



Analysis of CO₂ emissions from passenger cars in Europe

MAY 2023

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Executive Summary



PAINPOINT: VISION OF THE ISSUE

The EU aims to have zero-emission cars by 2035. In 2021, average CO2 emissions were 114.7 g/km.



CONTEXT

The automotive industry is a complex system with many stakeholders: The stakeholders include environmental agencies, car manufacturers, governmental institutions, and car buyers.



AMBITION AND ADDED VALUE

- Identify the most significant variables that affect the CO2 emissions of new registered cars.
- Find the types of cars that emit the least CO2.



ANALYSIS FRAMEWORK

The analysis will be developed using public datasets by the European Environmental Agency (EEA) and several indicators.

Painpoint

The increment of greenhouse gases has led to an increment in the Earth mean temperature, which can be harmful for biodiversity, increase of fires, decreasing crop yields and people's health.

Increase of 2°C in less than three centuries!



By 2030, under the Paris agreement, the EU committed to reduce greenhouse emissions by at least 40% below 1990 levels by 2030 and be climate neutral by 2050.⁴ There is a social cost associated to agriculture, extreme heat, energy expenditures and sea-level rise.

Carbon dioxide (CO₂) is a colourless, odourless and non-poisonous chemical that is part of the greenhouse gases. One source of production of this compound is by the burning of fossil fuels



In 2017, transportation was the second source of contamination of CO₂ to the atmosphere with 15%, behind heating and electricity production with 31% according to the Center for Climate and Energy Solutions.

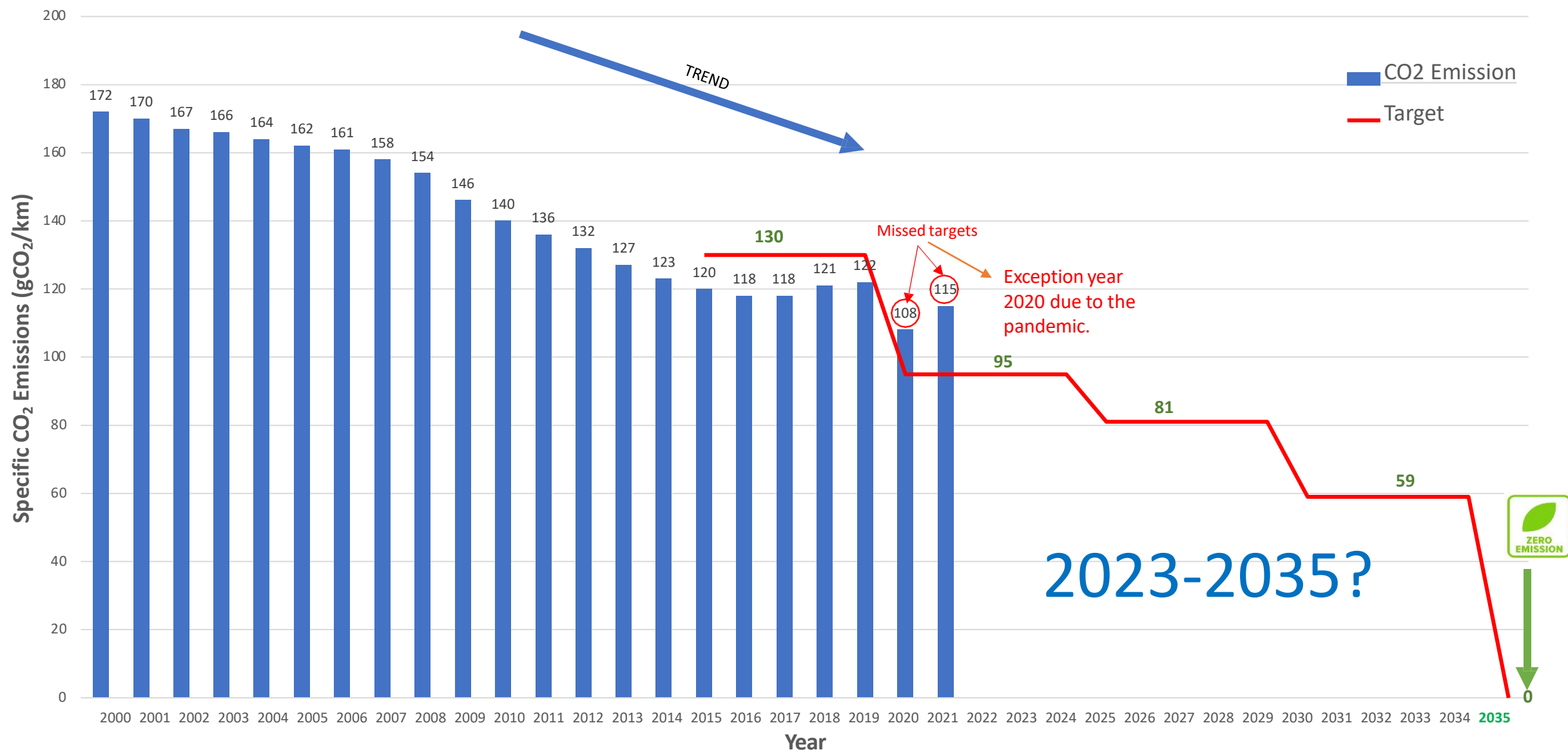
One way to reach this is by reducing passenger cars CO₂ emissions



1. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_emissions
2. <https://www.europarl.europa.eu/news/en/headlines/society/20180703STO07129/>
3. <https://www.c2es.org/content/international-emissions/>



Historical CO₂ New Registered Passenger Car Emissions in gCO₂/km and Targets



Context

Stakeholders

European
Environment Agency
(EEA)



- Sets the limits of carbon dioxide emissions to car Manufacturers
- Receives information of new car registers from Governmental Institutions and publish it.

set limits to

Car Manufacturers



- Responsible in offering alternatives to users.
- Give information of new registration to governmental institutions

Governmental
Institutions



- Responsible in requesting information of new passenger cars to car manufacturers.
- Give this information before the end of February yearly to the EEA.

Car Users



- Responsible in deciding which car to buy.
- Their decision may contribute to a low or high production of CO2 emissions.

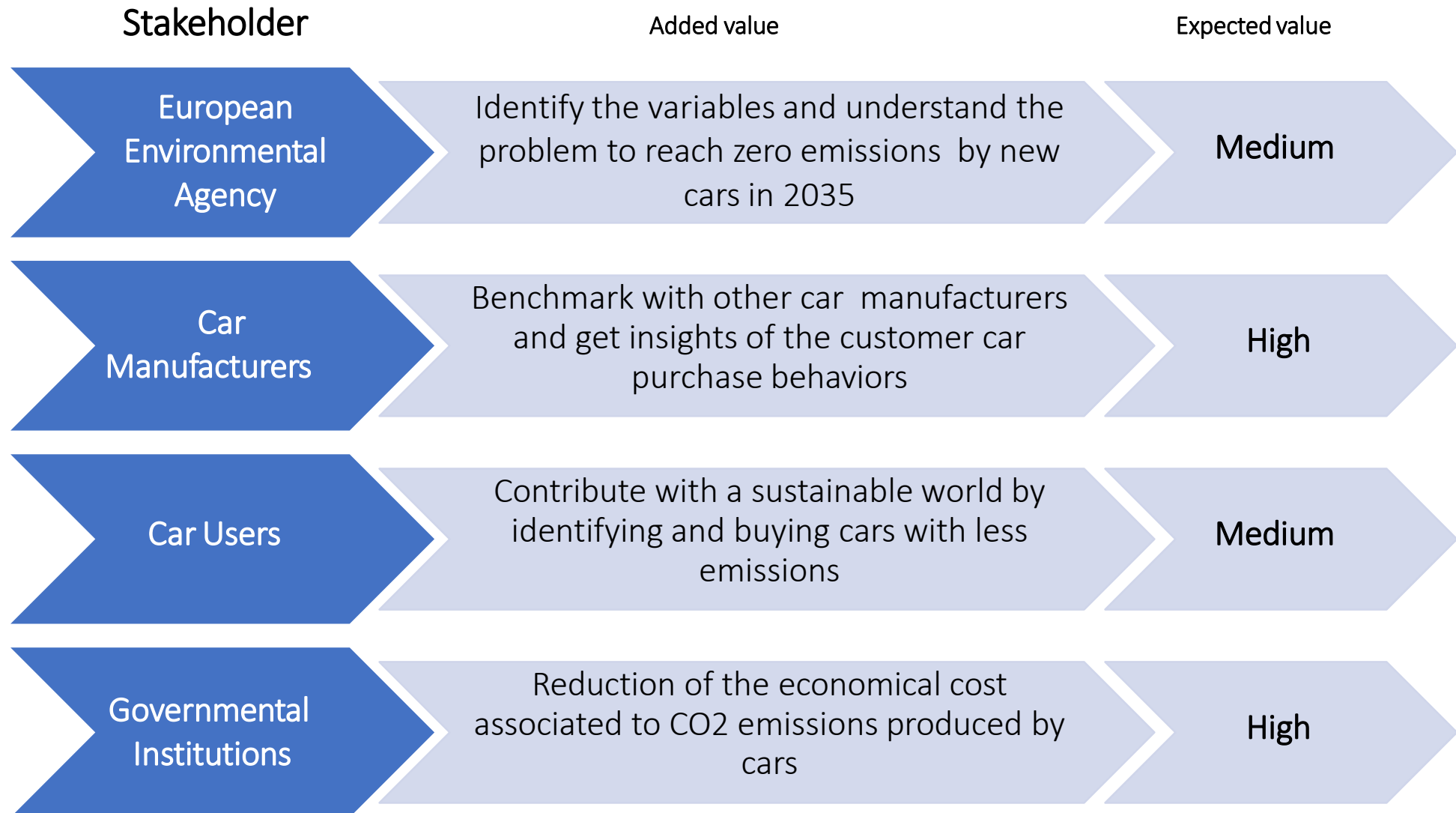
give information to

give information to

produce new tech to



Ambition and added value



Data Universes and Sets

Data Universes: Transportation

Main Dataset:

- CSV file of new registered cars in 2021
- More than 40 variables
- 9.02 million rows
- Type of variables: numeric, character and logical.
- CO2 emissions from new passenger cars registered in EU27, Iceland (from 2018) and Norway (from 2019) - [Regulation \(EU\) 2019/631](#).

Other Data Sets:

- Years from 2016-2020 (up to 15 million rows per year)
- Bridges using fuel-type and manufacturer information.

Data sources

[EEA Data: Monitoring of CO2 emissions from passenger cars – Regulation \(EU\) 2019/631](#) provided by [European Environment Agency \(EEA\)](#)

