

Analysis of transport emissions from a global perspective

Análisis de las emisiones del sector transporte desde una perspectiva global

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 Ángel Mena-Nieto^{1,2*}, Jonatan J. Gómez-Vilchez² y Georgios Fontaras²
¹ University of Huelva (Spain)
² European Commission. Joint Research Centre (JRC). Ispra (Italy)

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1. INTRODUCTION AND OBJECTIVES

According to the International Energy Agency (IEA) [1], by the end of 2021, there were about 16.2 million light-duty electric vehicles (EVs) on the world's roads, more than triple the number in 2018. More specifically, Figure 1 shows that 11 million Battery Electric Vehicles (BEV) and 5.2 million Plug-in Hybrid Electric Vehicles (PHEV) were reached in 2021 (blue and orange vertical bars, respectively). Those figures will grow strongly in the coming years because EV sales doubled in 2021 compared to 2020, reaching a record

of 6.6 million sales. To better understand this high sales rate, think that currently, as many EVs are sold in one week as were sold in 2012. In 2021, 9.6% of global car sales were EVs, and the IEA estimates that this figure could reach 60% in 2030 [1].

To be more precise, an additional 51,600 fuel cell electric vehicles (Fuel Cell Electric Vehicles-FCEV) should be added to the previous figures, which in 2021 existed worldwide, with South Korea and the United States of America accumulating 60% of them [1].

The electric buses and heavy trucks figures are much smaller than the previous 16.2 million. In 2021, 670,000 electric buses and 66,000 heavy electric trucks circulated on this planet's roads. It represents 4% of the world's bus fleet and 0.1% of heavy trucks. Nearly all new electric truck registrations in 2021 came from China (90%) [1].

Although internal combustion engines still power the vast majority of the world's car fleet, there are many reasons

why many drivers and companies around the world are considering replacing or eliminating their old internal combustion engine vehicle, and replacing it with a new battery electric vehicle or a plug-in hybrid. Among these reasons, the most important are:

- a) the severe pollution problems in many cities, which are caused by the emission of harmful gases and particulate matter for health derived from the combustion of fossil fuels [2] [3], and
- b) the progressive implementation of access, circulation and parking restrictions for vehicles with high emissions in certain areas in more and more cities [4] [5].

In the case of the European Union, regulations were approved in 2009 to reduce CO₂ emissions from the road transport sector, which established a target for the entire fleet of new passenger cars of 130 grams of CO₂/km for the period 2015-2019, and 95 g CO₂/km for the 2020-2024 period (applying the New European Driving Cycle (NEDC)).

During the last years of application of the NEDC protocol, the scientists discovered significant differences (15-38%) between the official measurements of CO₂ emissions and fuel consumption under standardized laboratory conditions and those recorded in driving tests obtained in the real world [6], [7]. In response to this, Europe introduced a new measurement protocol, the World Harmonized Light-duty Vehicle Test Procedure (WLTP), included in the European Regulation 2017/1151, which is currently used for the certification of CO₂ emissions. Later, in 2019, another new European Regulation 2019/631 was approved, with new fleet targets for 2025 and 2030 and a 15% reduction by 2025, with respect to the 2021 emission levels (based on the new protocol of WLTP measure [8]) and a further reduction of 37.5% by 2030 (31% for light commercial vehicles).

As a result, a steady decrease in emissions was achieved between 2010 and 2016 of almost 22 g CO₂/km. However, the

