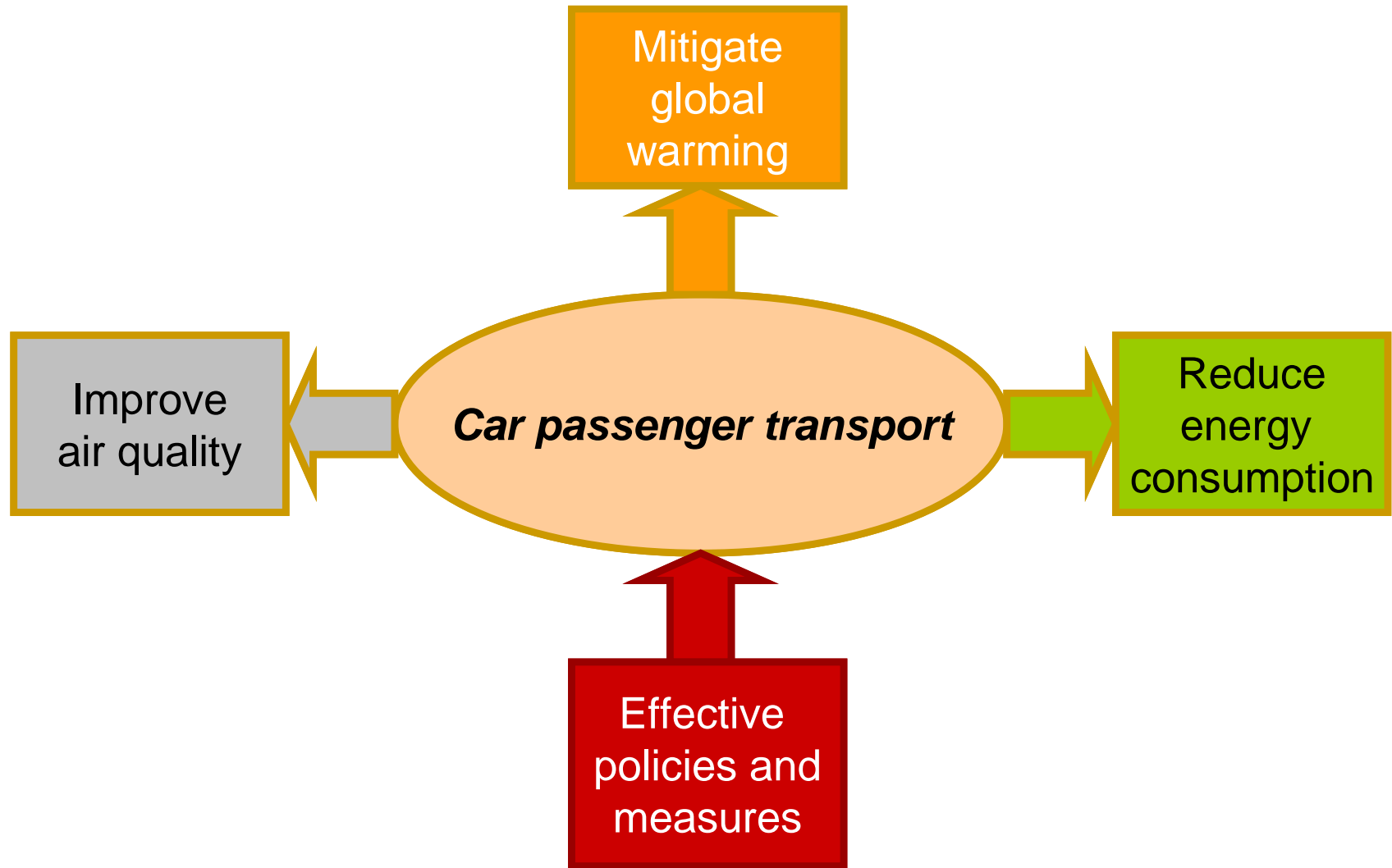


GHG

Greenhouse Gas Emissions (GHG)* by Sector: EU-27



The challenges for EU climate and energy policies



EU targets

EU - the first climate-neutral continent by 2050

European Green Deal

2030 climate & energy framework

40-32-32,5

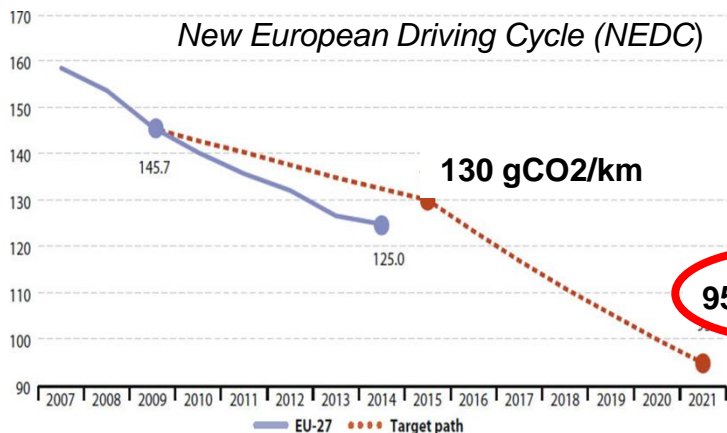
14%

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

95 gCO₂/km

-15%

-37,5%

Targets and average CO₂ emissions from new passenger cars in EU countries

World harmonized light-duty vehicles test procedure (WLTP)

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



Biofuels

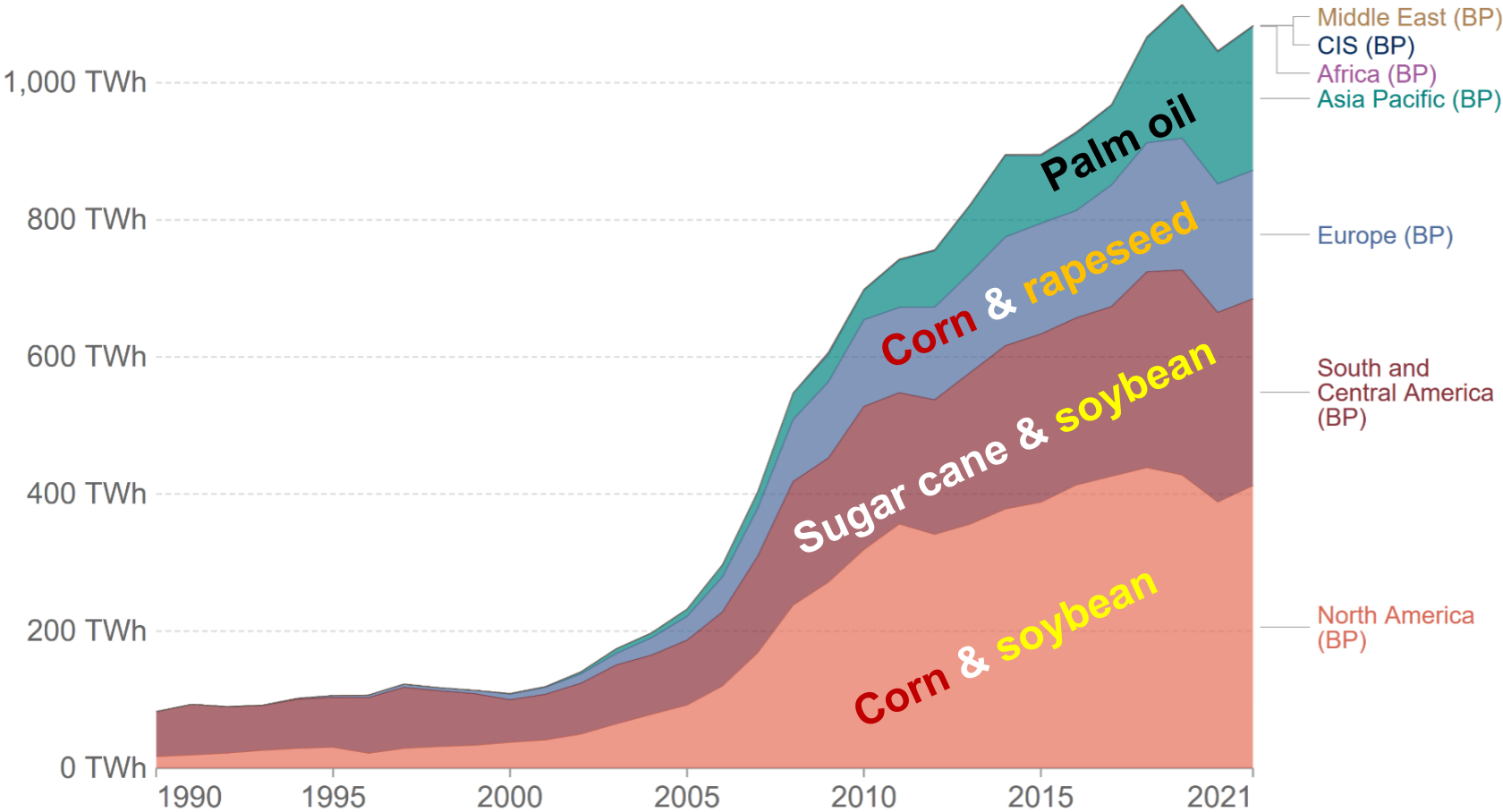
Mature biofuels
1st generation
biofuels

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

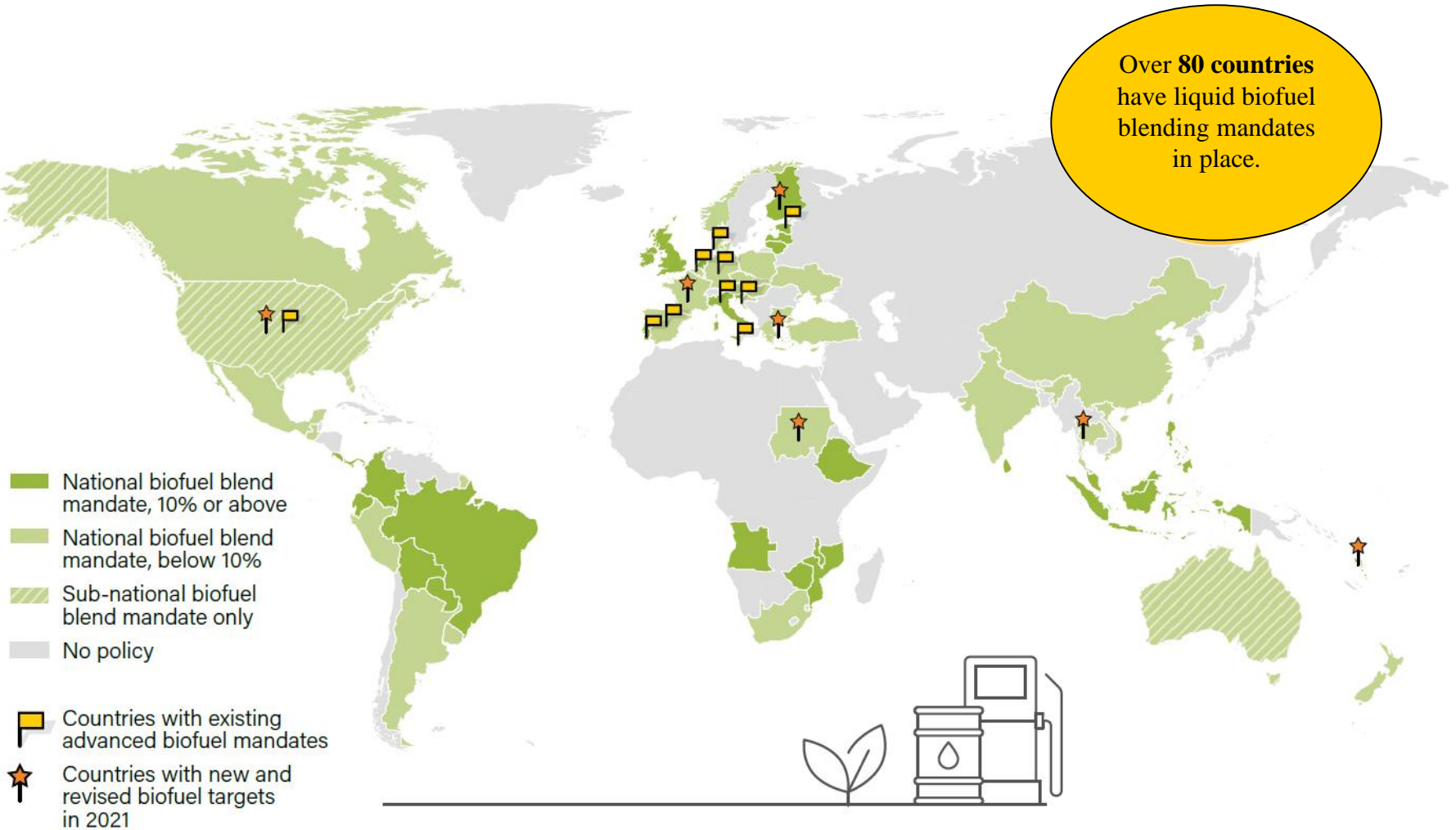


Source: Statistical Review of World Energy - BP (2022)

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

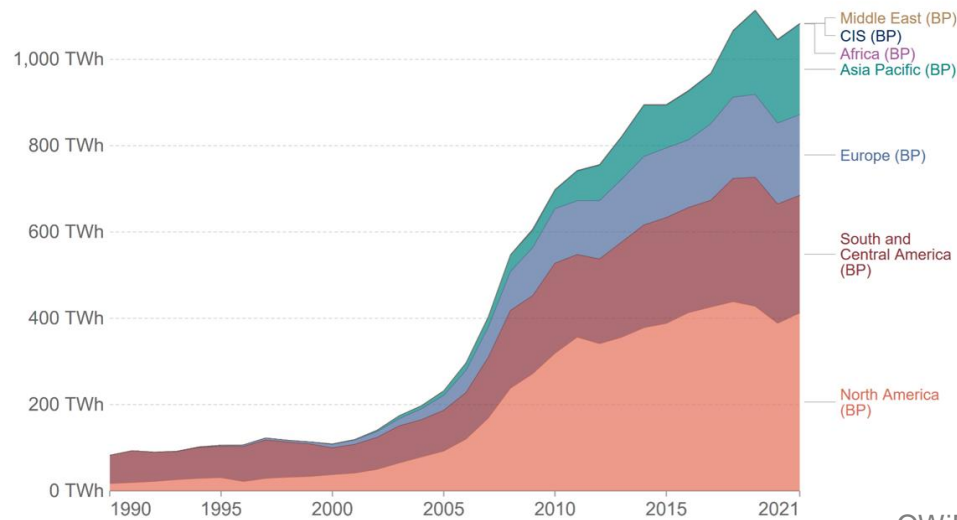


COVID 19

- ✓ 11 March 2020 – global pandemic
 - ✓ partial or total lockdowns....
- ✓ Impact on mobility



