Introduction:
Energy Economics in Transport

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

1. Introduction

Basic principle:

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

Service:
km driven

Fuel mix

Efficiency:
Liter/100 km

Infrastructur

Transport modes

Transport modes

Air

Rail

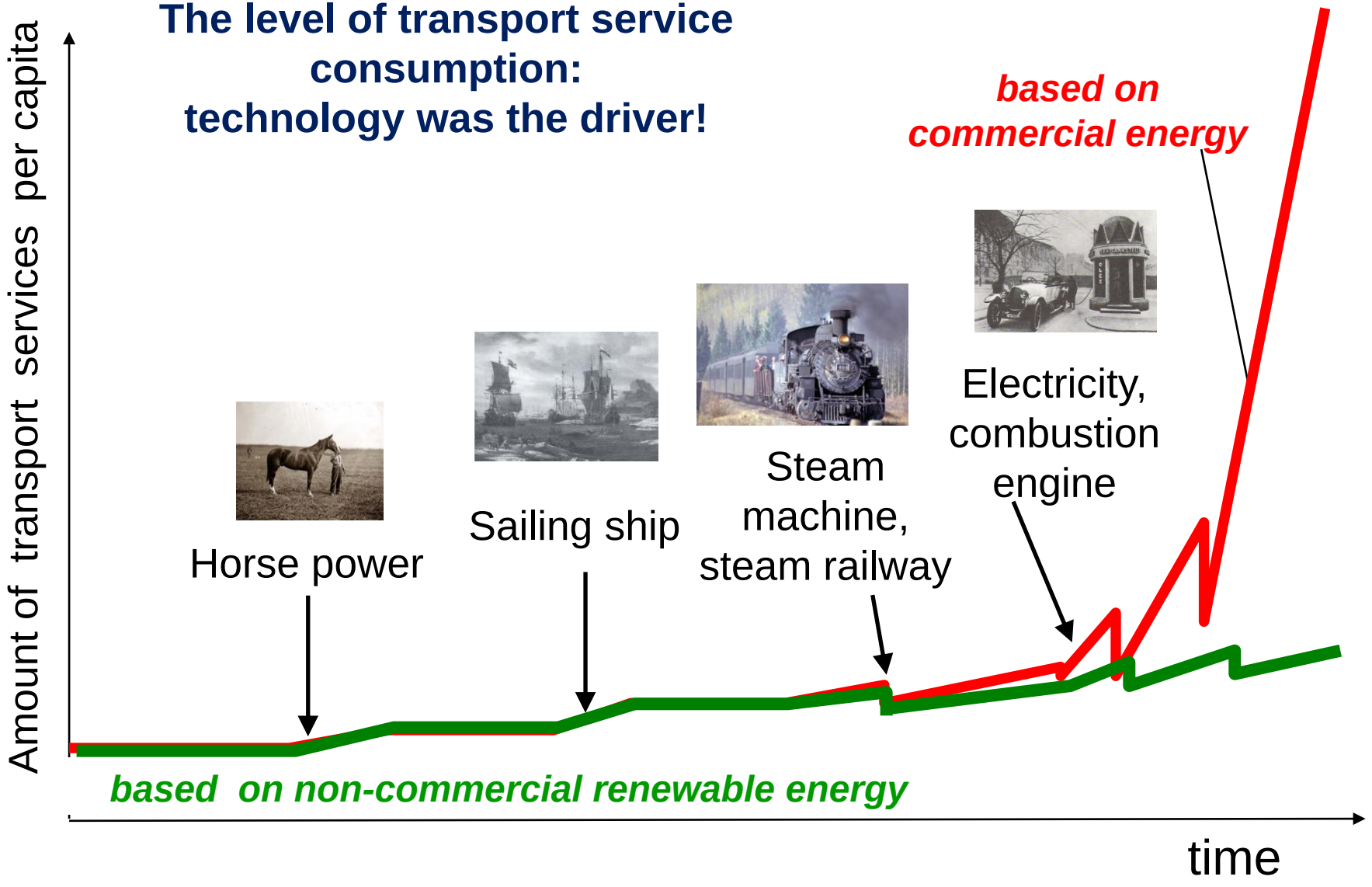
Maritime

Inland waterways

Road

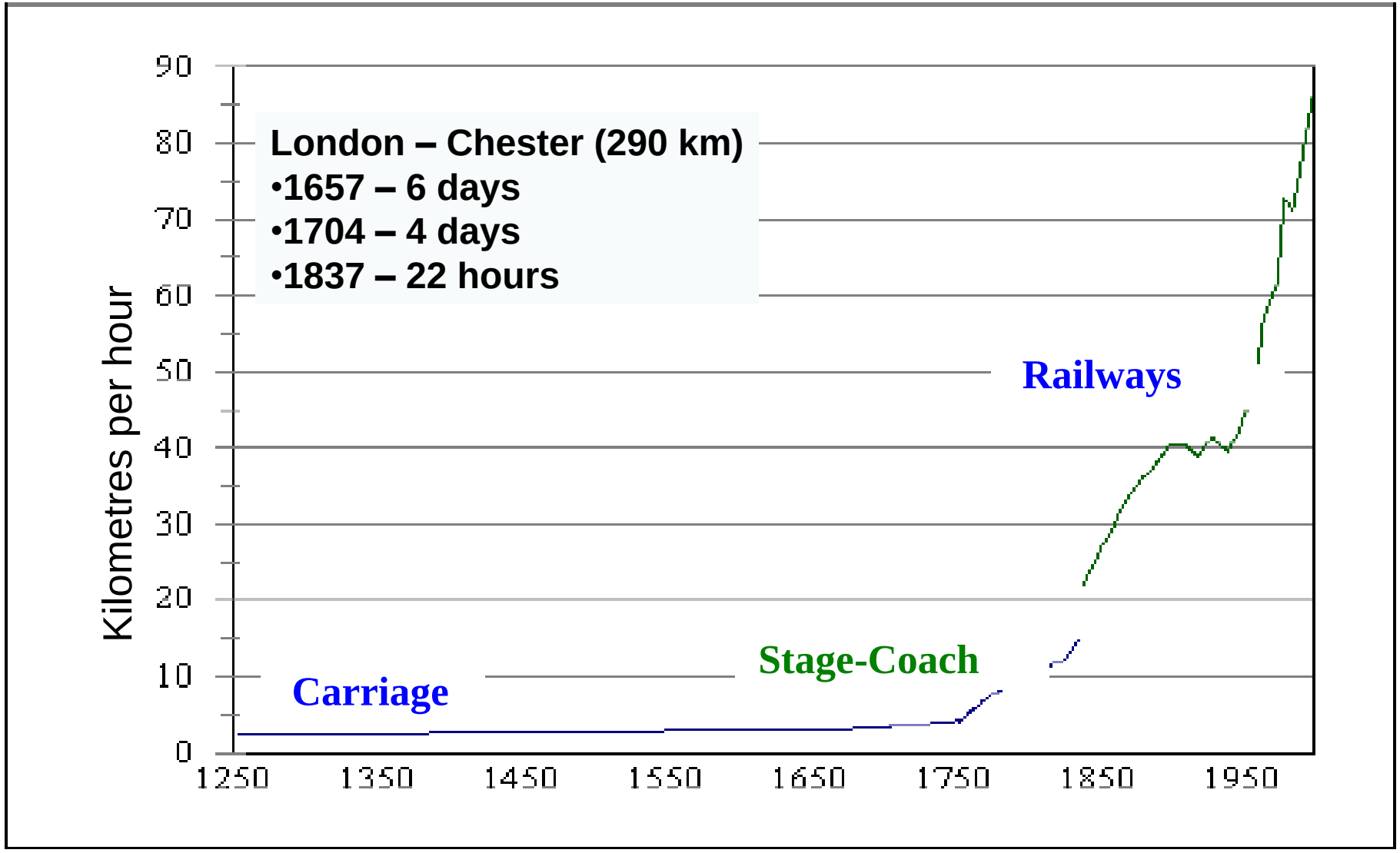
Historical developments

Introduction



The Speed of Transport

(Kilometres per Hour)

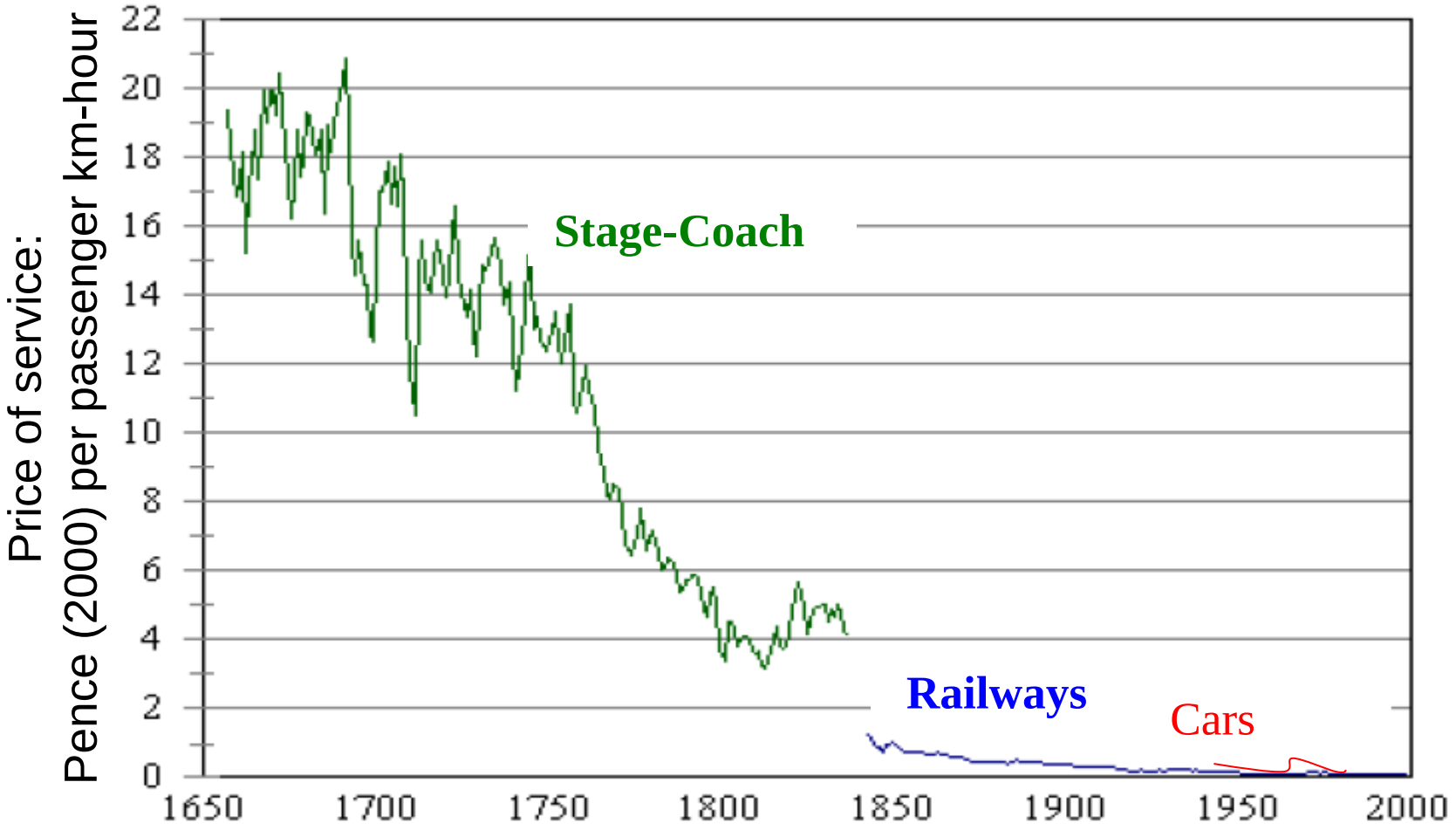


Source: Fouquet,2003

Price of Passenger Transport

(per passenger-kilometer-hour)

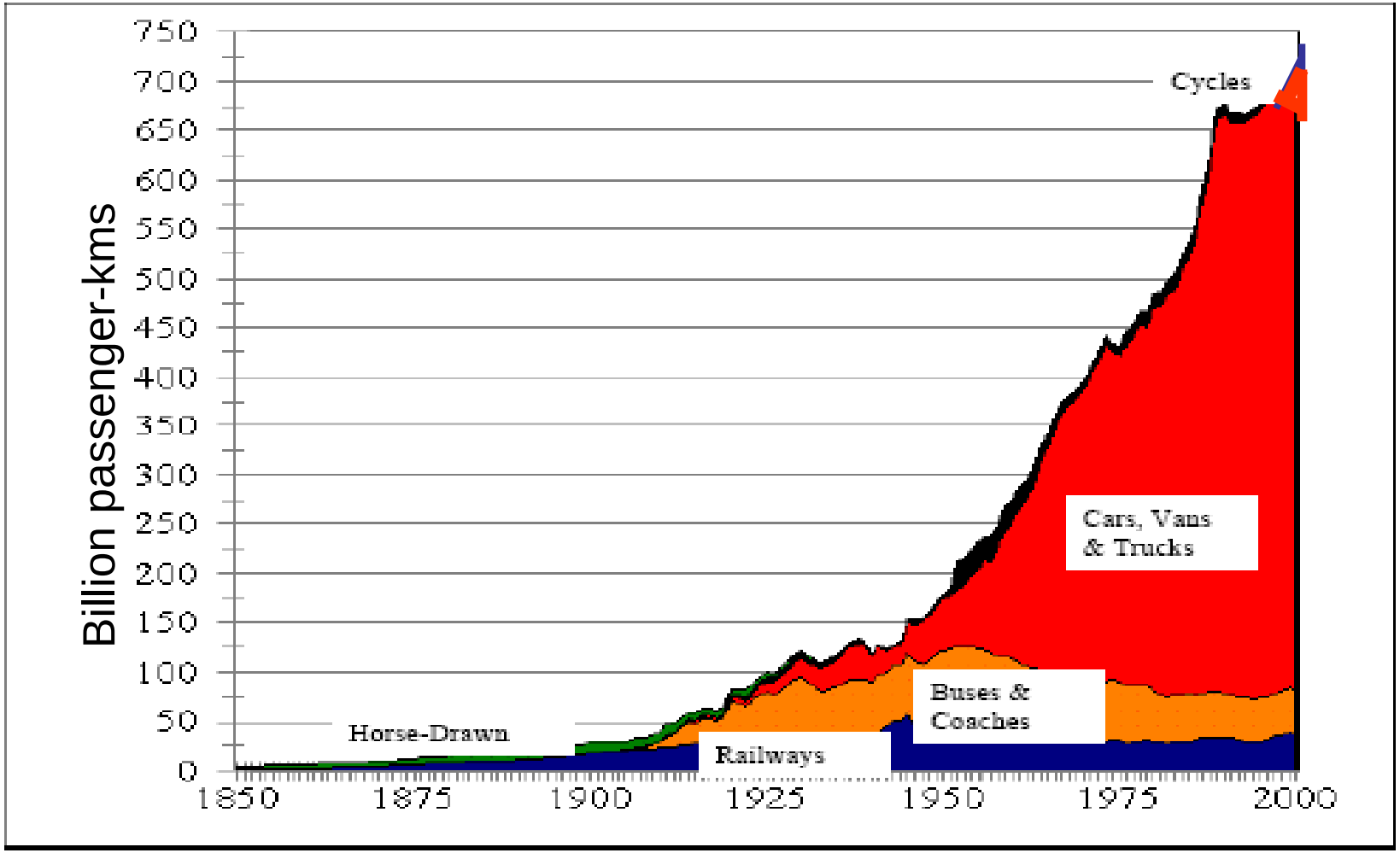
The price of service dropped dramatically!