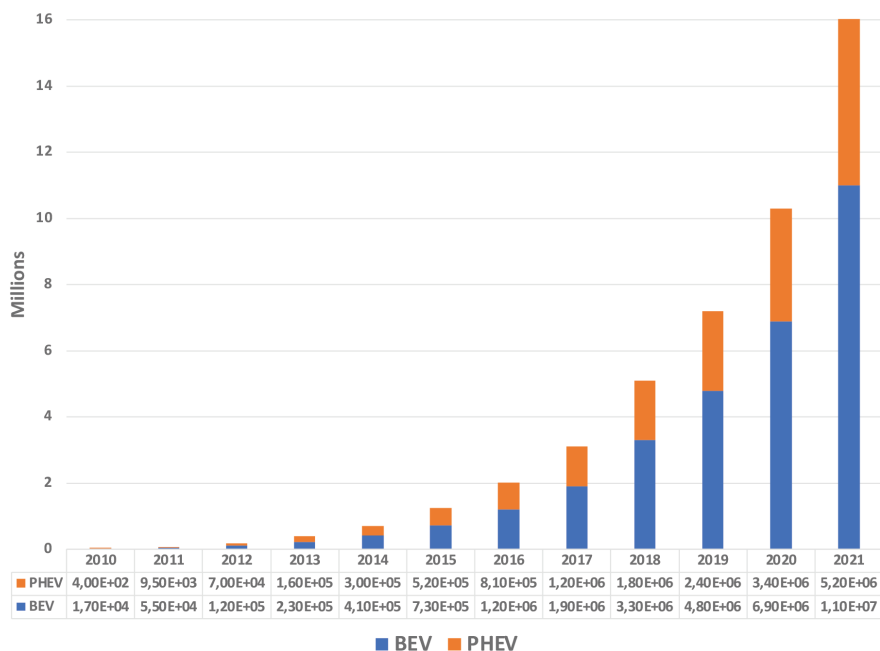


Fig. 1. Historical evolution of the number of battery electric cars and plug-in hybrids in the world (2010-2021). Source: Own elaboration based on [1]

* Affiliated as a temporary Visiting Scientist. The origin institution affiliation is the University of Huelva. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

average emissions of new passenger cars increased in 2017, 2018 and 2019, reaching 122.3 g CO₂/km according to the European Environment Agency (EEA) in 2019 [9]. Although that figure remains below the 2015–2019 target of 130 g CO₂/km, it is well above the 2020–2024 target of 95 g CO₂/km. The EEA itself attributes this increase in emissions between 2017 and 2019 to the growth in registrations in the segment of SUVs and heavier passenger cars. The most recent data indicates that the average emissions of new passenger cars sold in 2020 stood at 107.8 g CO₂/km [9].

Another way to reduce emissions is to replace fossil fuels with biofuels or alternative fuels with lower emissions. Currently, they only account for 3% of the total demand for transport fuels, but they are expected to grow in the coming years. In 2016, they contributed 3.38 exajoules to global energy consumption and reached 4.01 exajoules in 2019 [10]. However, to achieve carbon neutrality in 2050, their consumption would have to triple by 2030, reaching 12 exajoules [10]. To achieve it, countries would have to increase investment in infrastructure essential for their development. That was the objective of Directive 2014/94/EU in the

case of the European Union. A very recent analysis of European countries' plans for developing recharging and refuelling infrastructure for freight vehicles and ships can be seen in [11] and [12].

To further complicate matters, the war in Ukraine has caused a considerable increase in energy prices in international energy markets. Not surprisingly, in 2020, Russia was the world's largest exporter of fossil gas—with 25% of world exports—and the third largest exporter of crude oil (11.4% of the total) [13]. Added to this is the problem of the scarcity of the raw materials necessary for the manufacture of vehicles, caused by tensions in global supply chains, which strongly impact the automotive sector [14].

This article has a double objective; On the one hand, to present the primary data on the evolution and current situation of emissions from the transport sector from a global perspective. On the other hand, to analyse the decisive role that the reduction of emissions in this sector can have in the fight against the climate crisis, despite the future increase in the demand for transport in the world, motivated by the growth of the population and the demand transportation of people and goods expected for the coming decades.

Figure 2 shows the evolution of the world population from 1950 to 2021 (continuous blue line) and one of the projections made by the United Nations team of experts [15] until 2100, under the scenario of average fertility variation (dashed red line). The population growth experienced during the last decades is verified (the world population has doubled in the previous 47 years), and its growth until reaching the maximum in the mid-1980s, at which time a slow decline until the year 2100 is expected. It is estimated that we will go from the current 8 billion inhabitants to more than 8.5 billion in 2030. Therefore, it is reasonable to expect that the demand for the transport of people and goods will increase with these new 500 million additional inhabitants, and consequently, also its CO₂ emissions.

