A culture of mobility; Means of mobility; Energy of mobility

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Basics of Mobility and Transport

Mobility 1

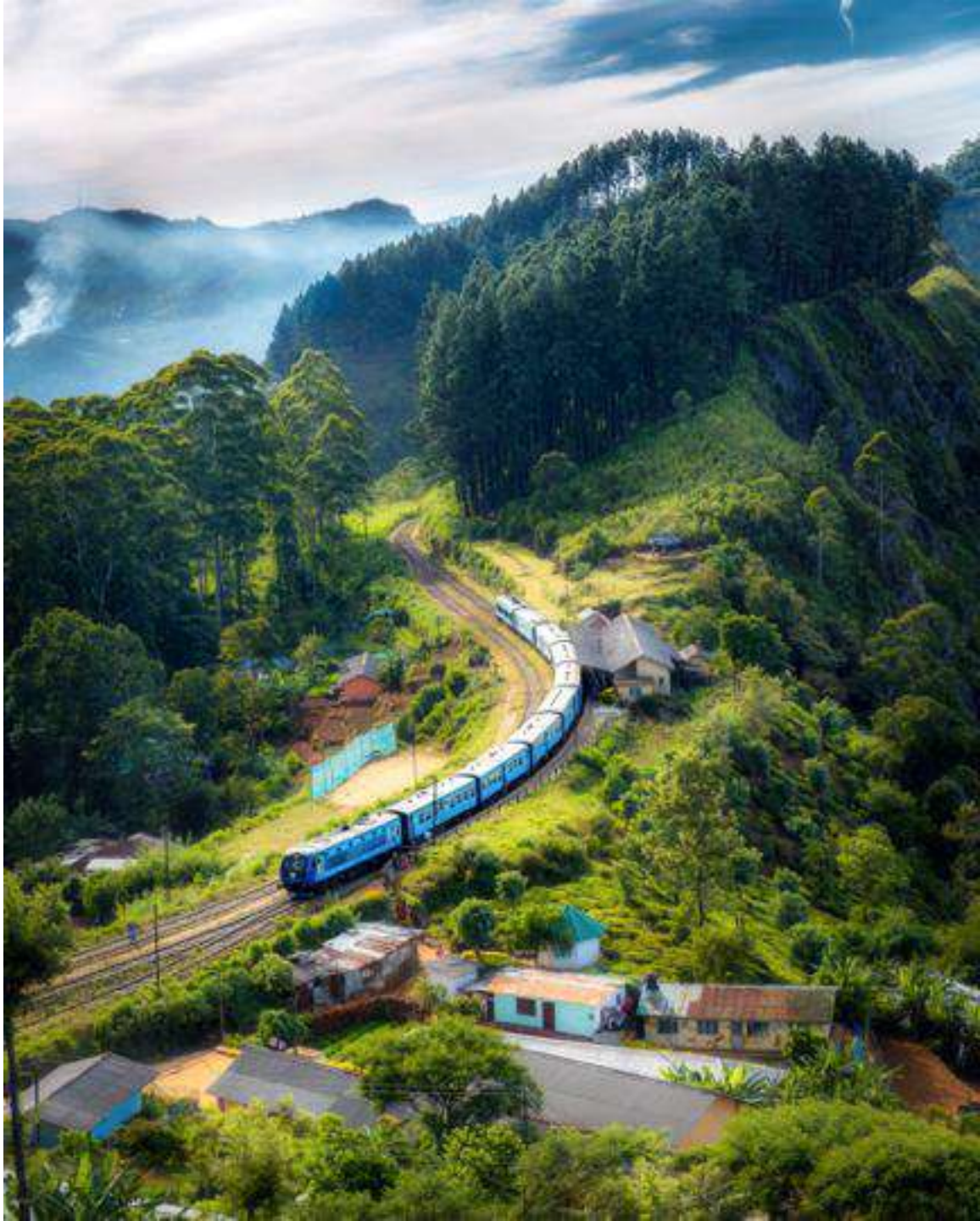
Mobility 2

Mobility 3

Mobility 4

Mobility 5

Mobility 6



Mobility 7

Mobility 8

Mobility definitions

A1. The ability to move freely or be easily moved

A2. The ability to change one's social or socioeconomic position in a community and especially to improve it

Source: The Cambridge dictionary

B1. the quality or state of being mobile or movable

B2. the ability to change one's social or socioeconomic position in a community and especially to improve it

Source: Merriam-Webster Dictionary

C1. the quality of being mobile

C2. the movement of people in a population, as from place to place, from job to job, or from one social class or level to another

Source: Collins Dictionary - American English

In this course, definitions A1 and C1 are the ones discussed

Transport definitions

Many definitions exist – the ones shown here regarded as most relevant

A1. to take goods or people from one place to another (verb)
A2. the movement of people or goods from one place to another (noun)

Source: The Cambridge dictionary

B1. to transfer or convey from one place to another (verb)
B2. an act or process of transporting (noun)

Source: Merriam-Webster Dictionary

C1. To transport people or goods somewhere is to take them from one place to another in a vehicle (verb)

C2. Transport is the activity of taking goods or people from one place to another in a vehicle (noun)

Source: Collins Dictionary - American English

Mobility is a main concern in our societies – we live in a mobility culture

The extent of mobility is 35 km per day and almost twice as high for those – **especially middle-aged men** – with the highest degree of mobility

On average **we travel close to one hour per day**. This time is fairly constant over time but the distance covered increases with faster cars, buses, trains, flights and better roads

Mobility **increases faster than GDP** in many countries. When we have more money we use much of it for travel

World Travel and Tourism Numbers 2025

Contribution to Global GDP = 9,8 %

In 2025, Travel & Tourism's contribution to global GDP totalled US$ 11.6 trillion. It grew at 4.1% year on year, exceeding overall global economic growth (2.8%) by almost 50%.

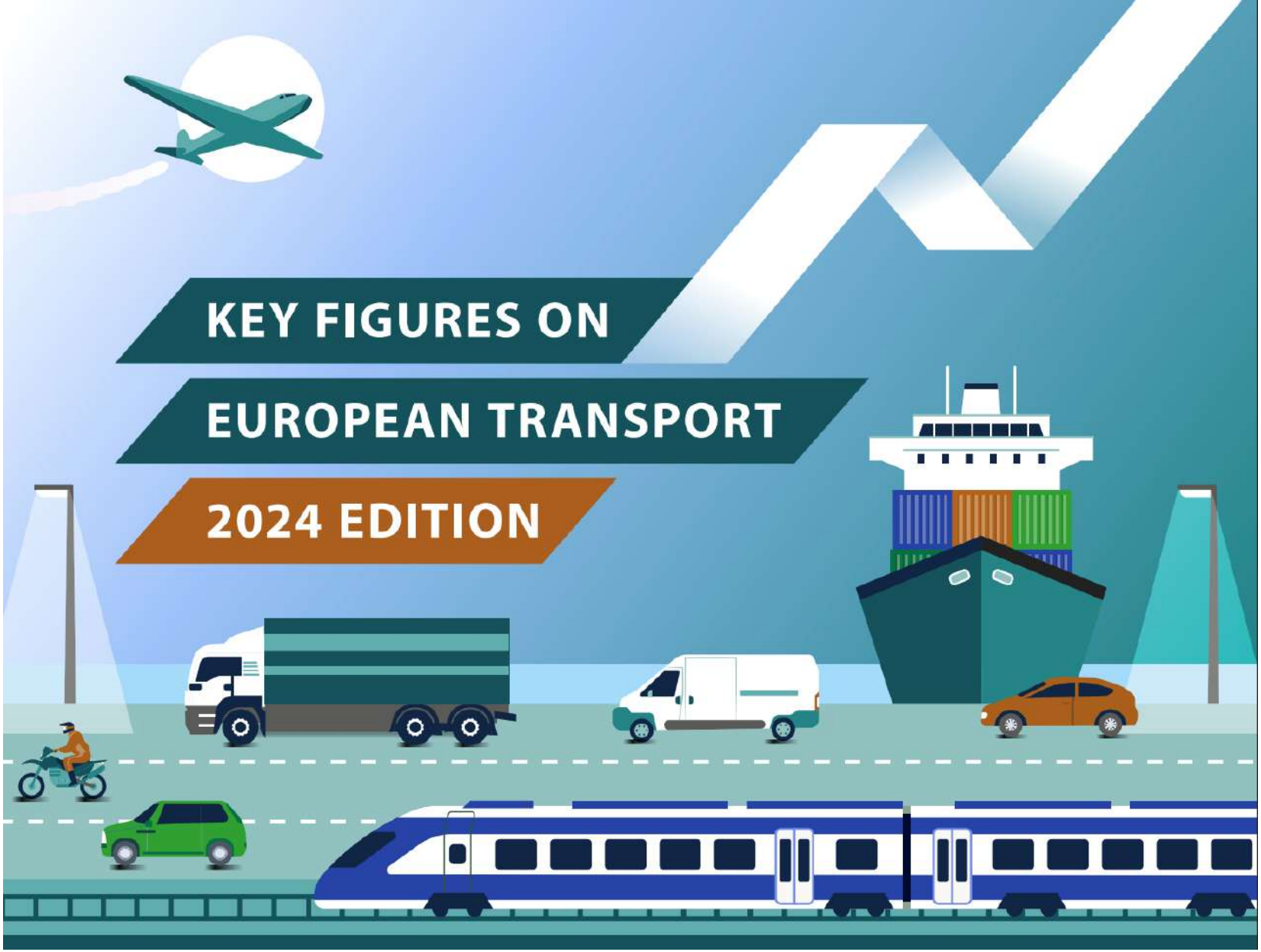
Contribution to Global Employment: = 366 million jobs

Travel & Tourism is also an important source of employment. In 2025, the sector supported a total of 366 million jobs globally, which is approximately 1 in 9 jobs. The sector also accounted for 1 in 3 new jobs created globally.