Source: Fouquet&Pearson (2003)

UK: The Use of Passenger Transport

(per Passenger-Kilometre), 1850-2000



Source: Fouquet,2003

Energy for Transportation

Fast facts

Energy for Transportation

Over 90% of transportation is fueled by oil, and transportation accounts for almost **two thirds** of the oil used worldwide.

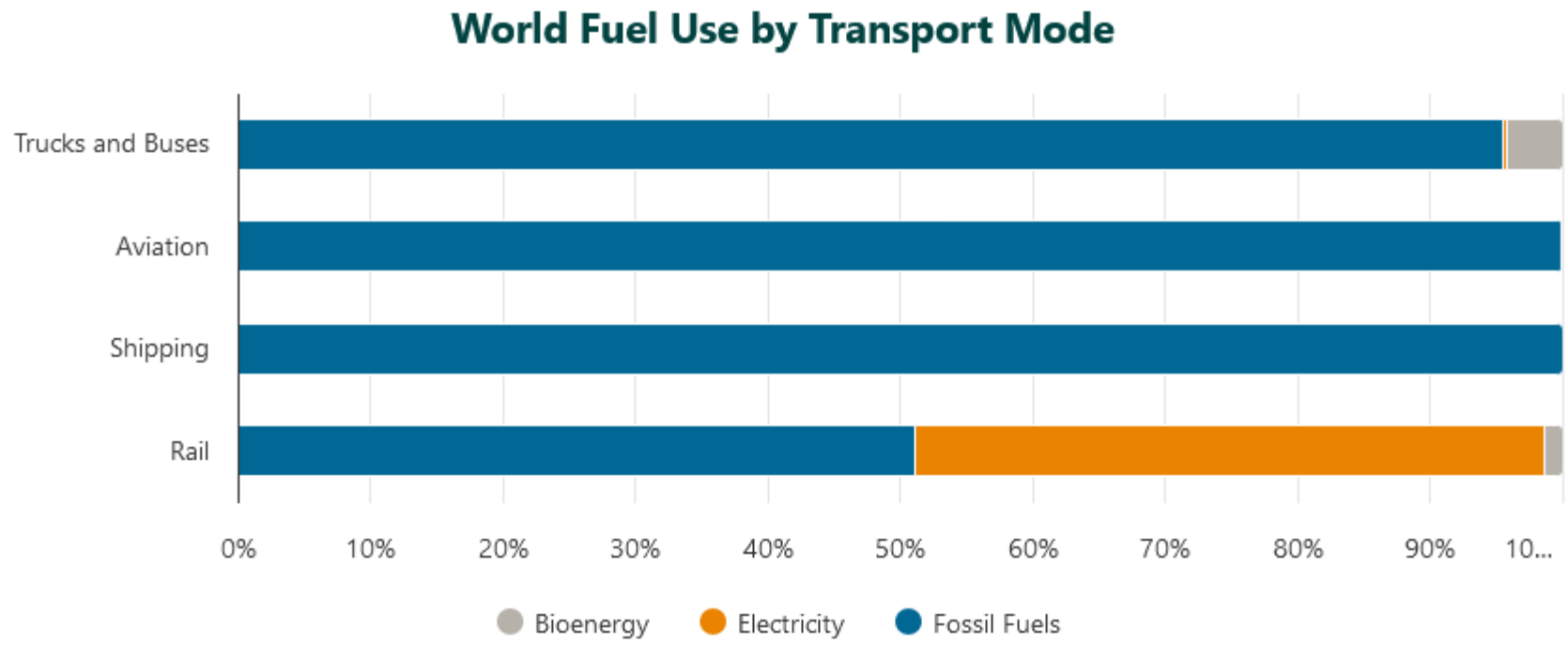
Transportation is responsible for 16% of global greenhouse gas (GHG) emissions and is a major contributor to other air pollutants that affect human health.

Total Energy Consumption

World 28% 🌎

of total **final** energy consumption is used in transportation

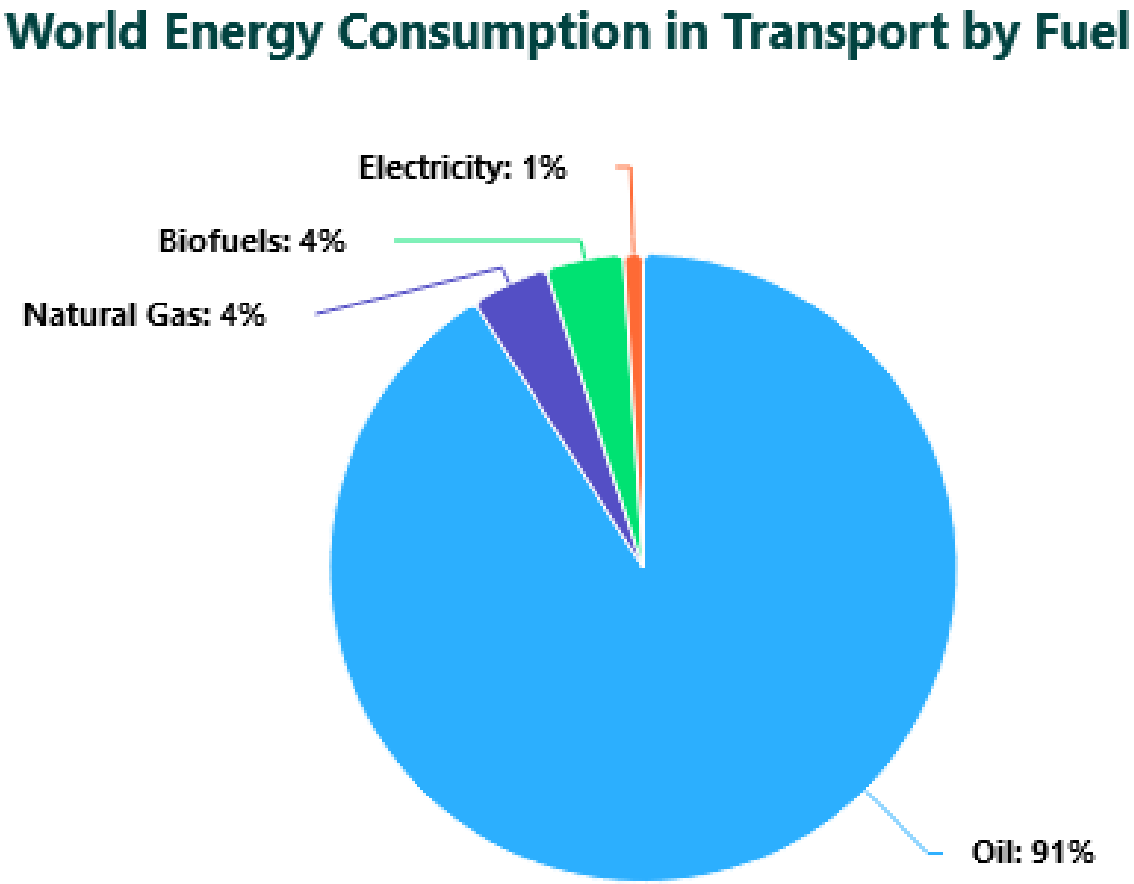
Fuel use: worldwide, 2022



Bar chart showing world fuel use by transport mode in 2022. This includes passenger and freight transport.