On the other hand, the energy needed to drive the world economy continues to be generated mainly by fossil fuels (80.9% of the total). For example, in 2019, of the 606 exajoules of primary energy supplied to the world economy, 30.9% came from oil, 26.8% from coal, and 23.2% from natural gas [16]. In addition, almost half (49.4%) of said energy was demanded by countries on the Asian continent (China, India and Japan). Hence these three countries emit close to 40% of global CO₂ emissions, and together with The United States (15%), the European Union (10%) and Russia (5%), constitute the top-6 of world emissions [17], although China doubles the emissions of the second, which is the United States. Replacing 80.9% of the world's energy currently provided by fossil fuels with electricity requires redesigning the entire energy supply and demand system so that energy needs have to be provided by carbon-free energy sources, and in that transition, the transport sector will play a leading role.

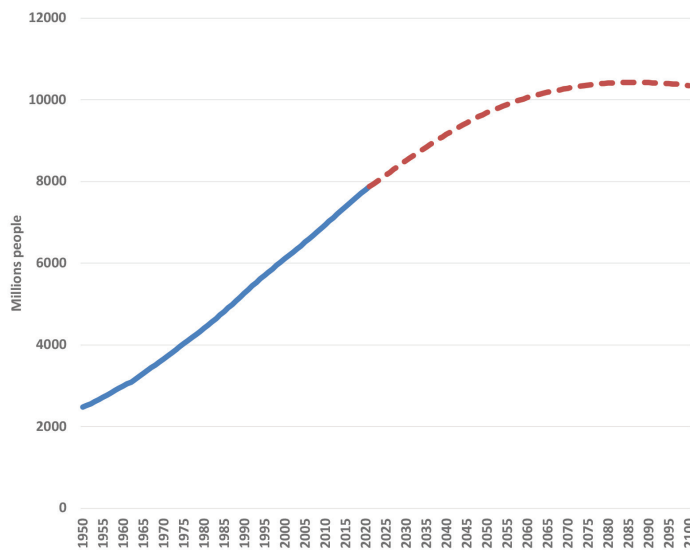


Fig. 2. Evolution of the world population 1950–2021 and prediction of its future growth 2022–2100 under a medium-fertility growth scenario. Source: Own elaboration based on [15].

CO ₂ fossil	World		European Union–27	
	2020–1990	2019–1990	2020–1990	2019–1990 EU–27 + UK
Power industry	+72%	+78	-43%	-39%
Other industrial combustion	+58%	+67%	-46%	-40%
Buildings	+1%	+8%	-31%	-23%
Transport	+58%	+78%	+8%	+18%
Other Sectors	+97%	+100%	-23%	-22%
Total	+58%	+68%	-31,3%	-25%

Table 1. Increase or decrease in emissions from 1990 to 2019 and 2020. Comparison between the World and the European Union for different sectors. Source: Own elaboration.

2. ANALYSIS OF EMISSIONS OF THE TRANSPORTATION SECTOR

2.1 GLOBAL PERSPECTIVE AND COMPARISON WITH THE EUROPEAN UNION

In 2020, global CO₂ emissions from the transport sector totalled 7.29 billion tons, representing 20.27% of the planet's total emissions, having experienced a growth of 58% since 1990 [18]. That figure includes road, rail, air, sea and pipeline transportation emissions. It so happens that transport is the only sector in which the European Union (EU–27) has not managed to reduce its emissions during the

period 1990-2020; instead, they have grown by 8% [18].

Figure 3 shows their historical evolution between 1990 and 2020 (upper orange line). As can be seen, they have followed a practically linear trend, except in 2020. The historical series maximum was reached in 2019 with 8,251 million tons (representing 20% of the total for that year), although they fell to 7,289 tons in 2020 due to confinement. The country with the highest emissions from the transport sector in 2020 was the United States, with 21%, while the European Union was responsible for 15% of them, its annual emissions being those represented in the blue line [19].