Domestic and Global Spending Growth Rate: = 3-4 %

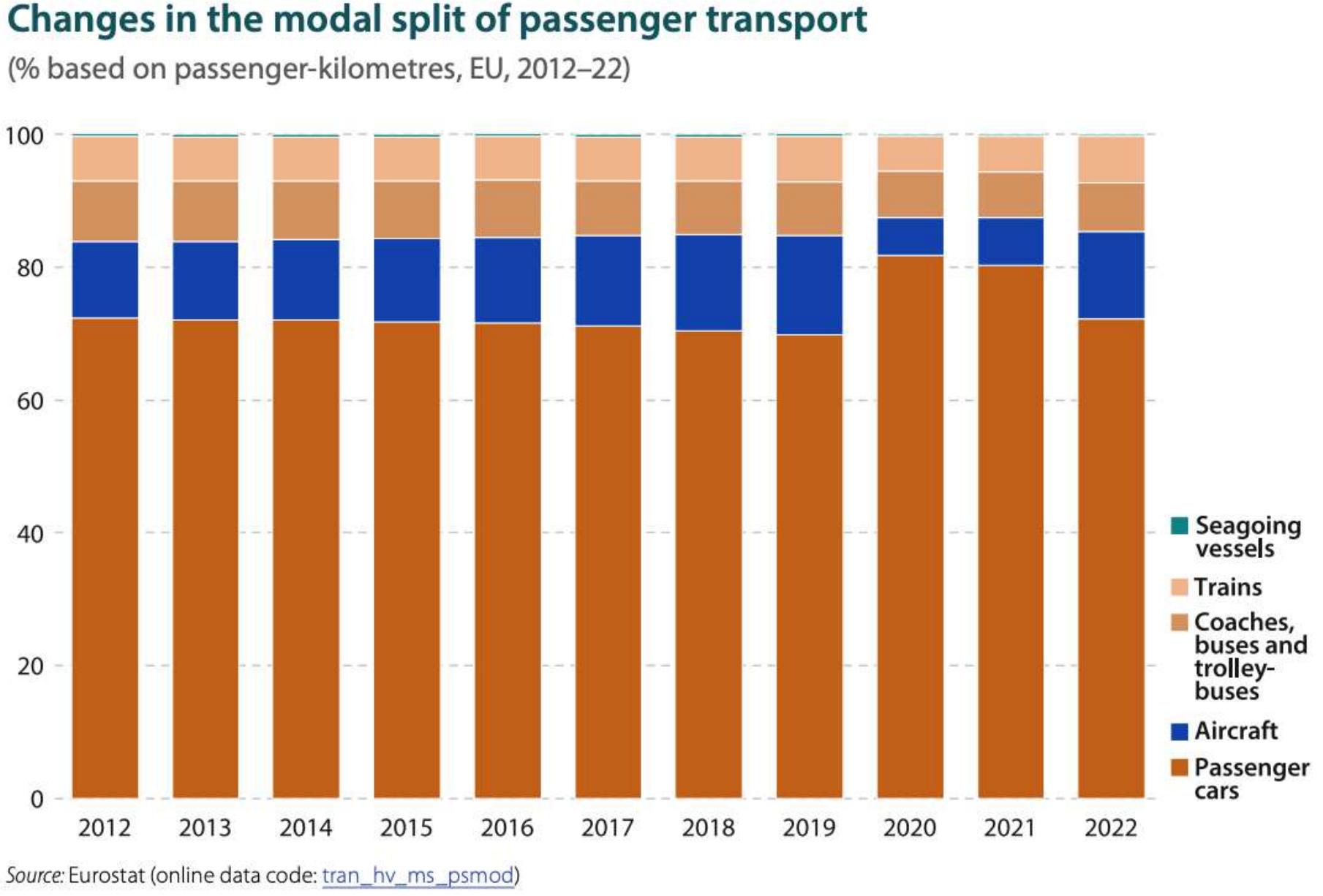
Domestic visitors spent US$ 5.63 trillion, growing 3.7% over the 2024 level. At the same time, spending by international visitors increased 3.2 % annually to reach US$ 2.02 trillion