11.6% drop in global BF production



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



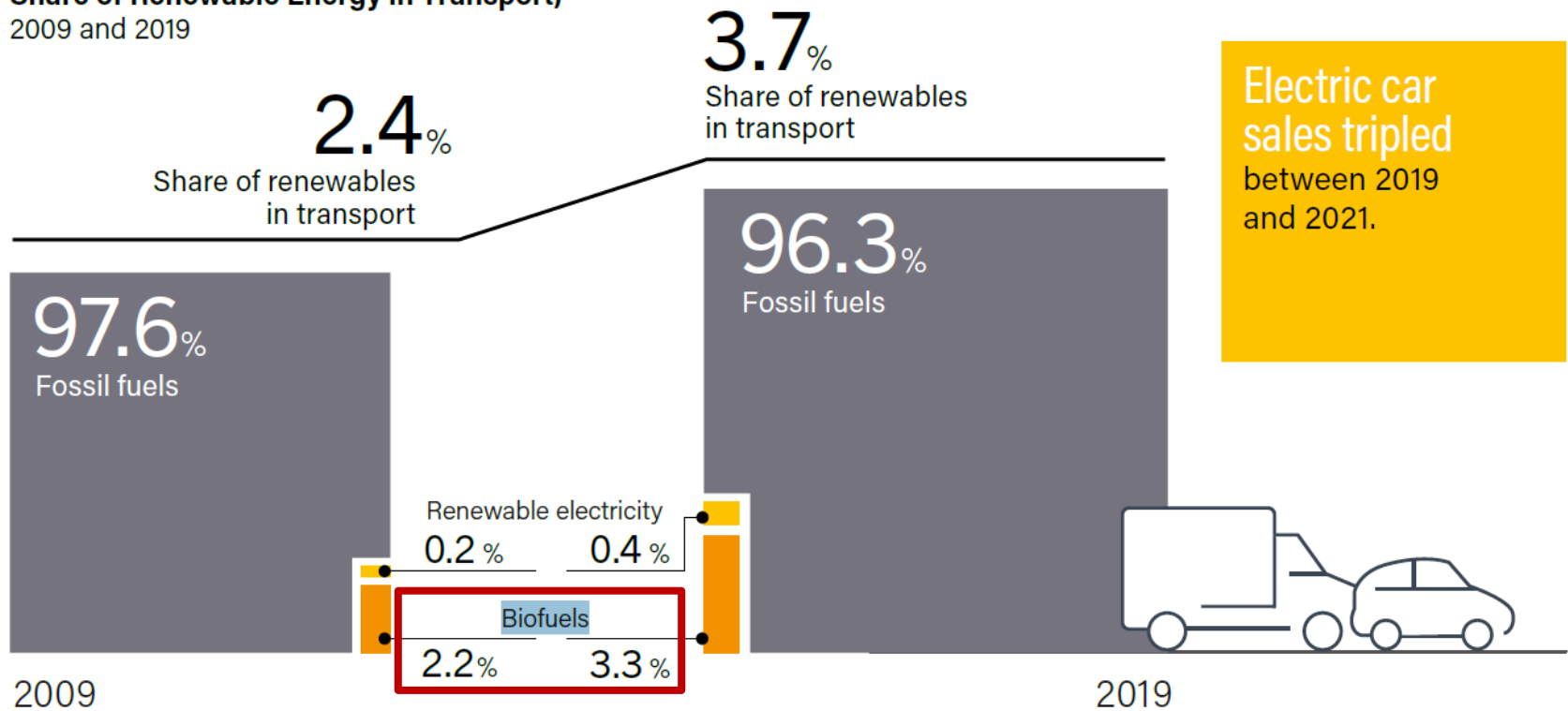
- ✓ ...increase in feedstock and energy costs...biofuels prices
- ✓ ...vegetable oil export losses from Ukraine and weather-related supply disruptions (drought in Latin America)....
Food vs fuel
- ✓ ... about 10% of all grain ...biofuel production.. could be used to reduce food insecurity in many parts 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.

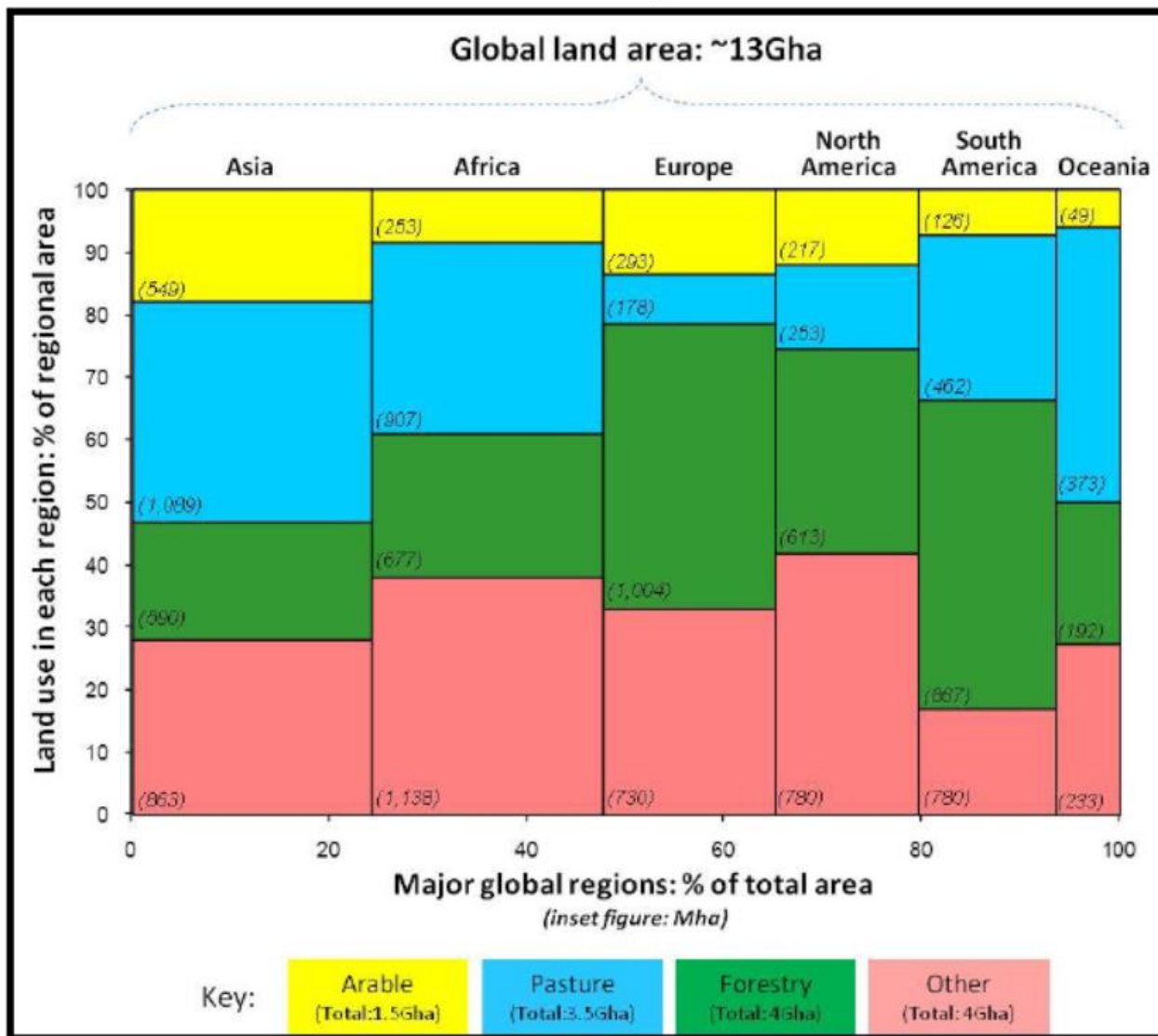
Share of biofuels

Share of Renewable Energy in Transport,
2009 and 2019



Note: ICE = internal combustion engine

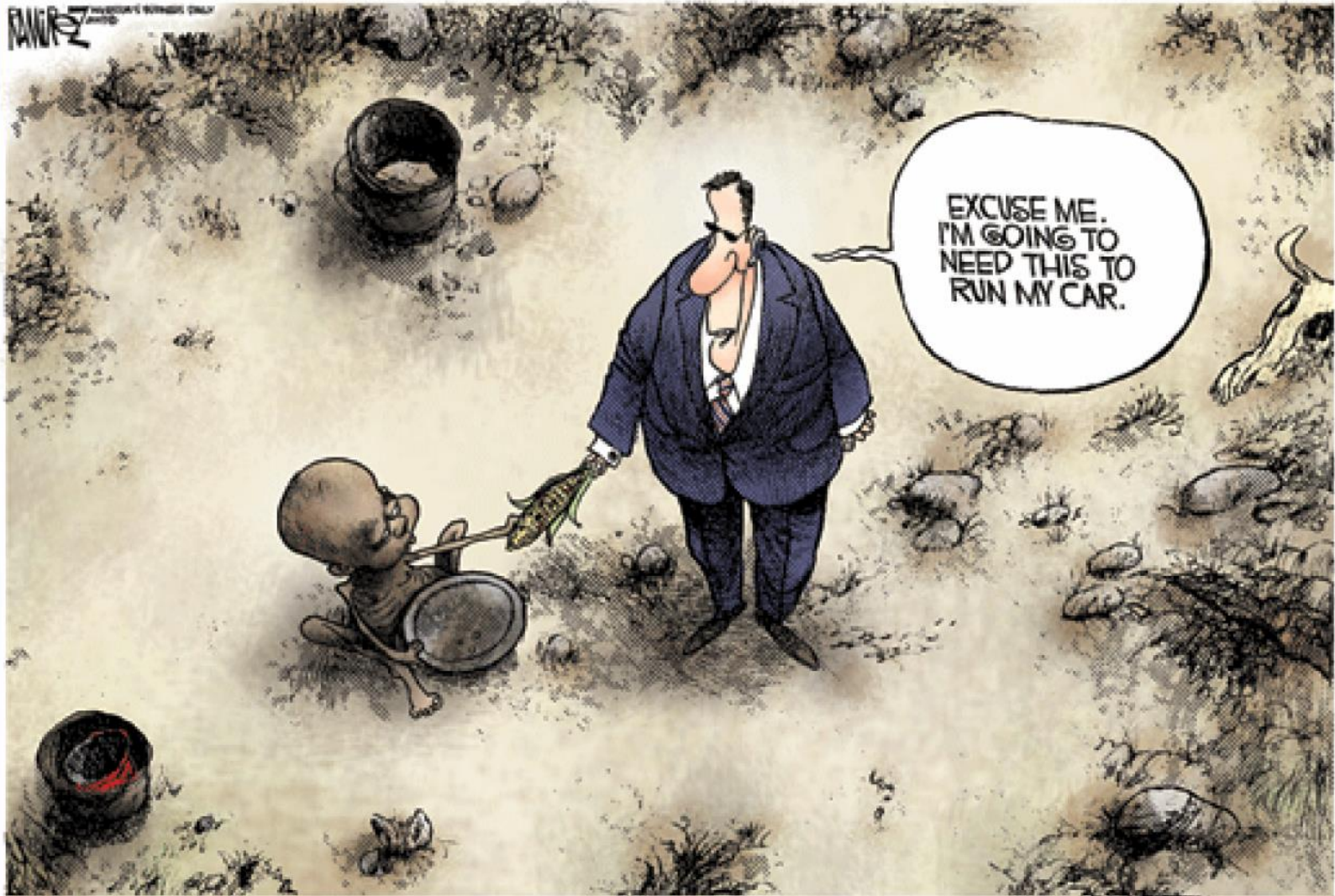
World land use



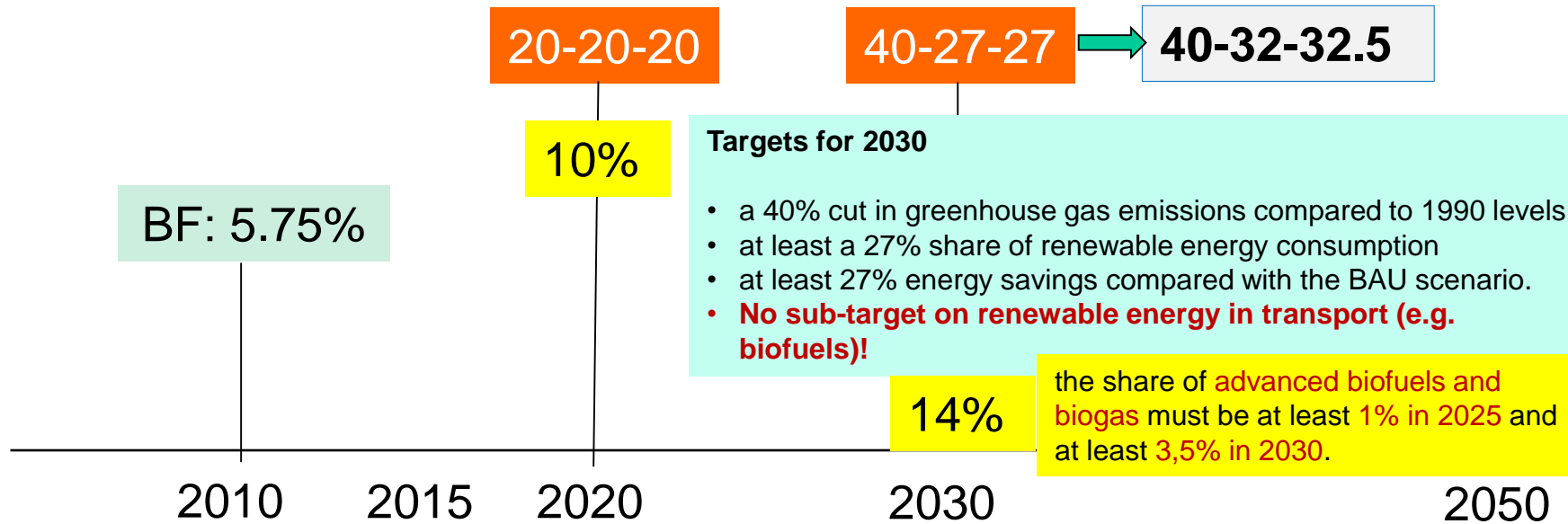
Source: (Slade *et al.*, 2011; based on FAO database).