If the global emissions of the 2019 record year are compared with those of 1990, which were 4,596 million tons, it is found that they increased by 79.5% in the period 1990-2019. If the same analysis is carried out for the EU-27, it is obtained that the increase was 24.2%. Ta-

	Emissions (Mt CO ₂)	%	N.º de vehículos (millions)
Vans	596	20,83	144
Medium Trucks	587	20,52	36
Heavy trucks	1183	41,35	27
Buses and Coaches	495	17,30	10
Total	2861	100	217

Table 2. CO₂ emissions and number of vehicles for the transport of goods in the world in 2020: Source: Own elaboration based on [23].

ble 1 shows the results of making these same comparisons for the five sectors into which emissions are divided using the period 1990-2020. It is found that, in the case of the European Union, transport has been the only sector where emissions have not been reduced.

Figure 4 shows, in more detail, the part of global emissions that corresponds to the EU-27, but extending the period of analysis to 1970, to better understand the historical behaviour of emissions and verify that the maximum of the series historical was not in 2019 but 2007.

2.2 ANALYSIS OF EMISSIONS ACCORDING TO THE DIFFERENT MODES OF TRANSPORT

Next, we will analyse the emissions of the subsectors (modes) in which the transport sector is divided. Figure 5 shows the detail of how these global emissions are broken down according to the different means of transport (land, air and waterborne transport) in 24 member countries of the International Energy Agency¹ [19], excluding the emissions generated by international aviation and maritime transport because these two subsectors are accounted for separately from the rest and will be analysed later. First, in the upper part of the figure, it can be seen that the vast majority (88.2%) come from the road transport subsector (larger light blue rectangle). Next in importance is national air transport with 8% (dark blue rectangle) and rail transport with 2.2% (lighter green rectangle). Lastly, the narrowest and rightmost greenish-blue rectangle represents transport by non-international waters (1.7%)².

The lower part of Figure 5 breaks down the 88.2% of emissions from road transport. The most important part is taken by passenger cars with 58.3% (yellow rectangle). Freight transport follows in importance with 27.2% (orange rectangle), buses with 2% (narrow red rectangle) and, lastly, motorcycles with 0.5% (almost imperceptible purple rectangle) [19].

Next, to complete the perspective, Figure 6 describes how the CO₂ emissions emitted by the transport sector as a whole were broken down in 2020, including aviation and international maritime transport. The most considerable contribution to CO₂ emissions comes from road transport, and within this, transport by passenger cars

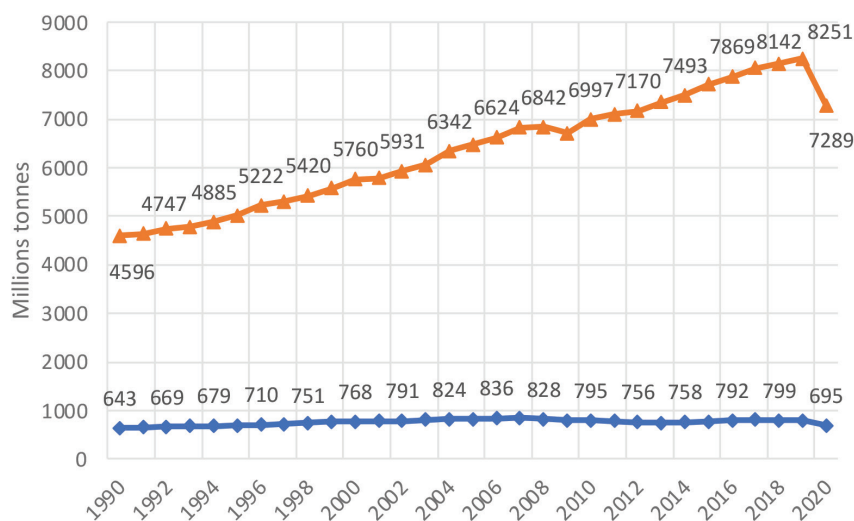


Fig. 3. Evolution of annual global CO₂ emissions from the transport sector (1990-2019) in the world and the EU-27. Source: Own elaboration based on [18]