https://wttc.org/research/economic-impact

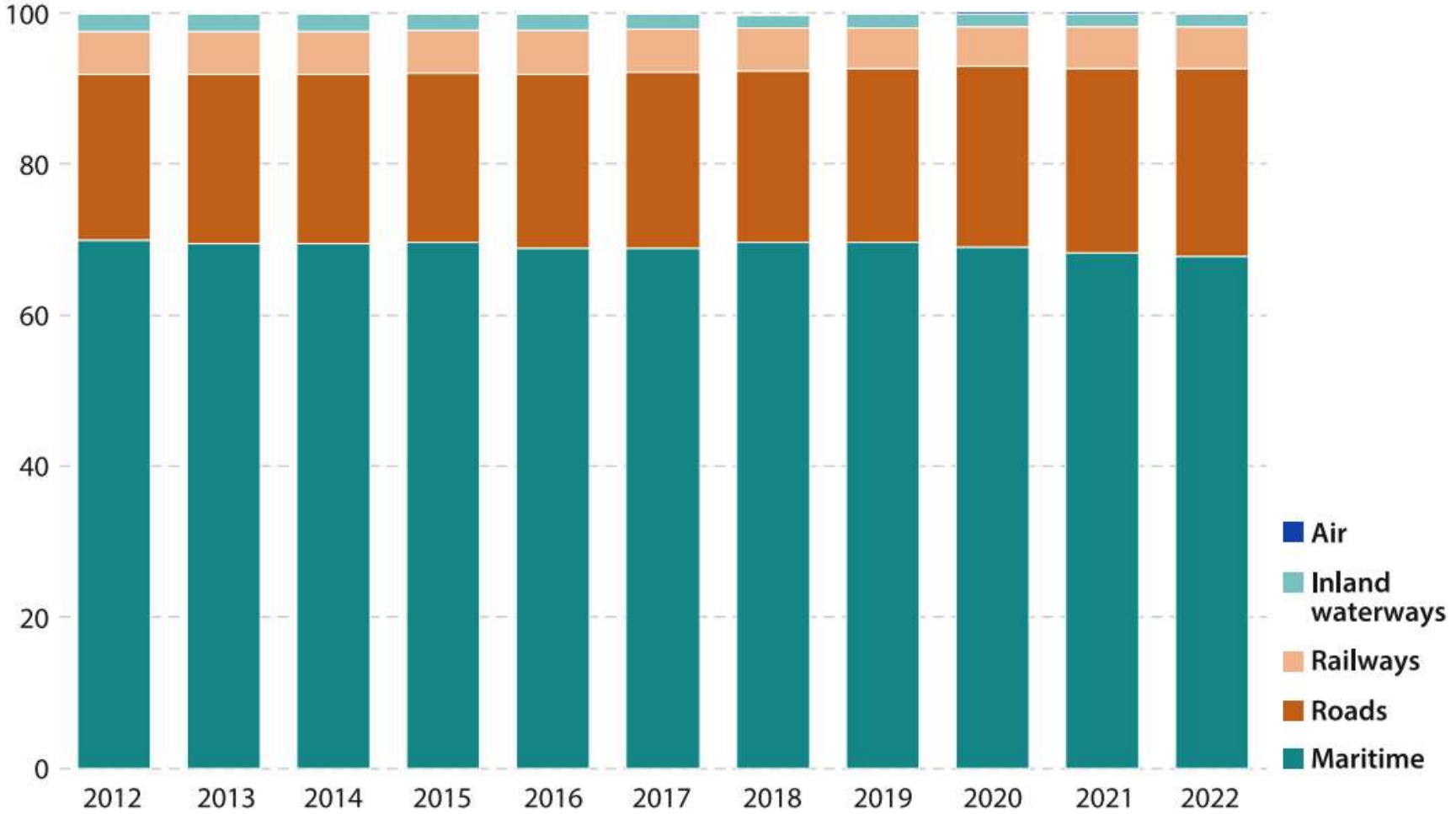


https://ec.europa.eu/eurostat/documents/15216629/20875401/KS-01-24-021-EN-N.pdf

Modal Split of EU Passenger Transport 2012-2022

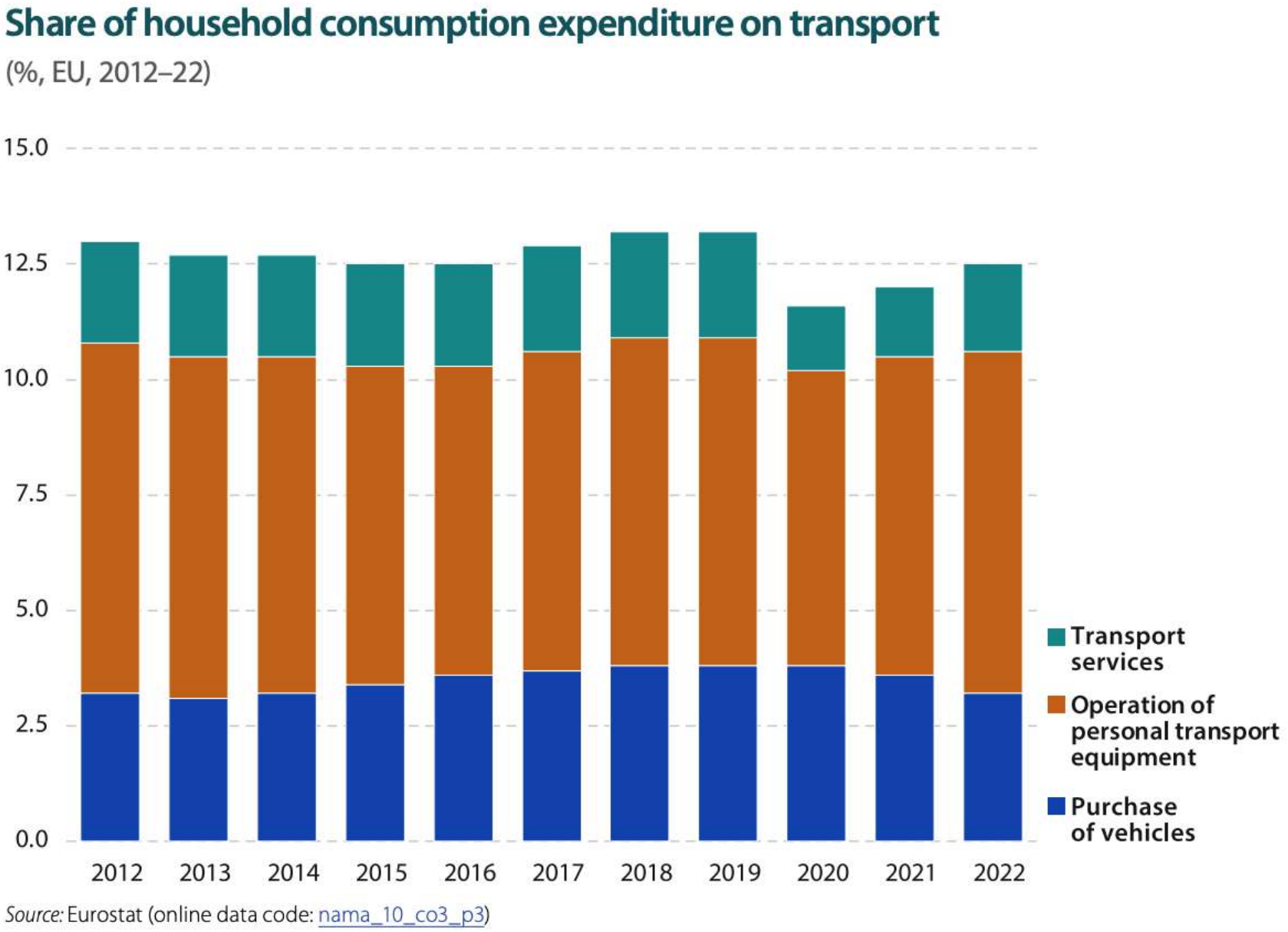


Modal Split of EU Freight Transport 2012-2022



Source: Eurostat (online data code: tran_hv_ms_frmod)

EU Household Consumption on transport 2012-2022

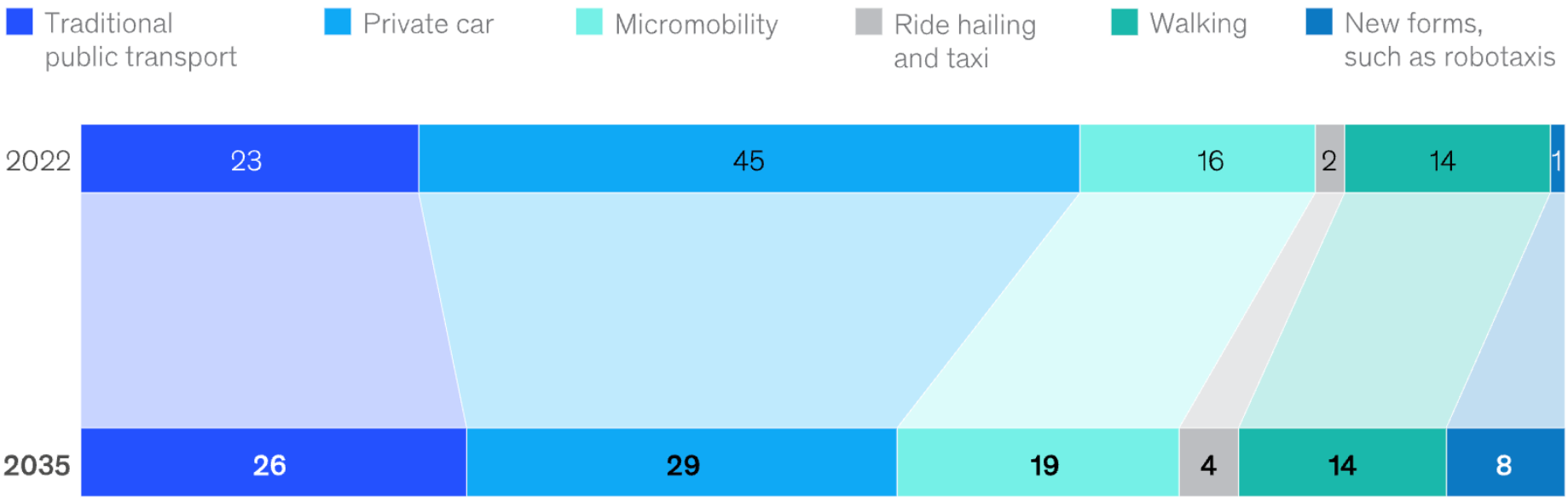


Source: Eurostat (online data code: nama_10_co3_p3)

Forecast of Global Mobility Development 2022-2035

Although private cars will remain the most popular transportation option, their share of total mobility will decline.

Mobility split by mode of transportation, worldwide, %



Note: Figures may not sum to 100%, because of rounding.
Source: McKinsey Center for Future Mobility

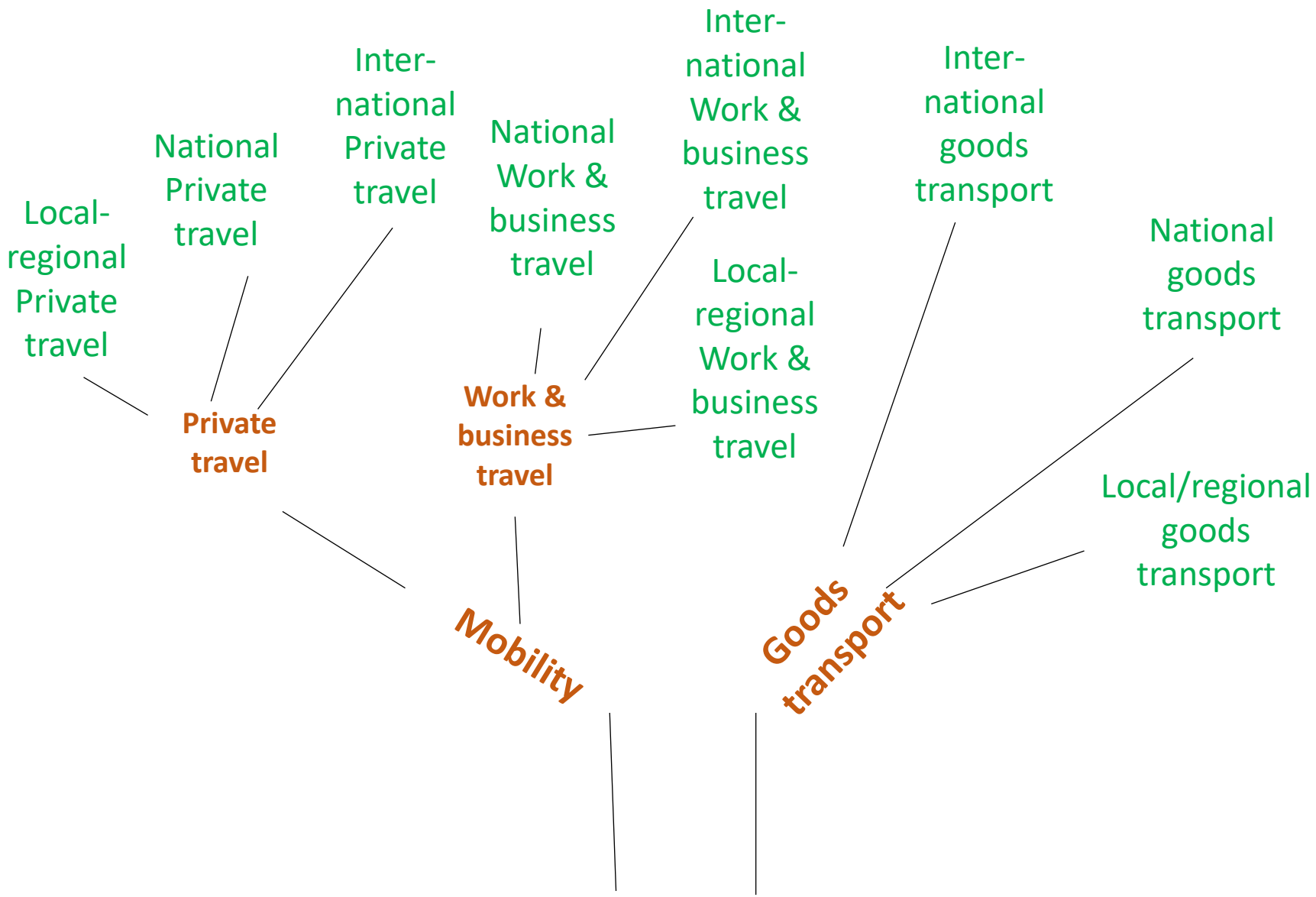
McKinsey & Company
https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-mobility-global-implications

Mobility is of two kinds

So-called ***forced mobility*** is travelling which is not wanted by the individual but required for work and needed social services. Most typical, this includes commuting between home and work, home and school or home and food purchase. Travelling as part of work has also increased rapidly until recently during the Covid-19 pandemic

Voluntary mobility is travel chosen by the individual for example in connection with free time and tourism. Voluntary mobility, especially for tourism, is an important part of most peoples' lives when income increases

