Clever

Bridging the climate neutrality, energy security and sustainability gap through energy sufficiency, efficiency and renewables

Establishment of energy consumption convergence corridors to 2050

Mobility sector

March 2023




***Clever** – a Collaborative Low Energy Vision for the European Region*

ADEME AGENCE DE LA TRANSITION ÉCOLOGIQUE · 2050 PATHWAYS PLATFORM · ASSOCIATION négaWatt

Content

This note was written by the negaWatt Association in the build-up of the CLEVER scenario (CLEVER for "Collaborative Low Energy Vision in the European Region"), with a view to constructing coherent decarbonisation pathways for the mobility sector in European countries. It proposes convergence corridors for the energy consumption for key indicators towards 2050, together with policy measures to support this transition.

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Introduction

Establishing a common vision on mobility

One of the translations of the bottom-up approach in the CLEVER scenario, led by the negaWatt association, was the construction of convergence corridors for the key consumption indicators. This note presents this construct and the convergence corridors in the mobility sector, together with first policy proposal to back-up these corridors.

The CLEVER scenario

Since 2018, a network of around 24 European partners led by negaWatt engaged a technical dialogue to ensure the collective development of a European energy and climate scenario. The latter, based on national trajectories (bottom-up approach), assesses all decarbonisation potentials through the analysis of the energy demand reduction (sufficiency and efficiency) and the renewable energy development. This ambitious European scenario targets (i) carbon neutrality, (ii) a 100%-renewable energy mix (both as soon as possible and by 2050 at the latest) and (iii) to be in line with 1.5 degrees pathways. Carbon neutrality in Europe requires a coordinated energy transition strategy supported by concrete and bold policies explaining their integration in the CLEVER scenario.

Energy consumption corridors concept definition

The CLEVER vision of energy demand reduction is based on the principles of feasibility and fair sharing of energy services. However, the baselines of each national trajectory initially differed significantly and became an obstacle to the elaboration of an equitable and convergent European trajectory.

To address this issue, it was decided to introduce the concept of "convergence corridors" during the elaboration of CLEVER scenario. For each major indicator of the scenario, a corridor to be achieved for each national trajectory by 2050 has been proposed. A lower bound is defined based on "Decent Living" studies and an upper bound is defined as a level of services compatible with a 1.5°C increase. This approach follows Kate Raworth's doughnut economy principle[1]: the new European societies defined by these corridors should be delimited between a social lower bound corresponding to the satisfaction of basic individual needs for all and an environmental upper bound corresponding to the planetary boundaries. Convergence corridors ensure that national specificities are taken into account while ensuring a common and coherent low energy vision for Europe.

The convergence corridor approach is a key element of the CLEVER scenario as it frames the way energy sufficiency is defined in this project. In order to explain this approach and share main modelling assumptions, the CLEVER energy consumption corridors and their development process is published in a series of publications for the mobility, industrial and residential sectors[2].

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[1] See her book: Raworth, K. (2017). Doughnut economics: seven ways to think like a 21st-century economist. Chelsea Green Publishing.

[2] These different publications are available on this webpage.

Defining sufficiency corridors for the demand-side modelling of the mobility sector

This document focuses on passenger transport (mobility). The evolution of freight transport considered in the CLEVER scenario will be available in the final publication.

This document details convergence corridors framing national CLEVER trajectories for key mobility sector indicators. For each of them, the structure is as follows:

- *Context elements* following a review of the literature carried out by negaWatt, allowing for each indicator the definition of the social lower bound[3] and the environmental upper bound[4].
- *National statistics*[5] allowing to understand the starting point of each trajectory, its specificities and the stakes to define a harmonised European vision.
- National trajectories to 2050 for each indicator. These trajectories were the basis for exchanges and the co-construction of assumptions between the CLEVER partners. This document presents the final trajectories, resulting from the harmonisation process. *Other existing European or national scenario assumptions* showing the level of ambition already proposed by other stakeholders[6].

The analysis of these inputs led to a technical dialogue between the project lead (negaWatt) and national partners to establish 2050 corridors that are fair, ambitious and achievable. Final corridors presented in this note served as a reference for partners to finalise their national mobility trajectories through the integration of transformation rates and levels of ambition that are feasible and coherent with their national context (if supported by the necessary policy framework).

Policy proposals to support the level of ambition

Defining an energy and climate trajectory in line with 1.5 degrees pathways requires setting very ambitious convergence corridors. To support this ambition, a policy work was carried out within the network. The aim of this work was to share, for each indicator, key policies and existing good practices from EU to local level.

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[3] Key sources used: Millward-Hopkins et al., 2020 ; Rao et Min, 2018

[4] Key source used: Grubler et al., 2018

[5] Data mainly coming from Odyssee database.

[6] Key sources used: Climact, 2018 ; EUCalc ; negaWatt, 2017 ; negaWatt, 2022 ; European Commission, 2018 ; IDDRI, 2017 ; Data from the CACTUS project

Content of the note

Global content

This note presents, for each key indicator of the mobility sector, the convergence corridors and the main factors considered to define them. There is a dedicated section to each of the indicators.

The seven key indicators were chosen to encompass the main issues and challenges of the mobility sector. They could be classified into three categories:

- Definition of the mobility needs (distance travelled per capita):
- Modal share choices (air distance travelled per capita, share of active mobility and collective transport, car occupancy).
- Choice of consumption vectors (motorisation and efficiency of cars).

A summary of the definition of these indicators and the final value of the convergence corridors are given in the Table 1 below.

Content of each indicator part

Each part begins by defining the indicator and its perimeter. It then outlines the values of the convergence corridor and the inputs used to define it: current statistics, context elements, other scenarios and partners first trajectories. It concludes with the policies proposed and exchanged across the network to support the defined level of ambition. The policies are prioritised in order of impact and scale (from EU to local level).

***Disclaimer:* The policy proposals in this note are the result of an introductory research work and consultation within the project's partners network. They should not be considered as the official position of negaWatt or individual project partners. Official consortium positions and policy recommendations will be presented with the final CLEVER report.**

Summary table of the proposed corridors

Indicator	Definition	Unit	Planned consumption corridor
Distance travelled per capita	Number of passenger-kilometres travelled per person and per year within the national territory. Excluding: Aviation, active mobility.	pkm/cap/year	**9500-13500 pkm/cap/year**
Air distance travelled per capita	Total annual air traffic per capita.	pkm/cap/year	Domestic flights: **0 pkm/cap/year** International flights: **600-1500 pkm/cap/year**
Active mobility share	Share of active mobility (walk and bike) in total passenger mobility. Excluding: Aviation	%	**7%-15%** of total passenger mobility
Collective transport share	Share of collective transport in total passenger mobility. Excluding: Aviation, active mobility.	%	**15%-40%** of total passenger mobility
Car occupancy	Average number of passengers per car while travelling.	person/car	**1.8 to 2.3 person/car**
Car motorisation share	Share of car traffic by motorisation	%	**95-100% full electric car** **0-5% fuel-cell car**
Car efficiency	Energy efficiency of new cars assessed through the energy consumption per unit of distance travelled.	l/100km or kWh/100km	Per type of fuels: • **Liquid fuel: 0,43 kWh/km** reached in 2035 (banned thereafter) • **Electricity: 0,13 kWh/km** reached in 2045 • **Fuel-cell: 0,22 kWh/km** reached in 2045

Distance travelled per capita

Definition: Number of kilometres travelled per person and per year within the national territory (excl. aviation; excl. Light Commercial Vehicles (LCV); excl. active mobility)
Unit: pkm/cap/year
Calculation: [Number of passenger-kilometres in one year] / [population]

Note & indicator perimeter

This indicator considers passenger mobility excluding air and active mobility. Active mobility is not considered here because it is not consistently considered in every statistical revue and prospective scenarios.

This indicator excludes light commercial vehicles (LCV) as they are included in freight transport. Moreover, this indicator refers to territorial traffic, which means that it includes foreign vehicles on the national territory, and it excludes national vehicles travelling abroad.

Historical data

In 2015, baseline year of CLEVER, there was a significant disparity in passenger mobility within Europe from **6.000-10.000 pkm/cap. (e.g., RO, ES, PT, BG) to 14.000-16.000 pkm/cap. (e.g., CH, DE, FR, DK, EL, IT)**. The lowest values might reveal social issues (e.g., decent living standards not reached by a significant part of the population) see the discussion of Figure 2 next page.