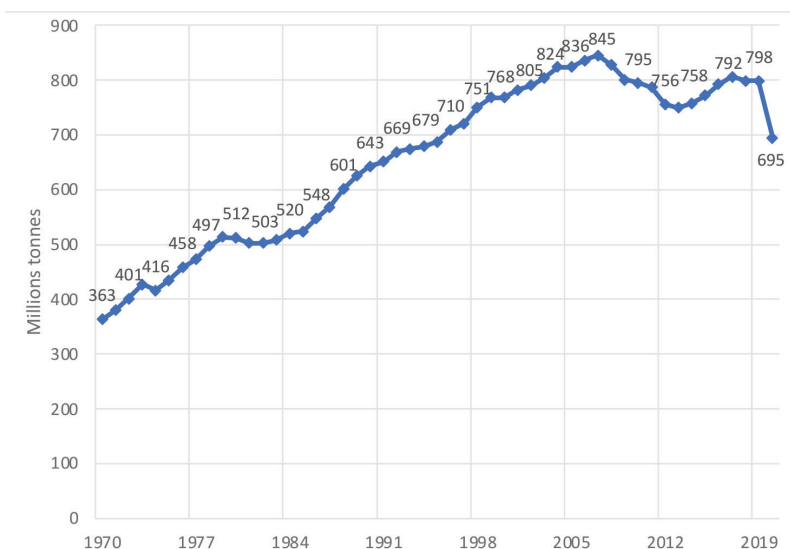


Fig. 4. Historical evolution of annual global CO₂ emissions from the transport sector (1970-2019) in the EU-27. Source: Own elaboration based on [18].

¹ Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Poland, Portugal, Slovak Republic, Spain, Switzerland, Slovak Republic, United Kingdom and the United States of America.

² the sum is not 100 due to rounding.

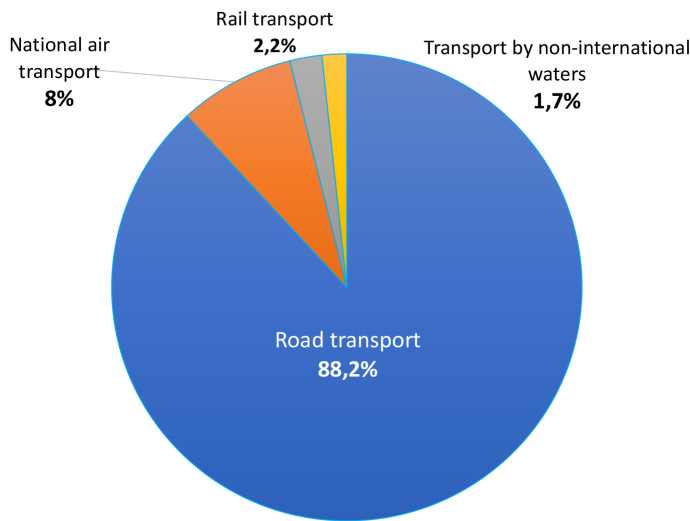


Fig. 5. Breakdown of global CO₂ emissions between the different subsectors. Source: IEA [19]

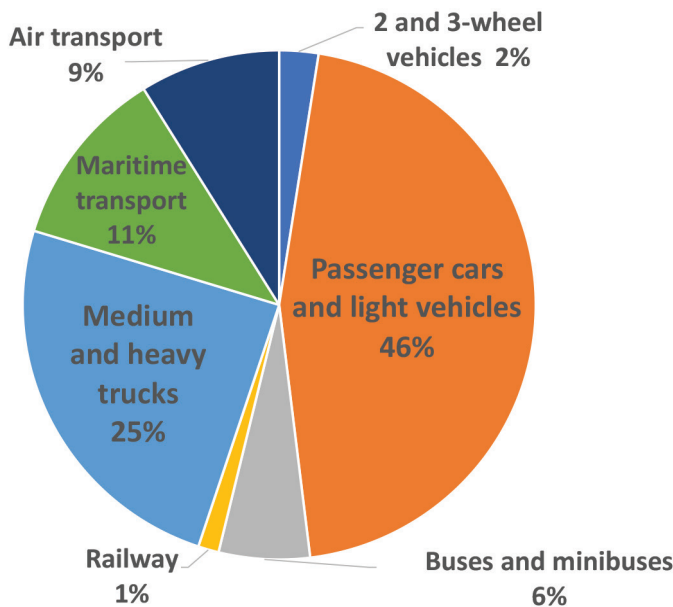


Fig. 6. Breakdown by subsector of CO₂ emissions in the transport sector globally in 2020. Source: Own elaboration based on IEA data [20]

and light vehicles³ (46%), followed by medium and heavy trucks⁴ (25%), maritime transport (11%), air transport (9%), which in 2020 suffered more than other sectors, buses and minibuses (6%), 2 and 3-wheel vehicles (2%) and rail (1%). The predominance of road transport of people and goods (79%) is confirmed compared to the rest of the subsectors.