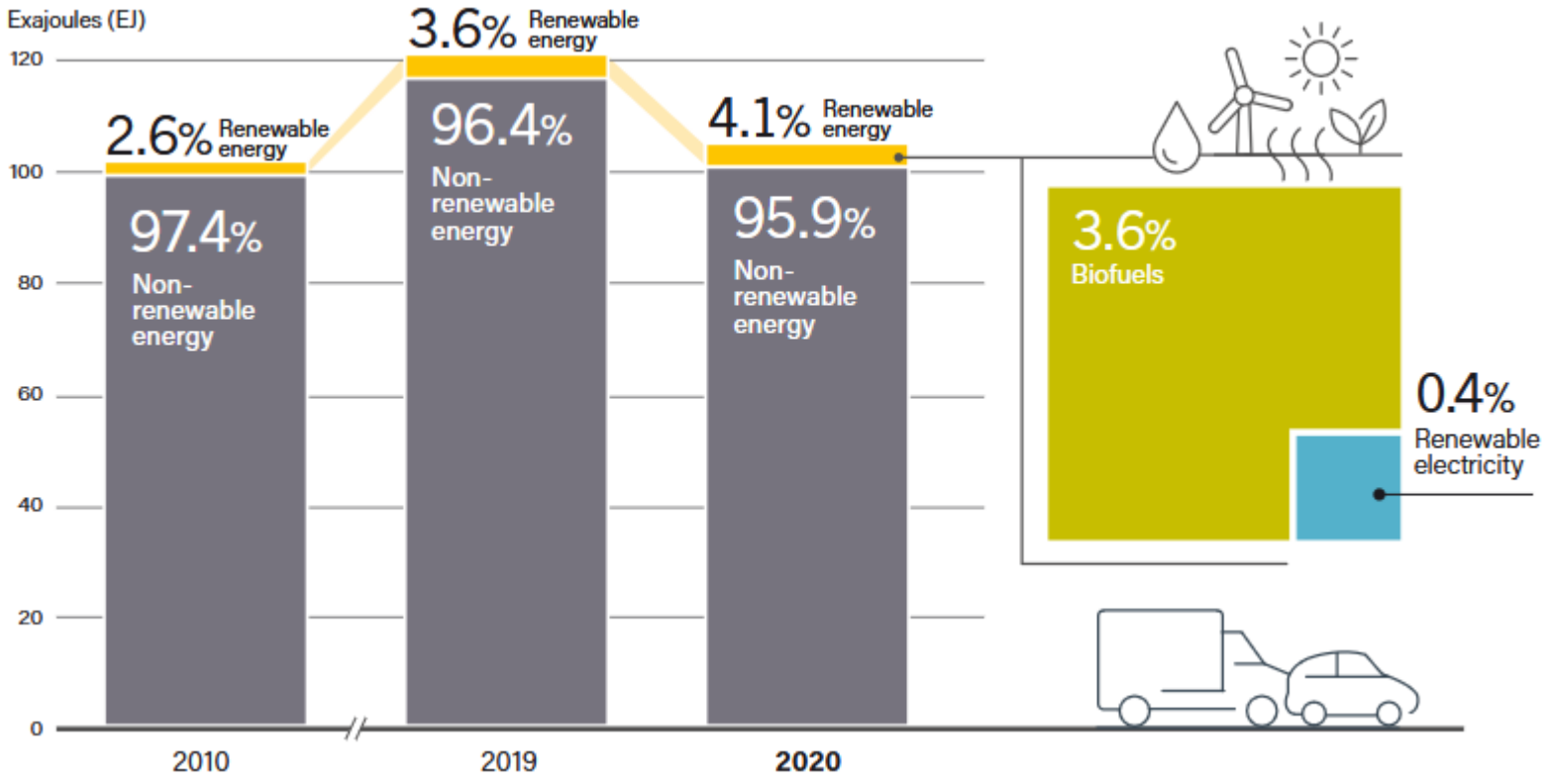
Highcharts.com

Oil Dominates Transport Fuels



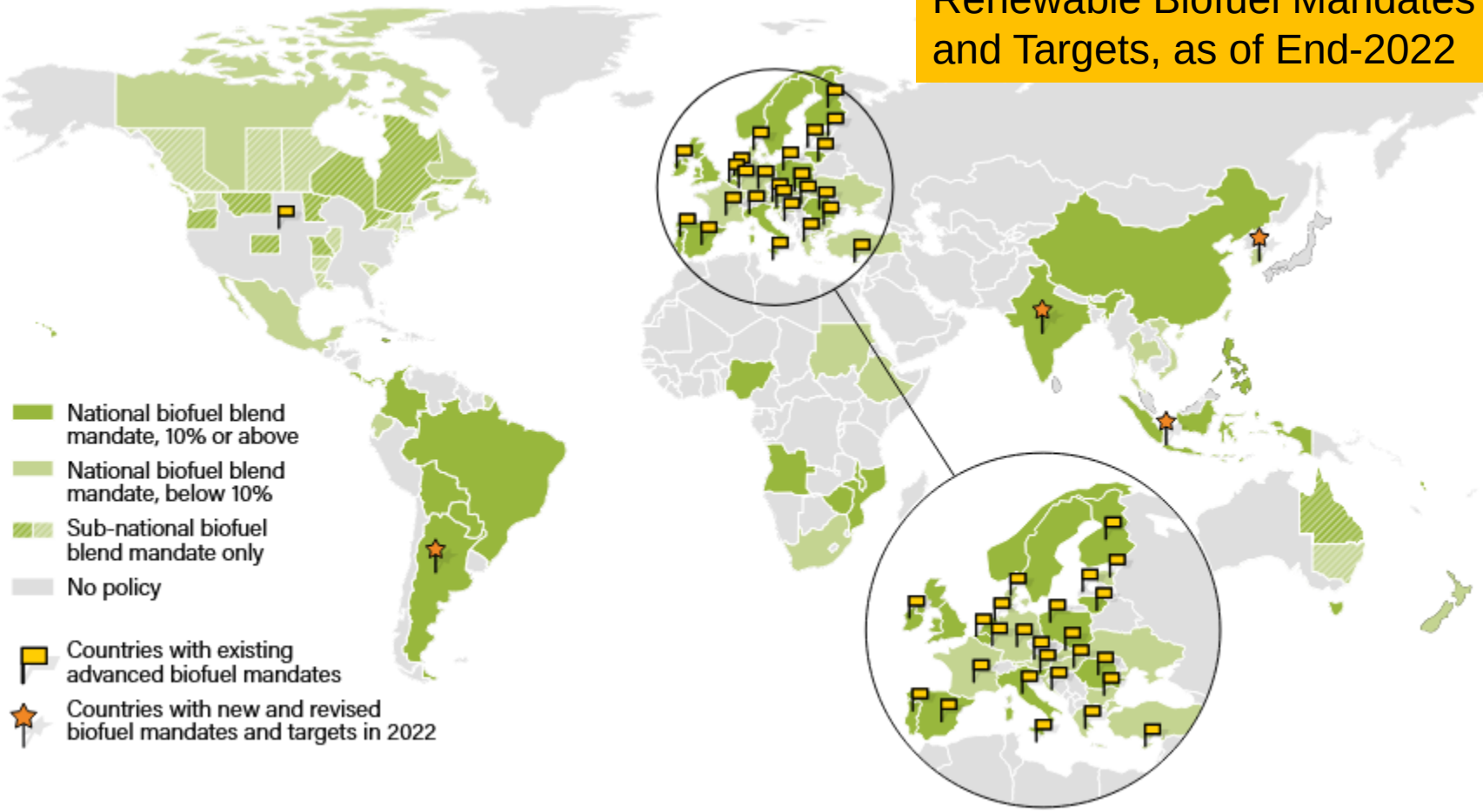
Alternative fuels

Renewable Share of Total Final Energy Consumption in Transport

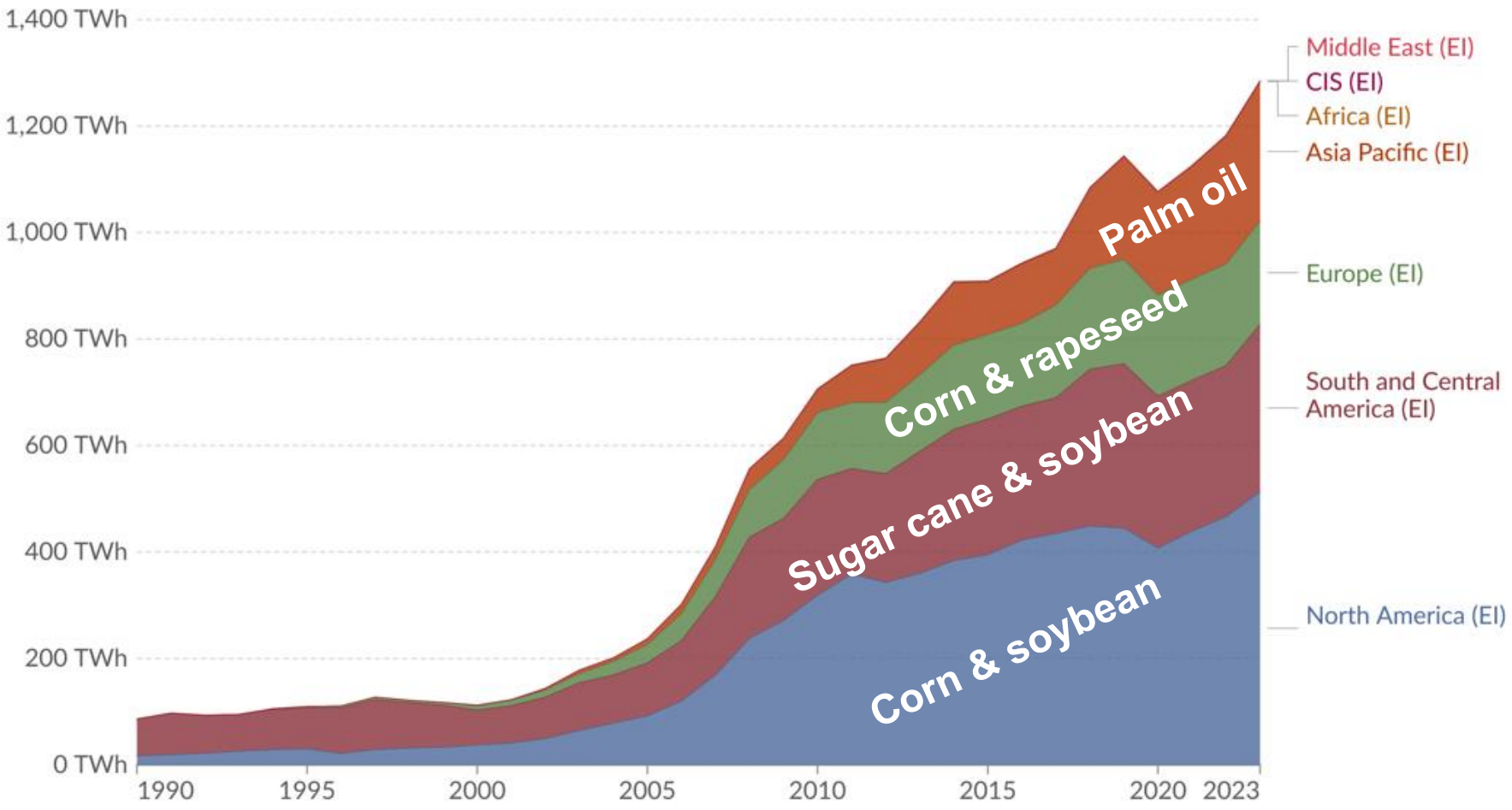


Biofuel blending mandates

National and Sub-National Renewable Biofuel Mandates and Targets, as of End-2022



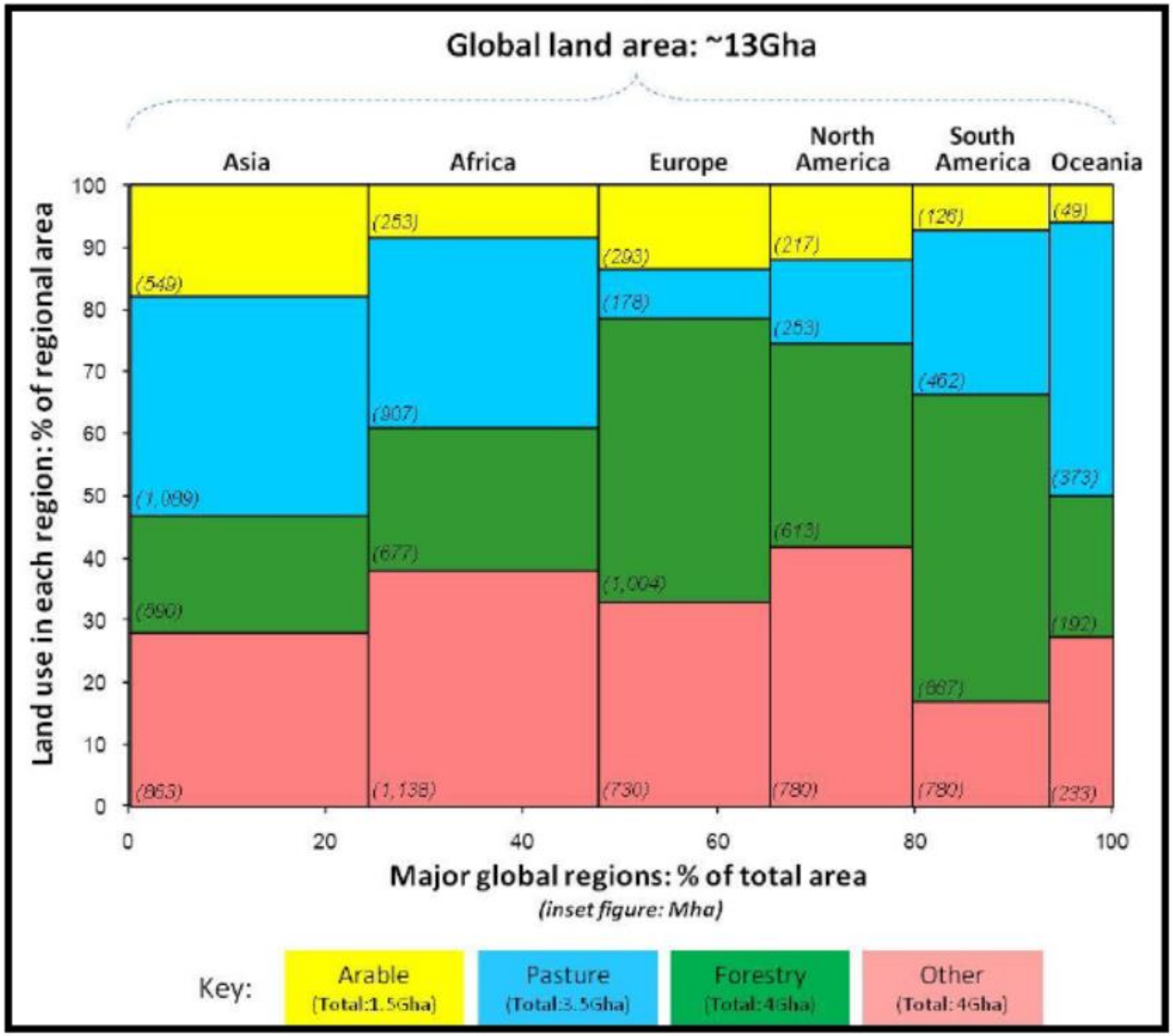
Biofuel production by region



Data source: Energy Institute - Statistical Review of World Energy (2024)

OurWorldinData.org/renewable-energy | CC BY

World land use



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

Fuel vs food

EU targets

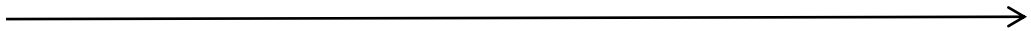
European Green Deal

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

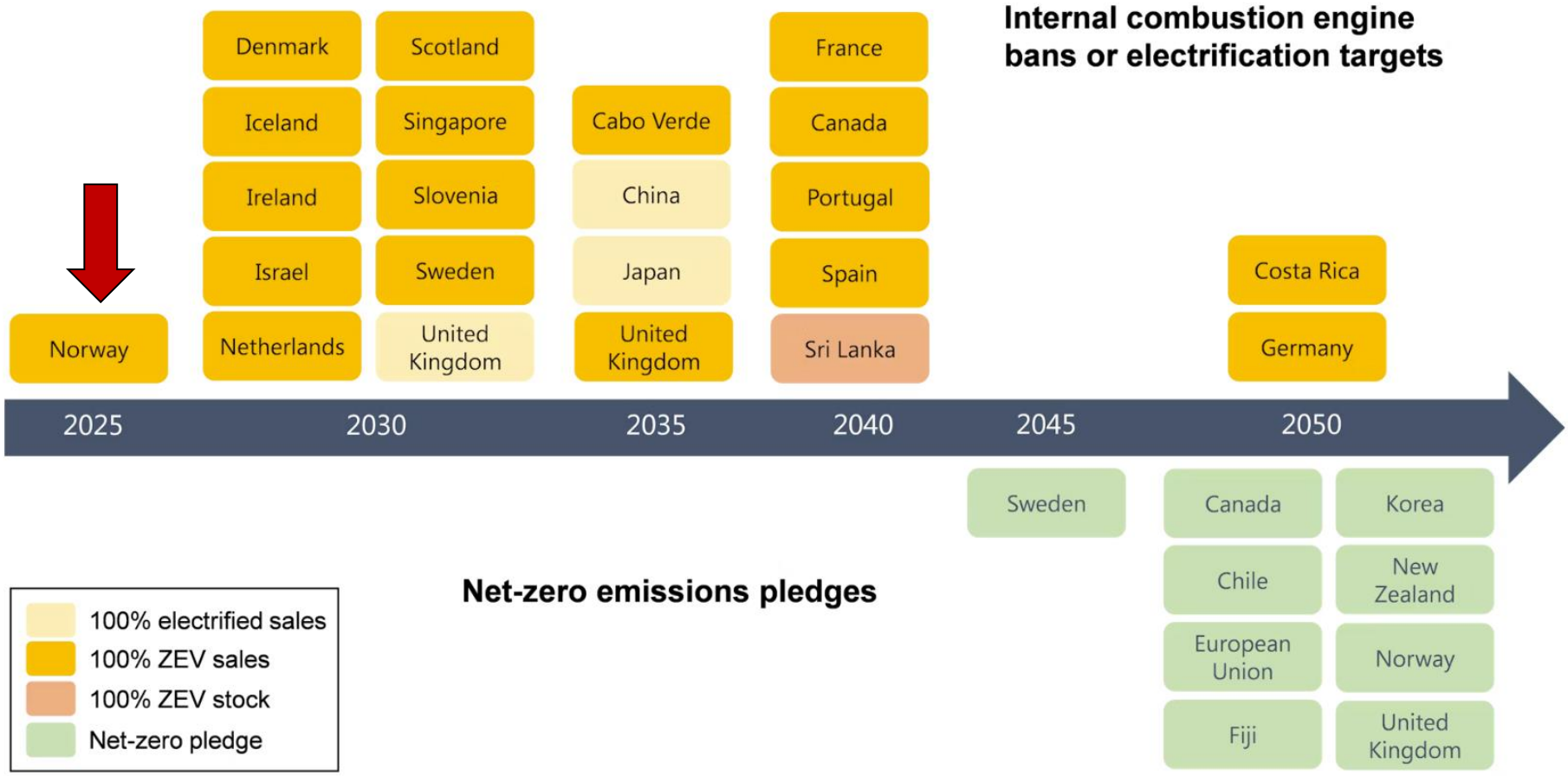
nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission.