To go deeper, an analysis of the evolution of passenger mobility in the EU between 2000 and 2018 is given in Figure 1. It shows a significant change over time. Countries with lower passenger mobility per capita (<8 000 pkm/cap) had a high increase between 2000 and 2018. Latvia, Estonia, Romania and Bulgaria have almost doubled their passenger mobility in the last 20 years. On the other side, many countries with high passenger mobility in 2000 show relative stability (increase in Switzerland, Finland and Norway, decrease in the UK, stable in Italy, France and Sweden).

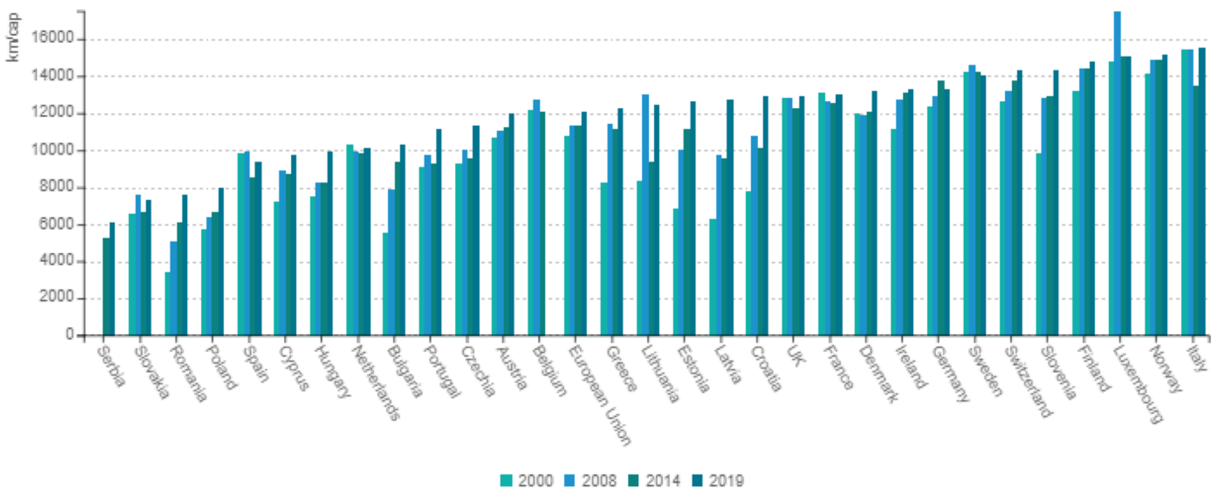


Figure 1: Passenger mobility per capita and per year (excluding air and active mobility)
Source: Odyssee, Sectorial Profile – Transport[7]

[7] Odyssee, 2021

Main factors considered when defining the level of ambition

Influence GDP per capita and urbanisation

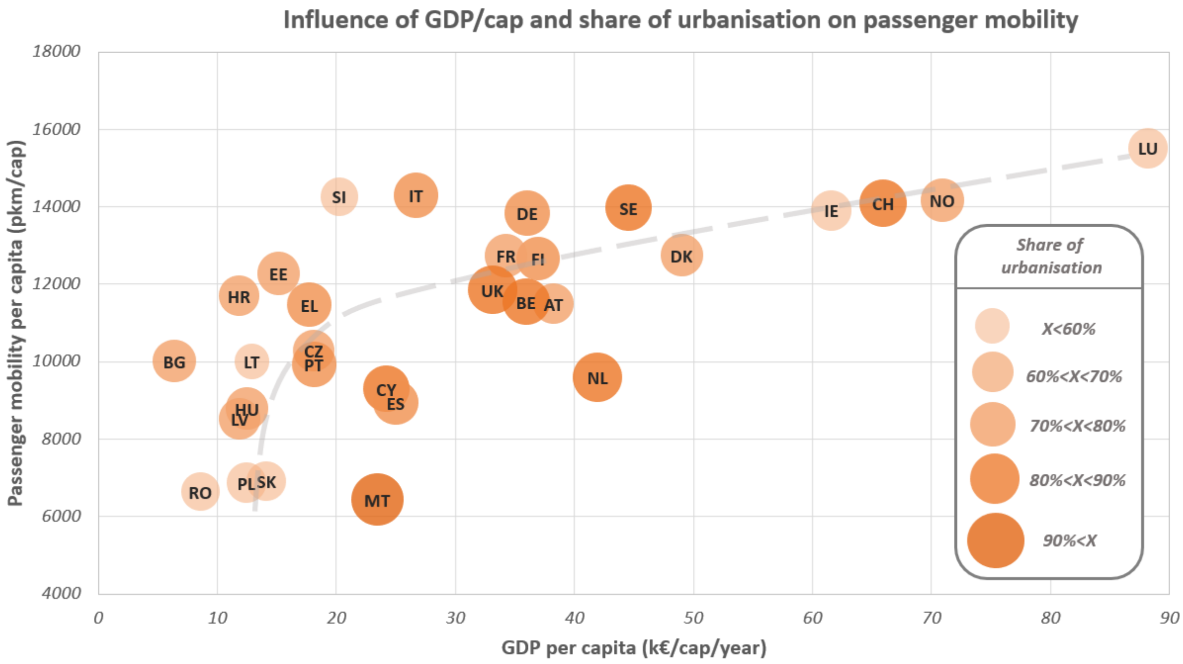


Figure 2: Influence of GDP/cap and the share of urban on passenger mobility (year 2015)
Source: Elaboration based on Eurostat data

Figure 2 shows that on a European scale there is a correlation between passenger transport volumes (pkm/cap/year) and per capita income (GDP/cap/year) when the latter is below 40,000€/year. Above this level of income, there is no direct correlation between these two indicators. Thus, the increase in household income allows them to meet their mobility needs up to a certain level and that beyond this level, the increase in their income will not necessarily result in an increase in their mobility since their needs will have been met. At the same time, the graph shows European heterogeneity: There is no linear relationship between indicators. One level of transport volume can be achieved with very different levels of GDP/cap; or, at one level of GDP/cap there may heavily varying levels of transport.

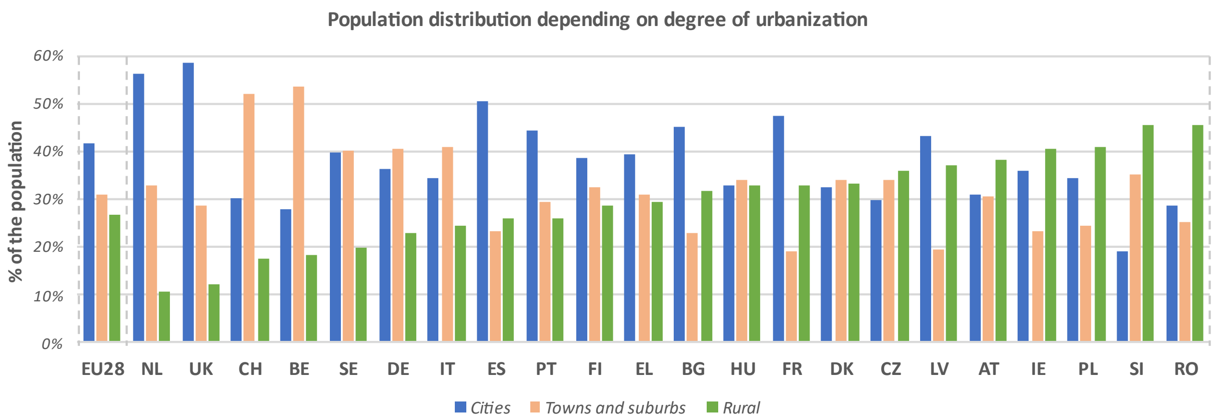


Figure 3: Distribution of the population depending on the degree of urbanization (year 2018)
Source: Own elaboration based on Eurostat data

Figure 2 and Figure 3 show that on a European scale, there is no significant correlation between passenger mobility (pkm/cap/year) and the urban/rural share. This result is counter intuitive as mobility in rural areas is generally considered higher than in urban areas. According to an IDDRI study for France[8], the influence of the place of living (non-metropolitan), influences the global mobility needs around 1000pkm (i.e. 7% - see Figure 4). Given that the share of people not living in cities varies between 40% and 80% between European countries, the differences at the same level of access to mobility than in France, would therefore be limited to a maximum of 6%. It is even possible for this value to be lower as the definition of metropolitan in IDDRI study is more restrictive than the city definition for Eurostat[9]. It is concluded that the urban/rural ratio is not a predominant indicator. It will not be considered in this study to define the level of ambition on the land passenger mobility indicator (excluding active mobility).