FAVORITE

FOR THE WEEKEND ONLY

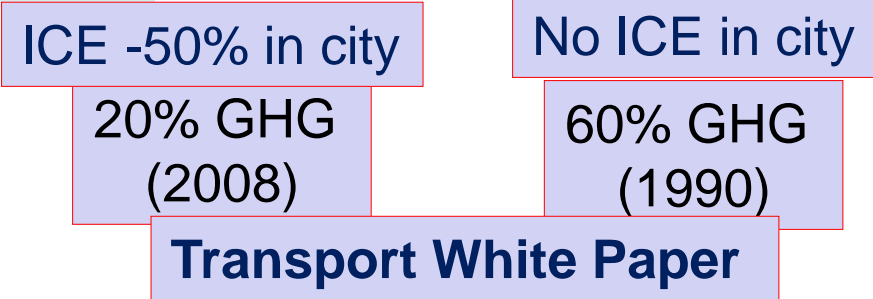






New legislation approved by European Parliament on 28 April 2015

- Cap of 7% on the contribution (to 2020 targets) of biofuels produced from 'food crops' to mitigate ILUC emissions
- No public support for food crop based biofuels post 2020



European Green Deal

EU - the first climate-neutral continent by 2050

Sustainable and Smart Mobility Strategy

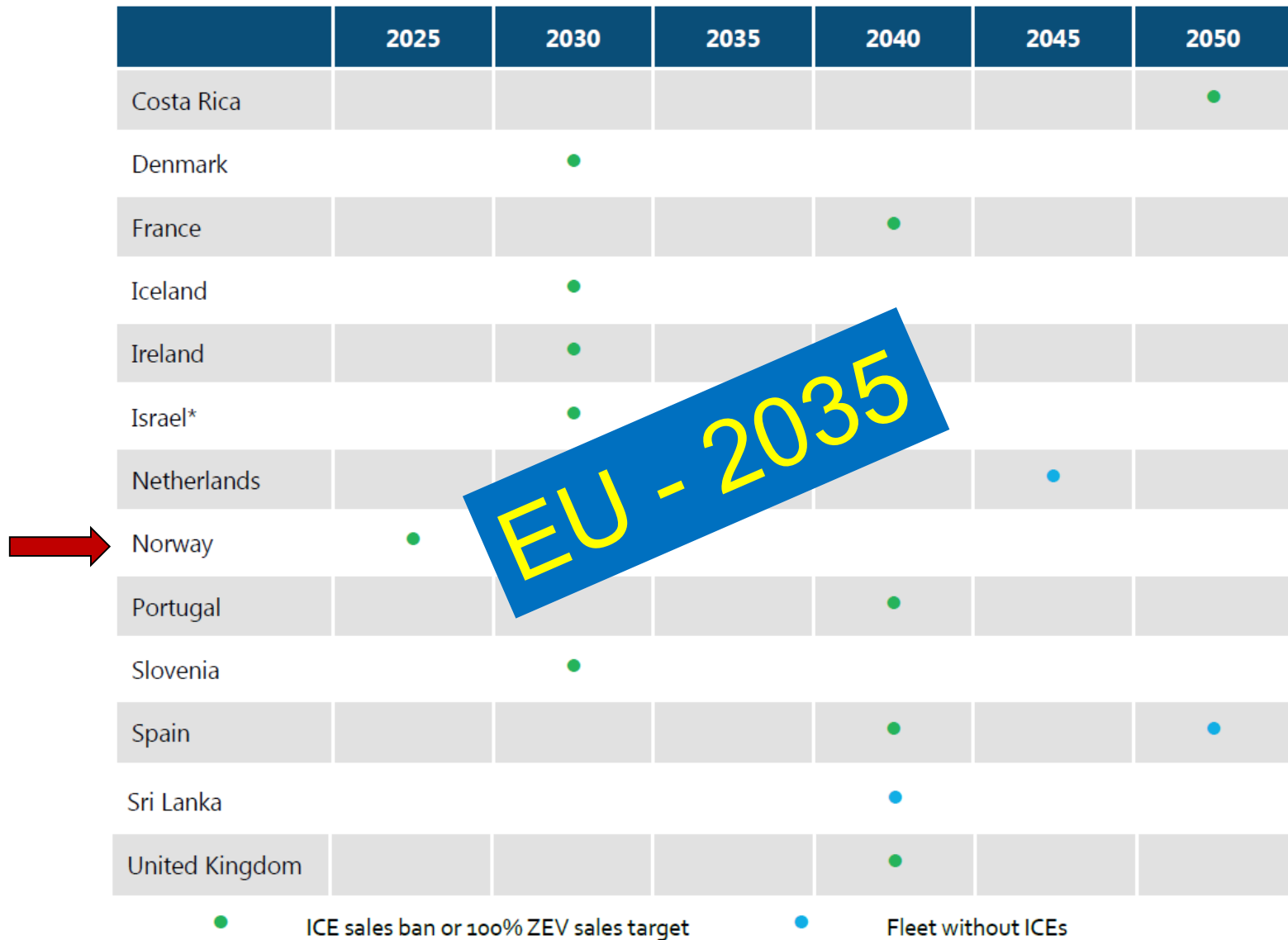
at least 30 million zero-emission cars will be in operation on European roads

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

2030

2050

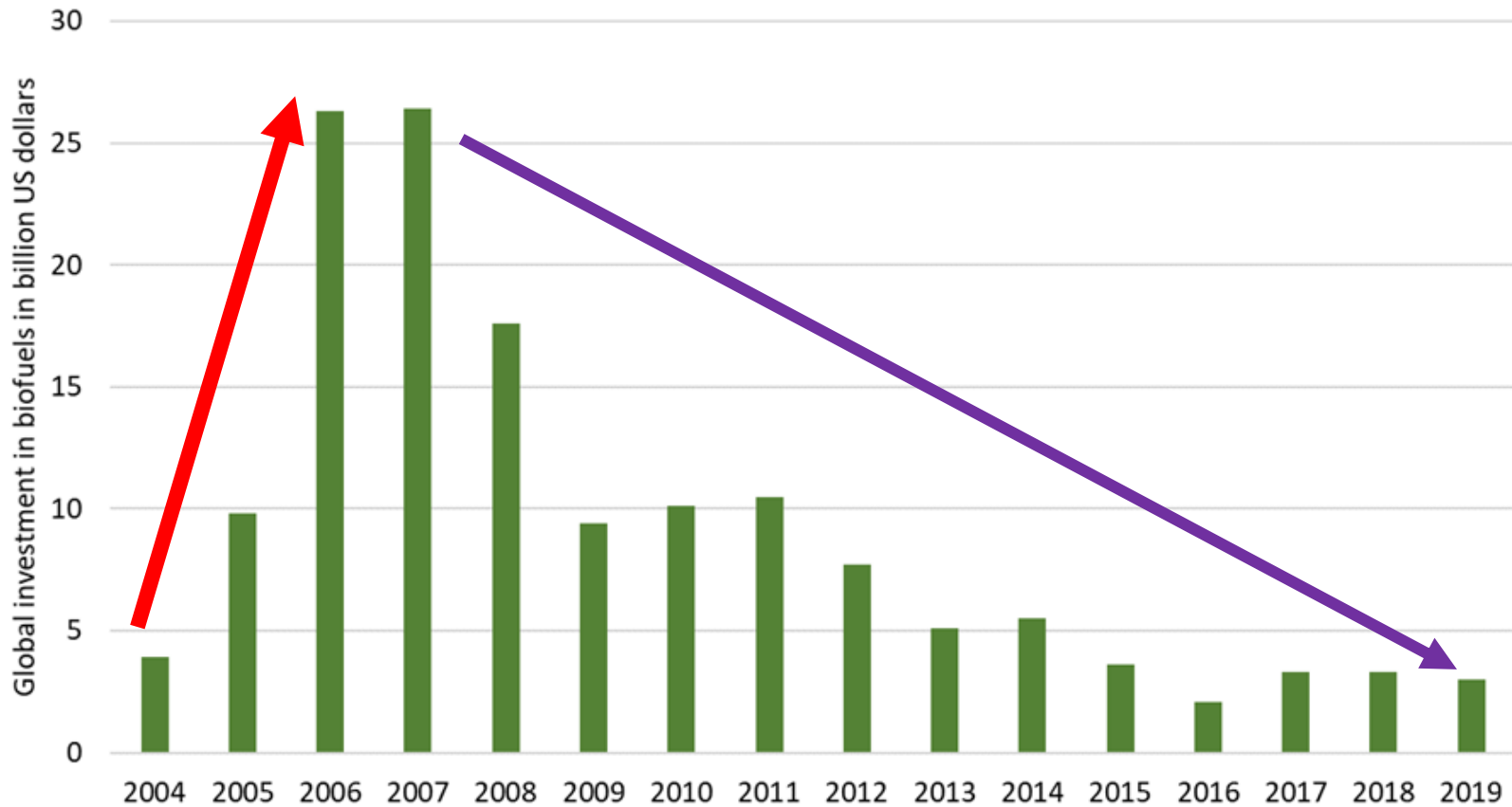
Announced 100% ZEV sales targets and bans on ICE vehicle sales



EU - 2035



Global investment in biofuels

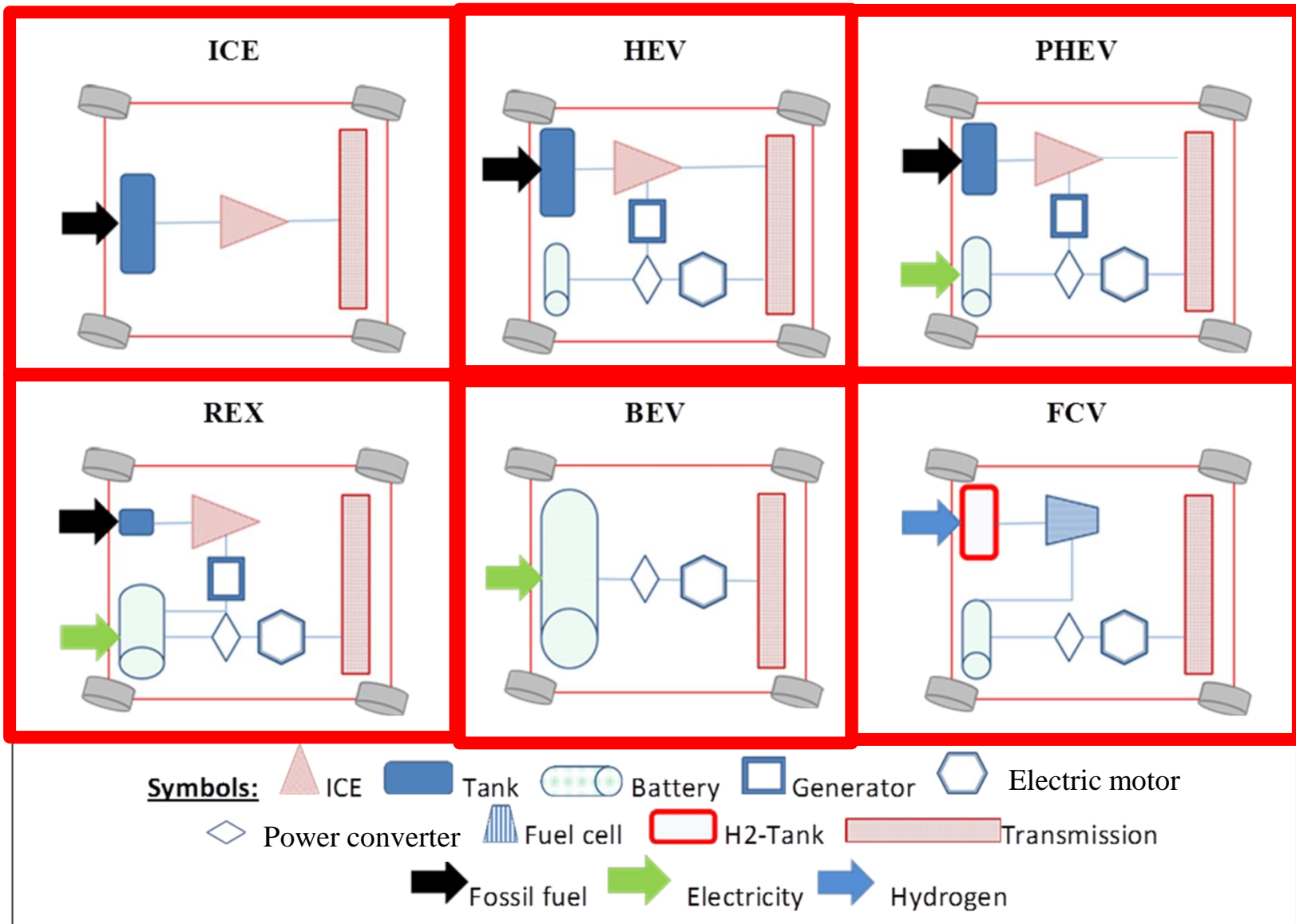


- The future prospects of biofuels are dependent on:
 - policy framework... the time of political promotion of biofuels is widely over, especially due to the current crisis and announced ban on ICE vehiclesno bright prospects for biofuels are on the horizon.
 - development of oil and feedstock prices
 - electrification

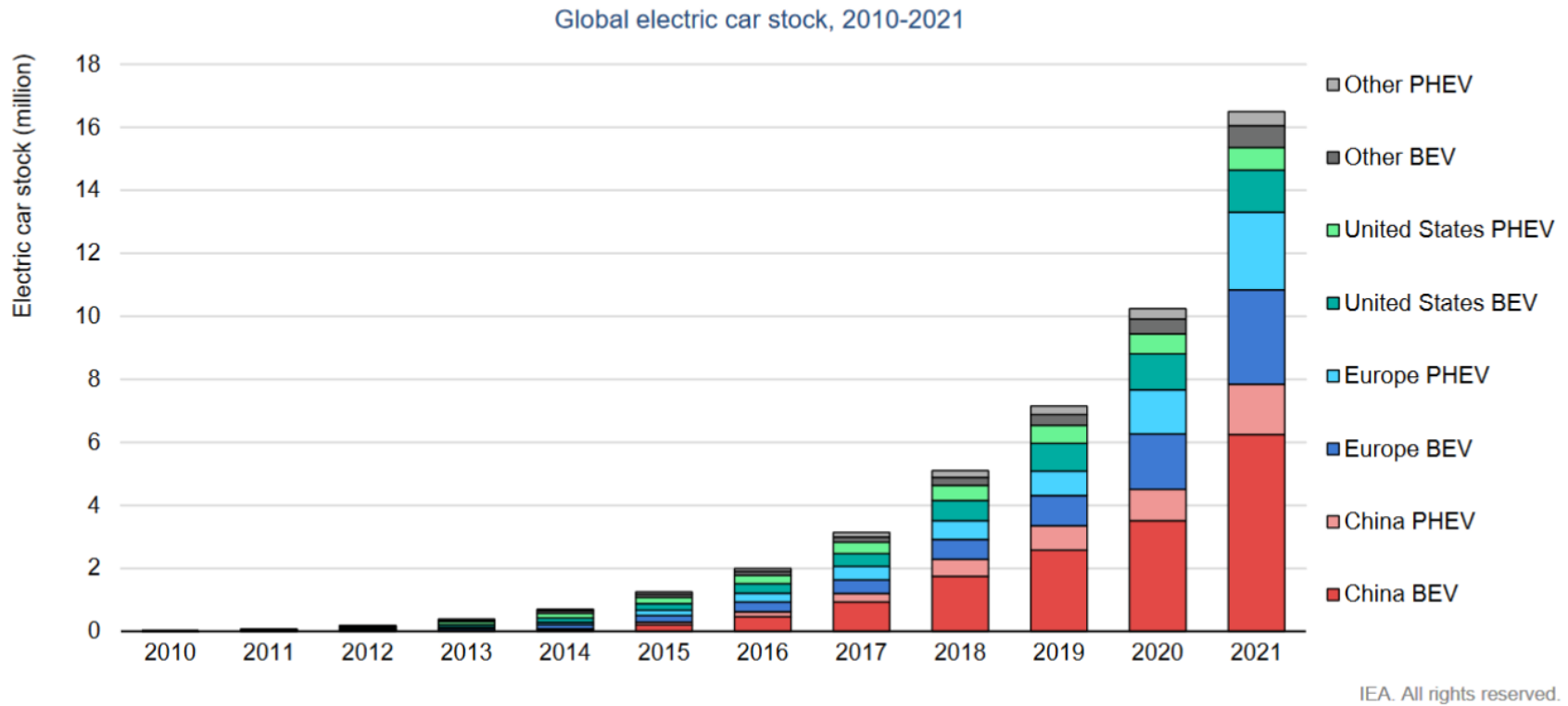
- The Ukraine war...
 - Food-versus-fuel debate
 - Accelerate the transition from 1st to 2nd generation biofuels...it is unlikely that there will be additional investments in conventional biofuels...incentives for the development of 2 gen. biofuels... especially from wastes and residues