2030

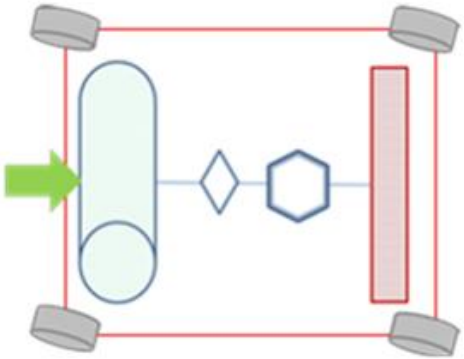
2050

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

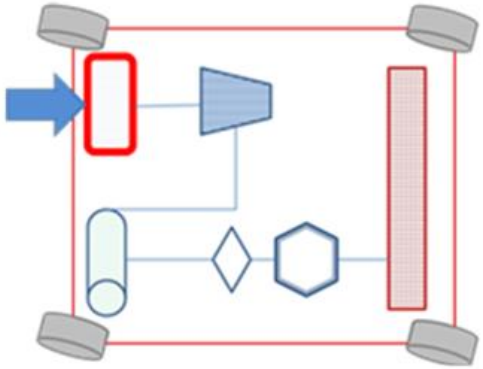


IEA

Zero-emission cars



BEV

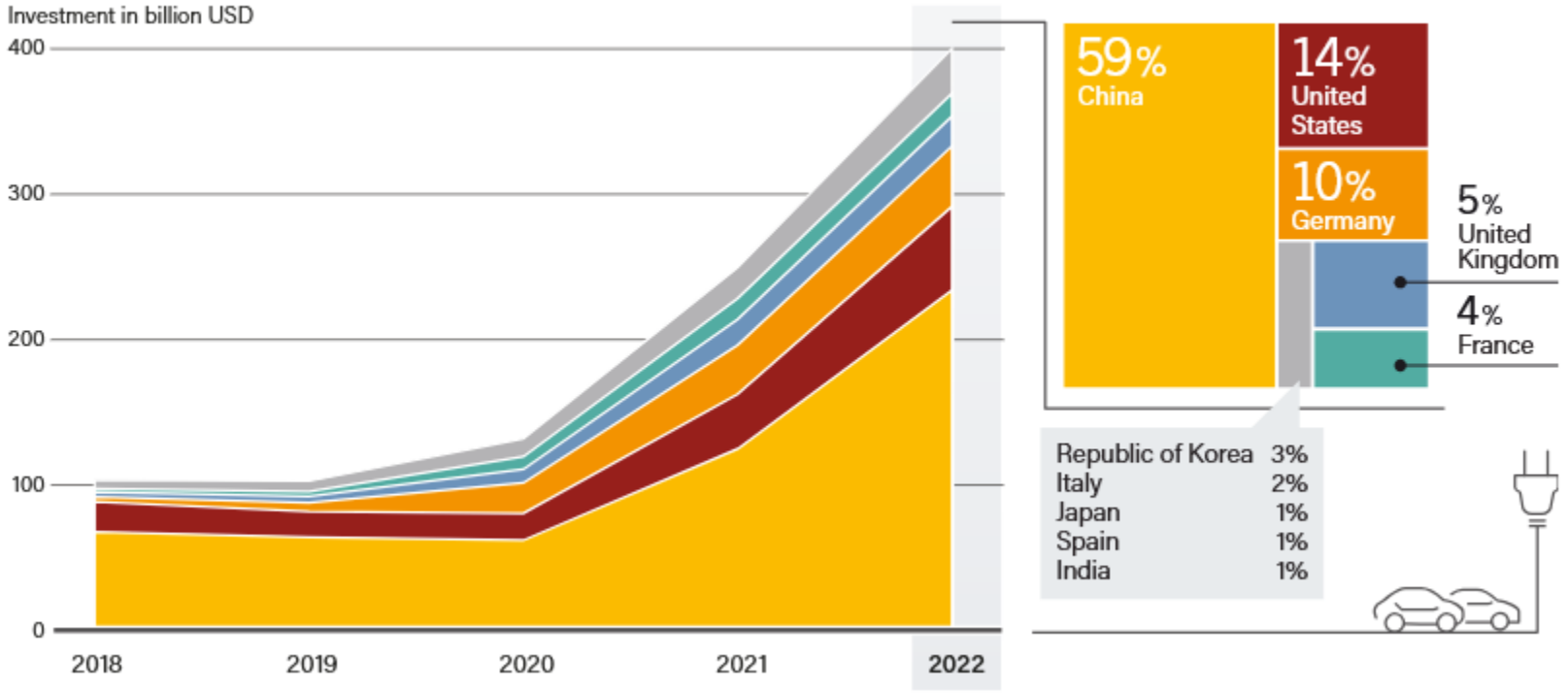


FCV

ZEV

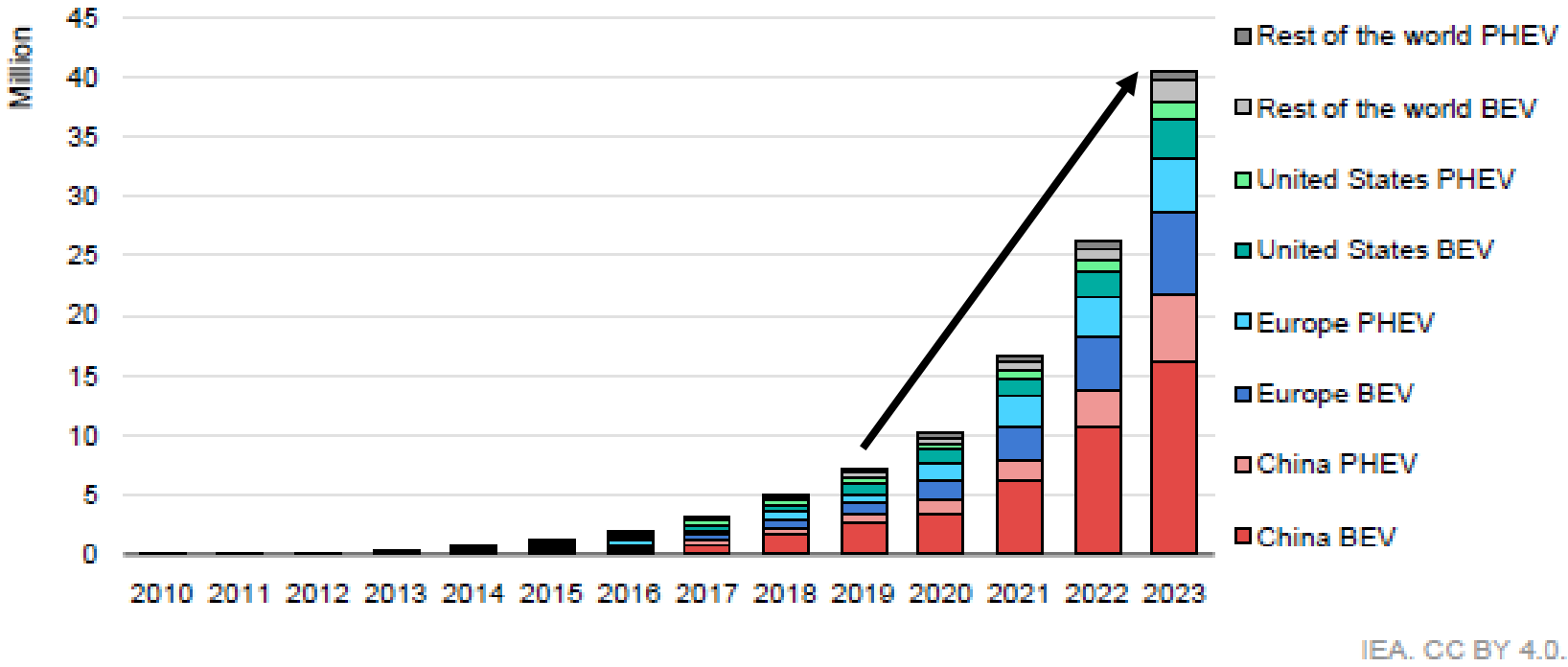
BEV: 28 000 000
FCV: 66 000

Investment in EV by Major Country



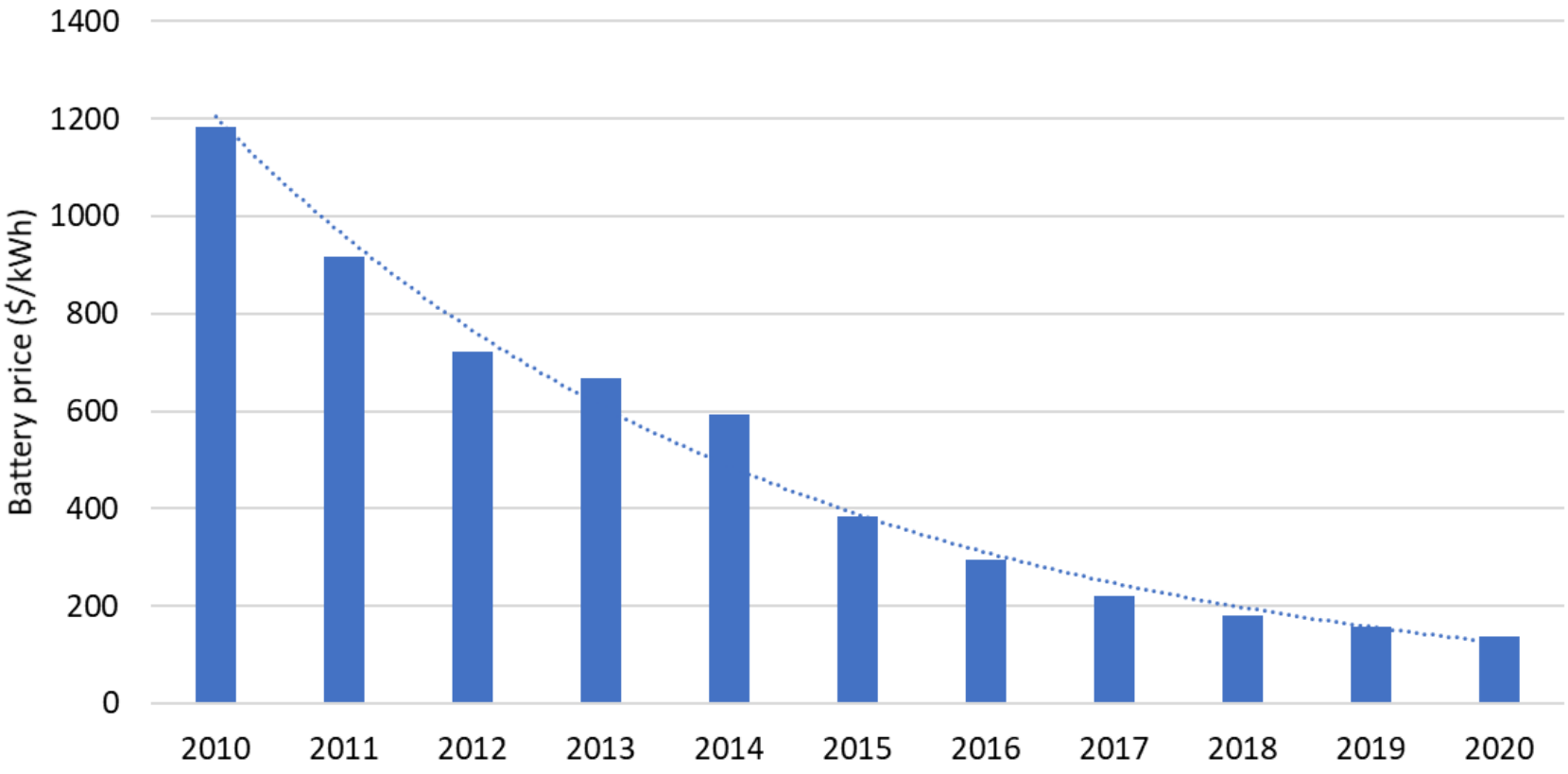
Electric vehicles

BEV: 28 000 000
PHEV: 12 000 000

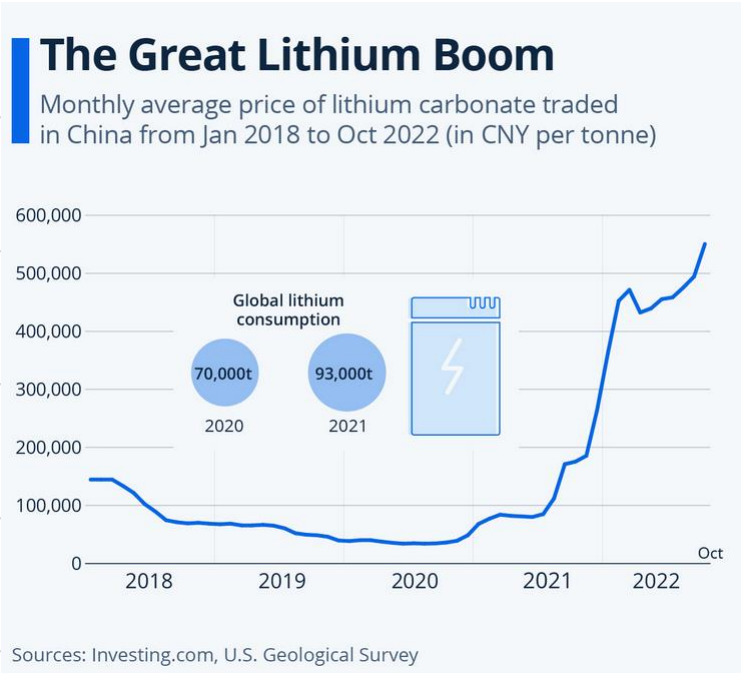


Over 40 million electric cars were on the road in 2023

Battery pack prices



Development of the battery pack prices



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]

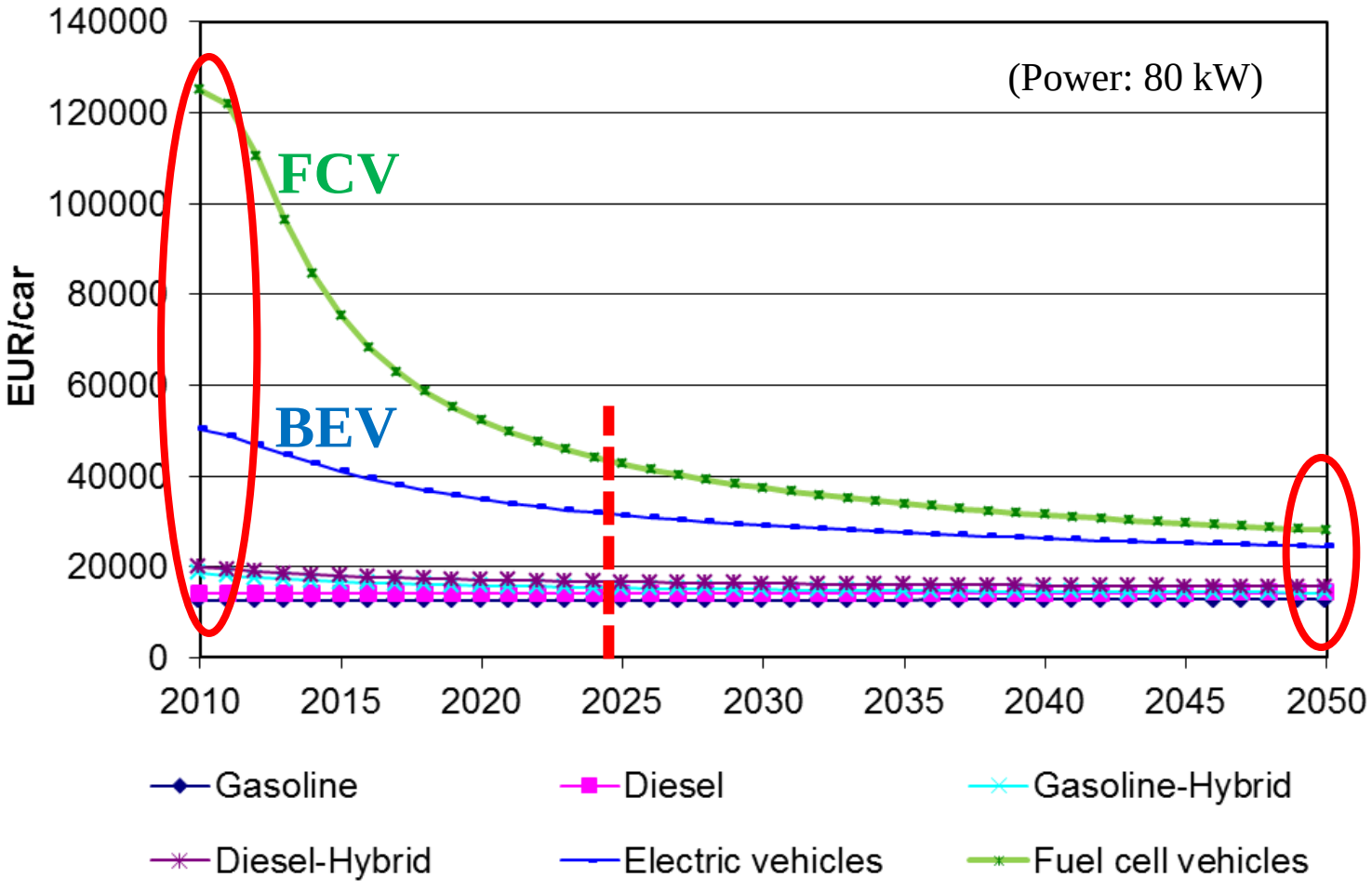
IC……investment costs [€/car]
α……..capital recovery factor
skm…..specific km driven per car per year [km/(car.yr)]
Pf……fuel price incl. taxes [€/litre]
$C_{O\&M}$…operating and maintenance costs
FI……..fuel intensity [litre/100 km]

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.