There may be other reasons driving this result. The association of longer distances and consequently higher pkm volumes in countries with a higher share of rural areas may hold true only for higher-income countries such as Austria, France, Denmark or Germany. Many countries with highest rural shares have rather lower GDP/capita such as Romania, Poland or Baltic countries. This shows the multidimensionality of the reasons.

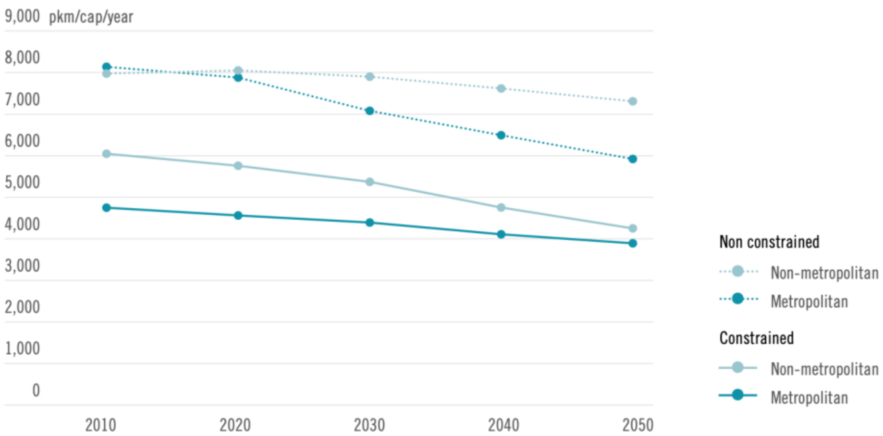


Figure 4: Annual individual distance travelled for constrained and non-constrained mobility in France[10]

Triggers for the demand for travel

There are two key drivers for demand for travel, **working** (commuting, business travel…) and **personal** interests and needs (leisure, personal business, accompanying trips...). For instance, in Germany in 2018, working travels represented 42% of travels (21% for commuting and 17% for business travel) and personal travel 58% (leisure travel 34%, personal business 21 %)[11].

Teleworking represents an interesting driver to reduce both commuting and business travels. Its potential has been assessed by EUCALC[12]. Before the Covid-19 pandemic, teleworking was already important in many countries. For example, in 2017 respectively 13% and 12% of employees from Netherlands and Finland worked from home[13]. There is a huge variation between European countries following the countries' cultures. The Covid-19 pandemic has revealed the strong potential for teleworking throughout Europe[14].

The global impact of teleworking on passenger mobility and its reduction potential is hard to assess: there could be many rebound effects (relocation to more remote locations, increase of personal travel,...). There is no consensus on this impact, but meta-analysis shows that a majority of studies measured a reduction of passenger mobility thanks to teleworking[15]. In particular, studies by ADEME

[8] IDDRI, 2017

[9] See Eurostat definition

[10] IDDRI, 2017

[11] Infas, 2019, p.61

[12] EUCALC Lifestyle documentation

[13] Eurostat, 2018

[14] Eurostat, 2021

[15] Hook et al., 2020

in France and the Wuppertal Institute[16] in Germany have assessed an interesting potential that could be modelled. In the ADEME study, the direct potential is -39% of the distance travelled per day of telework (from 9km to 5.5km). The gain, estimated in kg of CO2 in this study, is -271 kg of CO2/year per day of telework modulo the rebound effects considered on all sectors including residential or tertiary (giving a range between 187 and 412 kg of CO2).Nevertheless, some rebound effects that could have a significant impact on the mobility demand (such as the geographical extension of the professional horizons or the increase of new long travels for leisure mainly) are not included in the modelling.

Tourism in a key driver for personal travels. The Covid-19 crisis has shown potential to further develop domestic (or less internationally oriented) tourism. However, the evolution of tourism and its mobility may be difficult to estimate by 2050 and therefore be an obstacle. To move forward, it would be interesting to quantify beforehand the approximate mobility (in pkm) that tourism represents in 2015 and therefore know if it represents a significant share of the total distance travelled per capita.

Personal travels could also be reduced through an increase of the remote access of services[17].

There is finally a strong correlation between leisure travel and GDP/cap (Figure 5) in line with the general correlation between GDP/cap and passenger mobility expressed Figure 2.

More generally, as highlighted by EUCALC[18], behaviour and awareness represent key social drivers and urban planning key political drivers that influence passenger mobility. There is also an important impact of age on the travel time (Figure 5).

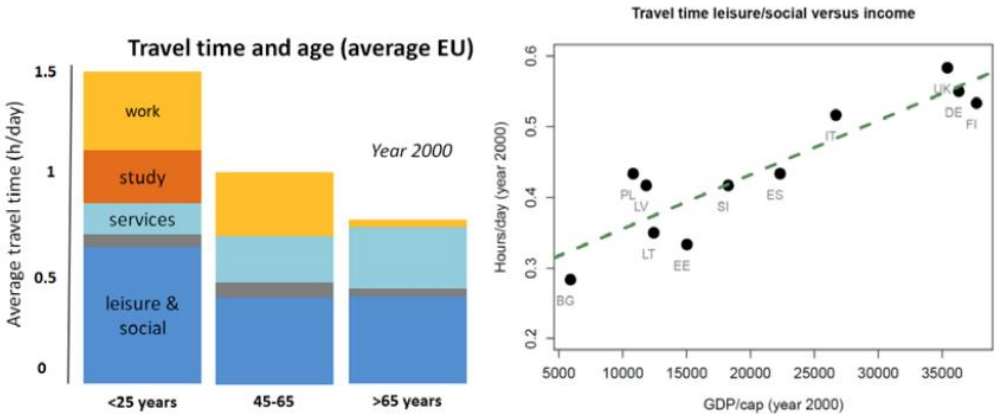


Figure 5: Travel-time by activity and age for European countries; linear correlation between travel time for leisure/social and GDP for the year 2000[19]

Modal shift from air to rail

Finally, an important factor to consider is the modal shift from air to rail for long distances. This modal shift reduces the energy consumption of overall mobility, decarbonizes long distances (as e-kerosene potential is limited), but also reduces overall mobility (in pkm/cap). Indeed, passenger travels by train are generally shorter than by air. That said, modal shift from air to rail could lead to a slight increase in land passenger mobility (which will be largely offset by other factors leading to a decrease). In the French negaWatt scenario 2022[20], rail mobility for long distances increases by

[16] See ADEME, 2020, Wuppertal, 2012 and German Zero 2021, p.209
[17] EUCALC Lifestyle documentation
[18] EUCALC Lifestyle documentation
[19] EUCALC Transport documentation
[20] negaWatt, 2022

100% between 2017 and 2050 reaching 1010 pkm/cap in 2050 (covering 34% of long distances mobility) compared to 504 pkm/cap in 2017 (covering 11% of long distances mobility).

Prospective: values considered in a selection of scenarios

European scenarios

In the EUCALC trajectories, the assumptions on passenger mobility at the EU28+Switzerland level for 2050 are[21] :

- Less ambitious level: "transport demand per person increases by 21.3% between 2015 and 2050, reaching **15 120 pkm/cap/year** [excluding active mobility and air]"
- Most ambitious level: "transport demand per person decreases by 7.1% between 2015 and 2050, reaching **11 521 pkm/cap/year** [excluding active mobility and air]**"**

In the EUCALC tool[22] (which includes some details of the hypothesis of the ECF/Climact "Net Zero by 2050" scenarios[23]), the minimum and maximum levels and the assumptions for ECF scenarios on passenger mobility (excluding active and air) at the European scale for 2050 are listed above:

- Less ambitious level: "transport demand per person increases by 24% between 2015 and 2050, reaching **14 885 pkm/cap/year** [excluding active mobility and air]"
- Most ambitious level: "transport demand per person decreases by 17% between 2015 and 2050, reaching **9 975 pkm/cap/year** [excluding active mobility and air]"
- ECF "Technology" scenario: **13 246 pkm/cap/year** corresponding to the less ambitious scenario
- ECF "Shared Effort" scenario: **11 315 pkm/cap/year**
- ECF "Demand-Focus" scenario: **10 311 pkm/cap/year** corresponding to the most ambitious scenario.