A Mobility and Transport Tree

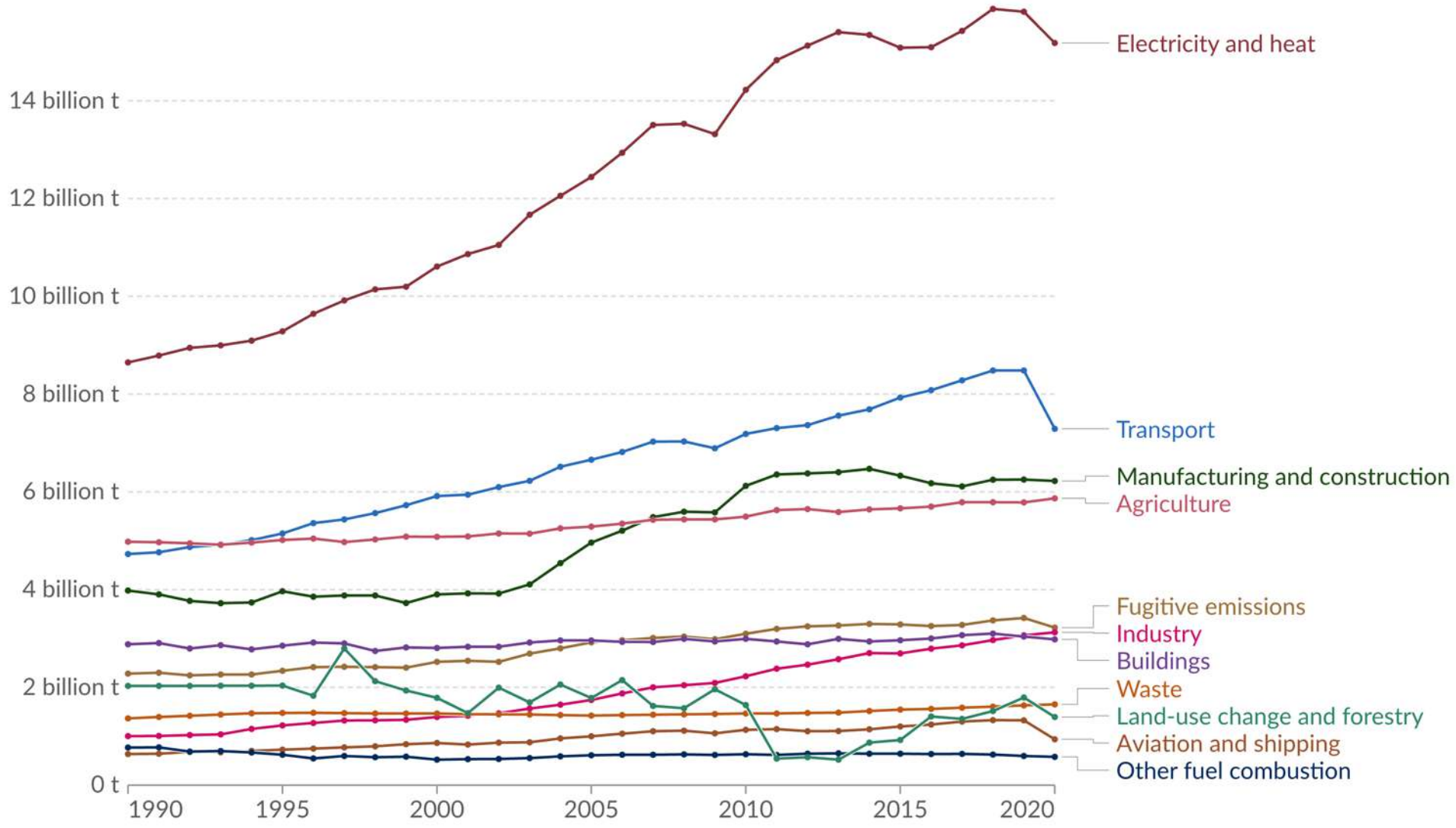


Source: Frostell 2021

Greenhouse gas emissions by sector, World

Our World in Data

Greenhouse gas emissions[1] are measured in tonnes of carbon dioxide-equivalents[2] over a 100-year timescale.

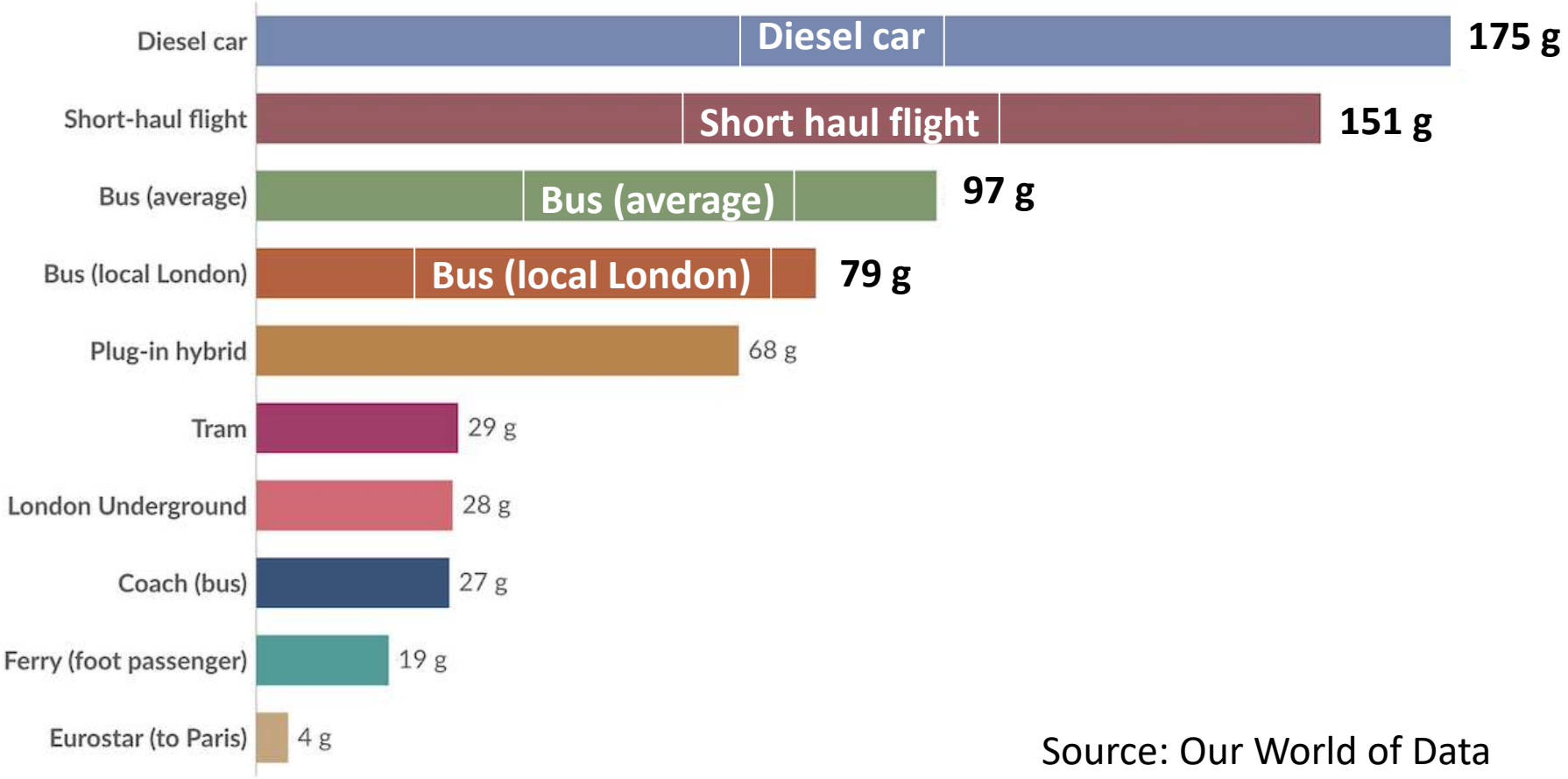


Data source: Climate Watch (2023)

OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

Carbon footprint of travel per kilometer, 2022

The carbon footprint of travel is measured in grams of carbon dioxide-equivalents per passenger kilometer. This includes the impact of increased warming from aviation emissions at altitude



Source: Our World of Data

Data source: UK Government, Department for Energy Security and Net Zero (2022)

OurWorldinData.org/transport | CC BY

Note: Official conversion factors used in UK reporting. These factors will vary across countries depending on energy mix, transport technologies, and occupancy of public transport. Data for aviation is based on economy class.

Milestones for EU Sustainable Mobility decided 2020 (1)

Milestones on reducing the current dependence on fossil fuels:

1) By 2030, there will be at least 30 million zero-emission cars and 80 000 zero-emission lorries in operation.
2) By 2050, nearly all cars, vans, buses as well as new heavy-duty vehicles will be zeroemission.
3) Zero-emission ocean-going vessels and large zero-emission aircraft will become market ready by 2030 and 2035, respectively.

Milestones on shifting more activity towards more sustainable transport modes:

4) Scheduled collective travel under 500 km should be carbon-neutral by 2030 within the EU.
5) Traffic on high-speed rail will double by 2030 and triple by 2050.
6) By 2030, there will be at least 100 climate-neutral cities in Europe.
7) Rail freight traffic will increase by 50 % by 2030 and double by 2050.
8) Transport by inland waterways and short sea shipping will increase by 25 % by 2030 and by 50% by 2050.

Source: EU Document: Brussels, 9.12.2020 COM(2020) 789 final

Milestones for EU Sustainable Mobility decided 2020 (2)

Milestones on internalising the external costs of transport, including via the EU ETS:

9) By 2030, rail and waterborne-based intermodal transport will be able to compete on equal footing with road-only transport in the EU40 .
10) All external costs of transport within the EU will be covered by the transport users at the latest by 2050.

Milestones towards smart mobility:

11) By 2030, seamless multimodal passenger transport will be facilitated by integrated electronic ticketing and freight transport will be paperless.
12) By 2030, automated mobility will be deployed on large scale.

Milestones towards resilient mobility:

13) A multimodal Trans-European Transport Network equipped for sustainable and smart transport with high speed connectivity will be operational by 2030 for the core network and by 2050 for the comprehensive network.
14) By 2050, the death toll for all modes of transport in the EU will be close to zero.