- Biofuels...in aviation, shipping and heavy goods vehicles

Electric vehicles



Electric vehicles



Over 16.5 million electric cars were on the road in 2021, a tripling in just three years

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:

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

IC.....investment costs [€/car]

αcapital recovery factor

skm.....specific km driven per car per year [km/(car.yr)]

P_ffuel price incl. taxes [€/litre]

$C_{O\&M}$...operating and maintenance costs

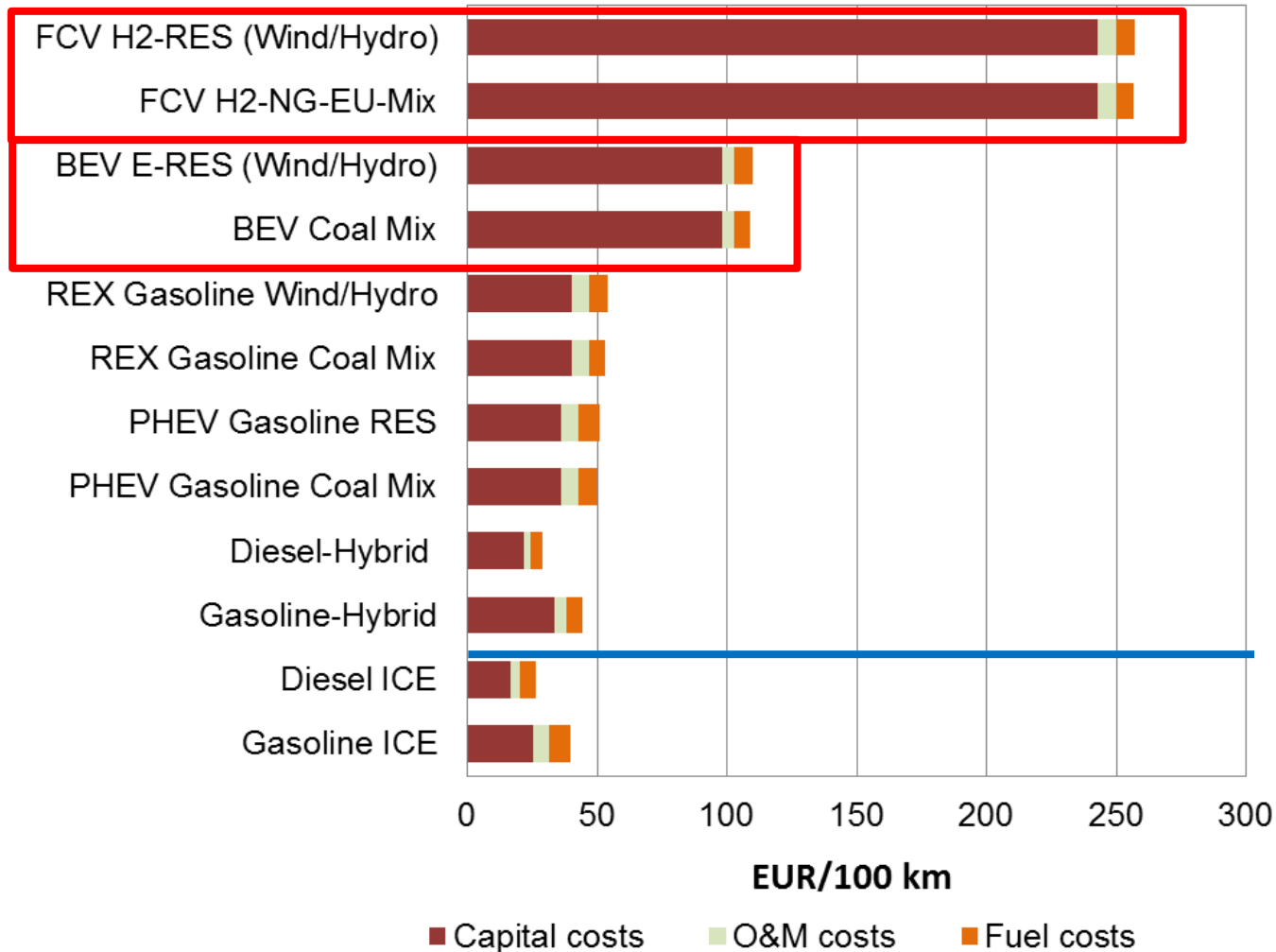
FI.....fuel intensity [litre/100 km]

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:

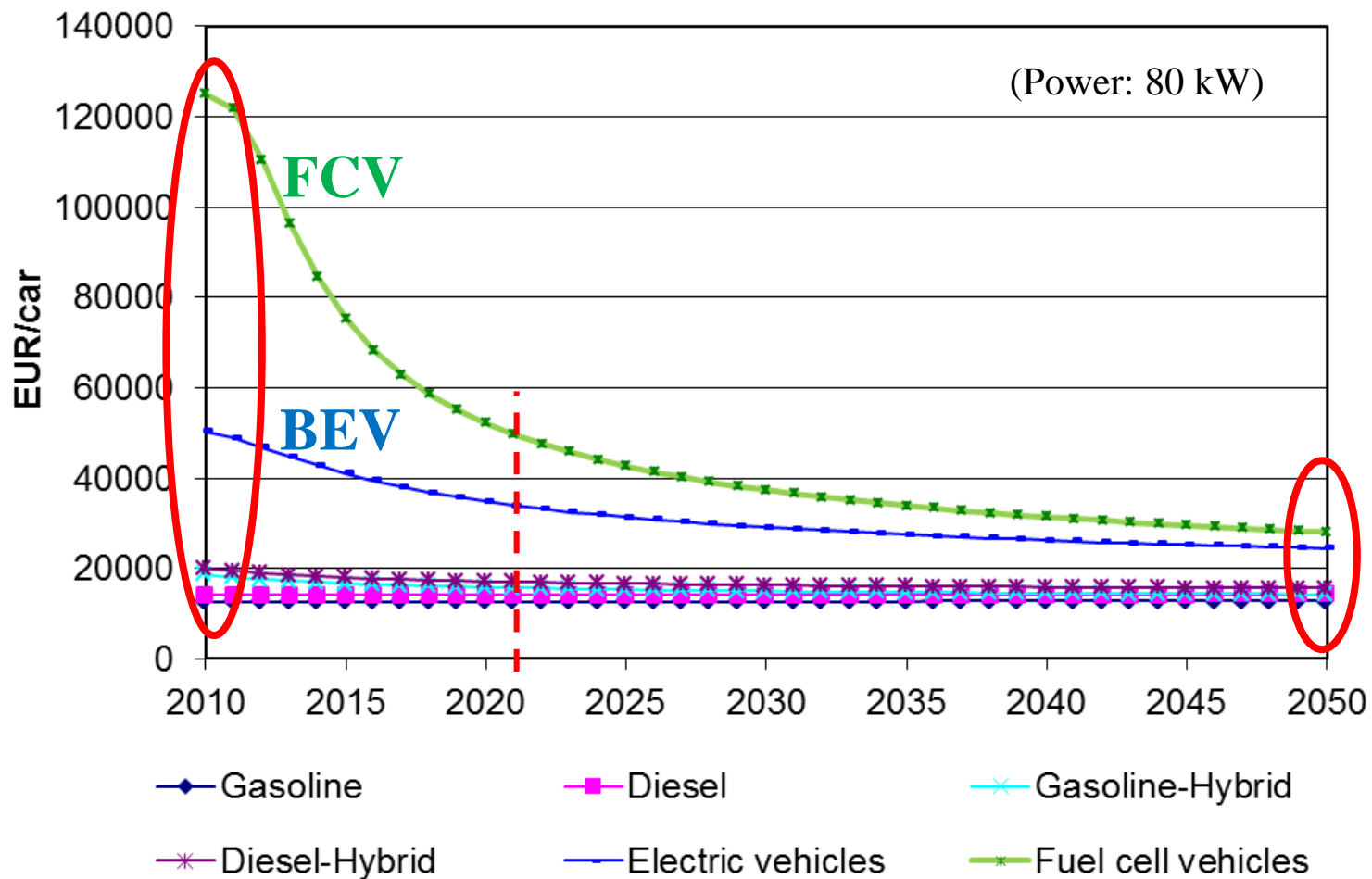
$$\alpha = \frac{z(1+z)^n}{(1+z)^n - 1}$$

nthe number of annuities received.

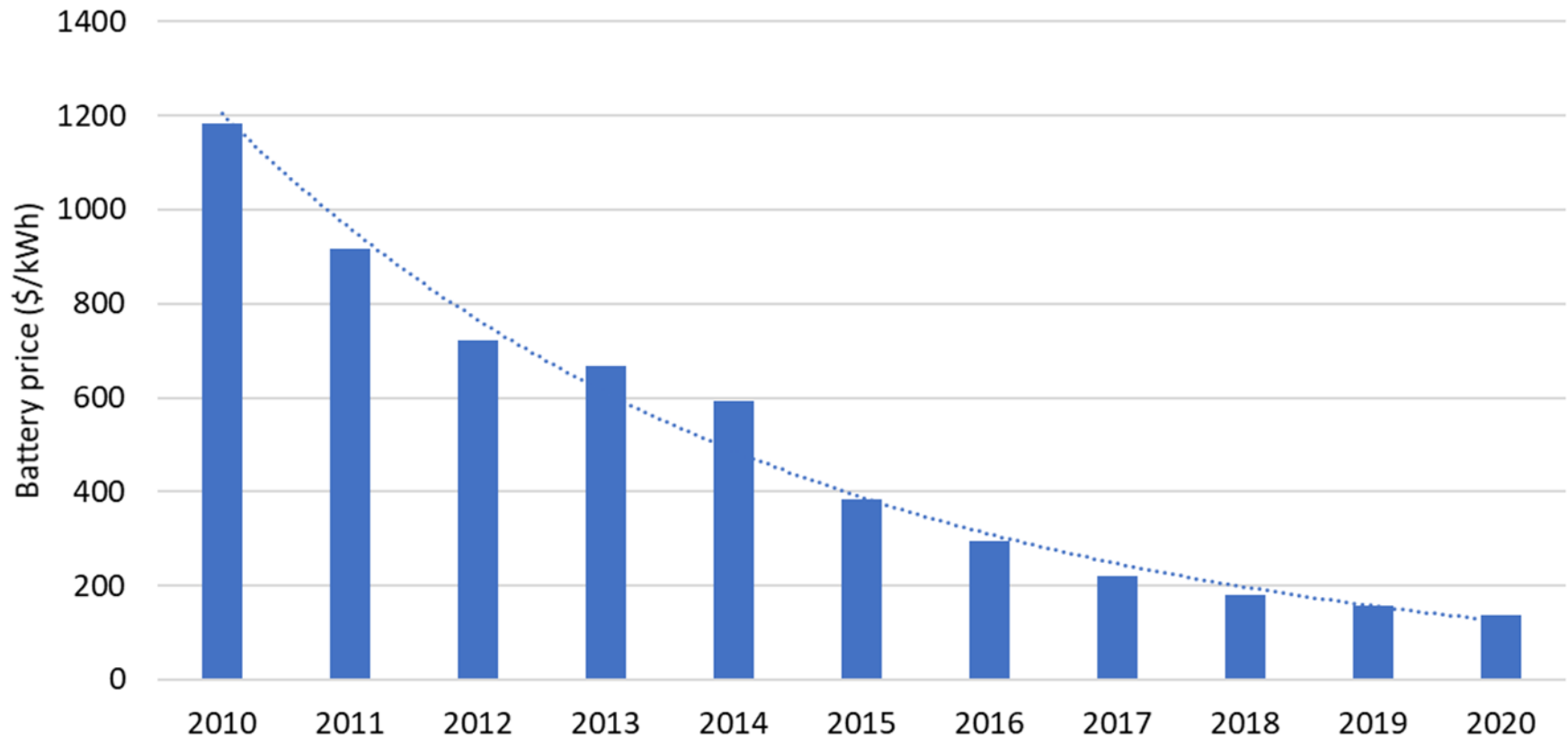
Total costs of service mobility



Scenario for development of investment costs



Technological learning – Battery



Monetary measures

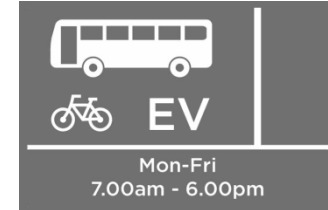
The most commonly used monetary measures are subsidies and exemptions (or reductions) from:

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

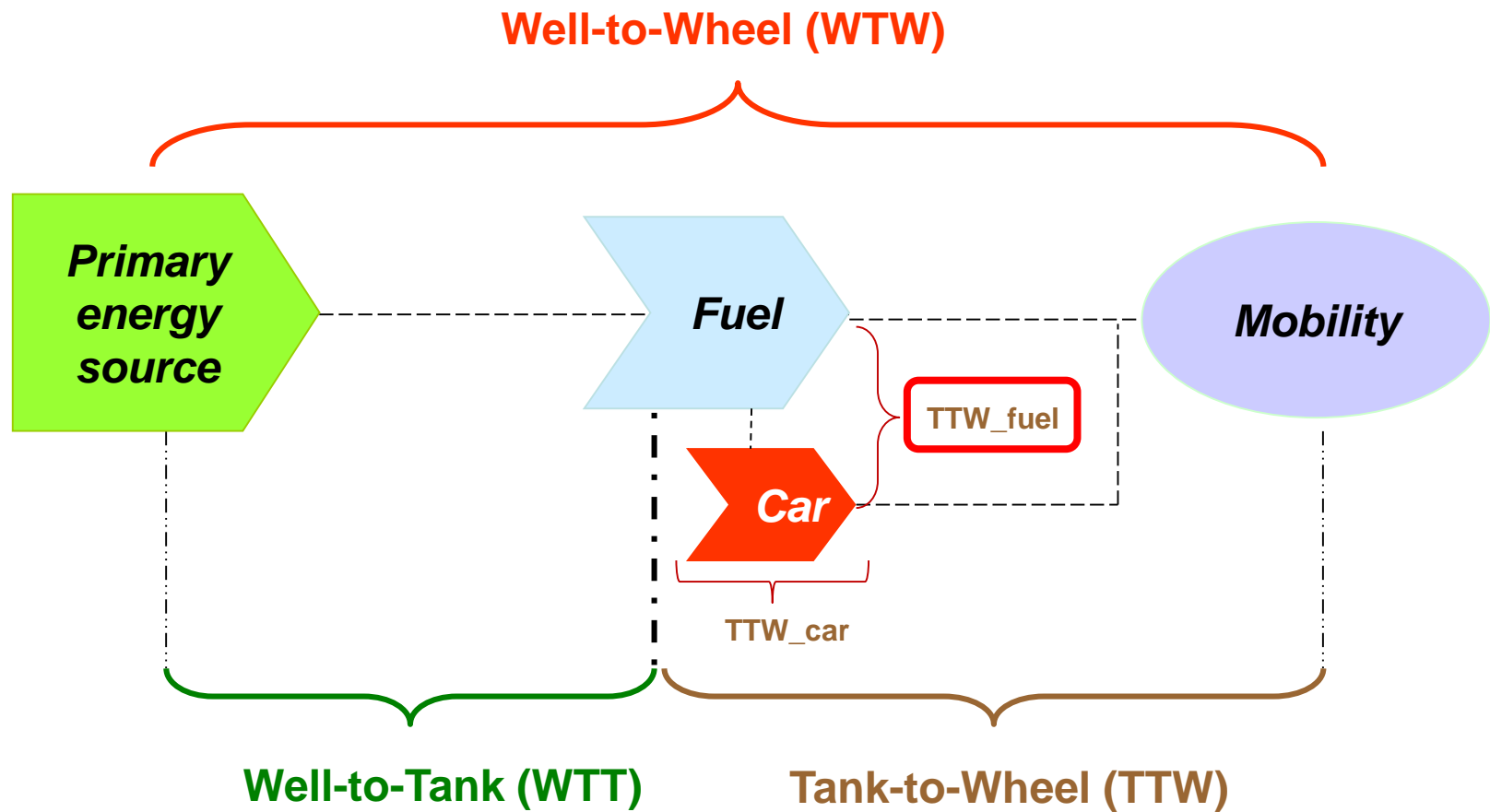


Non-monetary measures

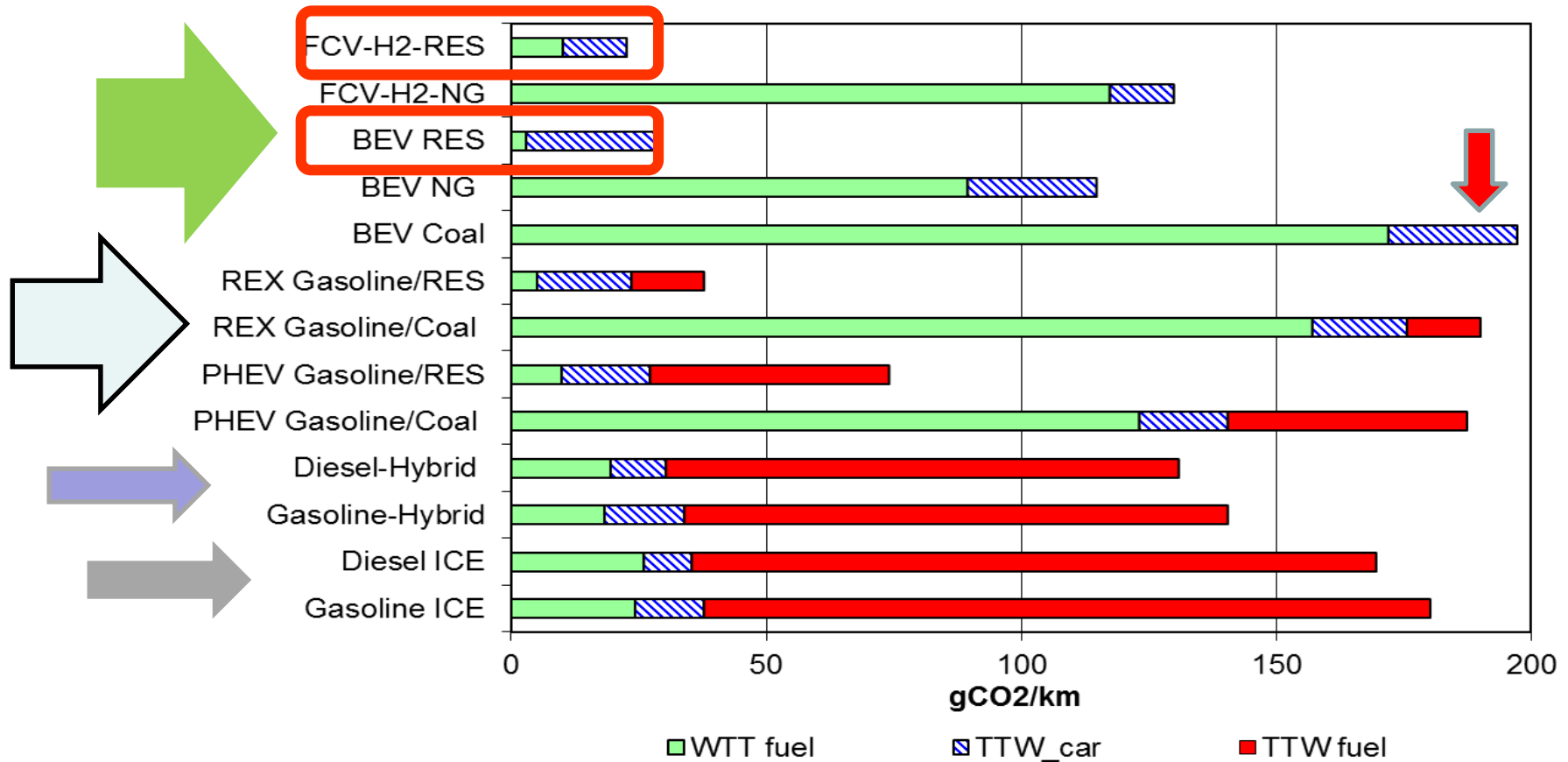
- free parking spaces,
- possibility for EVs drivers to use bus lanes,
- wide availability of charging stations,
- permission for EVs to enter city centers and zero emission zones.



Environmental assessment

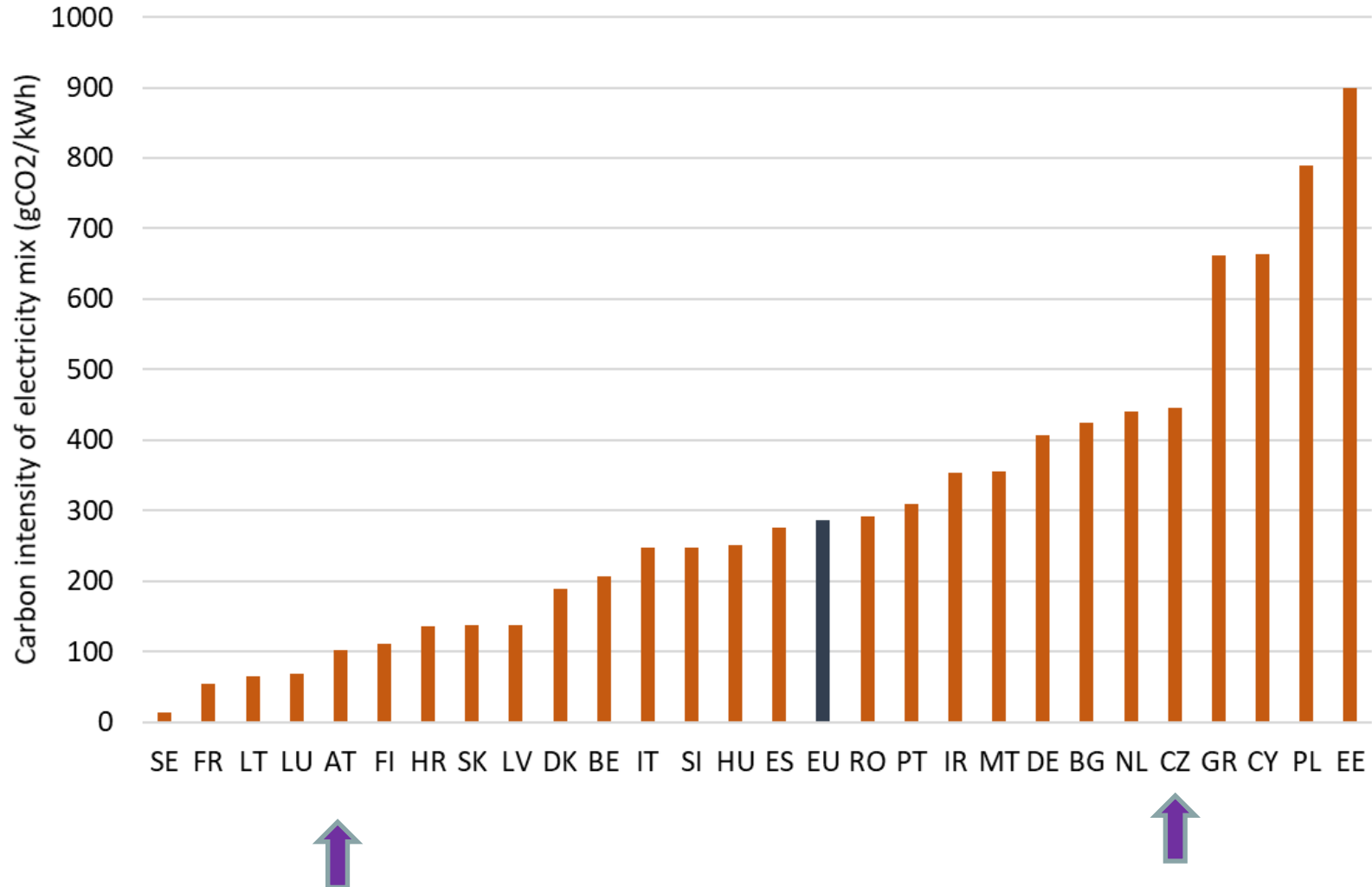


Environmental assessment

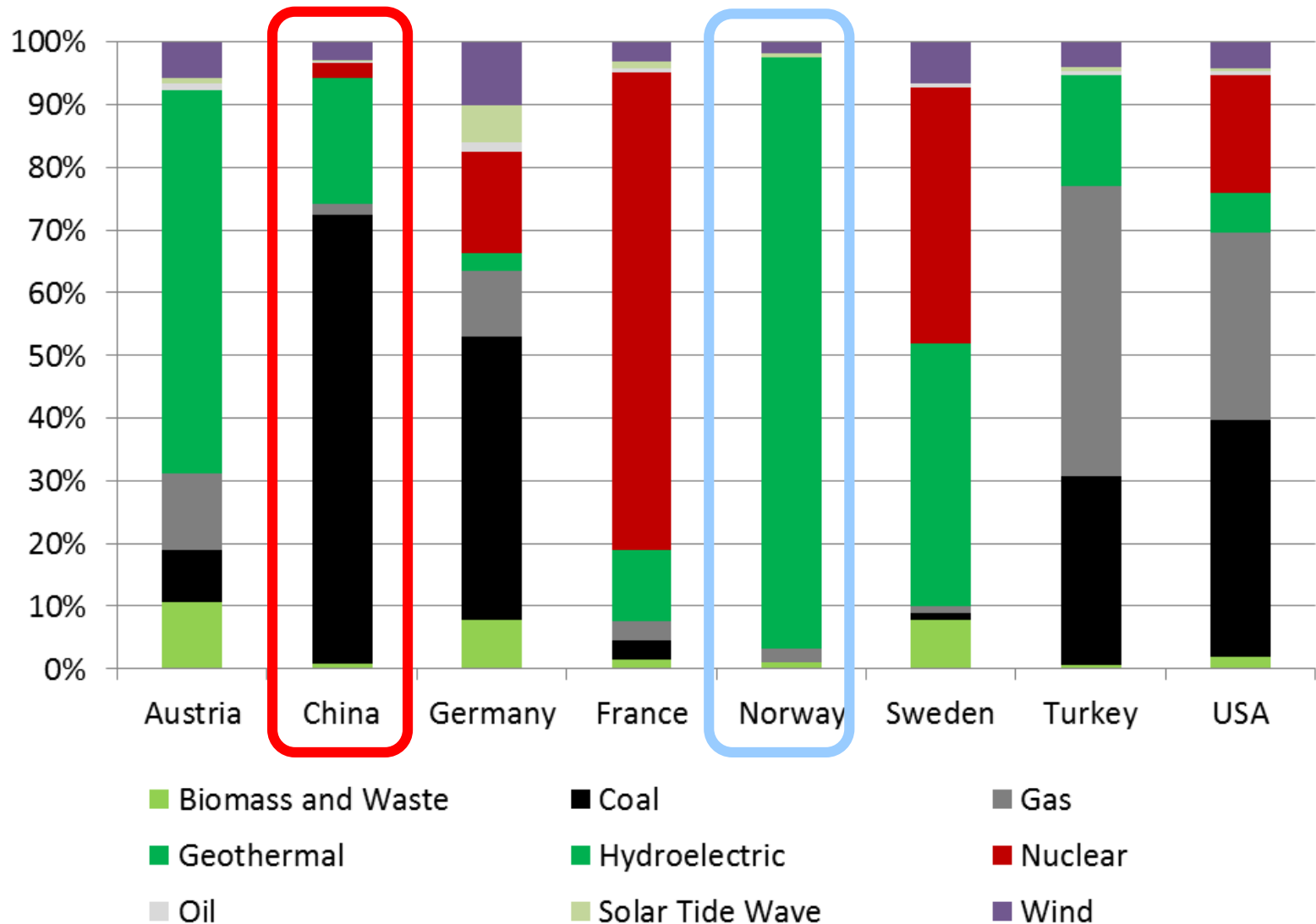


CO₂ emissions per km driven for various types of EV in comparison to conventional cars (power of car: 80kW)