Most ambitious objectives

In an international scenario defining how to provide decent living with minimum energy, Millward-Hopkins et al. (2020)[24] considered **a large panel between 5 000 and 15 000 pkm/cap/year** for the *Decent Living Energy* for vehicle propulsion.

In their low energy demand scenario for meeting 1.5°C target, Grubler et al (2018)[25] considered: "a factor of 2 increase across all modes (particularly flexible route-shared vehicles) in the global South; **20% fall** in the global North with larger reductions in road- based modes that offset increases in rail and air". According to EUCALC, air and active mobility represented respectively in 2015 8,6% and 6,6% of Europe's pkm/cap[26]. Excluding those modes, a **20%** fall in Europe (as assumed for the Global North by Gruber et al.) will lead to **11 500 pkm/cap/year**.

[21] EUCALC Lifestyle documentation
[22] Website available on this link
[23] ECF/Climact, 2018
[24] Millward-Hopkins et al (2020)
[25] Grubler et al (2018) – p.3
[26] EUCALC Transport documentation

National scenarios

Finally, the national variation from ambitious scenarios with various base level have been considered (see Table 1: Distance travelled per capita (except air) evolution for four European countries).

Country	Base year (2017)	Prospective (2050)	CAGR (2017-2050)
France[27]	14 988	12 050	-0.66%
Germany[28]	13 234	11 682	-0.38%
Lithuania[29]	12 274	13 340	+0.25%
Hungary[30]	9 341	13 499	+1.12%

Table 1: Distance travelled per capita (except air) evolution for four European countries

Proposition of a harmonised corridor

Corridor

A corridor between 9 500 and 13 500 pkm/cap/year is proposed for passenger transport (excluding active and air) to be reached between 2040 and 2050.

A target for passenger mobility (excluding active and air) that do **not exceed 13 500 pkm/cap/year** is proposed as it is considered more realistic and consistent with ECF/Climact scenarios as well as CACTUS project trajectories for Eastern Europe countries, EUCALC and EUCTI tools' boundaries. In the countries where a high potential of active mobility and especially cycling was available, a lower bound of **9 500 pkm/cap/year** has been set as it is beyond ECF Demand-Focus scenario and the most ambitious level of EUCALC.

A target of about **12 000 pkm/cap/year** seems to be a target consistent with the climate ambitions for countries with a high potential of active mobility.

Elements of trajectory

This level is based on:

- For working trips: a reduction by around 50% of the time spent on travelling to work/study reflecting opportunities of full teleworking potential.
- For personal trips: a drop of leisure travelling to 80% of the value typically found in Western European countries (e.g. France, Germany) countries by 2050; representing a shift in preferences for people to travel lower distances.

As detailed in the "main factors" parts, the main parameter that influences passenger mobility is the GDP/capita until the country reaches 40.000€/cap. This parameter is well considered in the previous proposed limits.

Moreover, passenger mobility can decrease rapidly thanks to the quick development of teleworking (resulting from Covid-19 crisis) in local and regular mobility and the quick decrease of air mobility in long distances (increase of local tourism). This is a key trigger for a quick reduction of passenger mobility in the short term, to answer the need of energy consumption reduction by 2030 due to the current energy crisis. It also makes it possible to reach in a longer term the target by 2040.

[27] negaWatt scenario for France, 2022

[28] Green Supreme scenario from RESCUE report (Umwelt Bundesamt, 2019)

[29] Data from the CACTUS project, see publications available on the project website.

[30] Data from the CACTUS project, see publications available on the project website.

Trajectories of CLEVER national partners

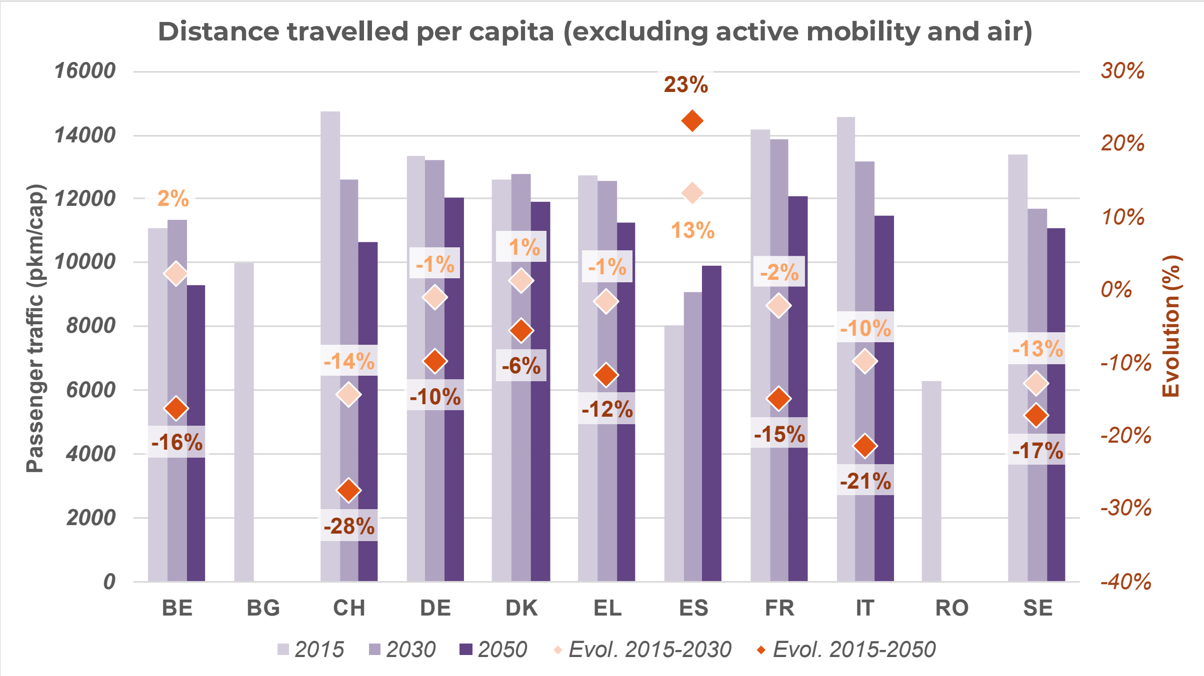


Figure 6: Distance travelled per capita (excluding active mobility and air) in 2015, 2030 and 2050 modelled in CLEVER national trajectories

In Figure 6, there is a great disparity between partners regarding (i) the passenger mobility in 2050 and (ii) the evolution between 2015 and 2050.

This difference in the 2015-2050 evolution is partly explained by (i) a decrease in passenger mobility in countries that were already above the 12 000 pkm/capita threshold in 2015; and (ii) an increase for Spain below the 10 000 pkm/capita threshold which started from a threshold of 8 000 pkm/capita in 2015 and reaches 10 000 pkm/capita by 2050. It is also expected that Eastern European countries such as Romania also increase passenger mobility to be above the 9 000 pkm/cap/year lower bound limit.

First proposals for policy measures to support ambitious objectives

<u>Objective:</u> Reduce the need for each type of travel through cultural and spatial changes:

Key measures

<u>EU, national and local level</u>:

Increase teleworking:

- Drastically **reduce international business travels** for meetings: encourage online meetings when possible and reduce the frequency of physical meetings while adapting to the needs of every profession. This measure will be complemented by policies to reduce air distance travelled per capita (*see the suggested policies in the associated section*).
- Set a legal framework to ensure good teleworking conditions (right to disconnect, flexibility of working hours, fundings for convenient telework installations…)[31].
- Act at local level with regional authorities and businesses to better organise teleworking. Encourage (or legally oblige where possible) companies to have at least **2 or 3 days of teleworking/week** depending on sectors[32]. Develop shared offices in cities and suburban areas to allow people to have workspaces close to their homes as a necessary complement to the development of teleworking.
- **Anticipate potential negative rebound effects**[33] and **social inequities**[34] of increased teleworking: enable and incentivise individuals to live closer to their place of work (e.g., space planning to improve life quality in cities near employment hubs, adequate and affordable housing and public transport), use shared spaces rather than moving to bigger homes and help workers unable to telework to shift to more sufficient commuting modes.