Source: EU Document: Brussels, 9.12.2020 COM(2020) 789 final

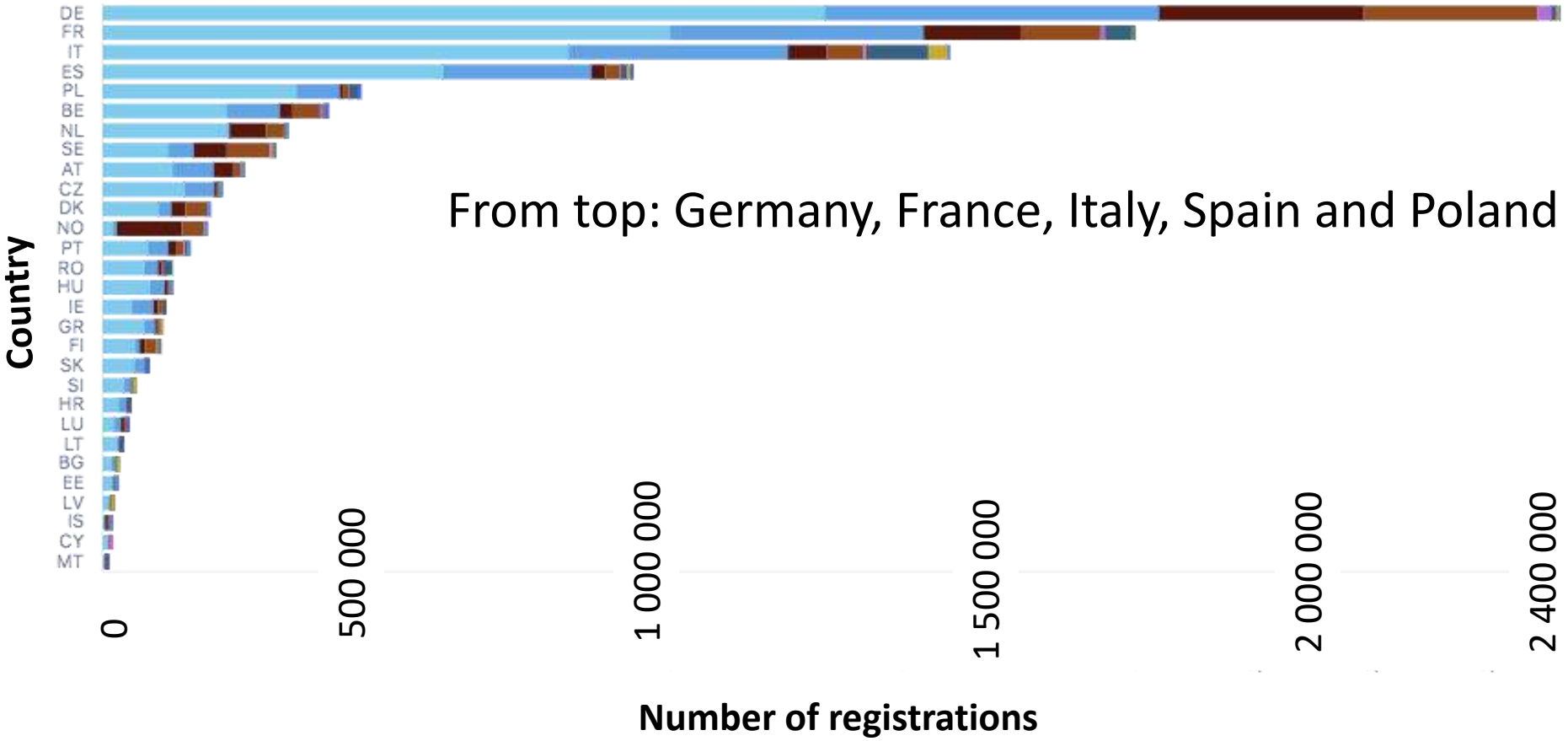
The personal car
in
Mobility and Transport

Car use

- Today mobility is completely **dominated by car use**. Within the European Union (EU 27) about 75 % of all kilometres travelled are by car (2025). (Source: Google AI)
- In interviews most people refer to comfort and speed as the reason for using a car. But car ownership certainly has more dimensions than practical for transport. For many a car symbolises freedom, independence and status
- In large cities, car use is now decreasing. We are beginning to pass peak car!

Number of car registrations in EU countries in 2021
With colours showing different energy sources

Light blue = petrol cars; dark blue = diesel cars; red = electric cars;
red-brown = petrol/electric cars; dark brown = diesel/electric cars:
Yellow = natural gas cars + others



From top: Germany, France, Italy, Spain and Poland

Problems with car use

- **Resource use - fossil fuels and CO_2 emissions.** The transport sector accounts for about 27 % of GHG emissions in Western Europe. Cars account for about 12 %

- **Environmental impact** – Pollution of air by car exhausts is serious and causes large negative health effects

- **Accidents** – In 2021, car traffic caused almost 20 000 road fatalities in the EU, appr. 44 deaths per million inhabitants (cf. the Sustainable Mobility milestones mentioned above

- **Congestion** – there is not enough space for all cars. The infrastructure required by car traffic is immense.

Shortcomings of the conventional car

It depends on fossil fuels. Fossil fuels represent a non-renewable resource that will come to an end sooner or later depending on intensity of use

It is heavy. A gasoline or diesel car often has more than one ton dead weight to transport an average load of appr 100 kg. It is an in-efficient solution to transport needs.

It has a combustion engine. In a conventional car the combustion engine is very inefficient. Typically some 18% (petrol) or 22% (diesel) of the energy in the fuel is used to move the wheels. The rest becomes heat.

The air pollution caused by cars is serious. The emissions comprise CO_2 as well as other substances that harm the environment

Cars are noisy especially at higher speeds

Cars need space. They take up a substantial part of available space in cities

Questions for the break

- Can we defend that a personal electric car of of the future has a weight of 2000+ kg and as an average has a payload (useful load) of appr. 100 kg (a little bit more than one person)?

- How would you like to see the personal transport being developed in the future? What action should politicians take?

The needs for a systems approach to Mobility and Transport

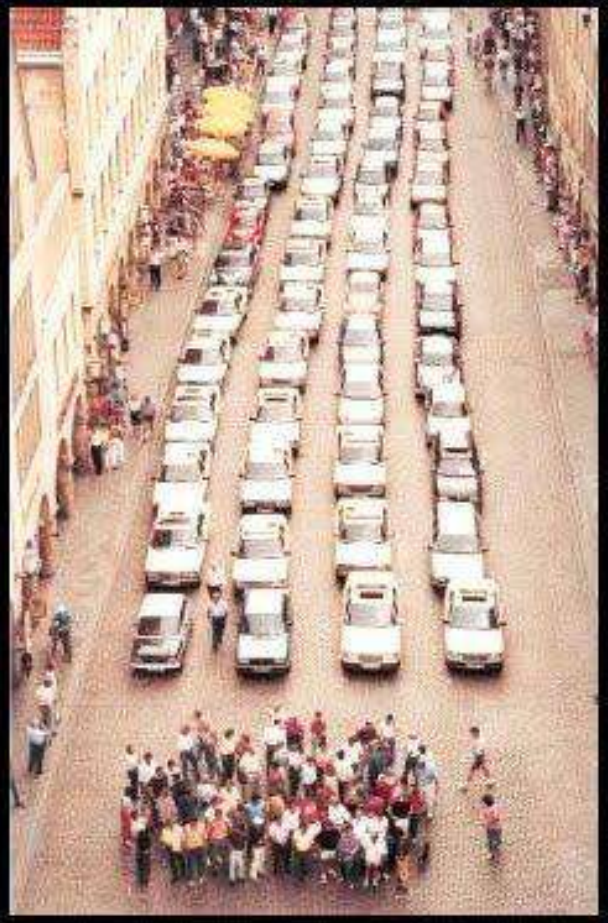
A mobility infrastructure

- The increased preference for cars has obvious consequences for how our cities, villages and countryside looks like. To create an efficient **mobility infrastructure** is a key feature of our societies.

- **Traffic-scapes** are dominating our outdoor environment especially in cities but also in countryside. In cities this is mostly negative for culture and the architecture, possibilities to meet and social relations. In cars, people are isolated and do not interact

- "**Reclaim the cities**" is a counterforce; the increased number of car-free city centres as well. In the countryside roads and railroads are cutting off mobility for animals, and reduce biodiversity. It is sometimes acted upon by constructing animal tunnels and bridges

Space required to transport 60 people



Car

Bus

Bicycle

Eisenstadt Austria -before

Eisenstadt Austria – after

30 000 pedestrians per day

Source: Hermann Knoflacher TU Wien

This environment attract people to walk, relax, communicate…

Public transport and car-sharing

- In **public transport** emissions per person kilometre is drastically reduced both when bus is used, and even more so in train or tram

- Traffic infrastructure would be much better with more public and less private transport, and congestion would diminish. Good public transport avoids waiting and time lags

- Halfway between private and public transport is **car sharing** when a group of people, have a so-called car pool. Car sharing has many advantages: cars are used more, the maintenance of the cars is better organised. Car sharing is increasing in big cities, and the number of cars in big cities are decreasing in many countries.

Car2Go: electric car sharing programme

300 electric cars to take & park anywhere in Amsterdam

Rail traffic - a sustainable alternative

- A large part of the energy consumption in cars is caused by friction between the tyres and the road. That is why **rail traffic** is energy-wise so much better than road traffic.

- Electric vehicles on rail, trains and trams, is the most energy-efficient way to move both people and goods on land.

- A well functioning metro, tram and local train systems are important components of a sustainable transport system in a city.

- Train traffic is also the best alternative for freight traffic on land. Fast trains have the possibility to replace much air travel without much time loss and much comfortably running from city centre to city centre, with dramatically reduced environmental impact.