Application data last refreshed **22 September 2022 14:42 PM**. Version info **eeacms/esbootstrap:v3.1.5** and tag version **v3.1.5** on **elastic7-app-CO2-cars-esapp-1**.



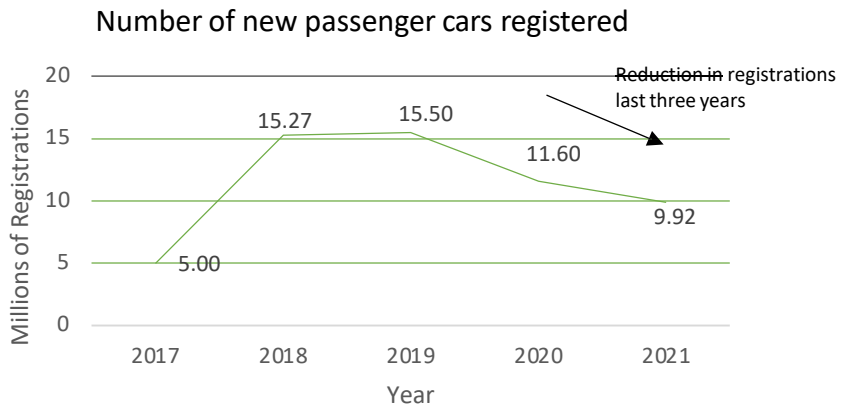
Main Variables found in the analyzed Data Sets

Variable	Description	Units	Type
ID	Registration number	9920108 registered cars	character
Member State	EU countries, Iceland and Norway	29 European countries	character
Manufacturer Name	Car manufacturer	97 manufacturers	character
Mass in running order	Mass of the car	kg	numeric
Specific CO2 emissions	Grams of CO2 emitted by km covered	g/km	numeric
Fuel type	Combustible	10 fuel types	character
Engine Capacity	Size of the engine	cm3	numeric
Engine Power	Capacity of electric car	kW	numeric
Fuel consumption	Liters of fuel consumed by km	L/100 km	numeric
Wheel Base	Horizontal distance between fronts and rear wheels	mm	numeric
Axle width steering axle	Distance between centerline of two wheels same axle	mm	numeric
Axle width other axle	Distance between centerline of two axles	mm	numeric
Electric energy consumption	km covered by Wh	Wh/km	numeric
Electric range	km covered with one charge	km	numeric

Sources: Statista | [Global CO2 emissions from passenger cars 2020](#) | Statista Europa.eu | [Electric road vehicles in the European Union \(europa.eu\)](#)

Insights from Analysis of Data

Percentage of New Car Registrations by Fuel Type 2016-2021



Mean Emissions gCO ₂ /km in 2021		
Top pollutant	Type	Emissions
1	E85	160
2	Diesel	144
3	Petrol	135
4	LPG	121
5	NG/Biomethane	113
6	NG	105
7	Petrol/Electric	42
8	Diesel/Electric	39
9	Electric	0
9	Hydrogen	0

Target 2021: 95

Aligned with goal in 2035



IMPORTANT: Considering social cost of \$185 for each ton/CO₂ produced, and a mean of 20,000 km covered by car and the almost 10 million new car registers in 2021, the CO₂ cost was around 3.91 billion euros in that year.