Scenario for development of investment costs



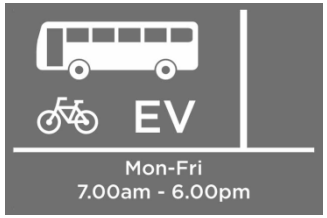
Monetary measures

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.

GDP and EV sales

73% of all electric cars are sold in just 4 countries (with some of the highest GDPs)

Electric cars < 3% of total sales
= average GDP < €17,000

Electric cars > 15% of total sales
= average GDP > €46,000

ACEA

GDP and charging infrastructure

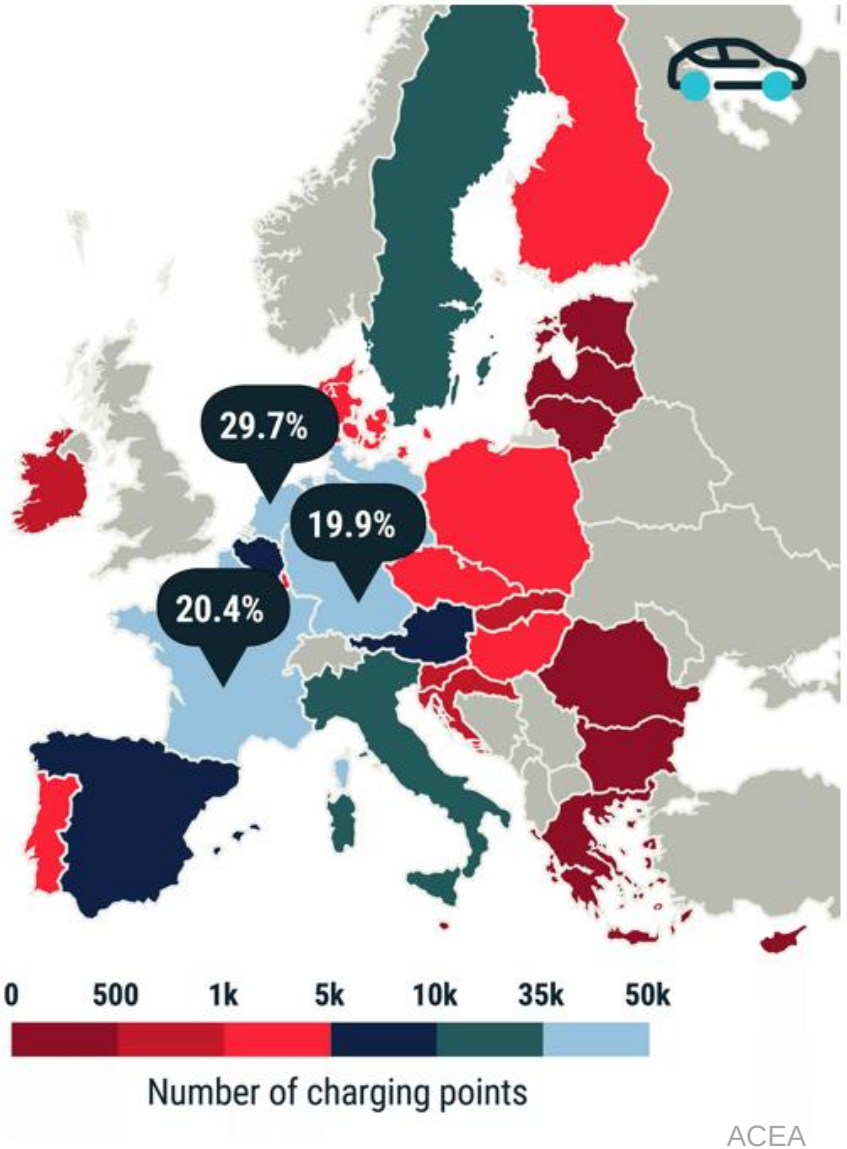
70% of all charging points:

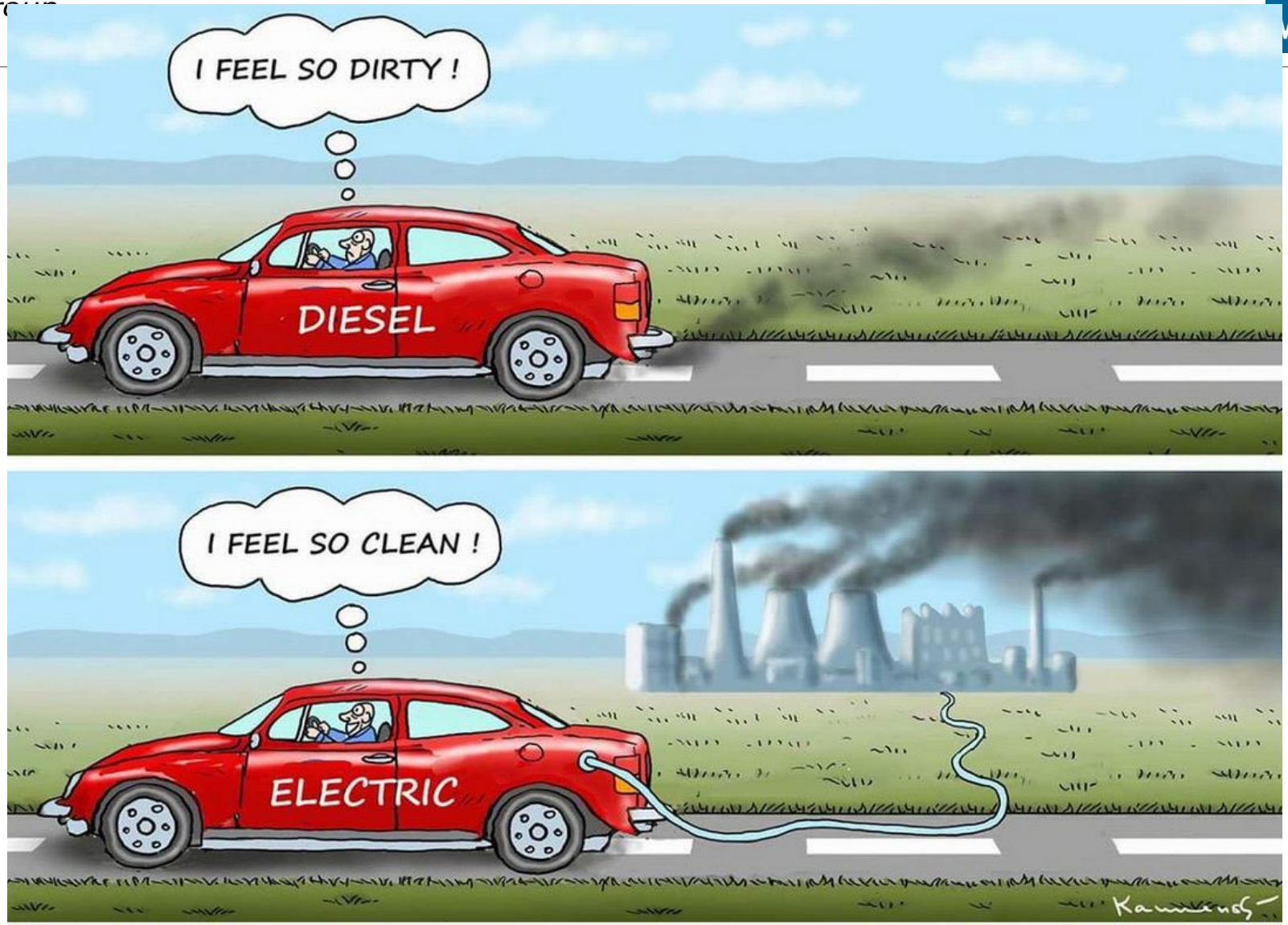
Located in just 3 EU countries

29.7% Netherlands

20.4% France

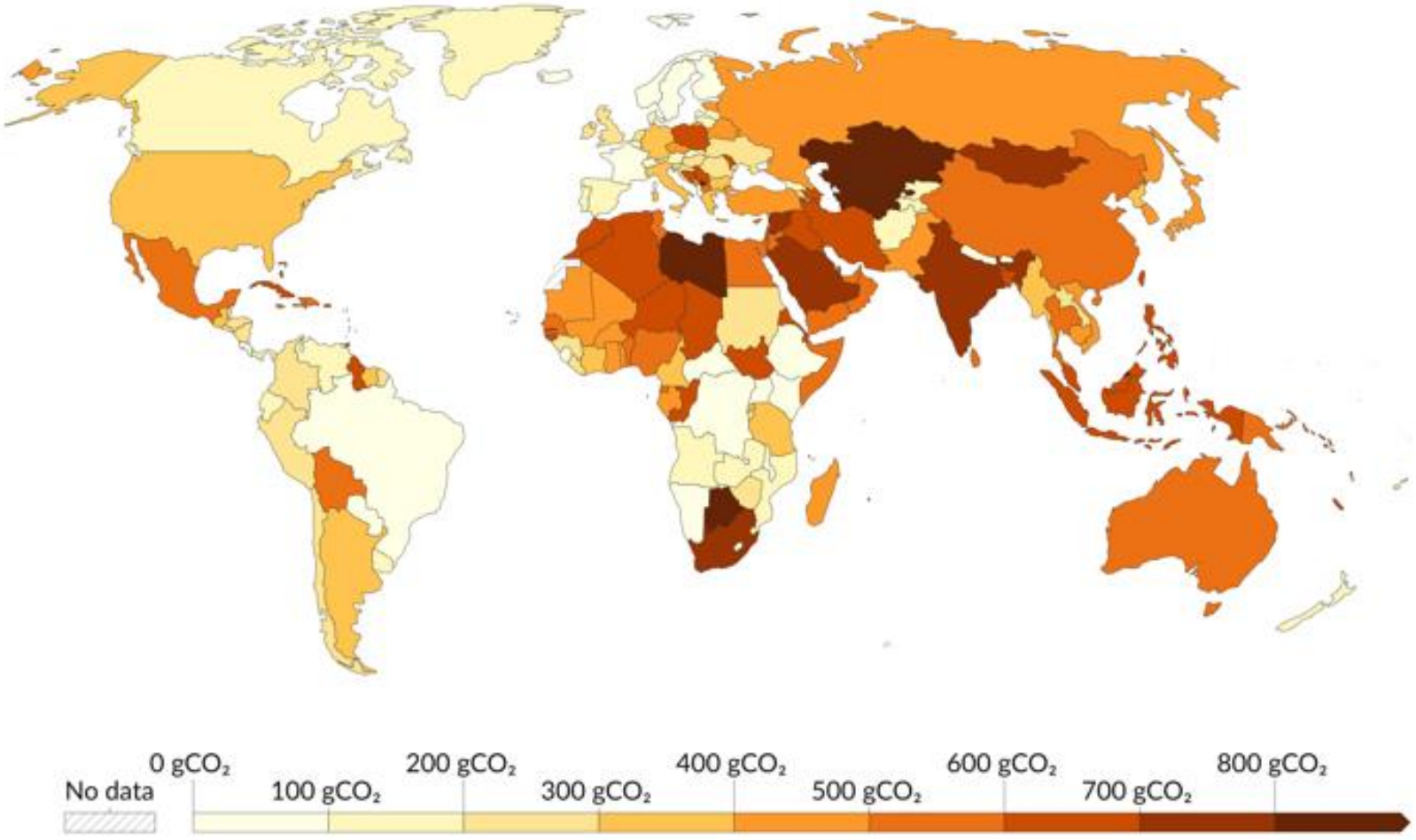
19.9% Germany





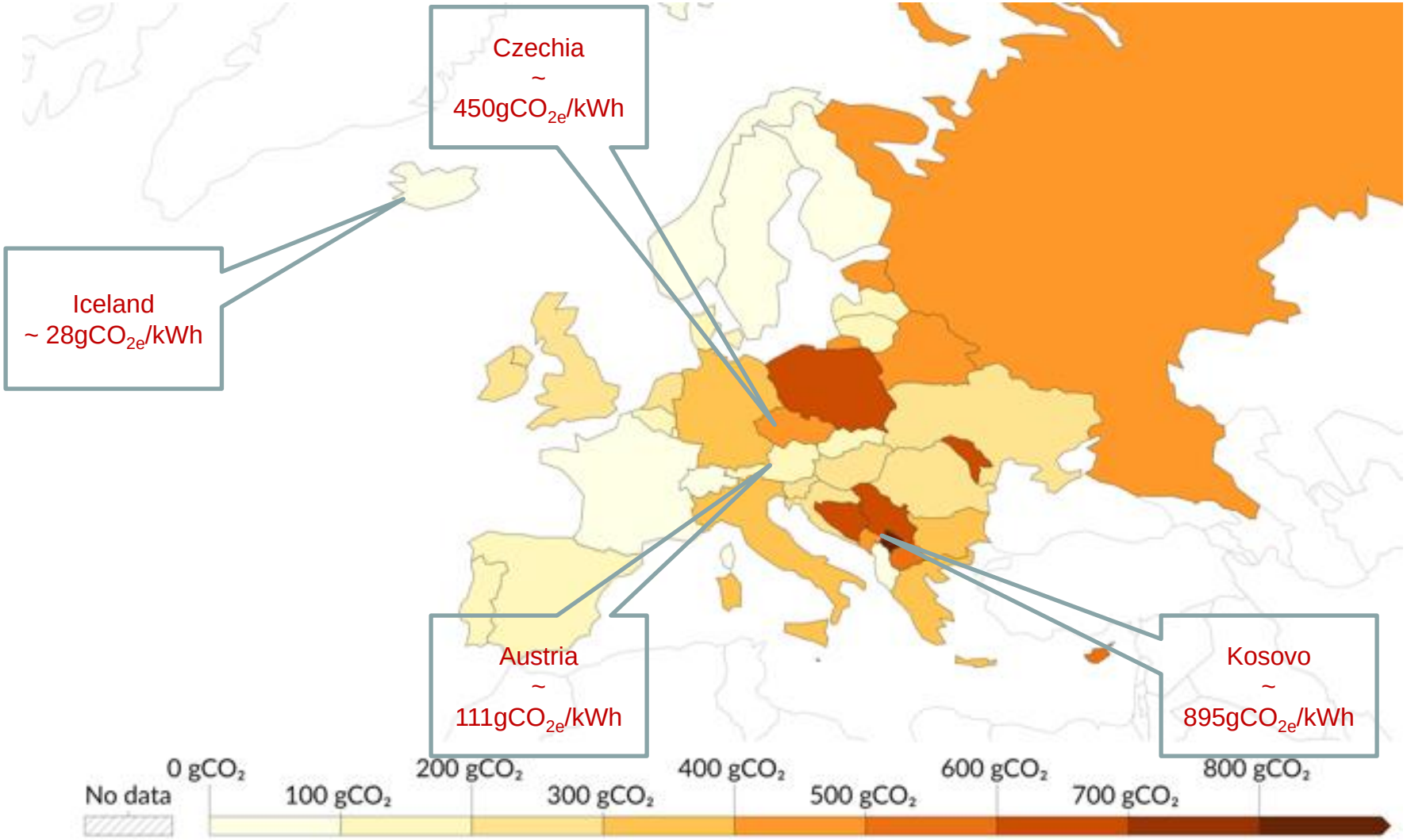
Artist: Marian Kamensky

Carbon intensity of electricity, 2023



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

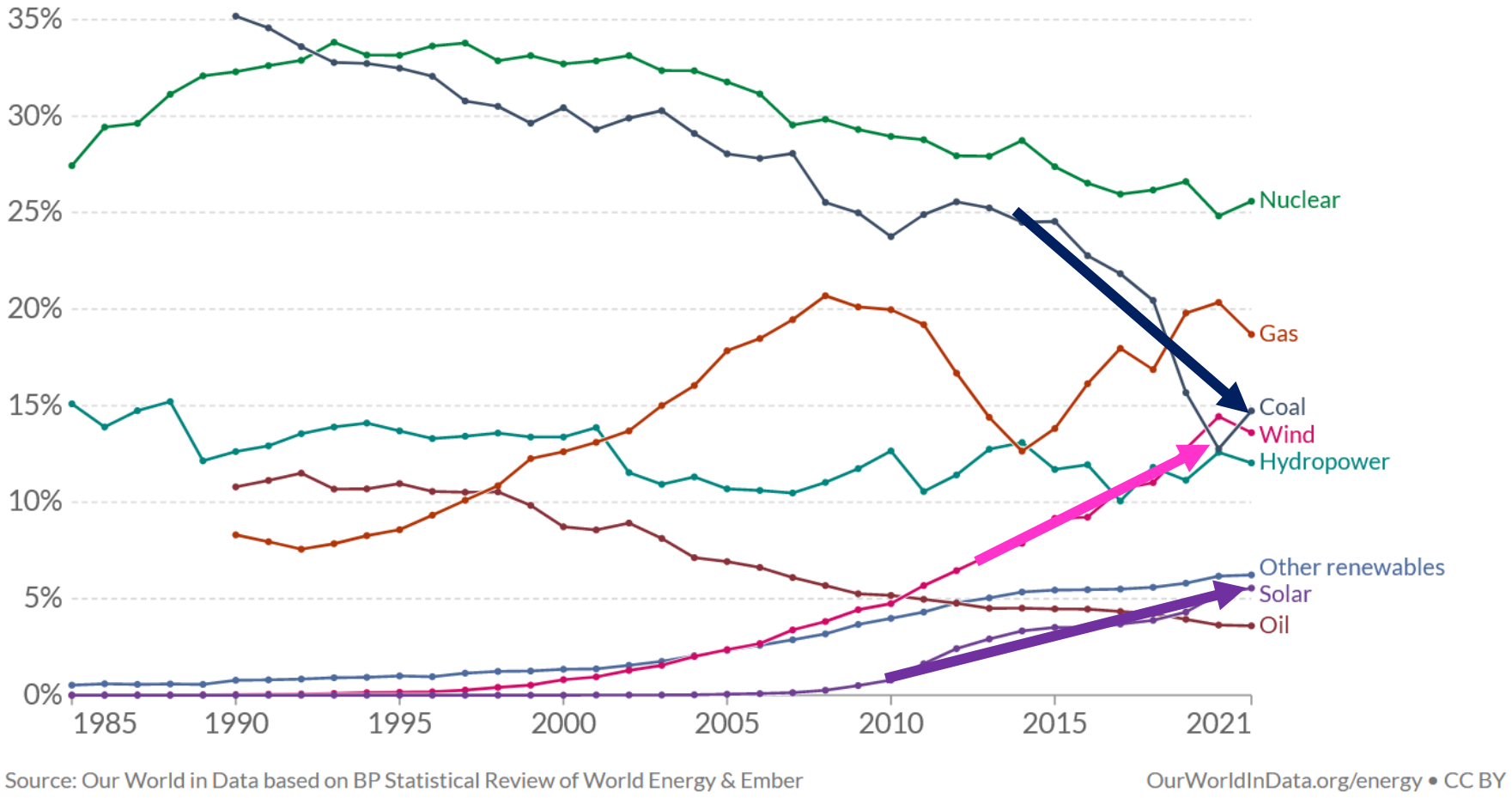
Carbon intensity of electricity, 2023



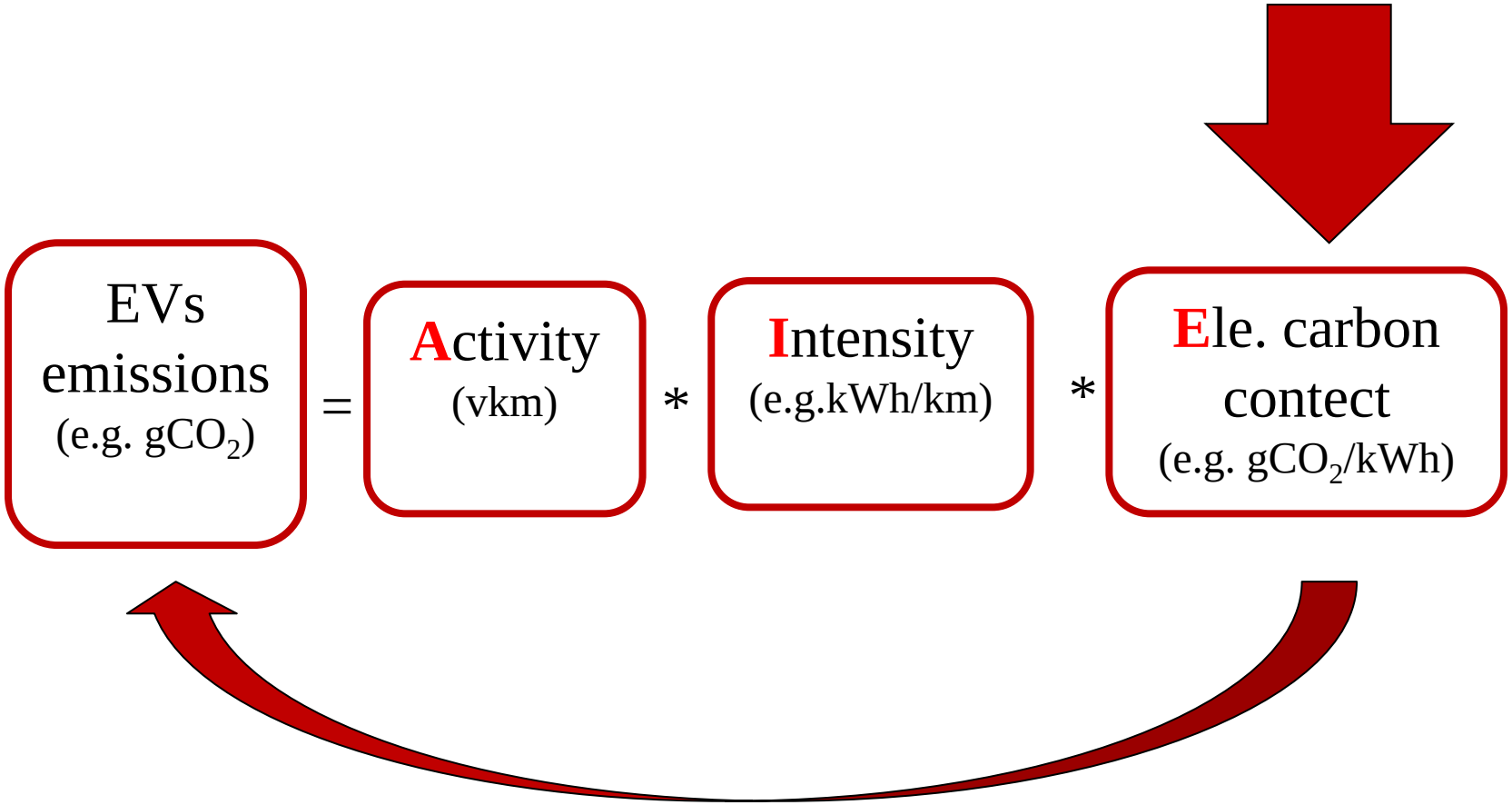
Carbon intensity is measured in grams of carbon dioxide-equivalents emitted per kilowatt-hour of electricity.