New trams in Marseille

Shipping and Freight Transport

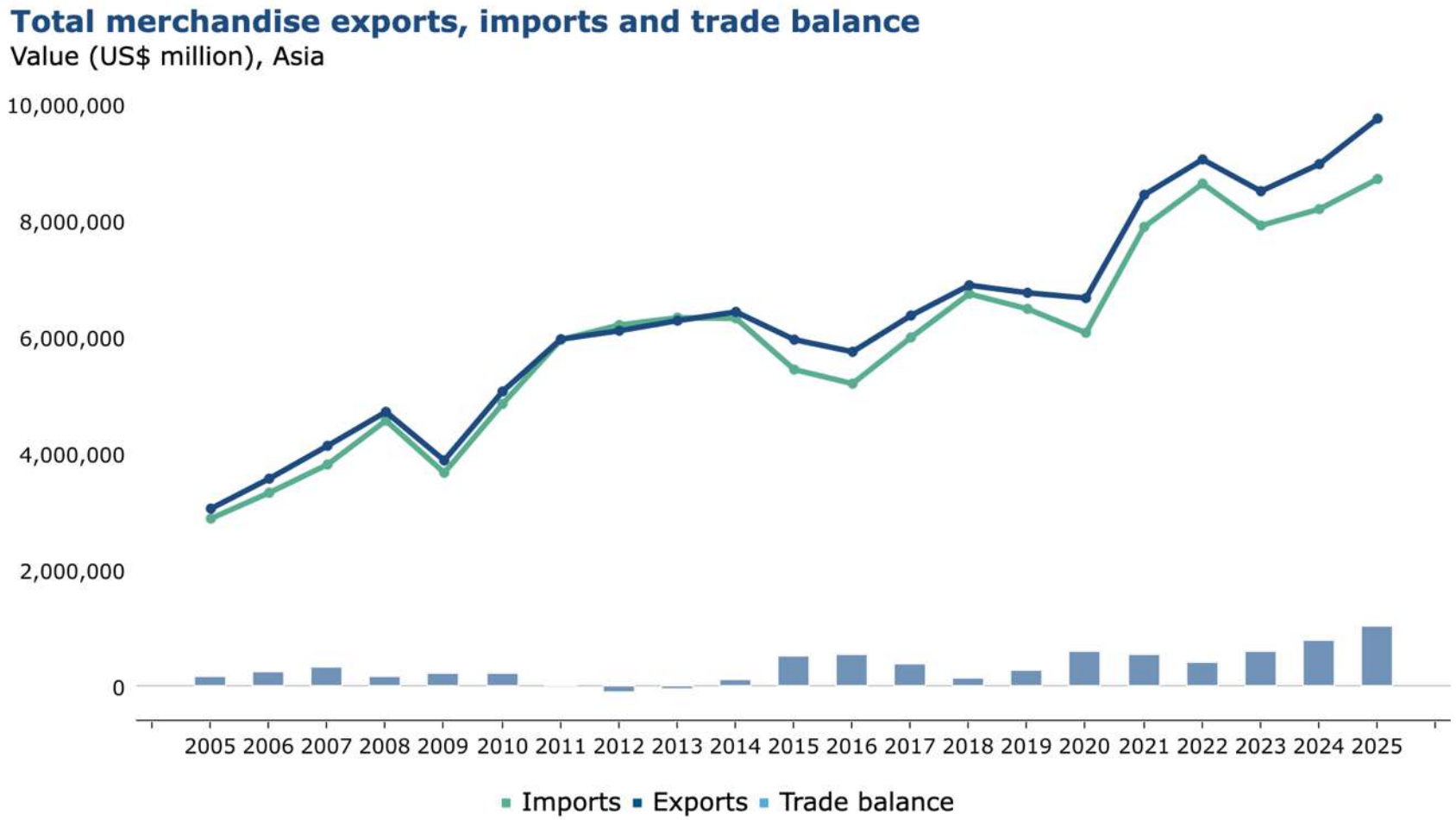
Shipping is a vital part of the global economy's bloodstream

We can all follow the influences of shipping on the global economy when we hear the news from the US/Israel vs Iran war and hear what happens in the Straight of Hormoz.

Shipping

- Shipping is expanding fast, both for business and pleasure
- Environmental impacts from shipping include emissions of CO_2 and acidic SOx, especially from the use of fuel with high sulphur content
- Toilet and other organic waste discharge, directly into the sea without treatment, is a common practice in many areas
- Regulations to reduce environmental impacts of boat traffic are much needed but only slowly implemented

World trade has grown steadily 2005-2025



Includes significant re-exports or imports for re-export.

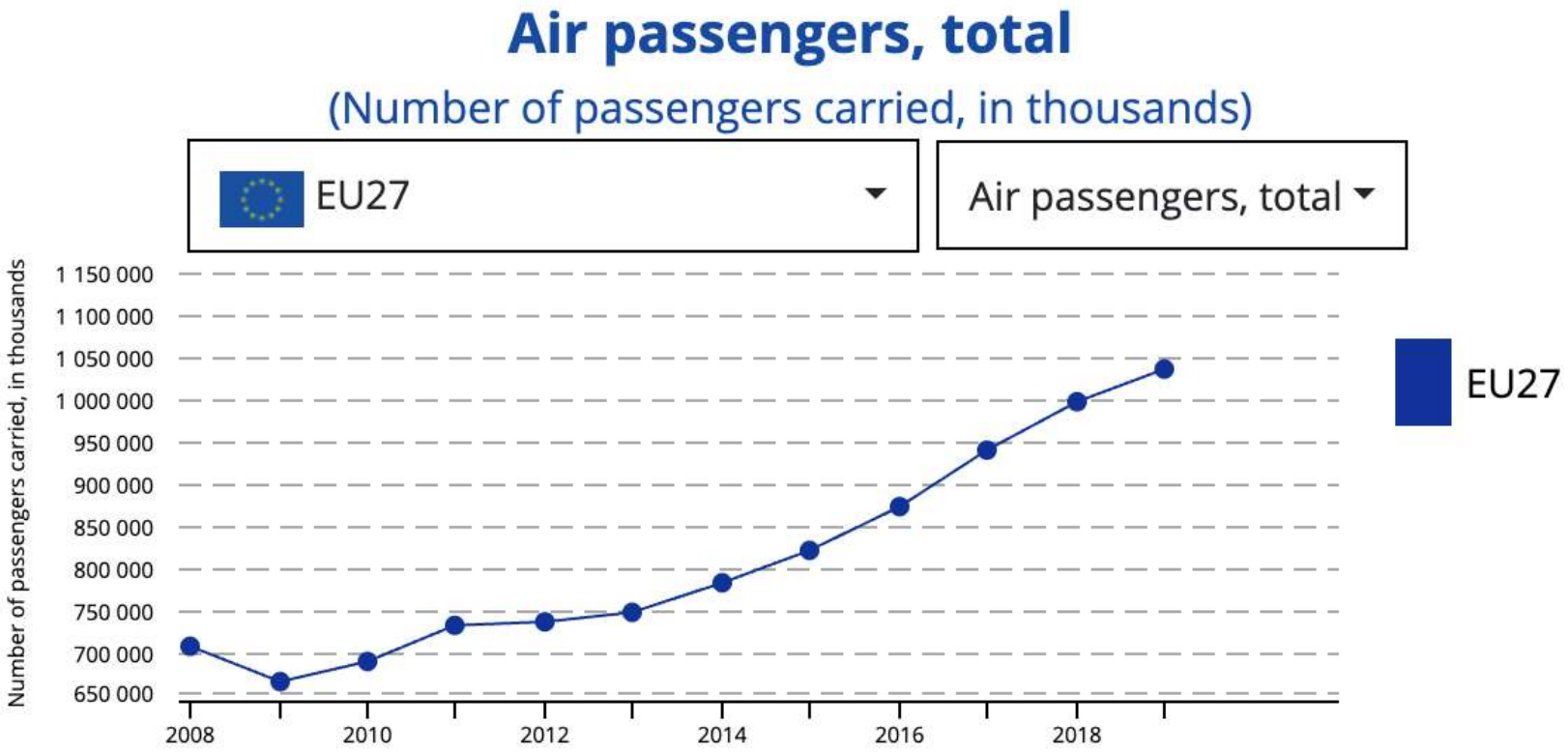
Aviation

Aviation

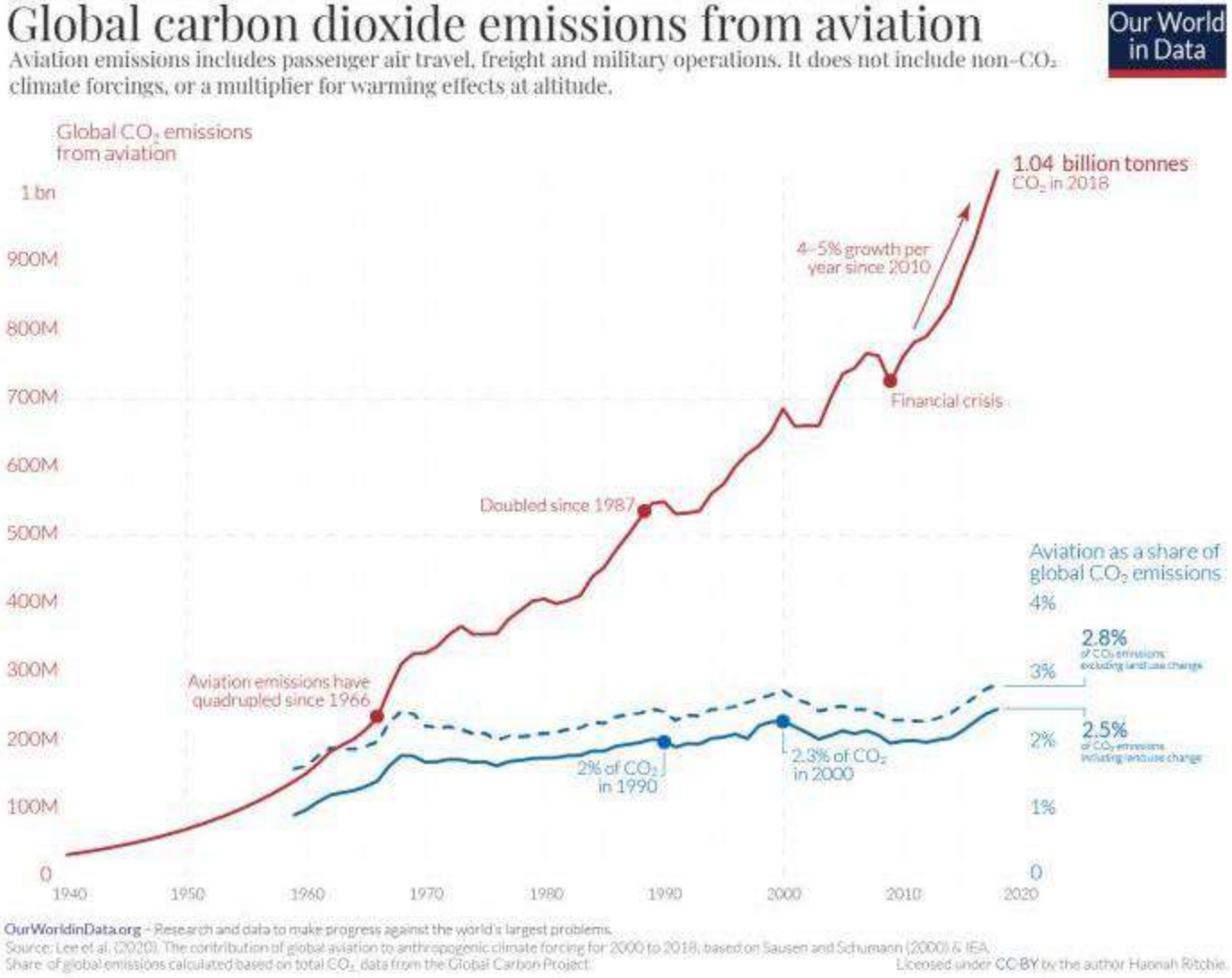
- Aviation accounts for only about 1-2 % of total travel, but still about 1 034 million passengers were carried by air in 2019 in the EU-27. The annual increase was 3.8 %
- Air traffic has the largest environmental impact per person kilometre
- There are small possibilities to reform air traffic into a more sustainable system in the short term, although research is on-going to produce biofuel for airplanes from biomass. Research aiming at electrification of part of aviation is also on-going
- The most reasonable development now is to substitute shorter air travels by fast trains, and use more ICT for business meetings