<u>Local level</u>: Spatial planning to increase proximity to services. Encourage local authorities to organise the space in order that all essential services are as near as possible to where people live. An inspiring concept is the **"15-minute city" concept[35]** that aims to provide a framework to city planning in order to create neighbourhoods where each service is within 15 minutes of active mobility.

Good case example: cities in Europe that increase the proximity of services

Many cities engaged in 2020 to implement the 15-minutes framework, especially Paris, Milan, Dublin and Valencia.

Good case example: Copenhagen finger plan

Copenhagen followed an urban planning plan created in 1947[36] that defined the whole urban area with urban branches spreading like fingers from the "palm" of central Copenhagen and with green

[31] Commissioner Schmit position of telework ; legal frameworks leading to high telework rates in Netherlands and Finland.

[32] In the French negaWatt scenario (negaWatt, 2022, p.28), 2.5 days of teleworking/week are foreseen for 40% of the total number of workers.

[33] Detailed in ADEME, 2020, p.14. It is important to note that telework also having positive rebound effects such as more sustainable food consumption.

[34] The inequities related to teleworking in Covid period have been studied in Sostero et al., 2020, gender inequities associated to teleworking are for instance observed in Finland

[35] Moreno et al., 2021

[36] Danish Ministry of Environment, 2015

spaces in between. Each finger is served by metro lines and neighbourhoods providing a full range of services were planned around each train station, minimising transports needs[37].

Other measures

EU to local level: Encourage the **shift to active mobilities** (*see* active *mobility policies below*).

National to local level: Increase the local availability of services: ensure a good density of schools, childcare facilities, medical facilities and local shops. This policy supposes a broad set of local and national measures in education, health and trade. Such measures are strongly dependent of local context and regulatory. In order to help decision-making, open-source models have been built that could allow to model the impact of these kind of measure[38].

It is especially important for rural regions, where travel distances are high and where local services have often been lost over past decade. National/local context-specific measures need to address respective reasons and barriers.

National level to local level: Encourage sustainable leisure travel through[39]:

- incentives to local tourism and to slow tourism (*see active mobility policies below),*
- air travels reductions (*see air distance travelled per capita section below*).

[37] Martin et al., 2020 – p.48

[38] Model developed in Arntz, 2022 to analyse the impact of transport policies on passenger mobility.

[39] See for instance Greenpeace guide for sustainable travel for France

Air distance travelled per capita

Definition: Number of kilometres travelled by air per person and per year
Unit: pkm/cap./year
Calculation: [passenger-kilometres travelled on domestic and international flights in one year] / [population]

Note & indicator perimeter

This indicator includes both domestic and international (intra-EU and extra-EU) air distance travelled. International air distance travelled corresponds to half of the arrivals and departures from/to the country of origin/destination.

Most the historical data found in publications is in number of trips and not in pkm/cap. However, this information remains interesting to understand European air mobility dynamics.

Historical data

First of all, there is a consistent lack of national historical data in many countries. For example, in some countries such as Czechia, there is no data available on this indicator. In other countries, air traffic in the models is calibrated according to energy balances.

According to ICAO (2019)[40], the European region represented 27% of all global 2019 air traffic (in pkm) with an average of 3 000 pkm/cap. A detail of these data in different European countries is given in Figure 1Figure 7.

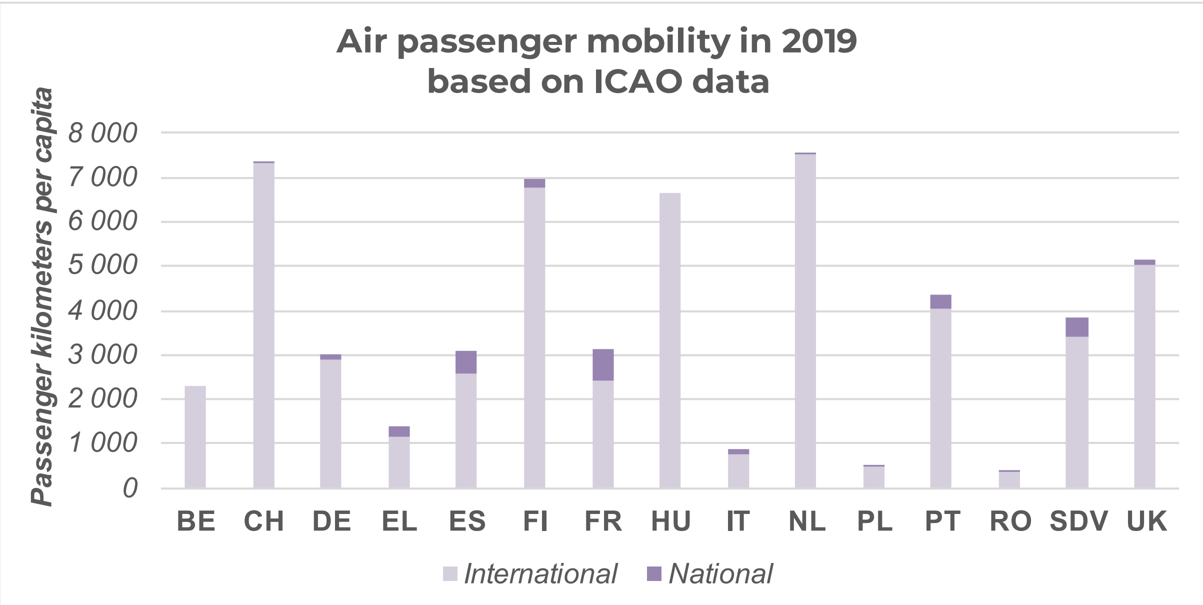


Figure 7: Total air distance travelled per capita in 2019 (in pkm/cap) according to the ICAO[41]
Note: SDV means Scandinavia (including Denmark, Norway and Sweden)

[40] ICAO (2019)
[41] ICAO (2019) ; SDV means Scandinavia (including Denmark, Norway and Sweden)

There are large differences between ICAO data and historical data found by CLEVER partners (based on national statistics;). This could be explained by the calculation methodology: mobility surveys or airport statistics (that could lead to bias for some countries where flight hubs exist such as Netherlands, France or Germany).

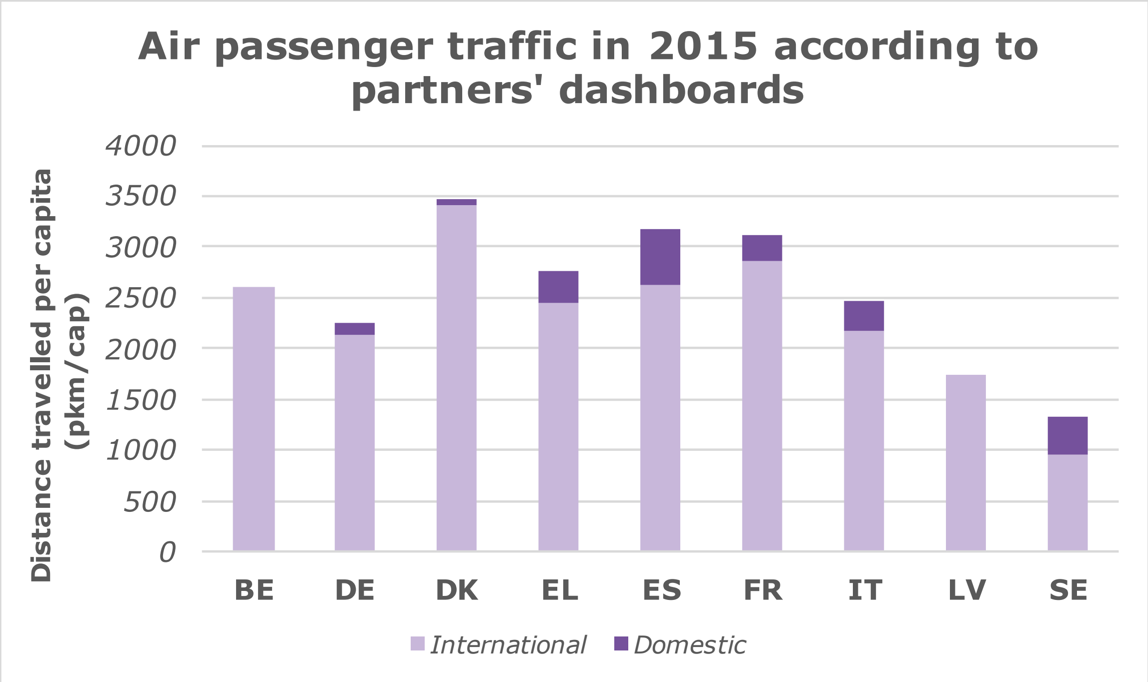


Figure 8: Air distance travelled per capita in 2015 according to data shared by CLEVER national partners

Flight use is within a global trend of social inequities. Indeed, in 2018, 1% of the world population emits 50% of CO2 from commercial aviation[42]. This inequity is visible between countries (see economic trends below) and within countries when comparing the flight use of the different quintile of income (see Figure 9 for an example in the UK).