OWD

Share of electricity production by source, EU-27

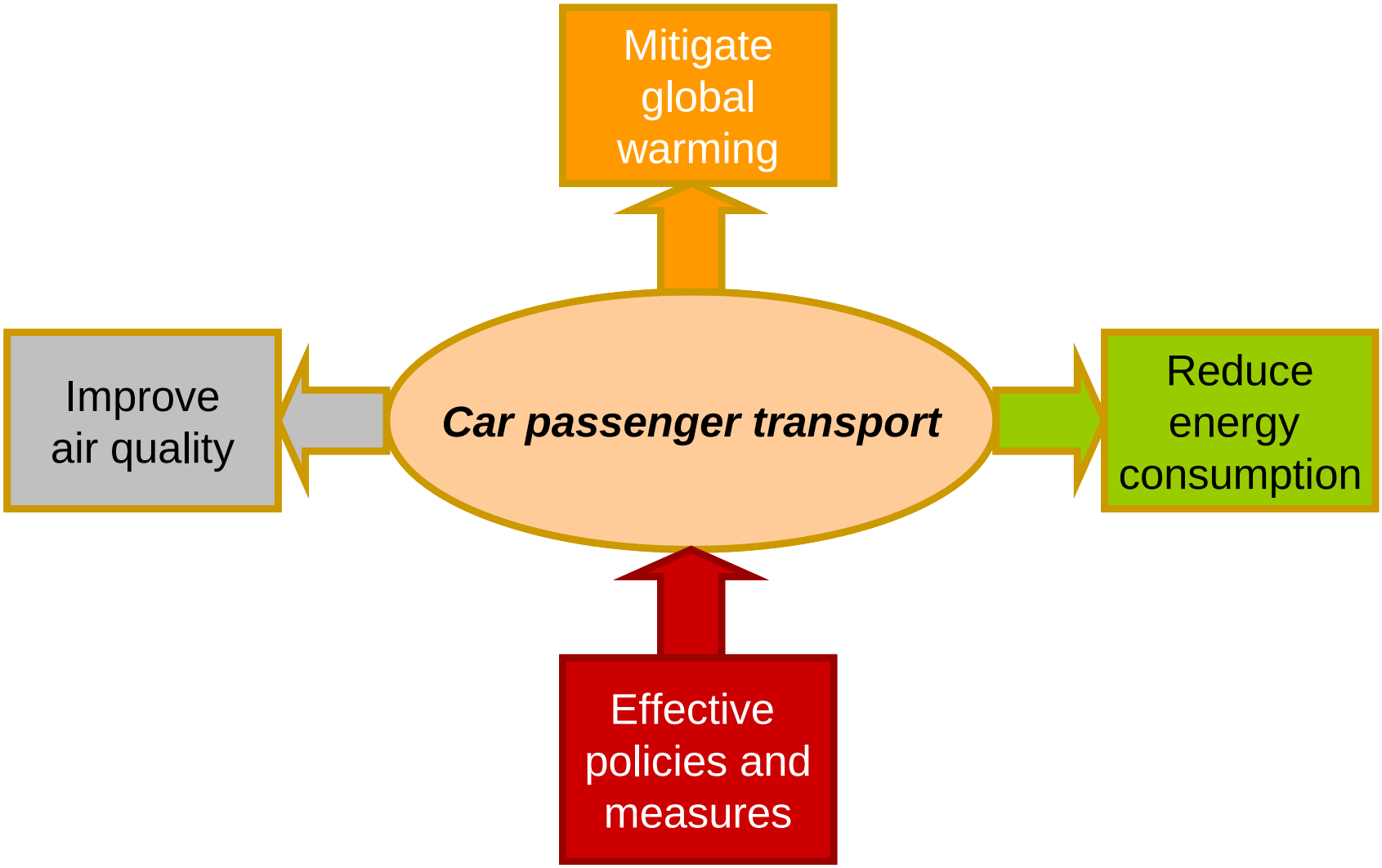


Car emissions



Energy policies

The challenges for climate and energy policies



EU targets

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

EU - the first climate-neutral continent by 2050

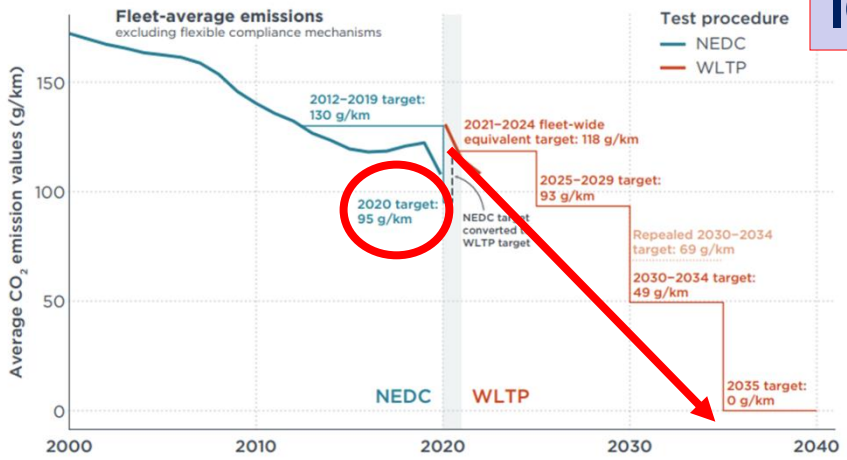
European Green Deal

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

Targets

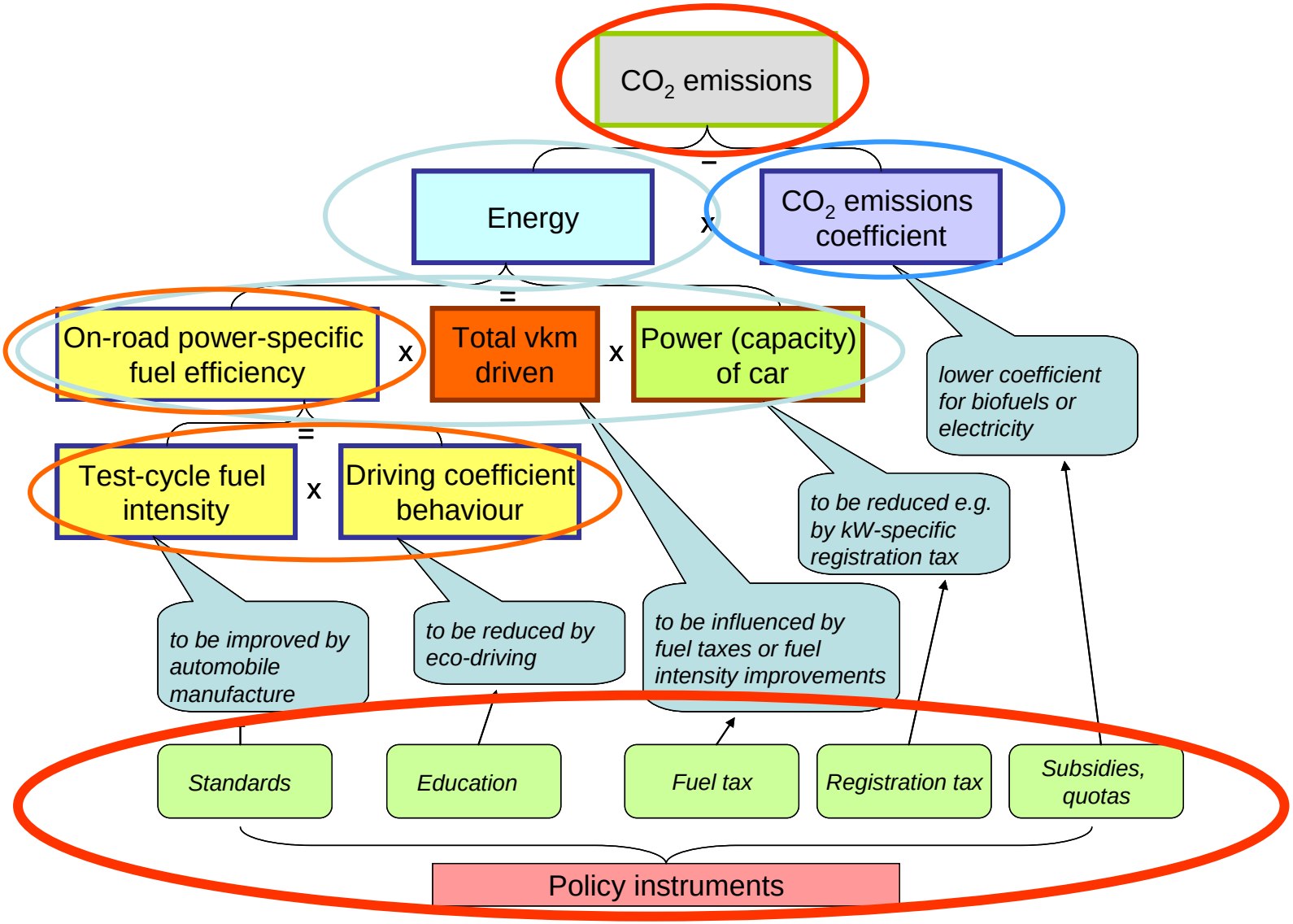
Paris Declaration on Electro-Mobility and Climate Change & Call to Action:

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

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	

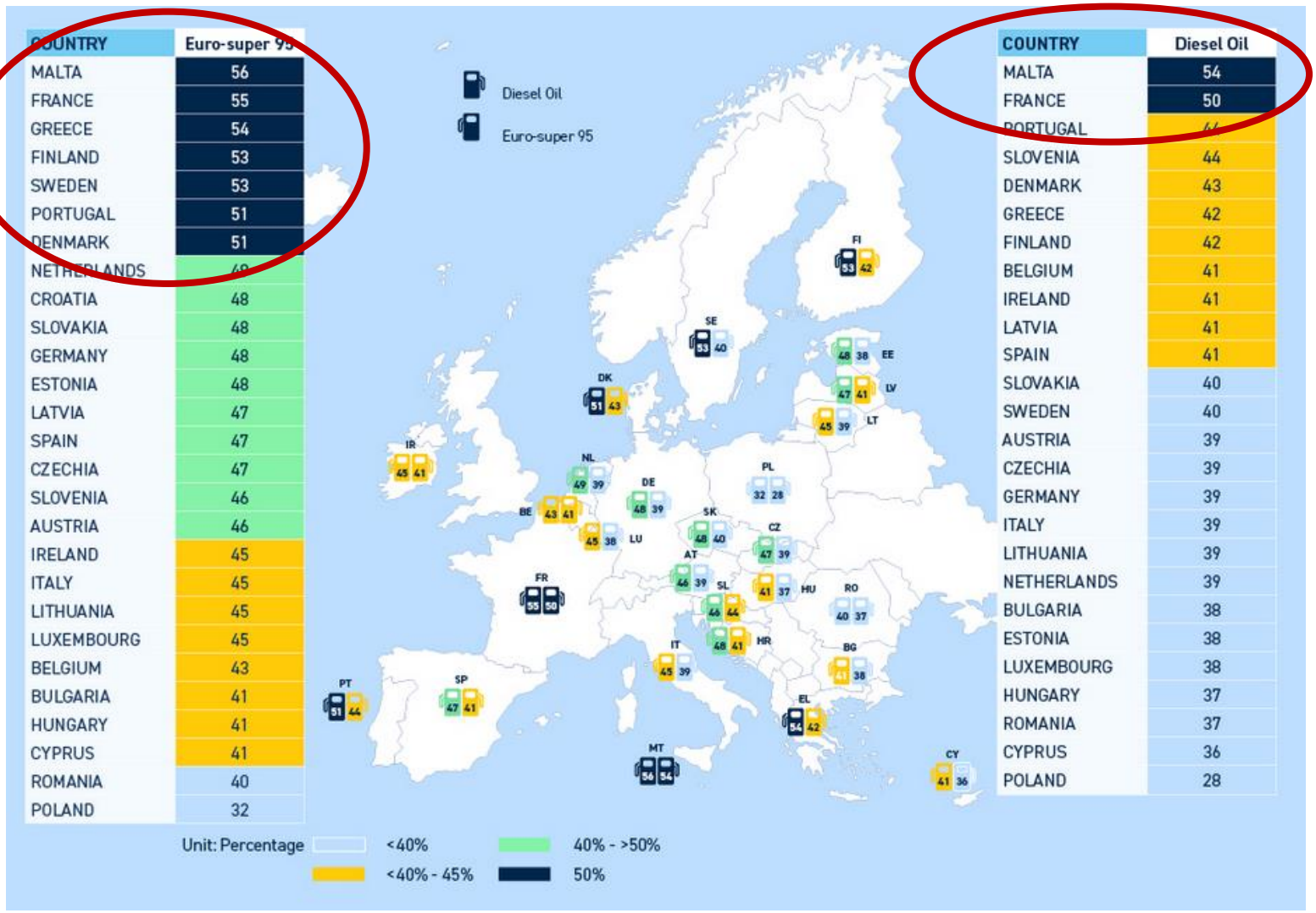
CO_2 emissions in passenger car transport



Impact factors on CO_2 emissions in the car passenger transport

Total taxation share in the end consumer price

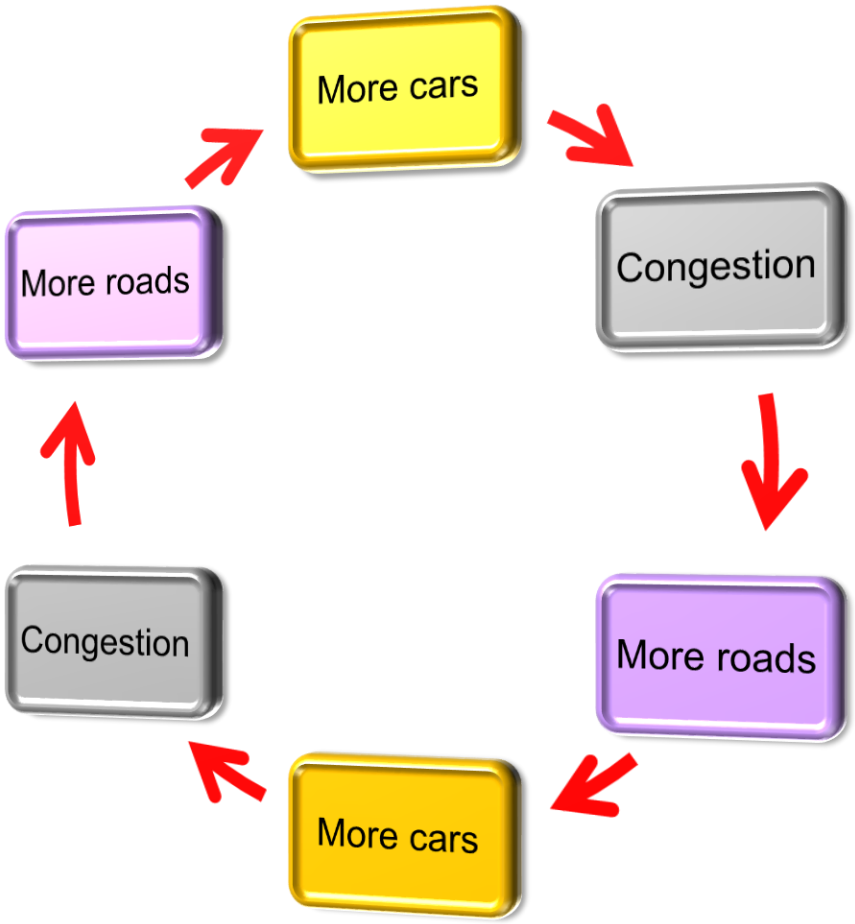
COUNTRY	Euro-super 95
MALTA	56
FRANCE	55
GREECE	54
FINLAND	53
SWEDEN	53
PORTUGAL	51
DENMARK	51
NETHERLANDS	48
CROATIA	48
SLOVAKIA	48
GERMANY	48
ESTONIA	48
LATVIA	47
SPAIN	47
CZECHIA	47
SLOVENIA	46
AUSTRIA	46
IRELAND	45
ITALY	45
LITHUANIA	45
LUXEMBOURG	45
BELGIUM	43
BULGARIA	41
HUNGARY	41
CYPRUS	41
ROMANIA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