Diagram showing development of total air passengers per year in EU27 from 2008 to 2019

OBS! Y-axis starts at 700 000 passengers/yr – increase overemphasised!



Source: Eurostat



Aviation accounts for 3.5% of global warming, including non-CO_2 climate impacts. It accounts for around 2.5 % of global CO_2 emissions, but it's overall contribution to climate change is higher. This is because air travel does not only emit CO_2: it affects the climate in a number of more complex ways. (https://ourworldindata.org/co2-emissions-from-aviation)

Biking and walking

Biking

- Mean speed of biking is about 20 km/hr; 6 km takes 20 minutes
- Biking has no emissions (except from human respiration)
- Infrastructure for biking (bike paths and parking) is cheap and requires limited space
- It is healthy for the individual, and many bikers like to be “outdoors”, rather than inside a car or bus
- Biking in cities are on the increase in e.g. Paris, London, Copenhagen and Amsterdam. In Stockholm 150,000 commute daily to the workplace by bike, a figure expected to double in ten years.
- There is a huge untapped potential for biking in cities in many parts of the world, e.g. In Central and Eastern Europe

Paris 2010

1. Rental bikes in Paris 2. Biking in Copenhagen 3. Biking in Uppsala 4. Biking in Vienna

Walking

Walking may also contributes to Mobility

- Walking can easily move you 5 km per hour, which means that all destinations within 2-3 km are suitable to walk to
- For such shorter distances, walking is an almost perfect combination of Mobility and exercise, especially for people of senior age
- The impacts on environment and on other aspects e.g. congestion of walking are very low
- Walking has another benefit - with the rushy life that characterises most modern life, walking promotes reflective thinking and personal psychological well-being

Mobility and Transport towards Sustainability

How to make mobility more sustainable?

- Technical solutions
- Policy tools
- Mobility management
- Rethinking – why mobility?

A sustainable mobility future

- Mobility and transport are central in our societies and have large benefits but at the same time, high environmental costs
- The combustion car has to be largely exchanged for the **electric car**. This will take time. The limited and expensive battery is the main obstacle
- We will also have to **drive car less**, especially in cities; an estimation for Stockholm is 30-50 % less. This corresponds to car driving on 1985 level.
- It is not difficult to live in a city without a car when **public transport and biking are working well**. In Stockholm, half of the households do not have a car today
- **Transport will have to move to train and boat**, while sustainable aviation is so far an unsolved dilemma

The renewable fuels car

- The biofuels include *biogas*, *bioethanol* and *biodiesel*. In some situations the use of biofuels may be the best alternative
- When food waste and other organic waste in a city are used for *biogas* production it may be sufficient for all city buses, thus establishing a sustainable recycling system
- Large-scale production of *bioethanol* is only sustainable if it is not using fossil fuels during production or it is competing with other more important uses of the crop
- Bioethanol is today the dominant biofuel but is not considered to be a long-term solution. Similar considerations are valid for biodiesel
- Both are today mixed in standard fossil fuels to decrease CO_2 emissions from traffic

Uppsala Sweden

Almost 100 buses in the city run on locally produced biogas

Biofuel from waste

Uppsala biogas plant uses organic waste as raw material for biogas

The electric car

- In an electric car, emissions from operation of the vehicle are negligible and essentially all climate impact stems from production of the car. This is an important reason why electric cars are seen as the future, especially when electricity and car production emissions are coming down
- Electric cars need expensive and resource consuming batteries – a Swedish study indicated that overall climate performance passes that of a fossil fuel car after 17 years
- An intermediate system is the charging hybrid car; it may use electricity from the grid for shorter (e.g. urban journeys up to 100 km) trips and fossil fuels for longer journeys

Electric Mobility in Sweden March 2025

Swedish population is appr. 11 million inhabitants

- Number of rechargeable cars 640 000
- Number of fully electric cars 352 000
- Number of rechargeable buses 1 675
- Number of rechargeable light trucks 30 100
- Number of rechargeable heavy trucks 1 060
- Number of rechargeable motorbikes 3 100
- Public points for charging 7 000+

Electrification is fast, but slower than predicted

Source: https://powercircle.org/elis-elbilsstatistik/

National transport polices

- National transport polices exist in all countries, and also at the European level
- Local actors depend on actions taken at the national level as the **regulations and taxation** belong to this level
- The dilemma for policy actions is to balance the needs of transportation against the costs
- An important part of the policies is to make more **sustainable alternatives more attractive** and the less sustainable alternatives less so
- This may be done by **supporting the more sustainable alternatives**. At the national level, it is for example possible to invest in the development of train traffic or fast trains

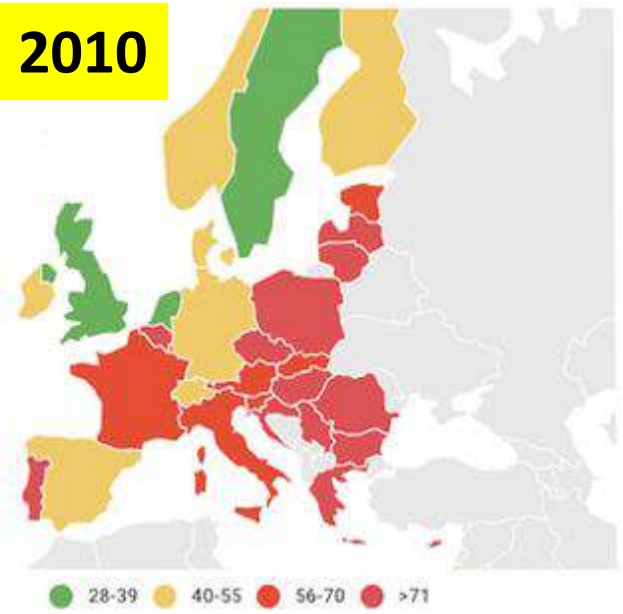
Policy tools - taxes

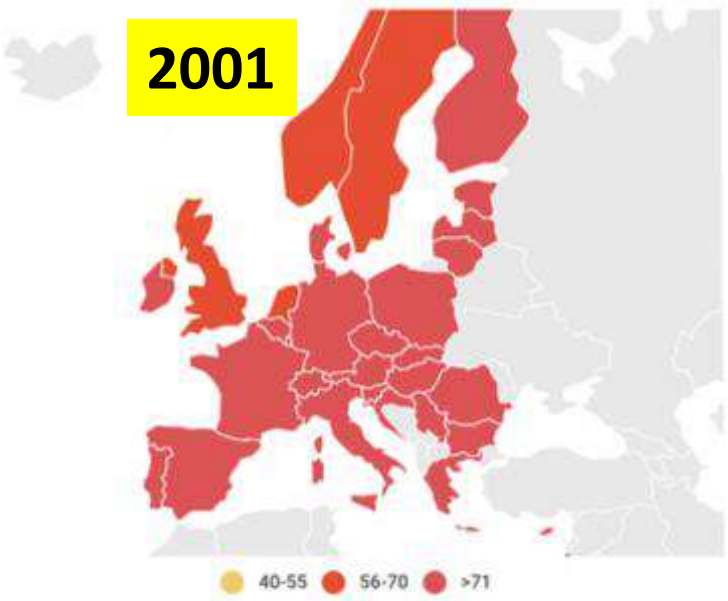
- Taxation of car driving is an important measure to reduce car traffic. The several taxes and charges used include tax when buying a car, tax for mileage, insurance costs and inspection costs
- Most important is tax on fuel and carbon dioxide emissions. If tax on petrol is high, fuel-efficient cars will be more attractive
- Taxation may be differential. Carbon dioxide taxation does not apply to renewable fuels, such as biogas, bioethanol or biodiesel, which increase the market for cars using such fuels
- So-called *green cars*, mostly cars using renewable fuels, may be exempt from some taxation, such as entrance fees to city centres