Key Factors

Key Success Factors

Identify significant variables in car CO₂ emissions



Key Performance Indicators

Significance of independent variables (P-value)



Develop a 3-Scenario Analysis to reach target in 2023 using historical data

3 different scenarios with CO₂ below 95gCO₂/km



Propose ideas to reach goals 2025-2035

3 ideas to reach 81, 59 and 0 gCO₂/km

Main Goal



Reduction of new registered car CO₂ emissions

Years	gCO ₂ /km
2023-2024:	95
2025-2029:	81
2029-2034:	59
2035-onwards:	0

Hypothesis

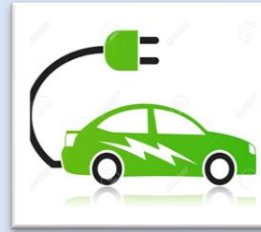
Hypothesis 1

Petrol cars are the most registered in 2016-2021 records.



Hypothesis 2

Electric cars (and electric-hybrid) demand is increasing in 2016-2021 records.



Hypothesis 3

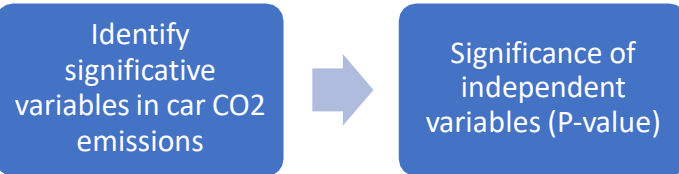
- The heavier, more powerful, and less fuel-efficient a petrol car is, the more CO₂ it will emit.
- The wheelbase and axles distances also affect CO₂ emissions, but to a lesser extent.



Objective 1: Identify significant variables in car CO₂ emissions

Key Success Factors

Key Performance Indicators



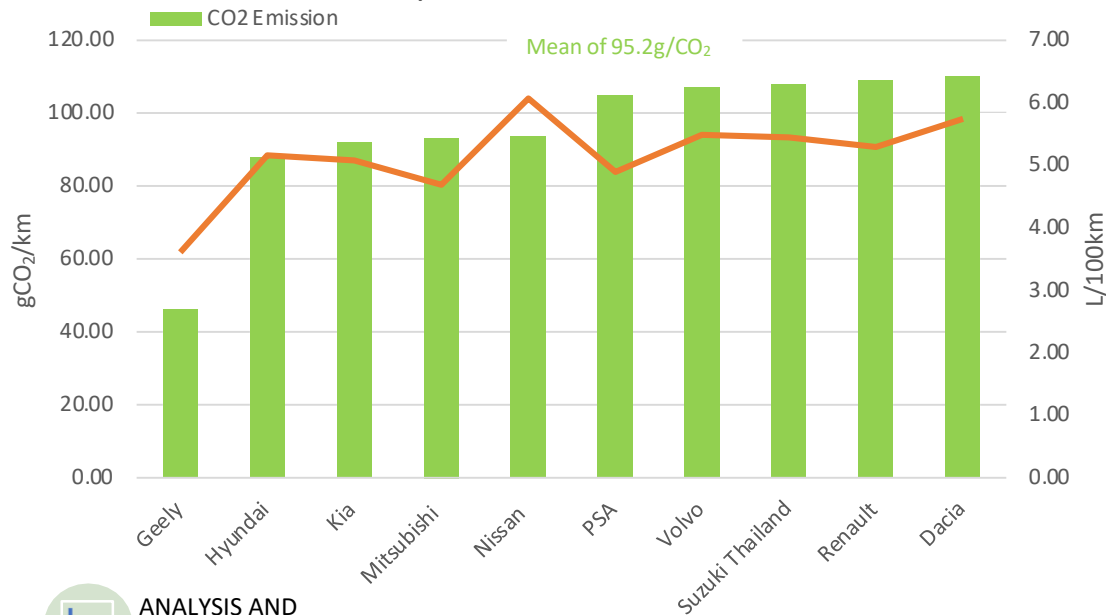
Data from petrol and diesel was considered since they represent almost 80% of the new registrations in 2021 (Pareto principle).