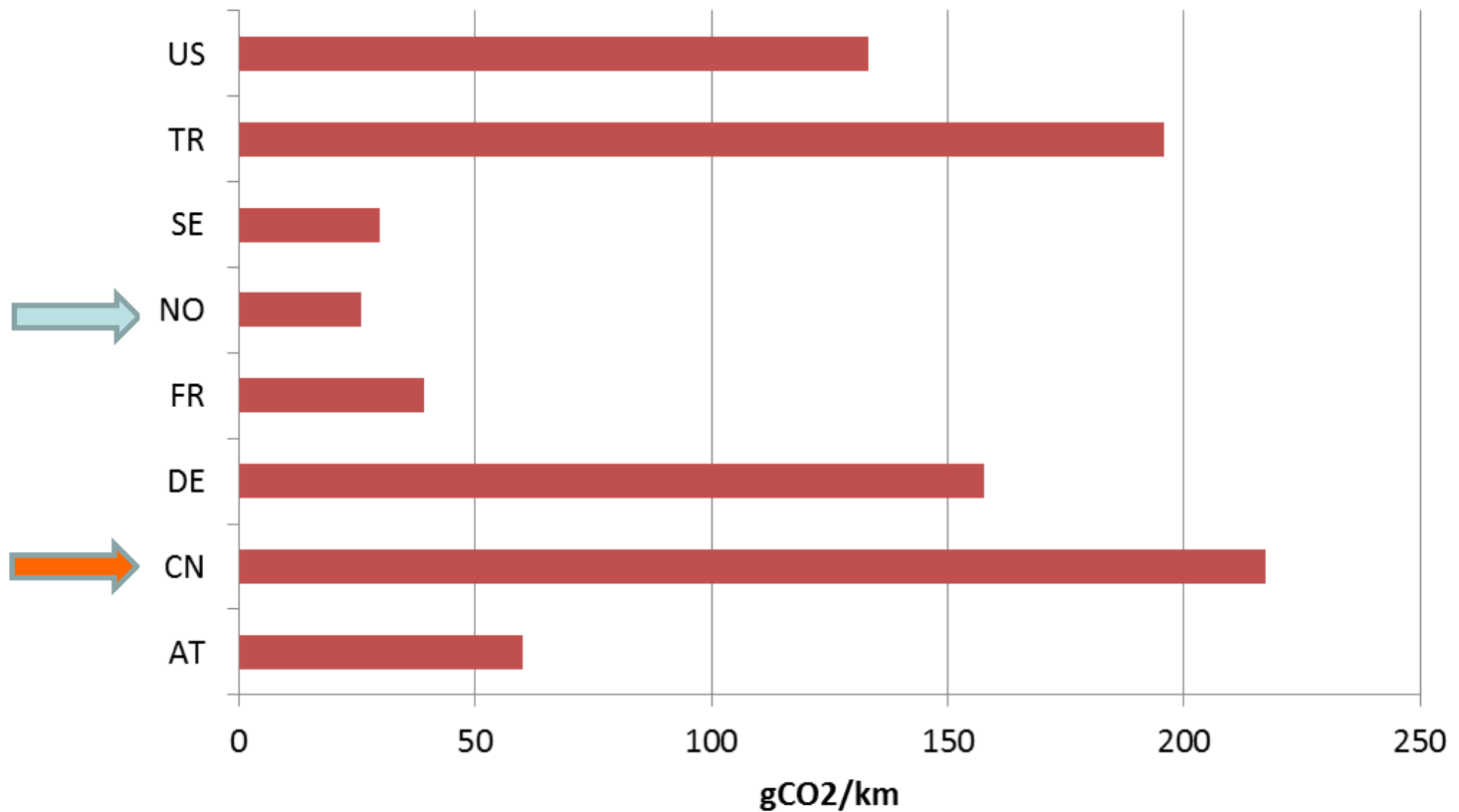
The carbon intensity of electricity mix



Electricity mix

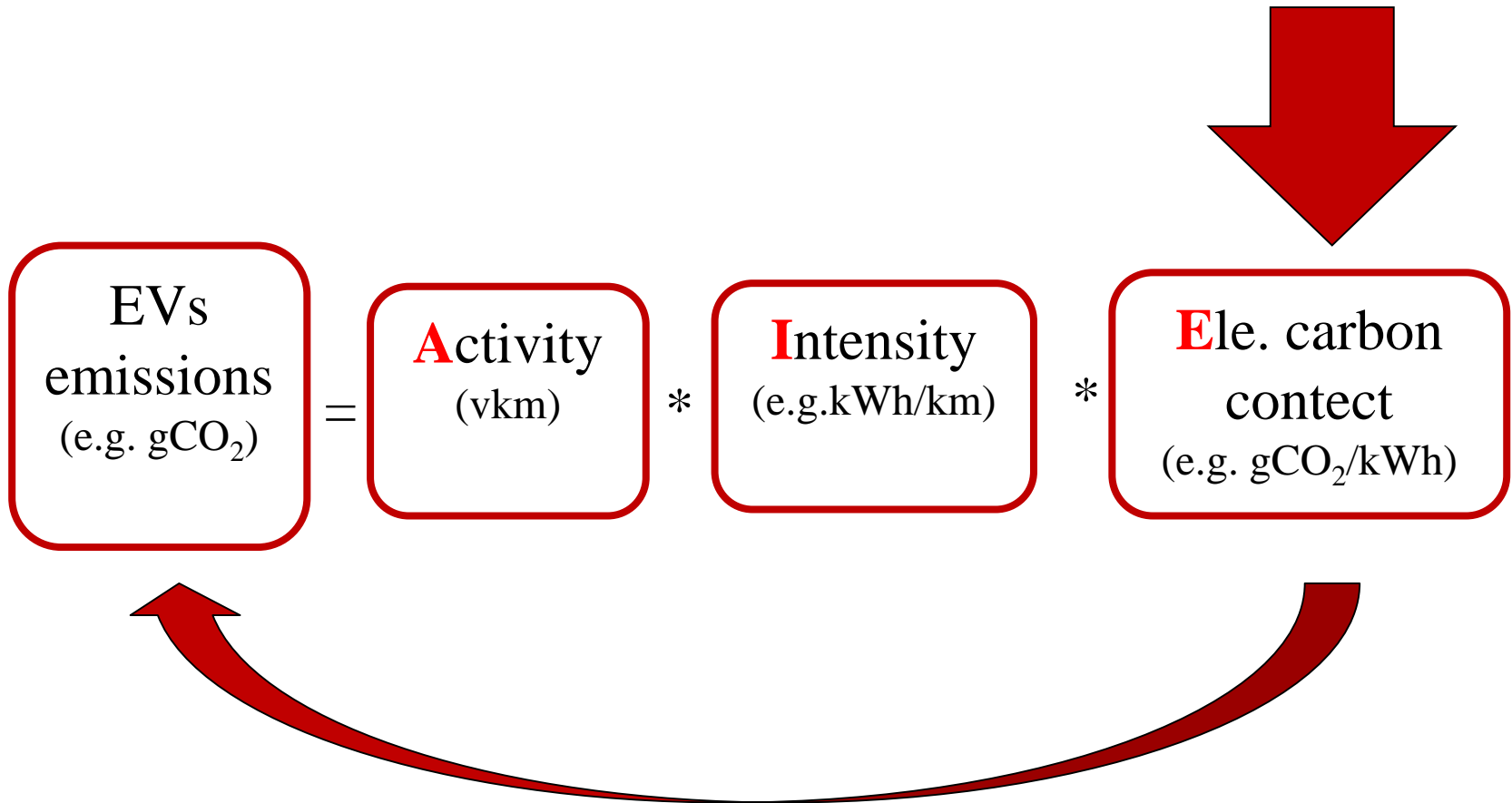


Environmental assessment



CO₂ emissions per km driven for BEVs powered by grid electricity in different countries

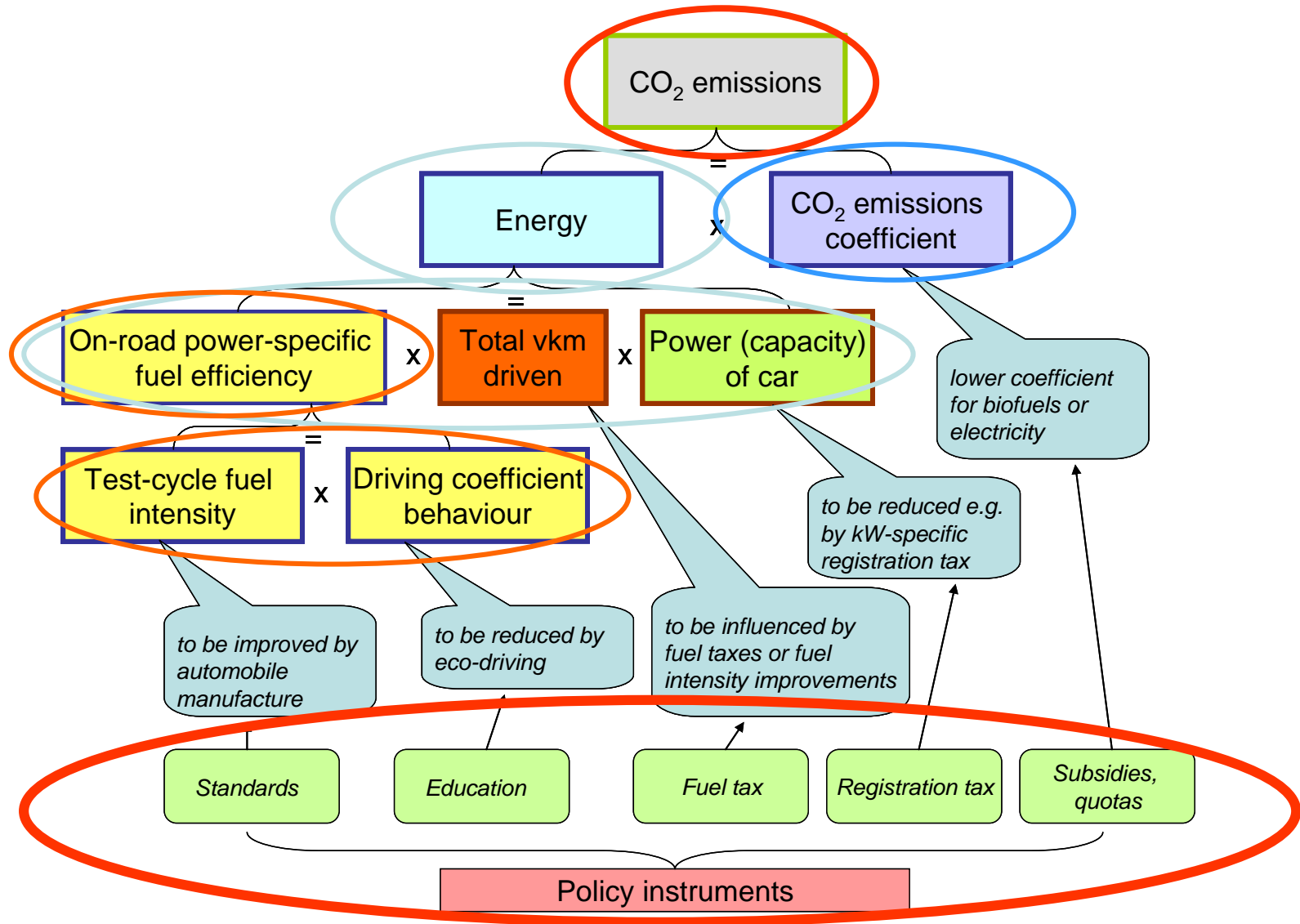
Car emissions



Policy instruments

Regulation	Monetary incentives	Information
<ul style="list-style-type: none">• Fuel efficiency standards	<ul style="list-style-type: none">• Energy efficiency or CO2 emission based element in the annual circulation tax	<ul style="list-style-type: none">• Car labelling based on fuel use or emissions
<ul style="list-style-type: none">• Pollutant emission regulations	<ul style="list-style-type: none">• Tax incentives for the purchase/first registration of efficient vehicles	<ul style="list-style-type: none">• Eco driving campaigns
<ul style="list-style-type: none">• Speed limits	<ul style="list-style-type: none">• Inclusion/exclusion in/for road pricing/congestion charging schemes	

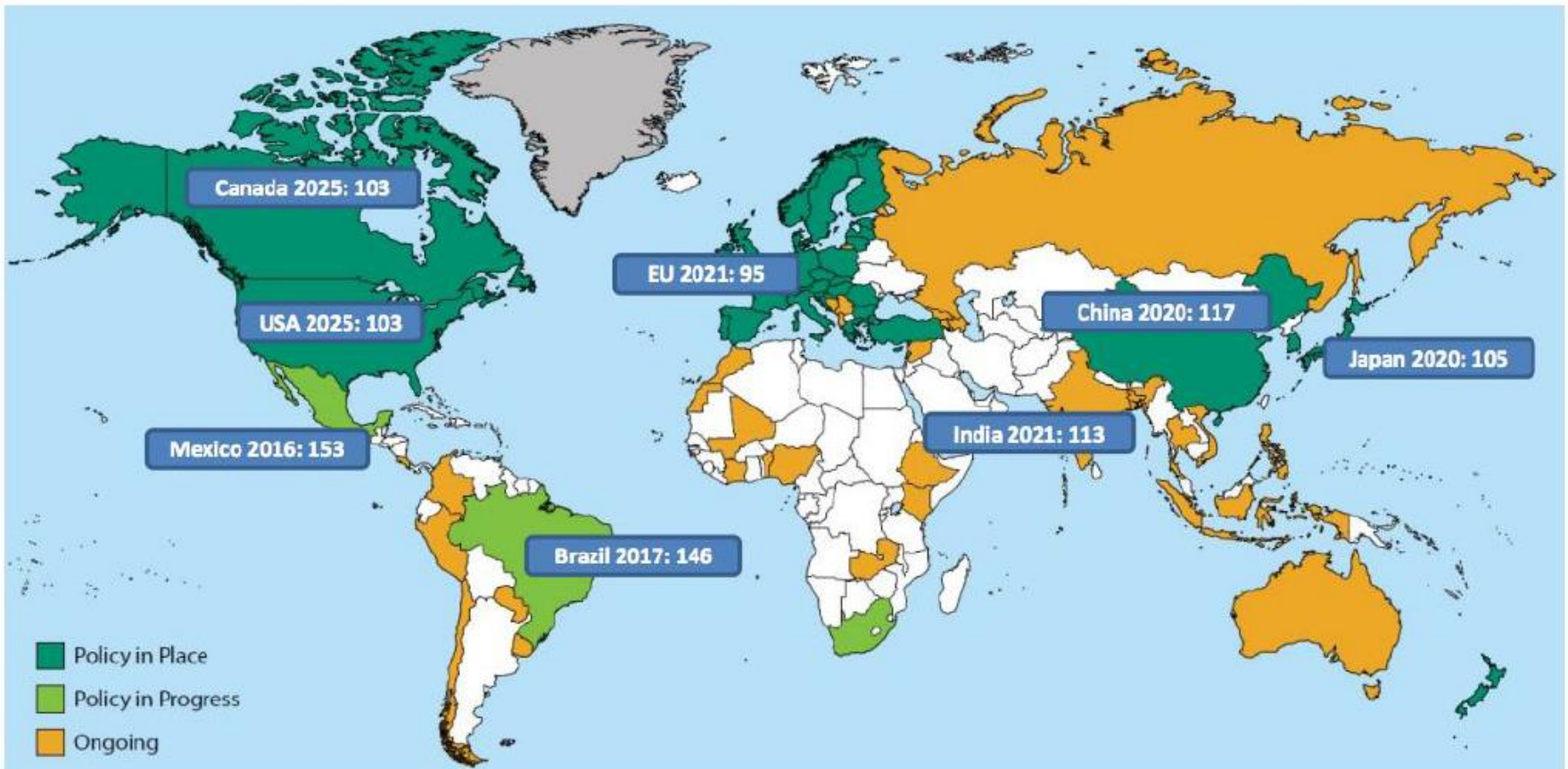
CO₂ emissions in passenger car transport



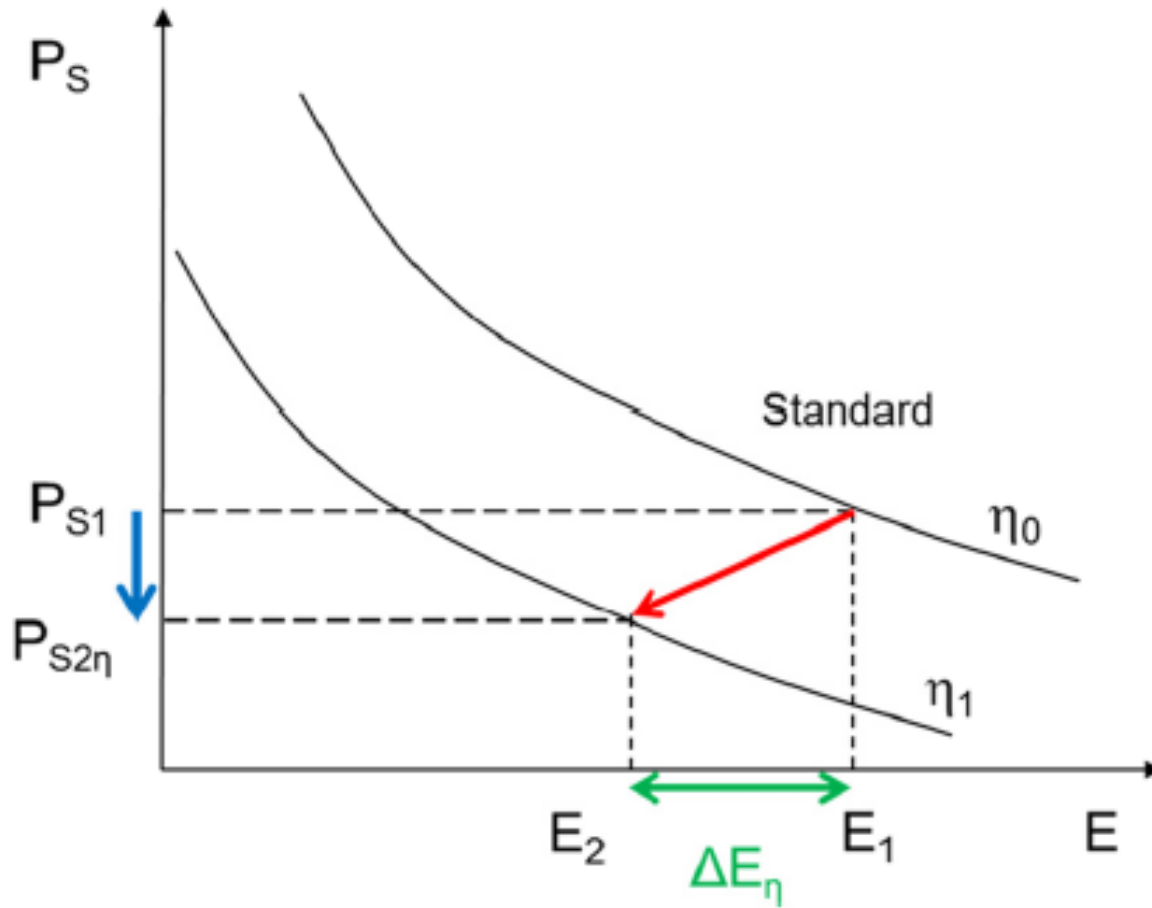
Impact factors on CO₂ emissions in the car passenger transport