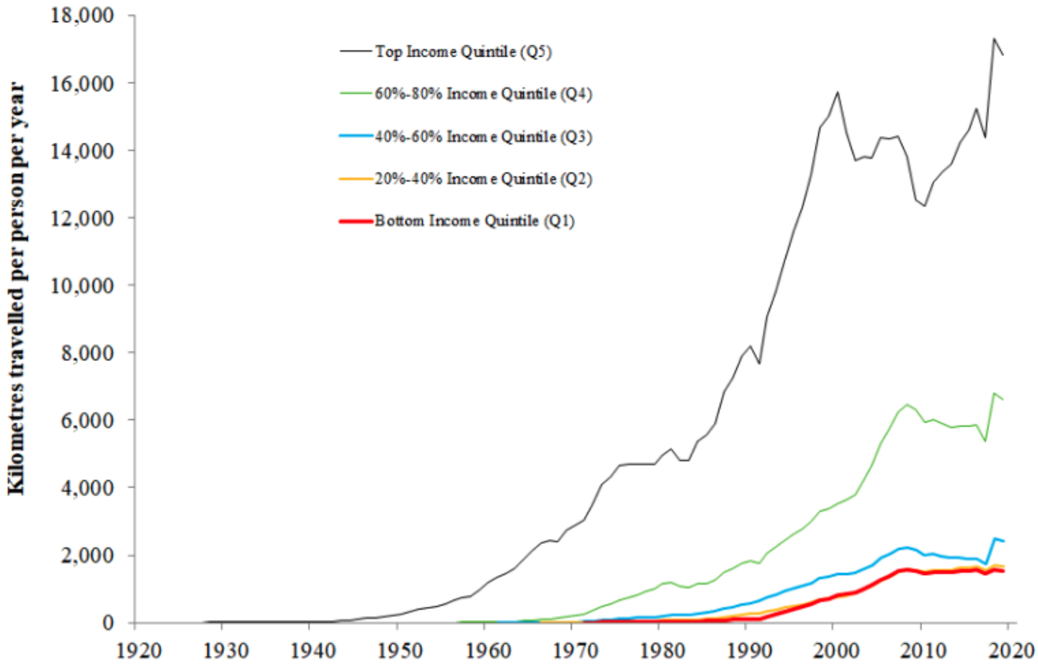


Figure 9: Air travel by income quintile on UK registered airlines (Fouquet et O'Garra, 2020 – p.9).

Economic trends

In line with these social inequalities, the Figure 10 shows a correlation between the number of trips and the GDP per capita. Following the same trend, there is a strong disparity of flight use following the level of income. For instance, in the United Kingdom registered airlines, the top income quintile flew more kilometres in 2019 than the rest of the population (see Figure 9)[43].

However, Figure 10also shows a stabilisation of traffic above a certain level of GDP/cap. And, as for other indicators (e.g. total distance travelled per capita), strong policy measures can enable to reduce the level by which it stabilises.

[42] Gössling et Humpe, 2020

[43] Which represent the majority of flight use, see for instance statistics in the UK: Fouquet et O'Garra, 2020

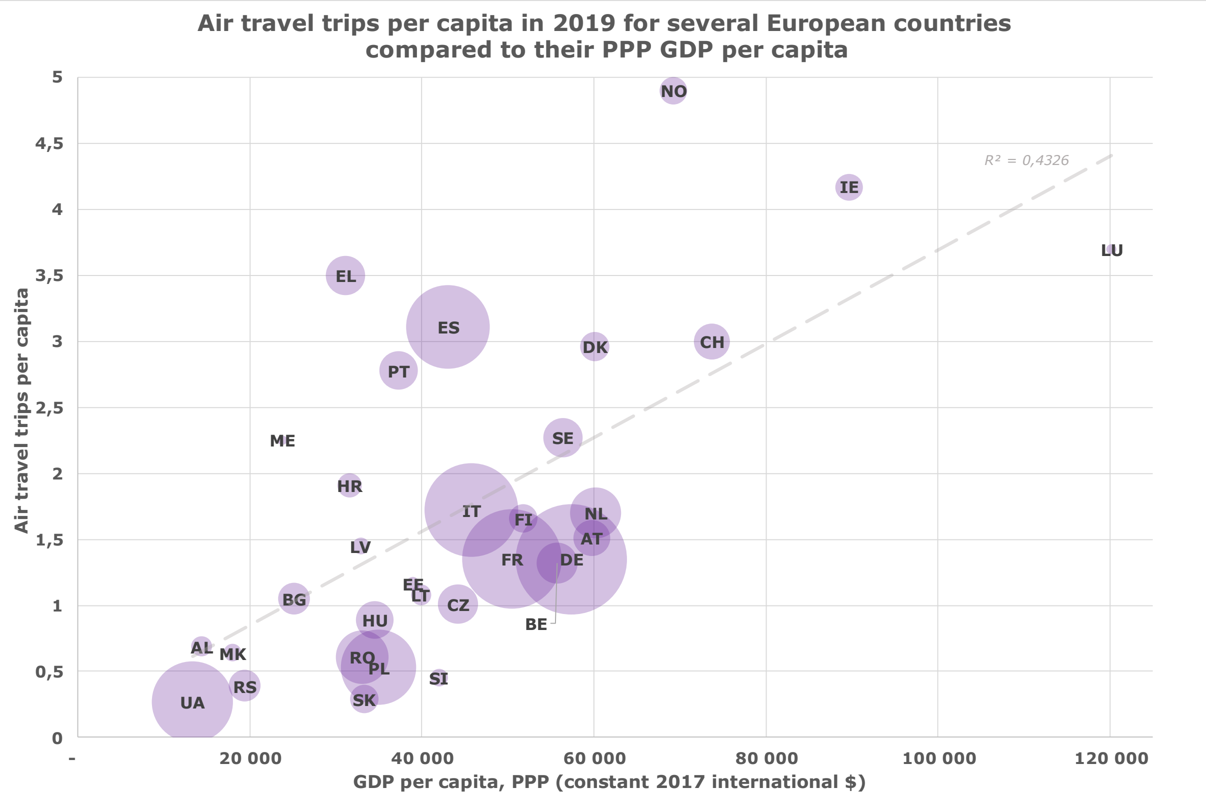


Figure 10: Airline passenger trips in 2019 for European countries compared to their GDP per capita[44]

An obstacle to the reduction of air traffic emerges from this correlation between wealth and flight use as the European countries have a high (for the western Europe countries) or growing (for the eastern Europe countries) GDP per capita. A reduction of air traffic is supposed to go against this trend which implies the need for strong policies such as regulations.

Possible reduction levers

Air mobility reduction is directly linked to alternatives, i.e. rail infrastructures, especially for national and intra-EU long distance travels. In other words, "no train, no plane reduction".

The rapid reduction or elimination of **domestic flights** is an important lever of flight traffic reduction as national policies could compensate domestic flight bans with an improve in train and bus services. However, domestic air traffic reduction might be limited for some countries including densely populated islands like the Canary Islands for Spain (2.2 million people in 2020), Azores and Madeira for Portugal (0.5 million people) and Greece with its high number of islands. Modal shift to sea transport should help to decrease air mobility but might not be enough for instance in Greece according to NOA (CLEVER Greek partner).

One key limitation of **international air traffic** reduction is tourism. This should be mainly the case of every highly touristic country such as Spain, Italy and Greece. This is an important issue to address as the tourism and travel industry represents between 10%-20% of the GDP of these countries. Aiming at a reduction of international flights will require to deal with this issue. It will come with incentives and communication to promote local tourism and reinforce the need of developing efficient European rail transportation.