Significance Analysis Petrol/Diesel Type Cars Data 2021 Response variable: specific CO₂ emissions

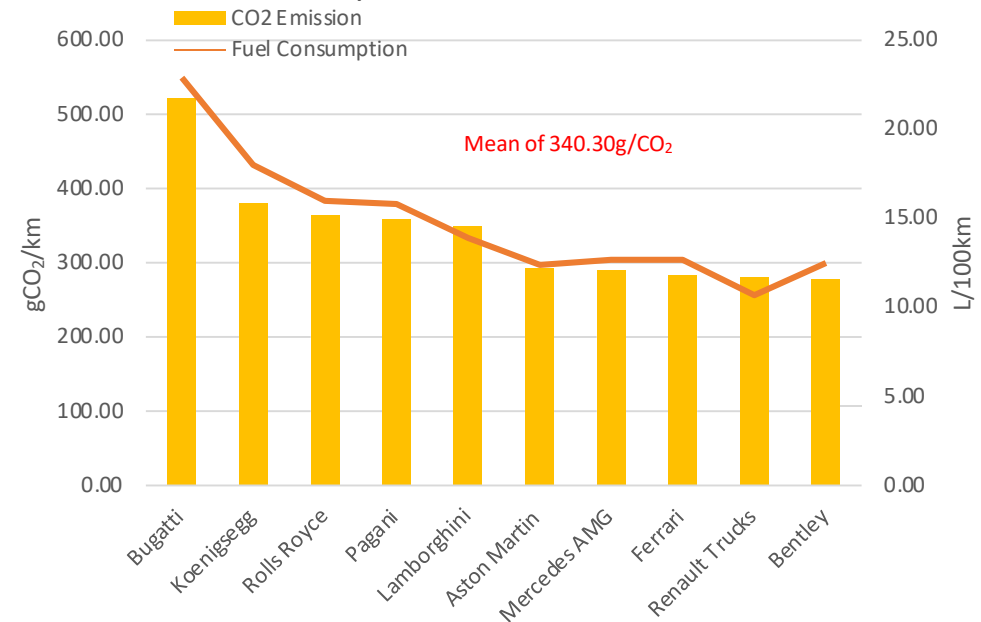
More significant ↑

No.	Independent Variable	Estimate	P-Value
1	Fuel consumption (L/100km)	10.02	2E-16
2	Axle width steering axle (mm)	0.07766	2E-16
3	Wheel Base (mm)	0.06931	2E-16
4	Mass (kg)	0.05465	2E-16
5	Engine Capacity (cm3)	0.02546	2E-16

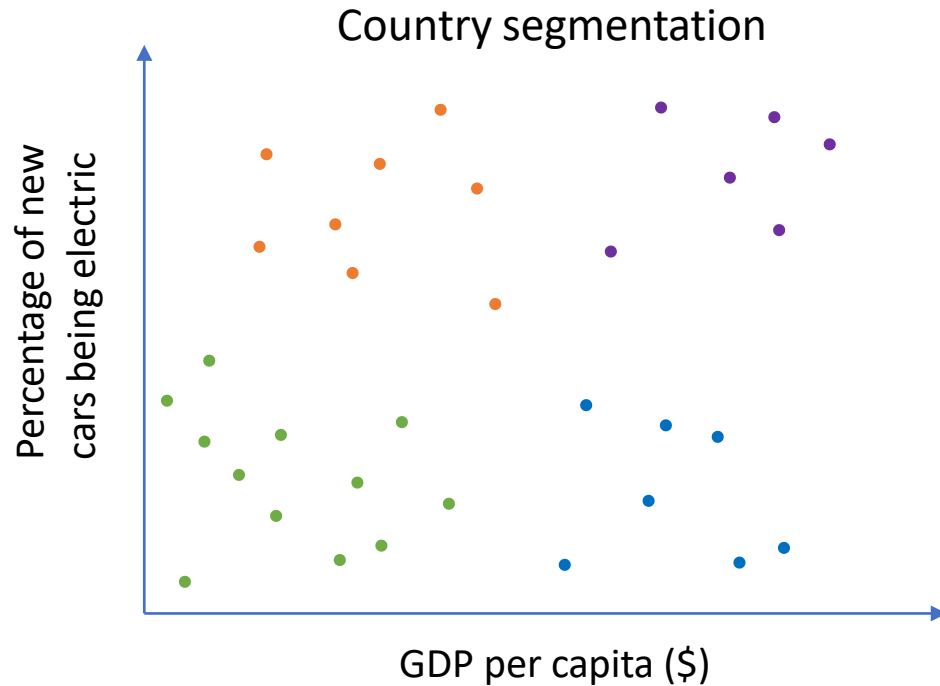
Top 10 Least Pollutant Car Manufacturers