Figure 7 provides quantitative data for 2020, in millions of tons of CO₂ equivalent, on the emissions of the same sub-

sectors of Figure 6. It is verified that the set of passenger cars and lighter vehicles, trucks and two-and-a-half vehicles with three wheels contribute around 73% of emissions, while public transport services (bus and rail) generate around 7%.

According to one of the latest reports of the International Transport Forum (ITF), the continuous economic development and the increase in the world population will increase the demand for transport in the coming decades. If current trends continue, transport activities will double in 2050, compared to 2015. Passenger transport is expected to multiply by 2.3; freight by 2.6 and air transport by 3.1 [21]. Additionally, although road and rail transport should be the modes of transport that contribute the most to global

decarbonisation, a reconfiguration of the global supply chains of international trade would be desirable [22].

Table 2 shows the CO₂ emissions from freight transport in the world in 2020. The total amounted to 2,861 million tons (Mt), of which the majority (41.35%), that is, 1,187 million, was generated by the approximately 27 million heavy trucks in the world. In contrast, more than 144 million vans generated only half of those emissions (20.83%).

Focusing now on passenger cars and lighter vehicles, Figure 11 shows their CO₂ emissions increased by 45% from 2000 to 2020. However, there was a 6% reduction in 2020 due to the pandemic [24].

Lastly, Figure 9 shows how the global CO₂ emissions of the international aviation (lower blue line) and international maritime transport (upper orange line) subsectors have evolved. Regarding aviation, the number of passengers and the cargo transported has followed a growing trend reaching 616 Mt of CO₂ in 2019, falling sharply during 2020 due to the pandemic. However, they have recovered the growth path during 2021 and 2022, and it is expected that they will continue to do so strongly in the coming years due to the forecasts of an increase in the world population, international trade and international tourism.

Regarding maritime transport, its historical maximum was also achieved in 2019, when emissions reached a record of 773.7 Mt CO₂ [18] but its decrease in 2020 was much smaller, only 1.2% compared to 2019. Bulk carriers were by far the main contributor to these emissions, emitting 440 Mt CO₂ in 2020 (57% of the total).

3. SUMMARY AND CONCLUSIONS

In this article, the annual CO₂ emissions of fossil origin on the planet have been analysed, breaking them down by sector, and it has been verified that the transport sector was responsible for 20.27% of the total of said emissions in 2020. Within the transport sector (see figure 6), road transport of people and goods is the main emitter since it is responsible for 79% of the sector's total emissions. Most (54%) come from passenger cars, vans, 2 and 3-wheelers and buses). Moreover, the remaining 25% comes from trucks that transport goods. Transporting people and goods by rail only adds an additional 1%. The remaining 20% is divided between aviation, which accounts for approximately 9% of total emissions, and

³ passenger cars and vans whose load capacity is less than 3.5 tons.

⁴ medium-sized trucks whose load capacity is between 3.5 and 15 tons and trucks whose load capacity exceeds 15 tons in weight.

maritime transport, which contributes 11%.

From a global perspective, if the evolution of the sector's total emissions in the period 1990–2020 is analysed, historical maximums continue to be registered yearly (see figure 3). On the contrary, the European Union has managed to reduce both total emissions (-31.3%) and emissions from all sectors (including energy industries), except those from the transport sector, which grew by 8% in the period 1990–2020 (see table 1). It highlights the difficulty of reducing emissions in this sector.

To meet the 90 % reduction target by 2050 as defined in the Green Deal, the European Commission presented the Sustainable and Smart Mobility Strategy in December 2020 (COM/2020/789 final). It has adopted a set of proposals through Regulation (EU) 2021/1119 of the European Parliament and the Council of 30 June 2021, the European Climate Act, to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. Reducing transport emissions is, therefore, crucial to meet climate neutrality goals. However, the technological improvements obtained in recent years in terms of energy efficiency and fuel savings by manufacturers have not managed to compensate for the increase in emissions caused by the greater presence of heavier off-road vehicles (SUVs) on their roads, which consume more fuel and are less efficient than other passenger cars.