Standards

Fuel economy standards have been enforced in several countries

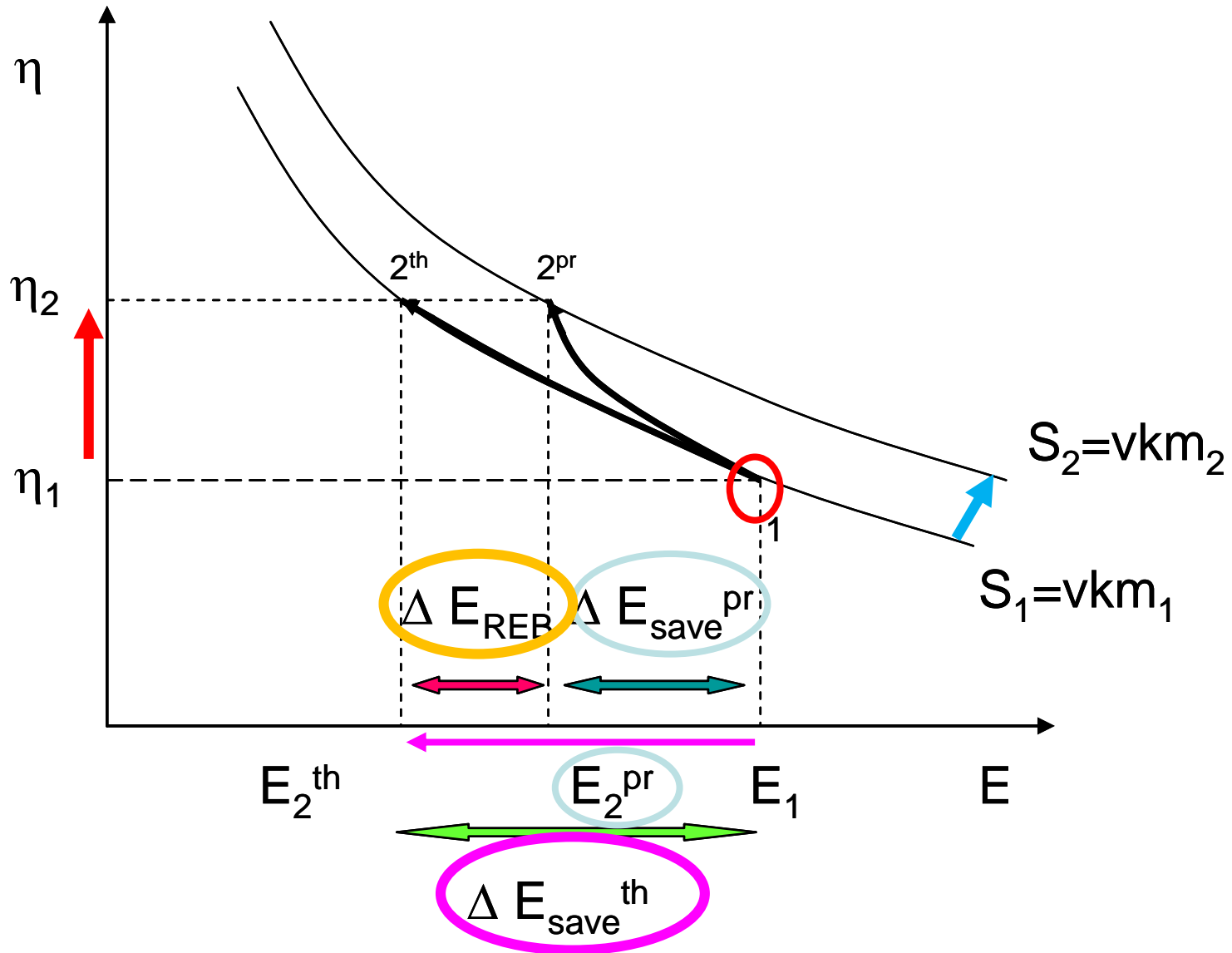


Standards

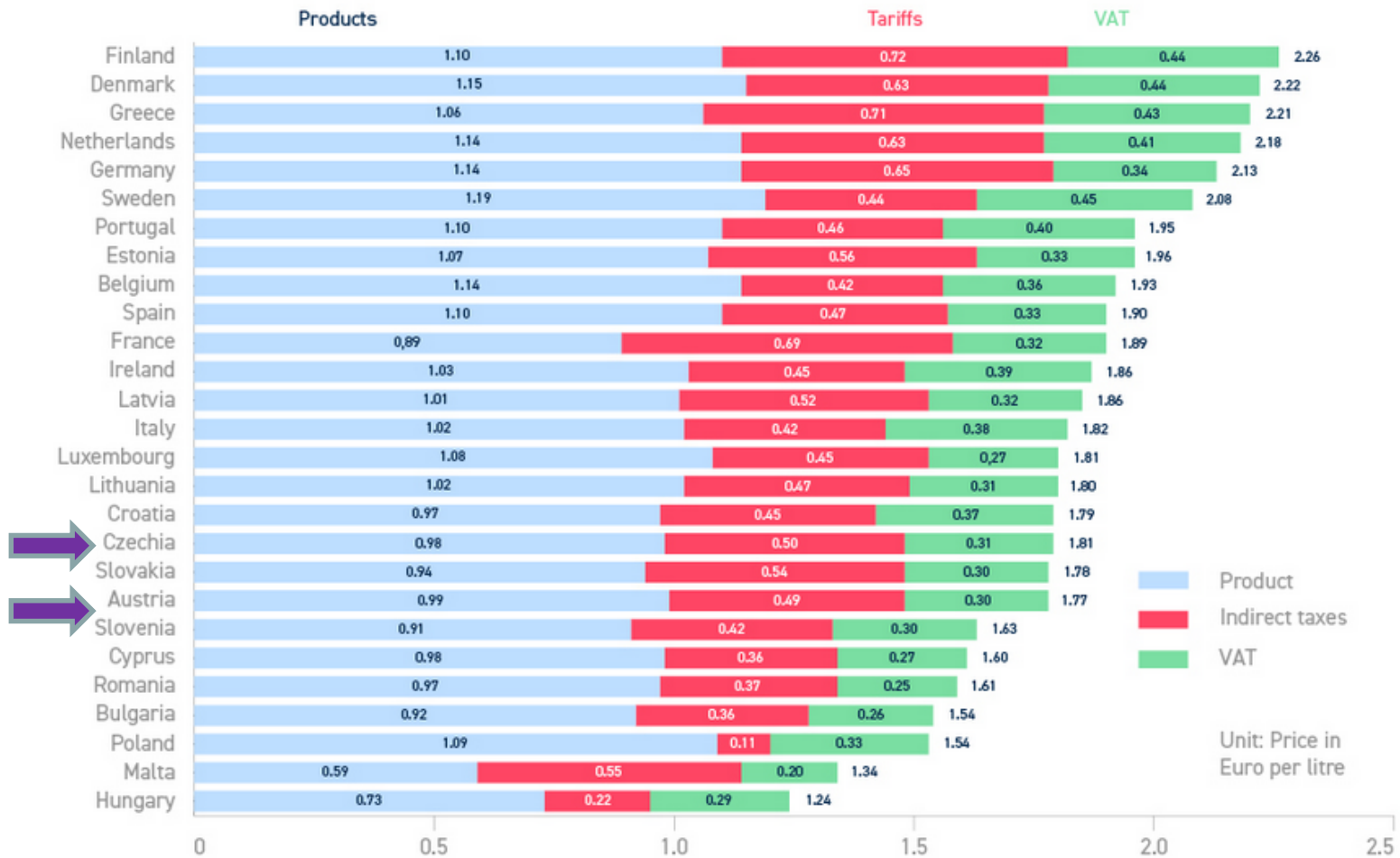


How a standard works

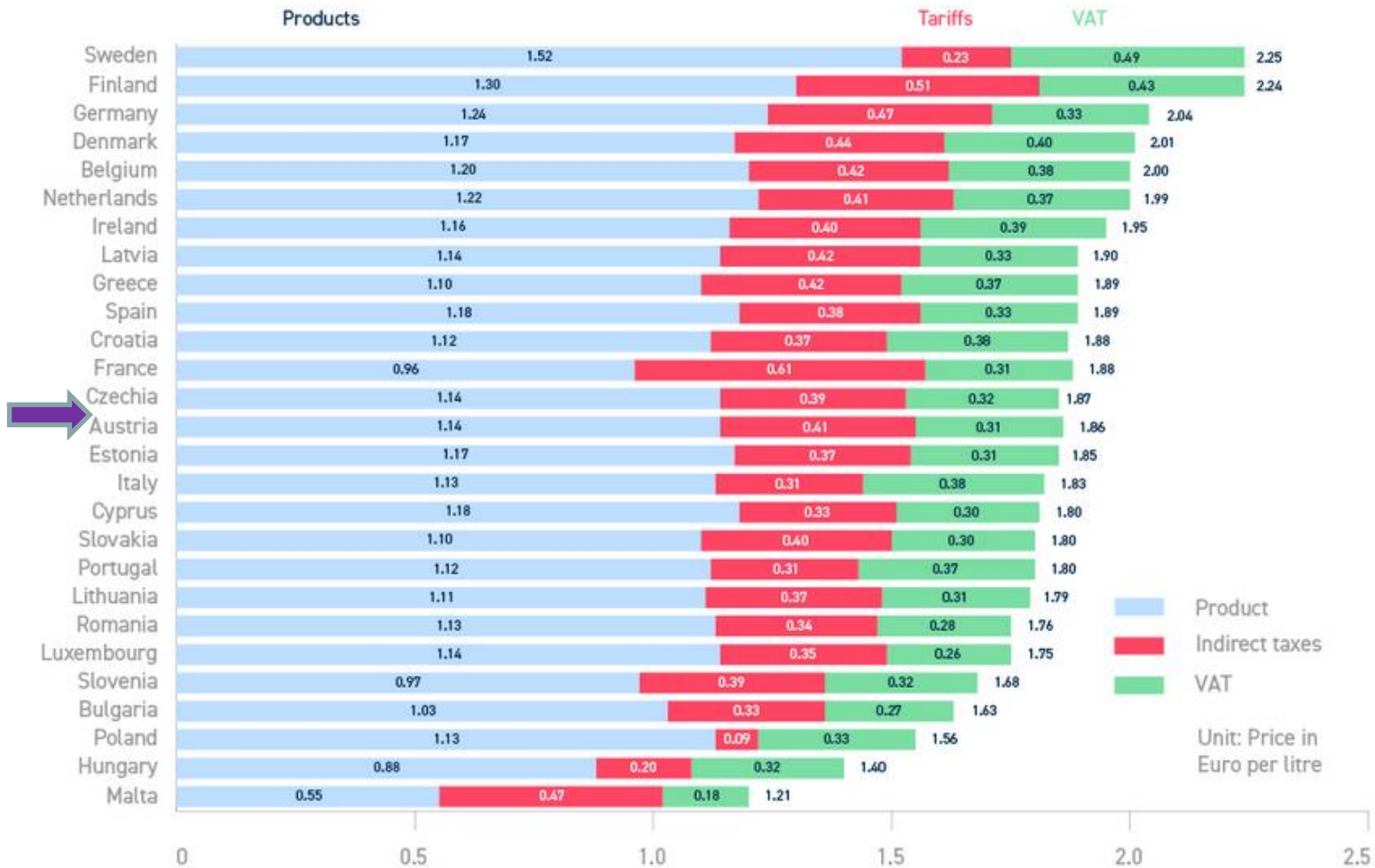
Rebound effect



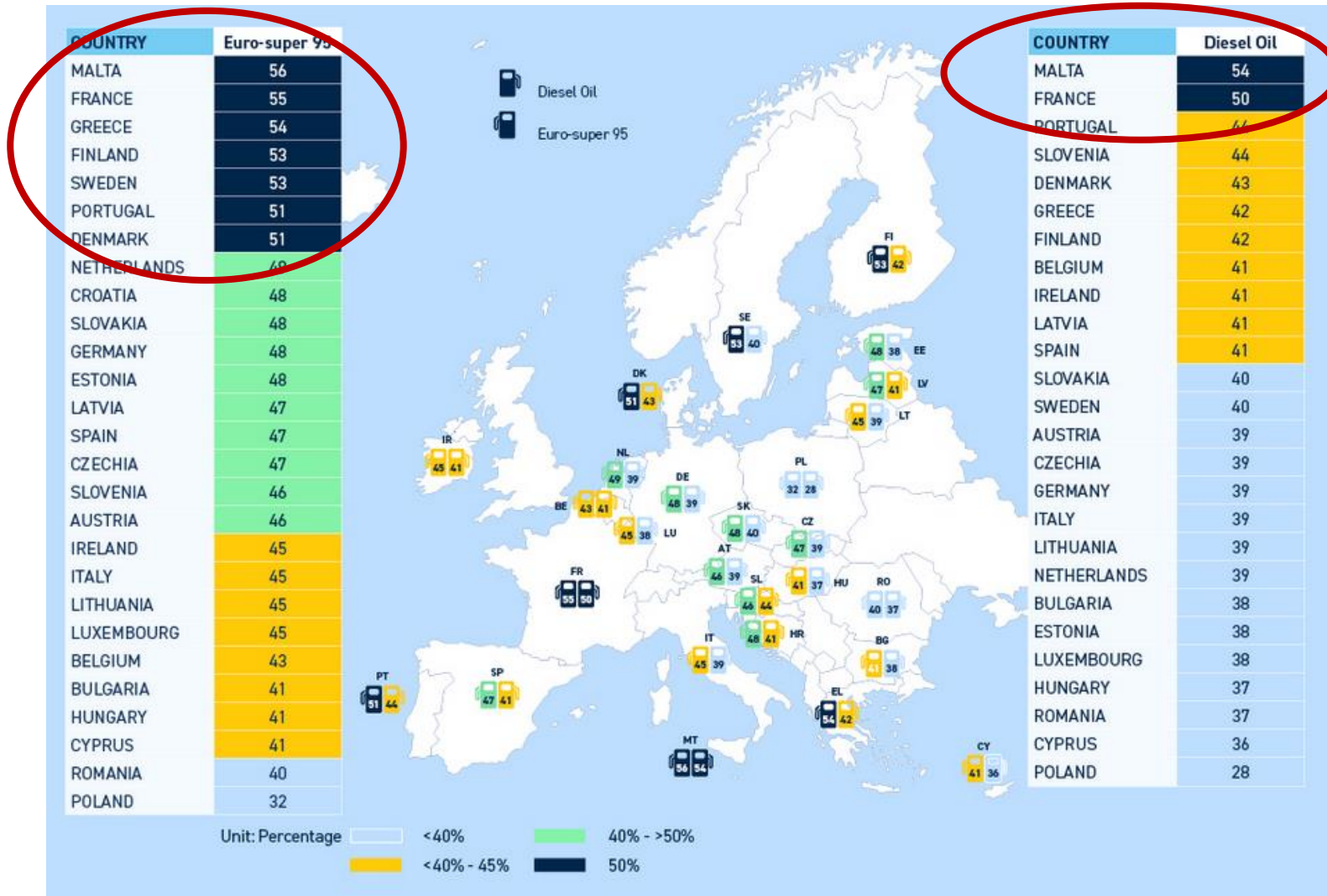
Price structure of gasoline, May 2022



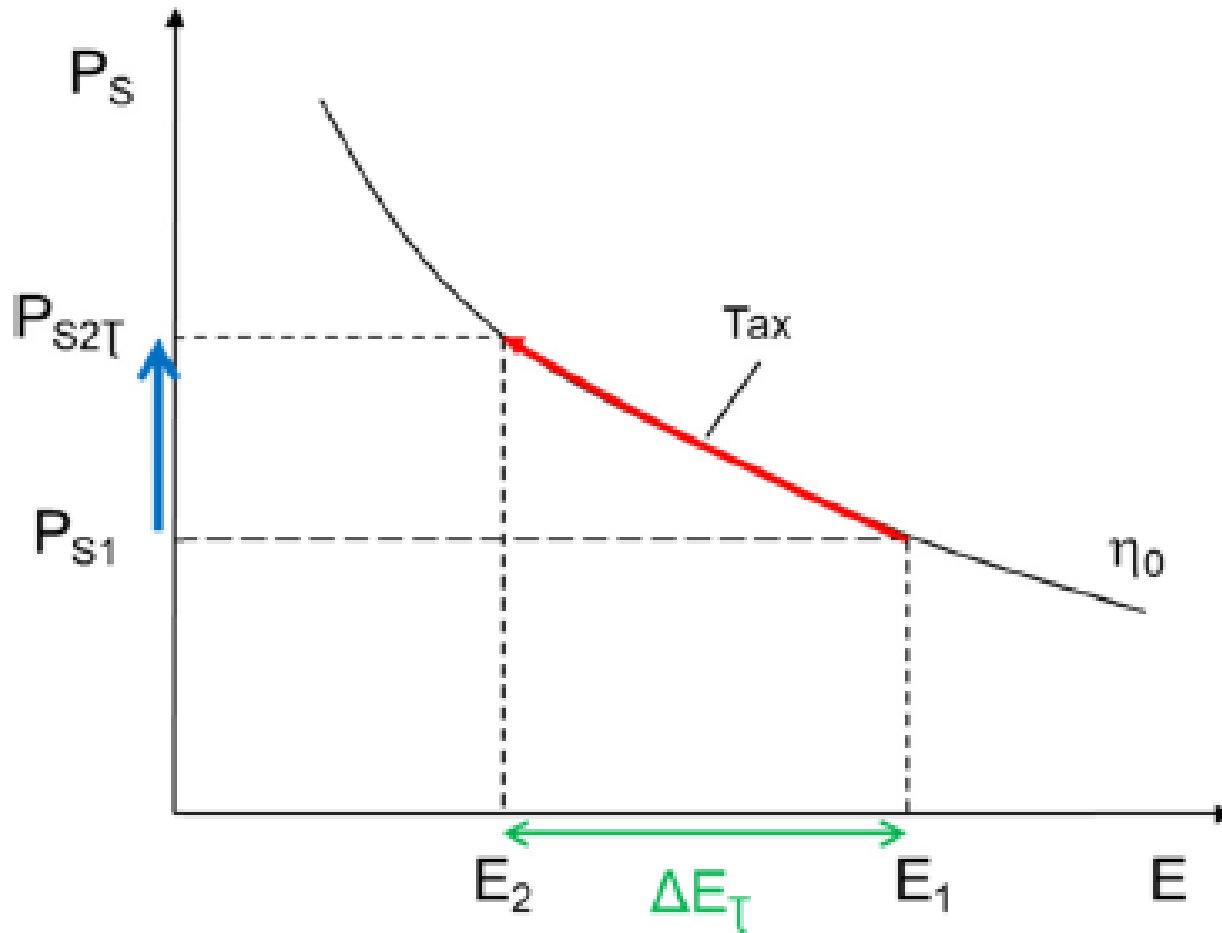