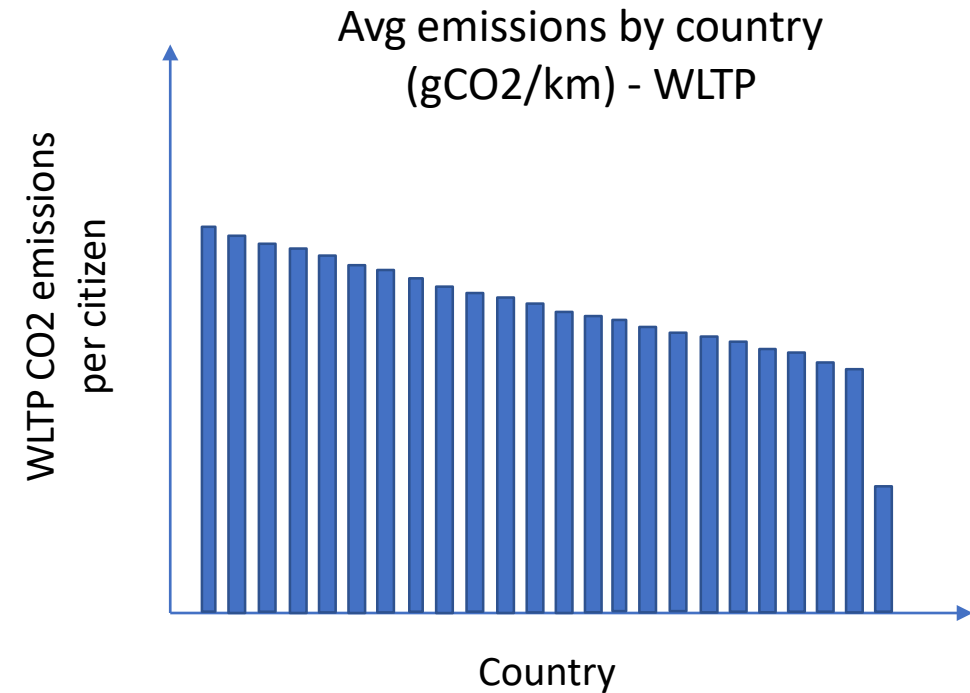
Top 10 Most Pollutant Car Manufacturers



Countries grouped and sorted by their average emissions to identify market trends and opportunities.



Each dot represents a particular country. The countries are clustered based on their GDP on the x-axis and the percentage of new cars being electric on the y-axis. The purple colour indicates countries that need to be targeted first. Then, the blue and orange colours indicate new potential opportunities to be pursued. Finally, the green countries will have the lowest priority.



Each bar represents a particular country. The length of the bar shows the average CO₂ emissions per citizen per country. Considering the Paris Agreement, countries with high emissions will sooner or later need to take actions to control their carbon footprint, thus will effectively create new opportunities for the EV and EV charging industry.



Objective 2: Develop a 3- Scenario Analysis to reach target in 2023 using historical data

Main Goal

 Years 2023-2024: gCO₂/km 95

Key Success Factors

Develop a 3- Scenario Analysis to reach target in 2023 using historical data

Key Performance Indicators

3 different scenarios with CO₂ below 95gCO₂/km

Historical Scenario in 2021		
Fuel Type	Market Share	gCO ₂ /km
Petrol	55.5%	135
Diesel	22.6%	144
Electric	10.1%	0
Petrol/Electric	8.5%	42
	96.7%	111.0

Petrol and diesel Market Share in 2021 was 77%. With electric and hybrid cars made up to 97%.

Simulating three different market share simulations can change the gCO₂/km, keeping data from emissions 2021.