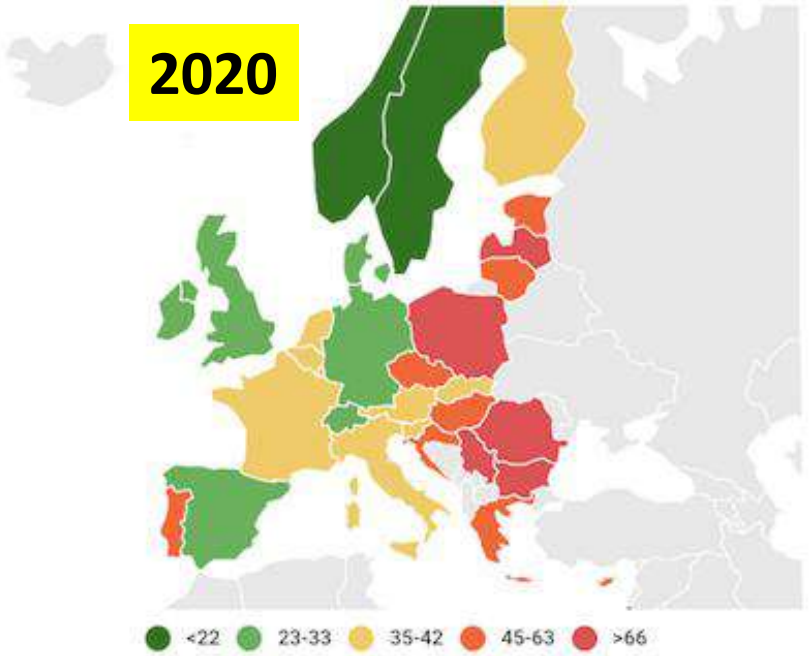
Increasing road safety

EU road traffic fatalities 2001, 2010 and 2020

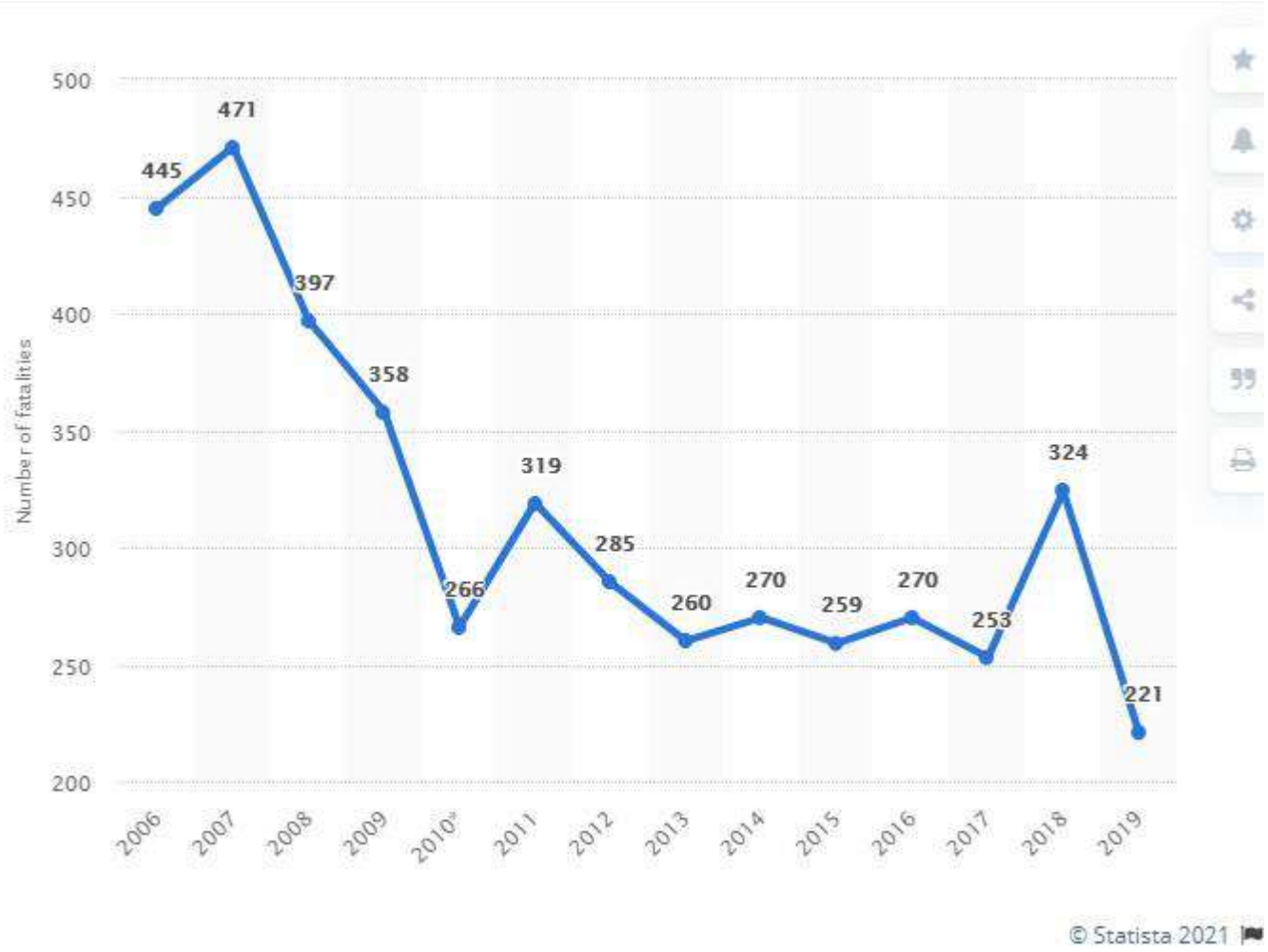
Substantial progress in road safety achieved. Sweden has the lowest number of traffic fatalities per capita in EU







Number of road traffic fatalities in Sweden from 2006 to 2019



https://www.statista.com/statistics/438009/number-of-road-deaths-in-sweden/

Road safety ”Vision Zero” the Swedish approach

Vision Zero constitutes the basis for road safety policy in Sweden since 1997. It embodies a set of principles for designing road safety policy. The most important principles of Vision Zero can be stated as follows:

1. The **level of physical impact that humans can sustain** constitutes the basic design parameter for the road transport system. No accident should exceed the threshold for a serious injury

2. **Vehicle speed** is the most important factor

3. **Roads design** especially the 2+1 roads, and fences between directions

4. **Vehicles design –** safe cars

5. **Rules** are set by the system designers


A Swedish 2+1 road

A Swedish traffic surveillance camera

Policy tools – Regulations on cars and other transportations

- Policies and regulations have been introduced on cars and other forms of transportation to foster sustainability

- Policies and regulations include safety measures such as speed limits, which also reduce emissions that increase steeply with higher speed

- Within the EU, there is a maximum allowed level of carbon dioxide exhausts per kilometre of driving, in 2021 year 95 g/km This emission level corresponds to a fuel consumption of around 4.1 l/100 km of petrol or 3.6 l/100 km of diesel

Mobility Management

- Mobility Management is an established method to **promote sustainable transport**
- The traditional core of mobility management is so-called **soft measures**. These include all kind of user services, such as information, coordination, education, etc.
- The soft measures are combined with, and increase the value of, **hard projects**, that is, infrastructure developments such as building roads, bridges, bike roads, tram lines etc.
- The soft measures are targeting the **mobility behaviour** of the inhabitants of a city or region, while the hard projects are addressing the structure in which they move around.
- A core objective of Mobility Management is to **reduce car use** and thereby car traffic

A Mobility Plan

- A Mobility Plan is a comprehensive and directive document that indicates how to implement a Mobility Management scheme for a specific site or area

- *The site* may be a working place, such as a hospital, a larger industrial plant etc.

- The Mobility Plan can “apply all measures that help to reduce motorised vehicle trips to and from the site. It can be limited to certain trip purposes on the site such as visitor traffic or commuter traffic of a company.”

Mobility Management project example

City of Helsingborg: Creating safe ways to school

- Increase number of ***children walking or biking to school*** (to reduce congestion and air pollution and provide an opportunity more physical exercise for children)
- '***Walking school bus***' has been successfully implemented. The municipality promotes the use of safety equipment such as helmet for bikers and, safety belt in cars
- The municipality carries out ***physical changes in traffic environment*** to increase the safety of the school children in the traffic, particularly near the schools (e.g. speed reduction measures)
- Increased traffic safety awareness is promoted among school children by ***integration of 'traffic' in the ordinary school subjects***

Sustainable Mobility and Transport
Short Summary

Mobility and Transport - the Positive

- To our knowledge, improved mobility and transport has contributed to economic and material well-being through history
- Improved mobility contributes to our possibilities to see the world, get in touch with other people and other cultures, supporting (i) learning about and understanding each other and (ii) improve cooperation

- Improved transport of goods and globalisation of economy has allowed us to spread risks in food supply due to weather and climate phenomena and to place production in a more economic way – thus supporting development all over the world

Mobility and Transport - the Negative

- Global economic activity and resulting ecological impacts have now reached a magnitude that threatens the global climate system and in the long term whole regional ecological systems
- In many economies, we see that the Mobility and Transport sector grows faster than the economy itself and also the climate and ecologic impacts
- The personal car dominates the Mobility and Transport sector despite it is a very, very resource inefficient way of organising mobility
- The electric car - in its current configuration – will only marginally contribute to an ecologic sustainability in the Mobility and Transport sector

Mobility and Transport – to do

- Mobility and Transport needs a **mobility infrastructure** (system optimisation), relying on the use of several different means of mobility, from walking to aviation
- The heavy dependence on the personal car in existing Mobility and Transport systems will have to be decreased in favour of (i) increased use of public transport and (ii) increased use of walking and biking for shorter distances
- Electrification is seen as a promising alternative in future Mobility and Transport
- As short rules of thumb, the following general advice for selection of Mobility mode is proposed (as possible):
  Shorter than 3 km ……Walking or biking
  From 3 km – 10 km……...Biking or public transport
  From 10 km - 50 km……..Public transport (bus, Metro)
  From 50 km – 500 km……Train, bus, car
  Longer than 500 km……Speed trains, aviation

Mobility and Transport - To read

1. The Baltic University Programme Sustainable Development Course. *7a. A culture of mobility*. *7b. Means of mobility – technology and systems 7c. Freight 7d. Policies and management of mobility* (http://www2.balticuniv.uu.se/bup-3/chapter-7).

2. Sustainable transport. https://en.wikipedia.org/wiki/Sustainable_transport.

3. Mobility and Urban Traffic Infrastructure. Building Sustainable Societies, Chapter 10. pp 150-168. (https://uzwater.ktu.lt/index.php/textbooks#module-b-sustainable-development).

4. Sinha, R., Olsson, L.-E., Frostell, B. (2019) Sustainable Personal Transport Modes in a Life Cycle Perspective—Public or Private?, *Sustainability, 11*, 7092; doi:10.3390/su11247092.

Thanks for your attention!

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