Price structure of diesel, May 2022



Total taxation share in the end consumer price

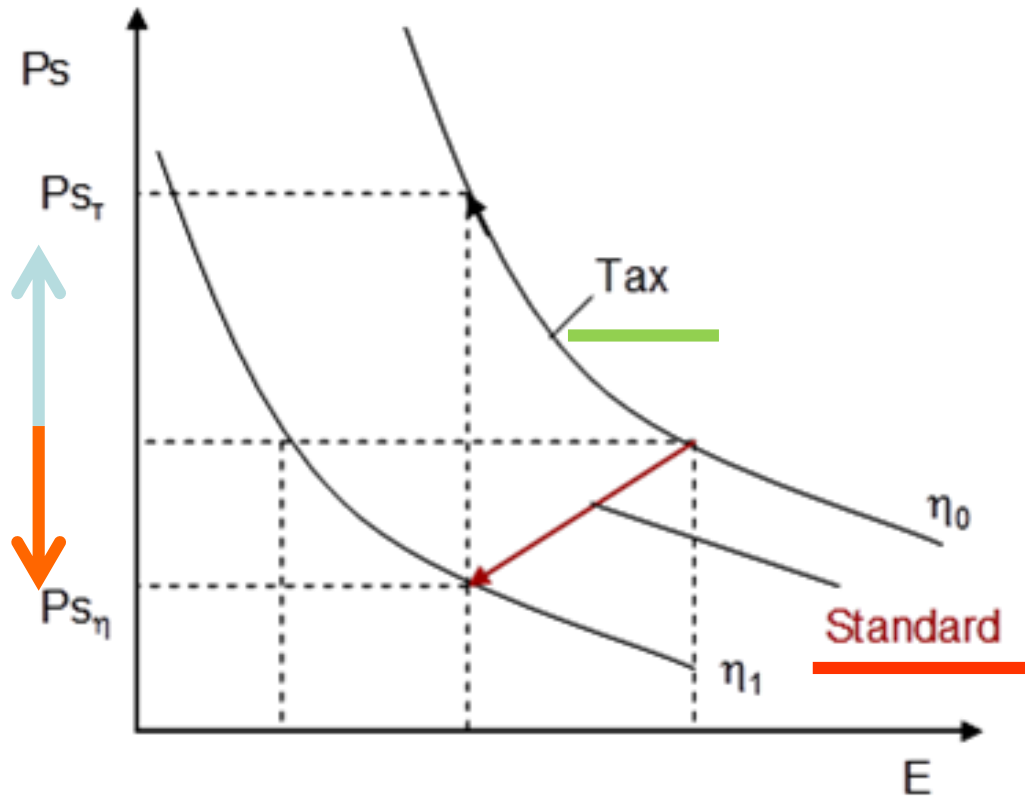


Tax

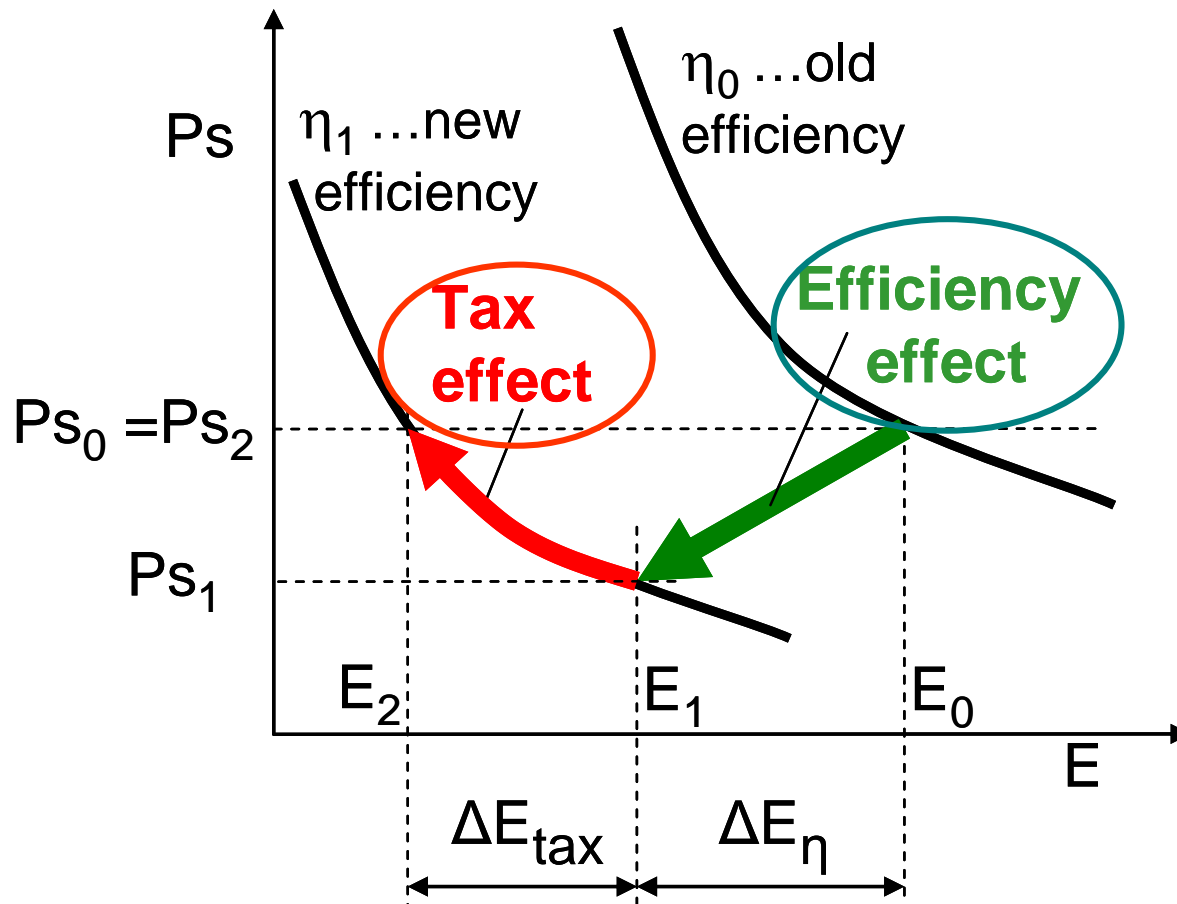


How a tax works

How a tax vs a standard works

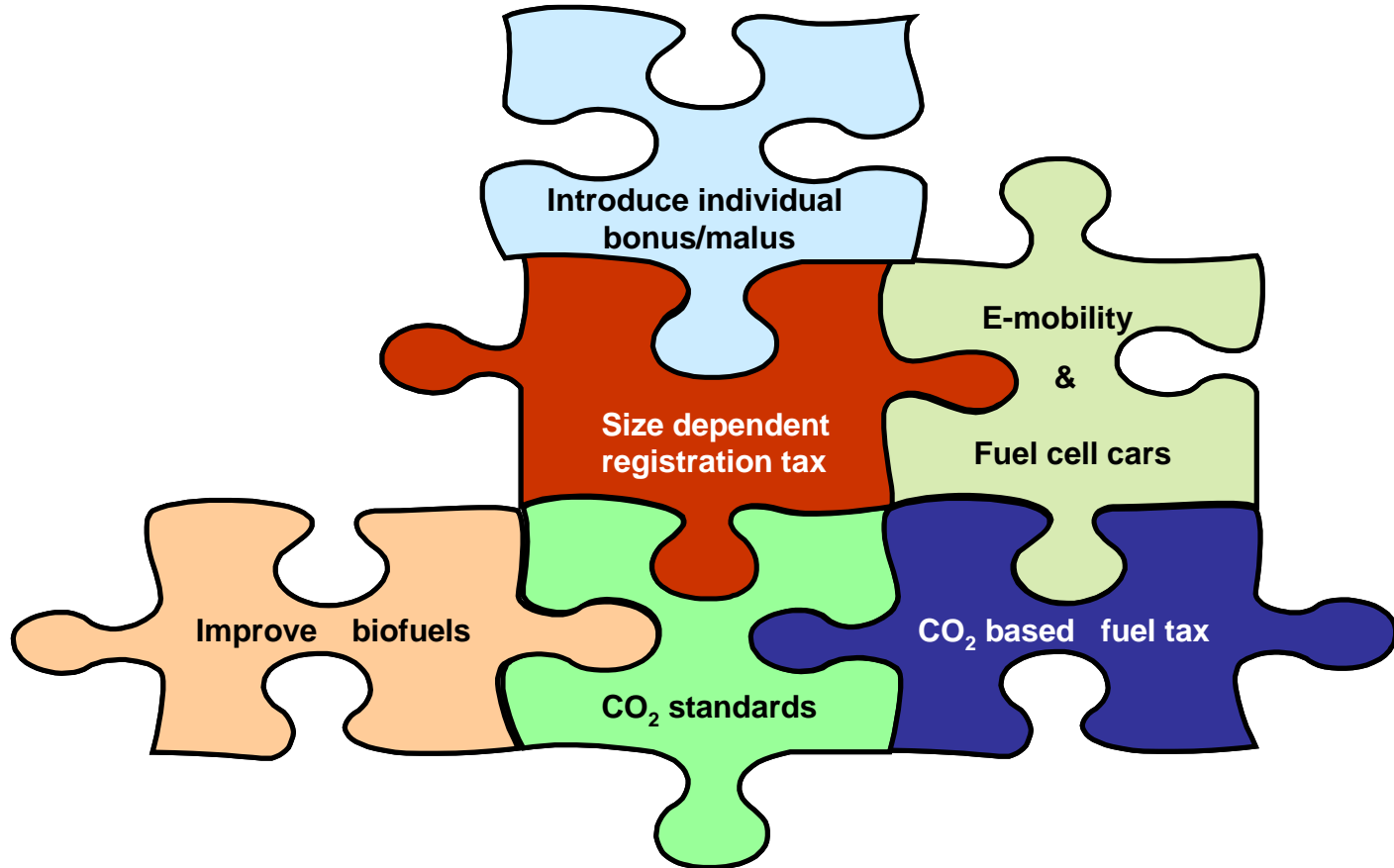


Standards & taxes



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

Conclusions



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