Base Case Scenario 2023		
Fuel Type	Market Share	gCO ₂ /km
Petrol	48%	135
Diesel	15%	144
Electric	19%	0
Petrol/Electric	15%	42
	97%	92.7

Best Case Scenario 2023		
Fuel Type	Market Share	gCO ₂ /km
Petrol	46%	125
Diesel	14%	144
Electric	21%	0
Petrol/Electric	16%	42
	97%	84.4

Worst Case Scenario 2023		
Fuel Type	Market Share	gCO ₂ /km
Petrol	52%	135
Diesel	19%	144
Electric	15%	0
Petrol/Electric	11%	42
	97%	102.2

1. Exponential increase of electric cars market share (MS) from 10.1 to 19%
2. Linear decrease of petrol and diesel car MS, from 55.5 and 22.6 to 48 and 15% respectively.
3. Economical of reduction of 620 millions Euros associated social cost of CO₂ emissions.

1. Increase registration of petrol low emission manufacturers cars (135 to 125 gCO₂/km)
2. Exponential increase of electric cars (MS) from 10.1 to 21%.
3. Linear decrease of petrol and diesel car MS from 55.5 and 22.6 to 46 and 14% respectively.
4. Economical reduction of 900 millions Euros associated social cost of CO₂ emissions.

1. Linear increase of electric cars (MS).
2. Small decrease of petrol and diesel car MS.
3. Economical reduction of Economical reduction of 300 millions Euros associated social cost of CO₂ emissions. .



Reduction of new registered car CO₂ emissions

Years	gCO ₂ /km
2023-2024:	95
2025-2029:	81
2029-2034:	59
2035-onwards:	0

Objective 3: Propose ideas to reach goals 2025-2035

Key Success Factors

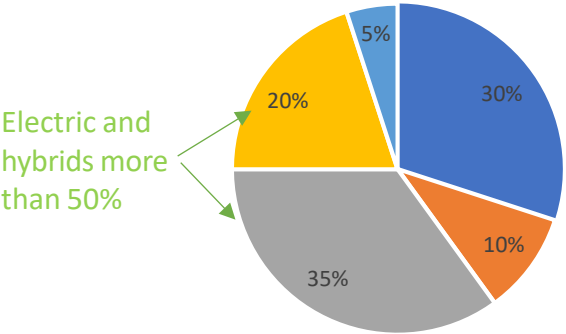
Propose ideas to reach goals 2025-2035

Key Performance Indicators

3 ideas to reach 81, 59 and 0 gCO₂/km

Economical of reduction by 2035 with zero car emissions of 3.91 billion Euros associated social cost of CO₂ emissions (agricultural damage, heating, cooling, sea level rise, etc.)

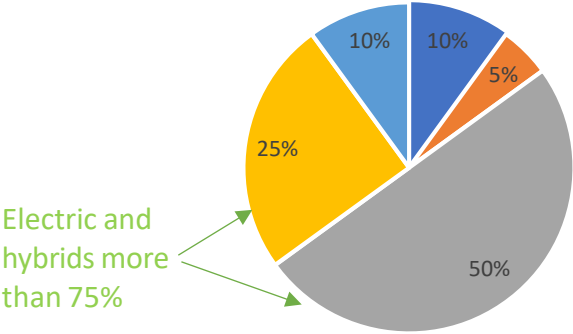
2025-2029



■ Petrol ■ Diesel ■ Electric ■ Petrol/Electric ■ Others

In the period 2025-2029, a significative decrease of fossil fuel types cars must occur, and an increase in MS of zero carbon dioxide emission cars of more than 50% to reach less than 81gCO₂/km

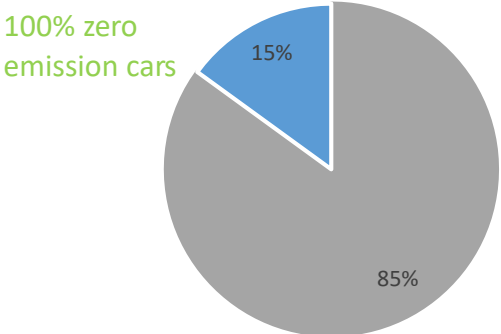
2030-2034



■ Petrol ■ Diesel ■ Electric ■ Petrol/Electric ■ Others

Between 2030-2034, an increase of electric and hybrid electric cars up to 75% of the market share to make possible less than 59gCO₂/km Other zero emission alternatives must be adopted