Car-oriented mobility

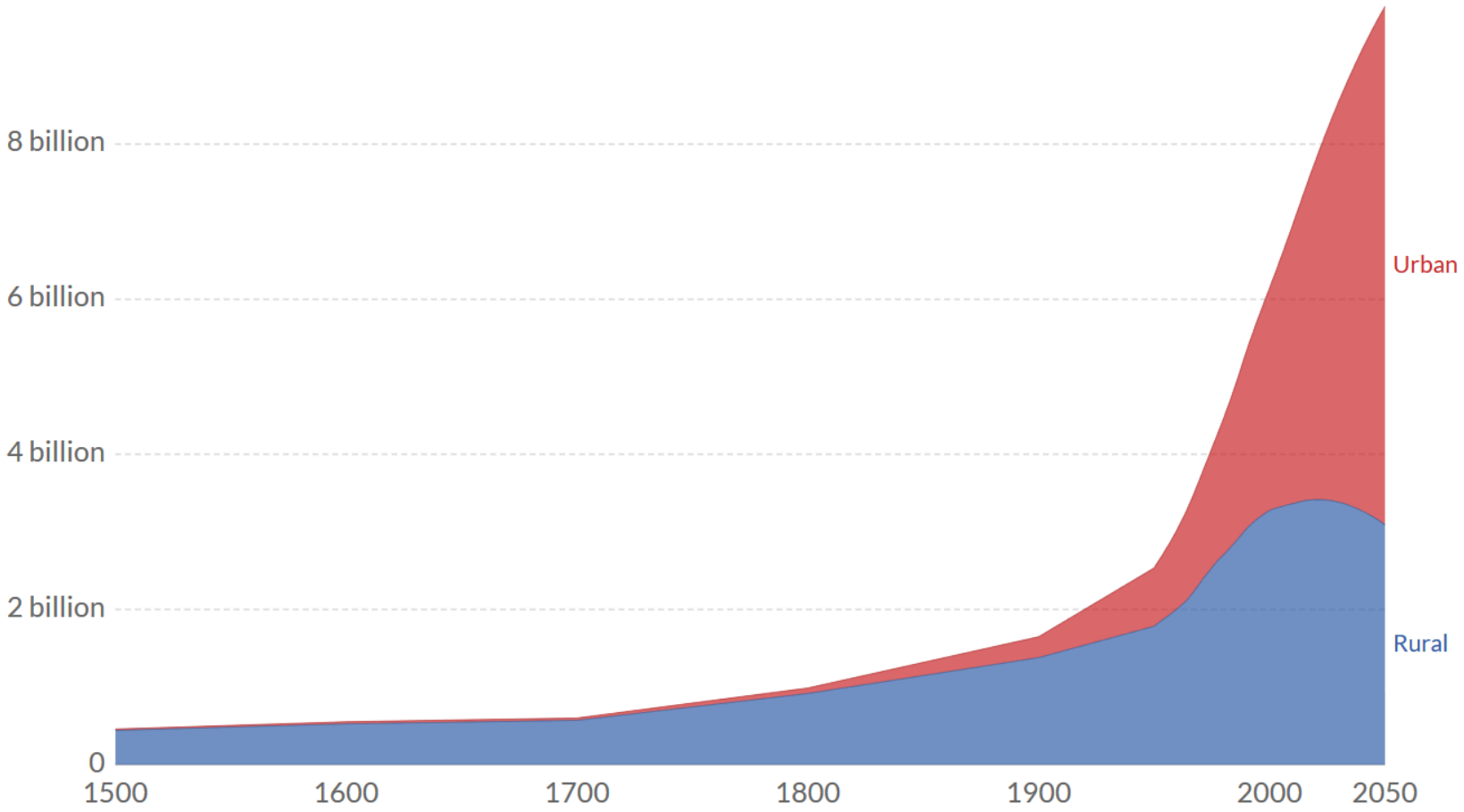


Mobility

Car-oriented transport development

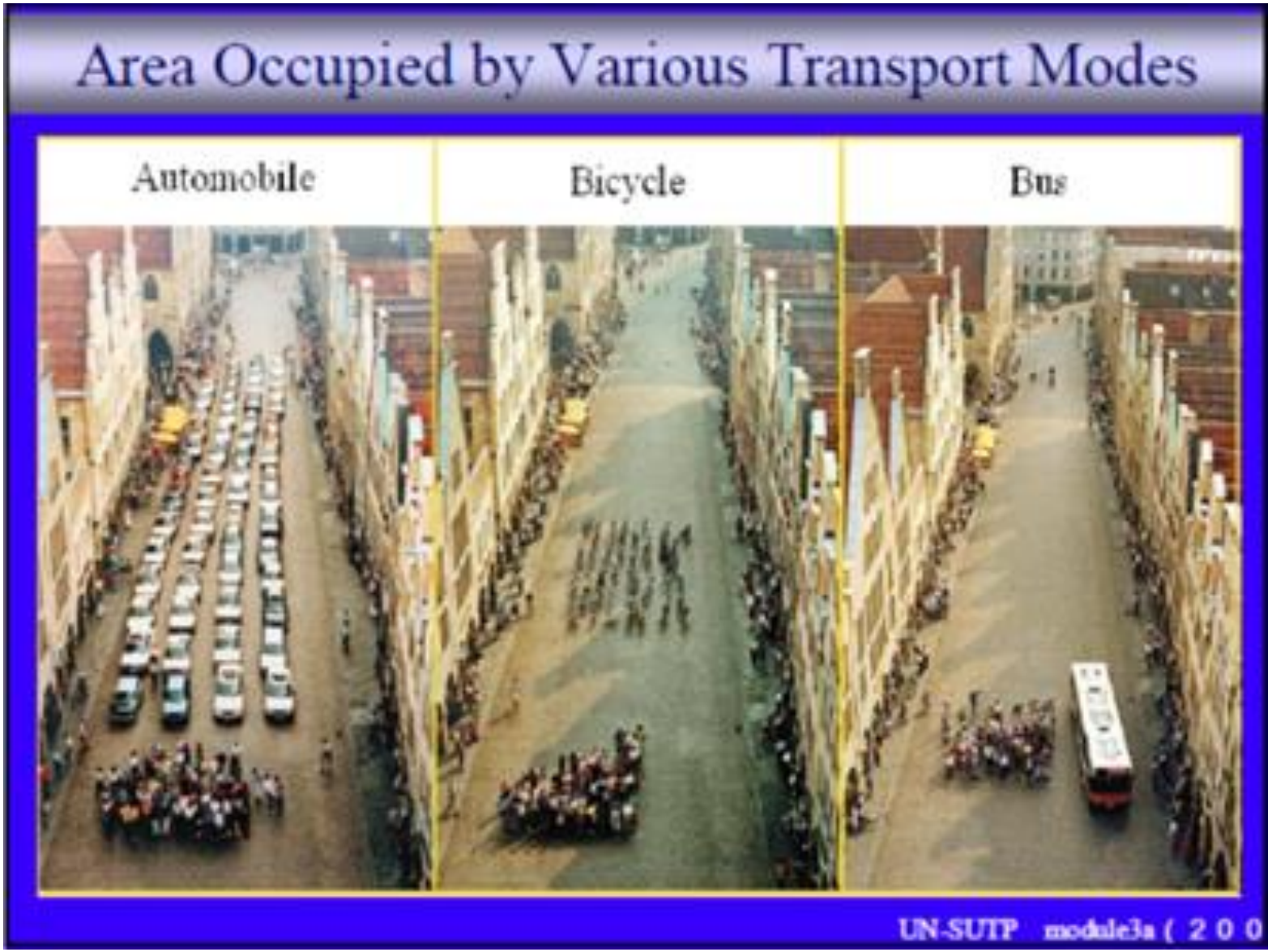
https://simotron.files.wordpress.com

Urban and rural population projected to 2050, world

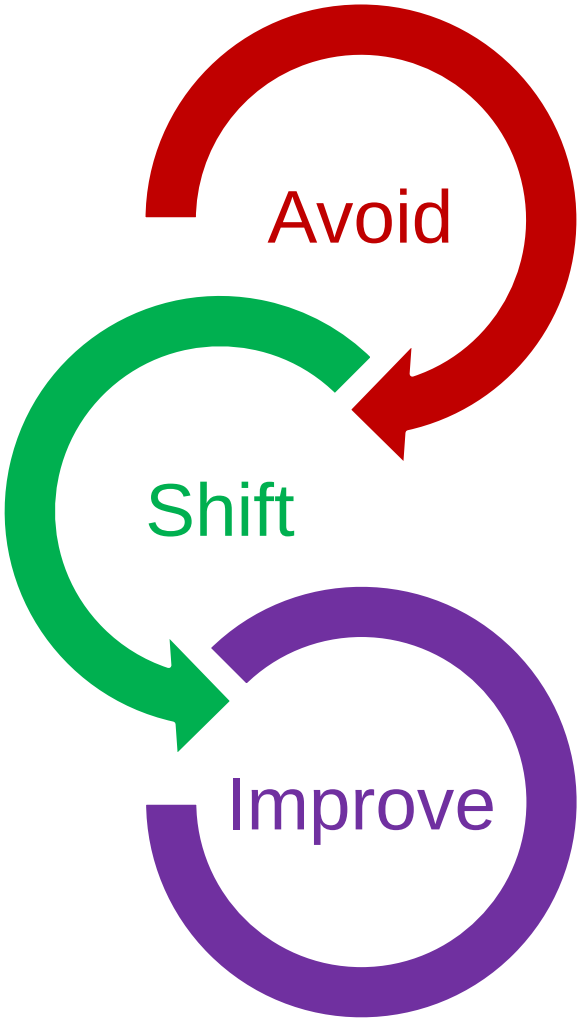


Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources)

Mobility


Area Occupied by Various Transport Modes
Automobile
Bicycle
Bus
UN-SUTP module3a (2 0 0

Towards Sustainable Mobility

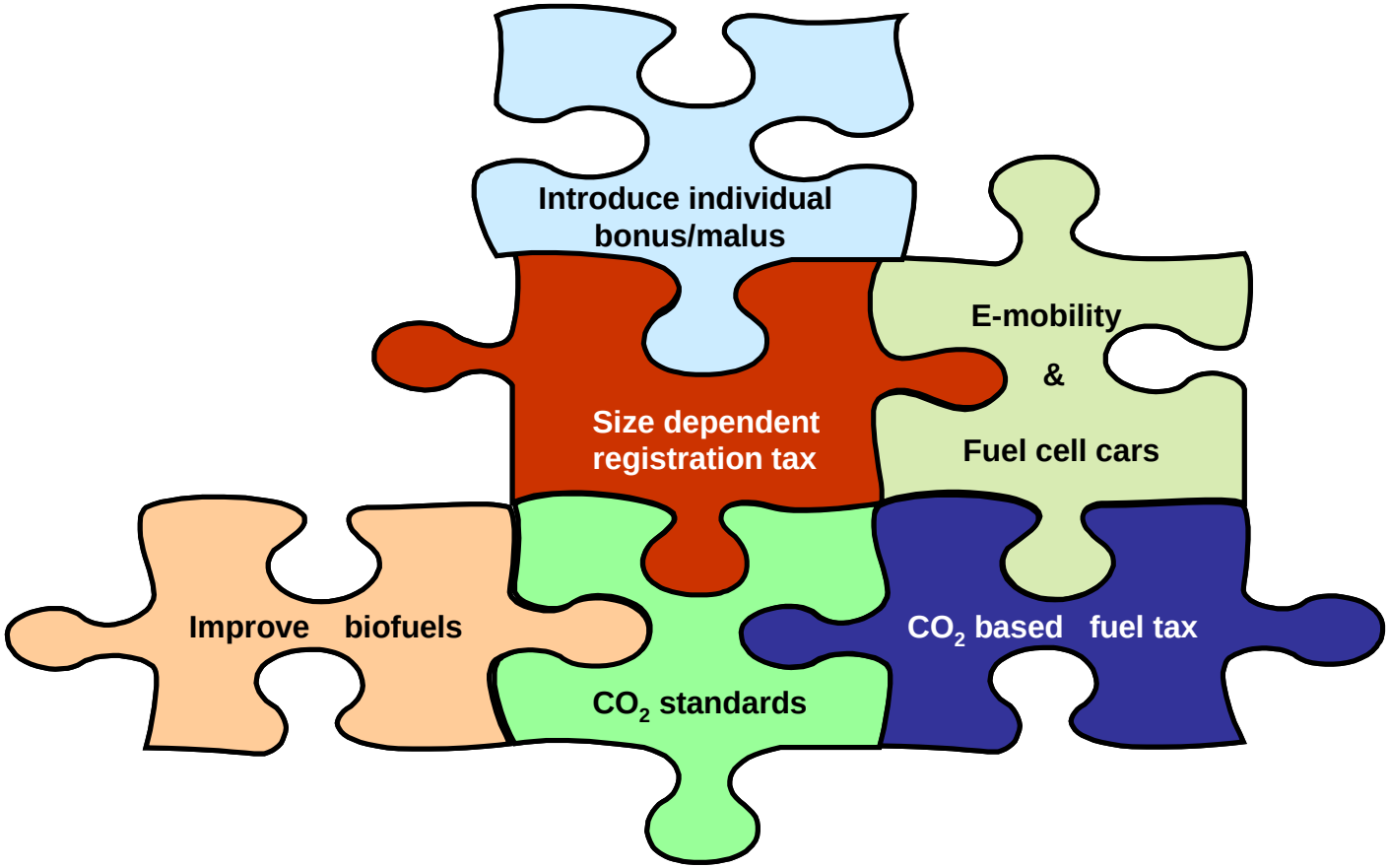


…unnecessary travel and reduce trip distances

….towards more sustainable modes

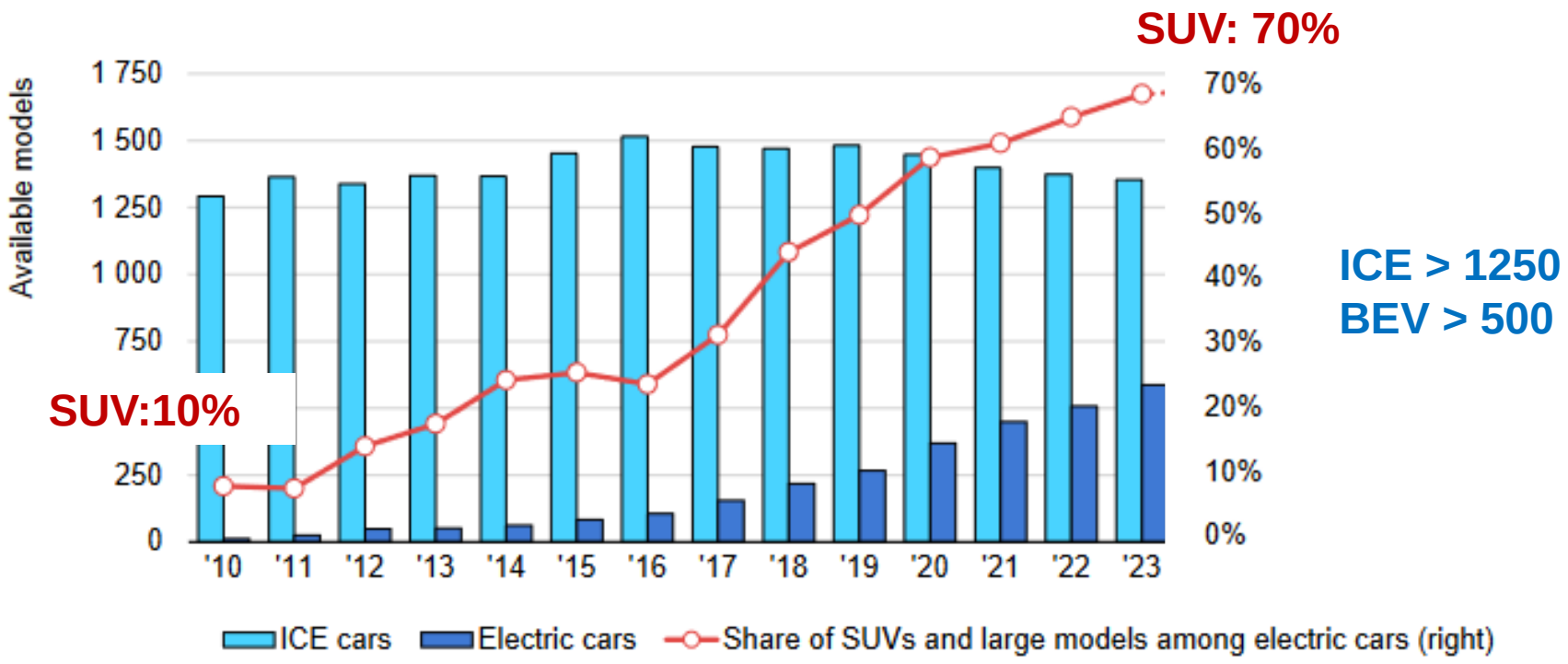
…transport practices and technologies

Conclusions

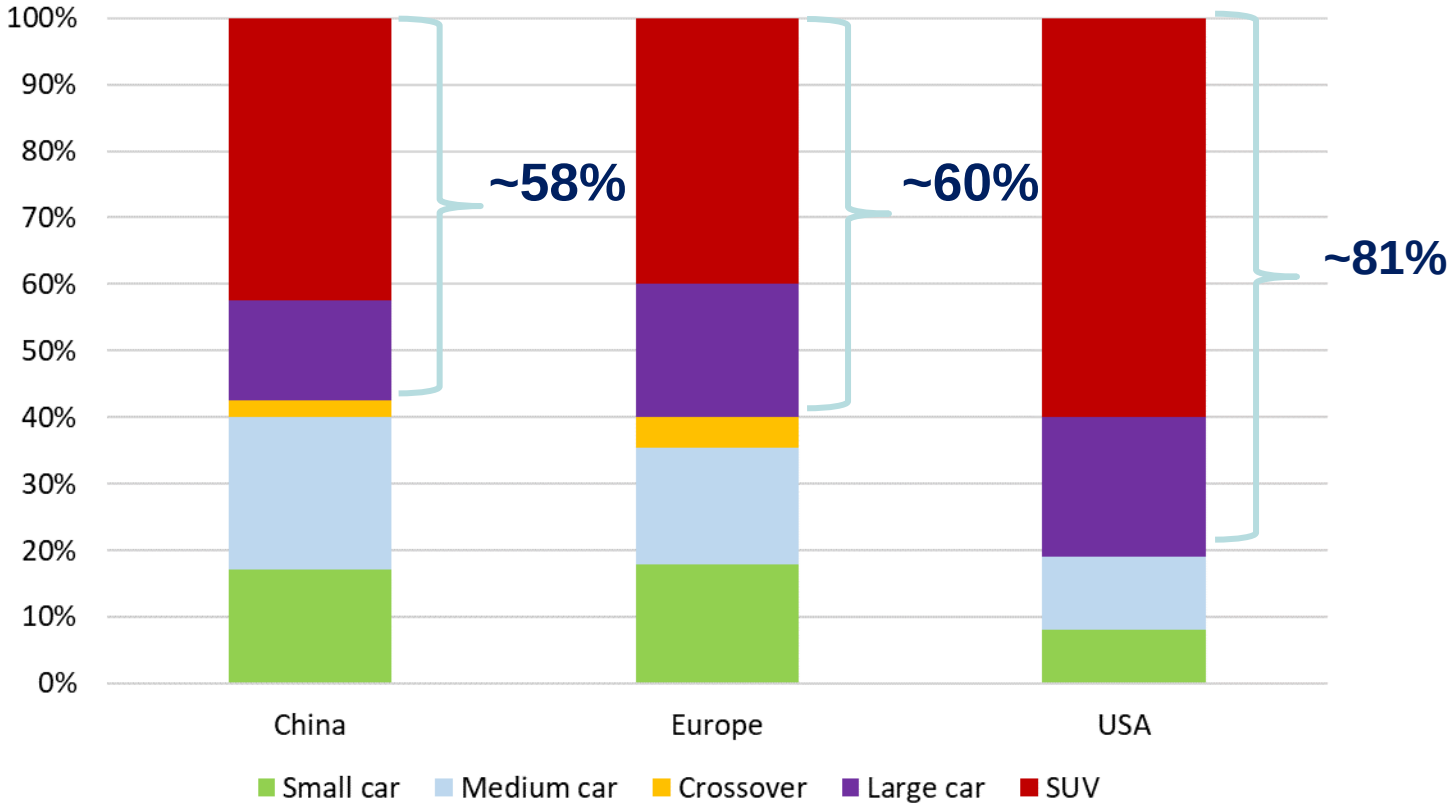


Environmental and social challenges

Car model availability



EV models (2022)



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