Data on population growth for the coming years (500 million more in 2030) have been provided. The zero-emissions challenge for the middle of this century, to which more than 70 countries have committed (including Australia, South Korea, the European Union, the United States, the United Arab Emirates and Japan by 2050, as well as China by 2060), it will be more difficult to achieve in a much more populated world and where the demand for land, sea and air transport of the future inhabitants of our planet will grow, which will test its limits.

In the past, economic growth has been the main driver of increased emissions; In order to reduce them, the world has two alternatives, either it manages to decouple the growth of global emissions from the gross domestic product (GDP), or it assumes that perpetual economic growth is not possible, putting at risk the improvement in living conditions of millions of human beings in the least developed

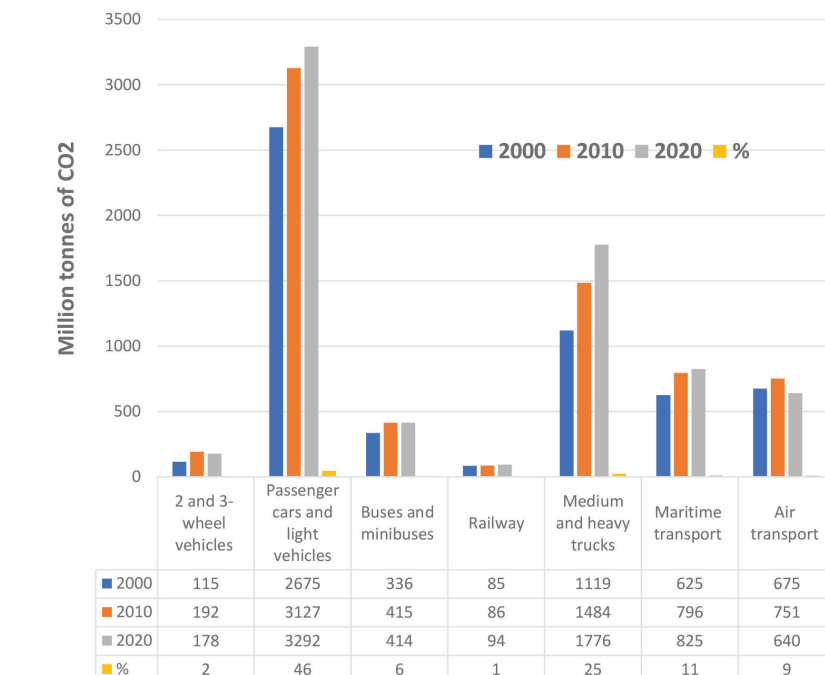


Fig. 7. Comparison between the emissions of the different transport subsectors in the years 2000, 2010 and 2020. Source: Own elaboration based on IEA [20]

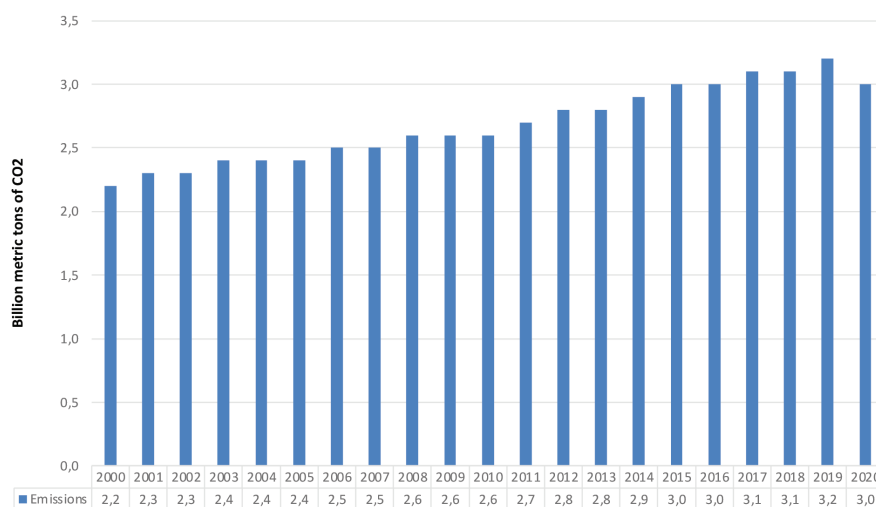


Fig 8. Global CO₂ emissions from passenger cars worldwide 2000–2020 (in billion tons). Source: Own elaboration based on [24].