Finally, the COVID crisis showed the rapid impact of air travel restriction of flight mobility. It led to the fast development of alternatives to flight travels such as the organisation of online conferences and meetings to replace business travel or the increase of local tourism. The recovery in air traffic

[44] World Bank, 2020 and Airbus, 2019, Global Market Forecast.

since 2020 has been slow[45], it could reflect a solid installation of some of these new behaviours. This slow recovery could be reinforced in Europe by the perturbations due to Ukraine war[46].

Prospective: values considered in a selection of scenarios

Most ambitious objectives

Millward-Hopkins et al., (2020), assumes in 2050 an air mobility of **1000 pkm/cap/year**; while Kuhnhenn et al., (2020), assumes a very low air mobility of **580 pkm/cap/year**. Grubler et al., (2018), considers in 2050 **1830 pkm/cap/year** for the "Global North".

European scenarios

In the ECF/Climact scenario[47], the assumptions on aviation passenger mobility at the European level for 2050 are:

- **4 384 pkm/cap/year** for the less ambitious scenario of ECF named "Technology"
- **2 095 pkm/cap/year** for the ECF "Shared Effort" scenario
- **1 845 pkm/cap/year** for the most ambitious scenario of ECF named "Demand-Focus"

National scenarios

A set of national scenarios gathered and computed in the CACTUS project[48] was considered (see Table 2).

Country	Base year (2017)	Prospective (2050)	CAGR (2017-2050)
France[49]	3307	1312	-2.76%
Lithuania[50]	628	1000	+1.42%
Hungary[51]	430	1000	+2.59%

Table 2: Air traffic values in key scenarios for three European countries

Proposition of a harmonised corridor

The CLEVER trajectories followed two targets for this indicator.

For domestic flight, trajectories followed a target of 0 pkm/cap/year. This target included exceptions for countries with densely populated islands far from the metropolis for which the air traffic remained at least at the current level of air traffic between the continent and the islands. For

[45] ICAO, 2022

[46] IATA, 2022, however, a relative increase in recovery was observed at the end of 2022.

[47] ECF/Climact,2018, trajectories available in the EUCTI tool.

[48] See the project website.

[49] negaWatt scenario for France, 2022

[50] Data from the CACTUS project, see publications available on the project website.

[51] Data from the CACTUS project, see publications available on the project website.

those countries, it was studied how modal shift from air to water could reduce air traffic. This target should be **achieved by 2040** if the speed of rail infrastructure development allows it.

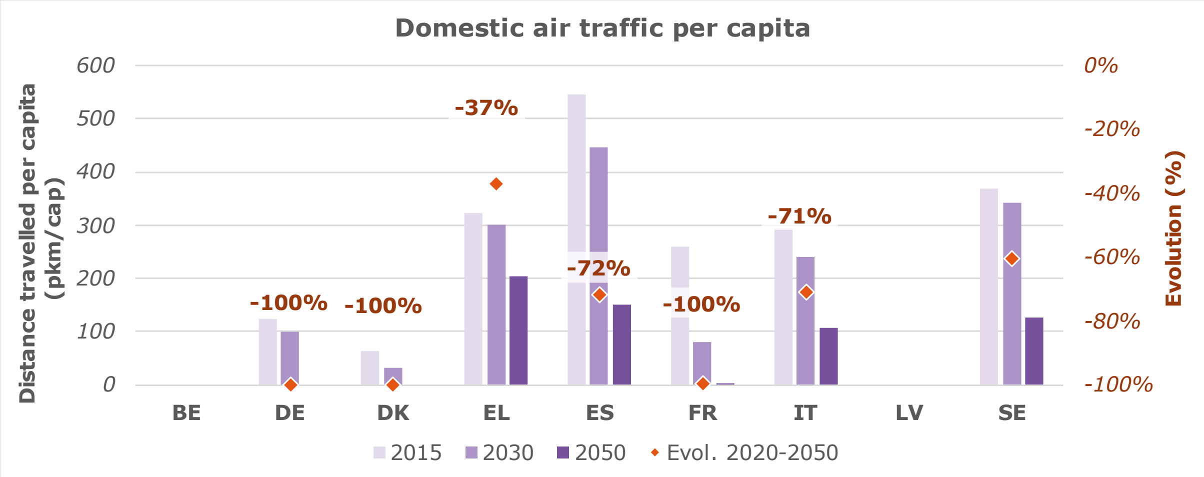
For international flights, **a corridor between 600 and 1 500 pkm/cap/year has been set.** This corridor is ambitious compared to other scenarios, reflecting the will of the CLEVER network to harmonise equitably international air mobility between European countries. The maximum value was set to be as ambitious as possible, following CLEVER's sufficiency strategy, while being realistic. It is near of the Grubler et al (2018) value and more ambitious than the ECF/Climact (2018) lower value. The minimum value was defined to be consistent with Millward-Hopkins et al. (2020) and Kuhnhenn et al (2020) level. This target should also be **achieved by 2040** if the speed of rail infrastructure development allows it.

The upper boundary of the corridor could be exceeded in specific conditions. In that case, **the aim was not to exceed 2 500 pkm/cap/year**.

Moreover, conservative trajectories in terms of post-Covid air recovery were made (not going back to pre-covid levels). This modelling choice was made following the observed slow recovery trend and the imperative of quickly reducing the European energy dependency due to the current energy crisis.

Achieving these two objectives will only be possible if strong policy measures are put in place.

Trajectories of CLEVER national partners



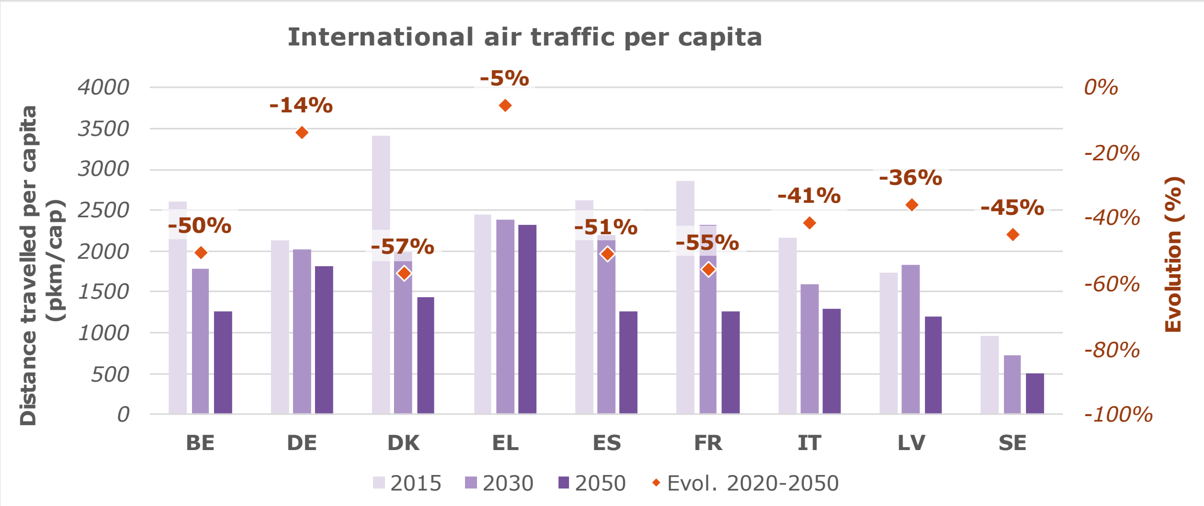


Figure 11: Evolution of the air distance travelled per capita (in pkm/cap) modelled in CLEVER national trajectories

In 2050, domestic air traffic is phased out for France, Germany and Denmark (0 pkm/cap in 2040 and 2050 respectively). Domestic air traffic remains in 2050 in countries where it ensures mobility from the mainland and islands (e.g., Canary Islands in Spain), between islands or to access to remote areas with limited infrastructure (e.g., North of Sweden).

Regarding international air traffic, there is a disparity in the starting point but also in the ambition by 2050. Denmark, France, Belgium and Spain have a very high starting points (above 2 500 pkm/cap) in 2015 and show a strong reduction in 2050 over 50%. Greece and Germany, with starting points over 2 000 pkm/cap show a much lower of 5% and 14% respectively. Sweden has a very low starting point, which reflects a methodological problem related to the lack of a major international hub (as might be the case for Paris CDG in France or London Heathrow in the UK). Thus, for a Swedish traveller, only flights from Sweden to a European hub are considered, whereas this is not the case for the hub flight to the final destination.