2035-onwards

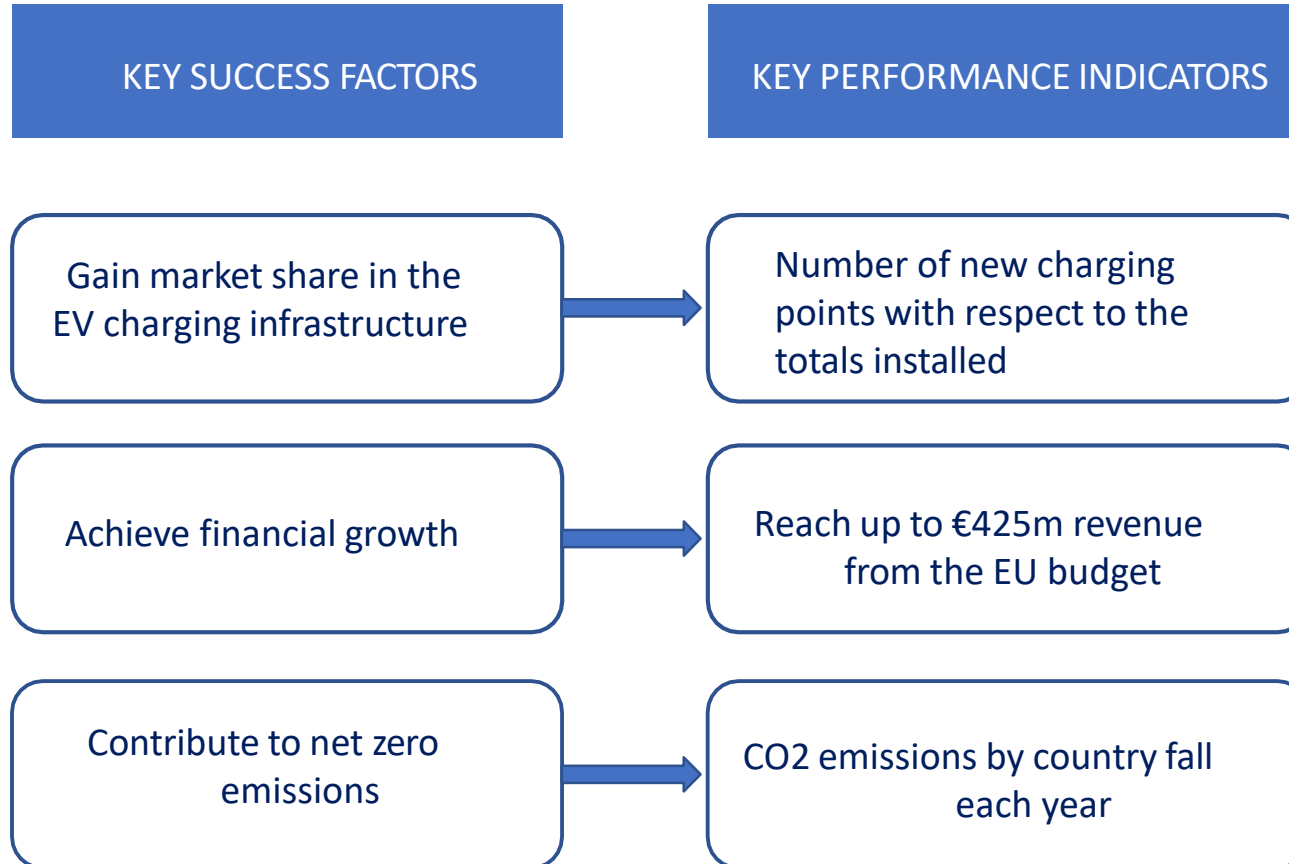


■ Electric ■ Others

By 2035, 100% zero emission new registered cars. Electric, hybrid electric and other types: hydrogen, etc.

Success defined by 3 key factors that are measurable

Contribute to a sustainable future



Limits

Data:

It was required to find additional data sources to understand data sets and complete them.

Knowledge:

- Specific technical terms.
- Tools for creating good graphics

How to address these limits?

Different sources of information needed



Recommendations

1. European Environment Agency (EEA)



- Keep sharing information yearly with insights about new car registrations.
- Request governmental institutions to prioritize targets for CO₂ emission.

3. Car Manufacturers



- Implement new technologies to reduce carbon dioxide emissions in new cars.
- Invest in R&D to develop new car alternatives with zero emissions.

2. Governmental Institutions



- Reward/punish car manufacturers to invest in new technologies for reducing CO₂ emissions in new cars.
- Raise awareness in car users to migrate to low or zero CO₂ pollutant cars.

4. Car Users



- Change purchase behavior to zero emission cars, such as electric or hydrogen.
- If not possible, migrate to hybrid- electric cars or petrol with low emissions.

Mission “Electrify” will pave the way towards a sustainable future for humanity and market growth.....

Thank You!