countries, foreseen in the 2030 Agenda. The European Union is an example that the first alternative is possible because, as has been shown, in 2020, it was able to reduce its total emissions by 31.3% compared to 1990, but in that same period, it also achieved economic growth of GDP of over 60%.

As has been explained, the growth in the standard of living and the population in developing countries will cause an unstoppable growth in the movement of goods and passengers in the coming decades. It may be thought that the electrification of transport, with the massive adoption of electric vehicles (cars, buses, vans and trucks) on the roads of the entire planet, can solve the problem. However, if

the electrical energy with which the batteries are charged comes from the combustion of fossil fuels (coal, oil or natural gas) in a power plant, such as when there is no wind or sun in sufficient quantity to satisfy demand, in that case, the emissions of electric vehicles would not be zero.

In short, the data provided highlights with the strategic importance of the electrification of transport to fight against the climate crisis. However, electrification and the use of alternative fuels to traditional ones will require new technological advances and specific policies that make this decoupling between economic growth, increased energy consumption and increased emissions possible. For example, to achieve climate neutrality in

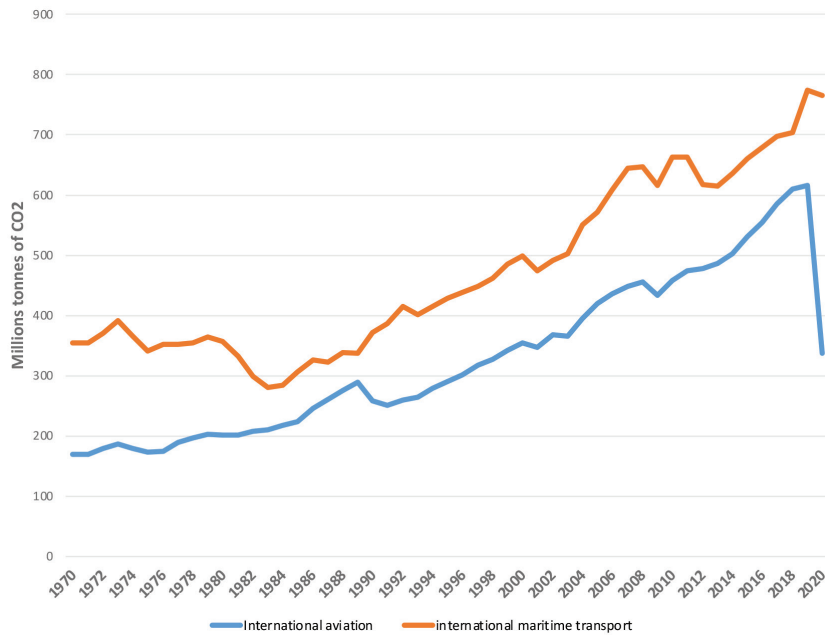


Fig. 9. CO₂ emissions from aviation and international shipping worldwide 1970-2020. Source: Own elaboración based on [18]

2050, the European Union intends to extend the emission rights trading system to fuels used for road transport from 2026 and progressively extend it to aviation and waterborne transport. Likewise, it has set national goals to install charging stations for cars and vans, hydrogen service stations, and recharging points for heavy vehicles by 2030.

Lastly, we cannot fail to mention the importance of promoting environmental awareness and education for all to make more rational use of the different means of transport to take environmental impacts into account in their purchasing decisions. It is also critical to reduce costs in key technologies, mainly in terms of electricity generation from renewable sources, and improvements in battery capacity and recharge times. Technology, just as it has done in the past, has to help our species overcome the challenge we face as a planet, that is, ending hunger, improving the lives of all the planet's inhabitants, generating clean and cheap energy that drives that economic growth but without causing an increase in environmental impacts. That, or find another planet for some of our future neighbours.

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