In sum, all countries show a reduction of internal air travel. All partners are below 2 500 pkm/cap/year and the majority are below 1 500 pkm/cap/year.

First proposals for policy measures to support ambitious objectives

Key measures

Objective: reduce air traffic as much as possible:

- *In the short term:* disincentivise air mobility in favour of less CO2 intensive modes.
- *In the medium/long term:* supress intra-European air connection when train alternative exists and distribute more equitably the remaining air mobility.

EU and national level: By 2030, ban intra-European air connection when **train alternative in less than five hours is possible[52].** In 2019, this measure could have replaced by train a third of busiest short-haul intra-European flight[53]: 31% of the 150 busiest short-haul flights in the EU have train alternatives under six hours in 2019 representing 33 millions of passengers[54]. It is supported by EU citizens in surveys[55].

Implementing this measure is more convenient for users. Indeed, airports are usually farther away from city centres than train stations and require longer check-in procedures[56].

Implement this measure step by step: suppressing air connection when train alternative is possible in less than three hours in 2025, then four hours in 2027 and five hours in 2030[57].

This measure should be complemented by: a massive development of domestic and European train lines trough EU measures (see measures for collective transports share) and a reinforcement of train comfort compared to planes, in particular ensuring to offer enough space, WIFI connection to work, cleanliness, and other comfort like catering.

Good case example in France:

This type of ban is already in place in France when there is an alternative train journey of less than 2.5 hours[58]. It has been validated by the EU commission, which opens the door to its generalisation in other EU countries[59].

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[52] French Convention for Climate Change (CCC), 2020, Greenpeace, 2021

[53] OBC Transeuropa, 2021 p.11; report commissioned by Greenpeace EU.

[54] And 11% of these flights could have been done in less than 4 hours (20 millions of passengers): OBC Transeuropa, 2021 p.15

[55] EIB 2019-2020 survey on Europeans willing to reduce carbon-intensive transportation.

[56] E.g. one of the reason of Alitalia company closure in Italy was the convenience of train travel (CNN, 2021).

[57] French negaWatt 2022 scenario: part 3 page 9

[58] Forbes, 2022

[59] EU Commission, 2022

<u>EU level:</u> Overhaul tax status of the airline transport industry in the EU[60].

EU Context: 2 key EU mechanisms define the air transport industry taxation status

- *Energy taxation* through the energy taxation directive (ETD) which current version (set in 2003) provide tax exemptions for flights. There is an ongoing recast proposal for this directive, ending this exception status, included in the Fit For 55 package[61].

- *Carbon taxes* through the EU ETS within EU border and the CORSIA mechanism for international flights. A recast proposal of the EU ETS is ongoing. It proposes the end of the free allowances for flight in the ETS by 2026 (Parliament position) or 2027 (proposal by the EU Commission)[62].

- In both taxation scheme, there are exemption for sustainable aviation fuels (SAF).

The tax status of EU flights is currently out of pace with the reality of the climate emergency. The two key schemes defining this status are currently under revision. They should be as ambitious as possible, with the aim to make flight mobility more expensive than train alternative in the majority of intra-EU travels:

- Impose a minimum level of tax on aircraft fuel for flights within the EU as proposed in the revision of the directive. The scope of the taxation should be applied to every type of flight (cargo-only flights, "pleasure flights" and "business aviation") for all member states and not only on a national basis as it is the case in the proposed text.
- ETS revision: include international flights in the new ETS with CO2 and non-CO2 warming effects[63].
- ETS revision: end free allowances to the aviation sector as soon as possible.

The revenue of these tax and additional EU transport funds should be used to support other transportation modes, especially train and the mutation of the air industry (vocational retraining aids towards other transport sectors and research for alternative fuels) in Europe.

<u>National level:</u> Increase the price of plane tickets through increased taxation and reverse the benefits toward a fairer and decarbonised society[64]. 2 policies should be put in place:

- **End VAT exoneration** on international plane tickets and supress reduced VAT rate on national flights.

- **Create an eco-contribution** at national level to increase and align plane ticket price on its real cost for society: aircraft noise, contributions to local air quality problems and to climate change, other factors such as townscape, landscape, biodiversity, heritage and water[65]. The money raised by this eco-contribution should be used to support the development of public transports (see Germany good case example in collective transport share).

This proposal cannot be applied to all territories uniformly; flexibilities have to be implemented especially for island states.

Good case example in Sweden:

In 2018, Sweden increased its eco tax from 6 to 26 euros on plane tickets outside of Europe for flights under 6,000 kms and 41 euros for flights over 6,000 kms. Flights that travel within Sweden

[60] A good analysis of the current state of EU policies and the taxation possibilities have been made for the EU Commission by Ricardo, 2021

[61] See the ETD recast official text and the Euractiv, 2021 analysis. Such recast could be complex to be set at EU level as it needs to be unanimously approved by the 27 MS. If it is not adopted, the flight taxation status could be revised at national or bi-lateral level as it is a shared competence between the EU and MS (see next policy).

[62] See the position of the Parliament in Euractiv, 2022 and the Commission position.

[63] As discussed within the EU Parliament.

[64] French negaWatt 2022 scenario: part 3, page 15

[65] This true cost remains relatively difficult to evaluate with medium to high uncertainties, most of existing literatures (including IPCC) principally focuses on the cost related to CO2 emissions.

or other between Sweden and other European countries will have a tax of 6 euros. The tax seems to be favoured by most Swedes: 53% of Swedes approve of the new tax[66]. The measure is paying off, as the number of passengers has decreased by 5% on domestic flights.

National level: Limit aviation emissions while ensuring a more progressive distribution of flight, tackling the huge social inequities in the use of flight (shown for instance in Figure 9). One of the two following levers could be considered:

- **Set a frequent flyers levy** corresponding to an increasing charge for every flight taken within a year, starting from zero[67].
- **Create a system of personal carbon allowances (PCAs) for private travels by plane**. This policy corresponds to setting a maximum CO2 emissions/person for private flights reducing over time. Such kind of policy sees many proposals, imagining fair rules for these PCAs and functioning of a trading scheme[68].

Social justice, emissions reduction and other positive externalities such as reduced air pollution and improved public health are the key benefits that should be gained thanks to this measure.

Other measures

EU level: Ban fossil-fuel driven private jets in Europe as soon as possible[69]. For the same route, travelling in private jet is 5 to 14 times more carbon intensive than using a passenger plane. Their use increased by 31% between 2005 and 2019. This is also a social measure as only a small share of wealthiest people uses private jets. Some EU countries, such as France, have already indicated their interest in this measure[70].

It could be done in 2 steps:

- *During the ETS transition period:* tax fossil-fuel private jets – with at least the ambition previously stated for the global airline industry.
- *As soon as 2030[71]:* put in place a ban.

As before, revenues raised from the tax during the transition period should be used to massively develop public transport in priority.

EU to national level: Ban air travel advertising. It could be done through a general ban on fossil fuel advertising in EU or national laws[72].

Good case Example - Amsterdam:

In May 2021 Amsterdam banned advertising for cheap flights and diesel cars from the city's metro system as part of a scheme to discourage the use of fossil fuels[73].

National level: Reduce airport extensions through national laws. Block new airports expansions through national climate laws or environmental commitments.

[66] NDTV, 2018

[67] New Economics Foundation, 2021

[68] Fuso Nerini et al., 2021

[69] Transport & Environment calls for a **ban in 2030** see the study: T&E, 2021

[70] See this article.

[71] T&E, 2021

[72] This policy was the topic of a European Citizens Initiative launched by Dutch Citizens' that fell short to reach 1 million people (see the website of the initiative and it's official EU registration).

[73] See this article.

Good case example in Britain

In 2020, Britain's plan to expand Heathrow Airport has been rejected by an appeal court judge. The judge said that the government's policy was unlawful as it failed to take into account climate change commitments it made when it signed up to the Paris Agreement[74].

[74] See this article for an analysis of the judgement

Share of active mobility

Definition: Distance travelled per person and per year via active modes (mainly cycling and walking) expressed in passenger-kilometre or as a share of total distance travelled per capita.
Unit: pkm/cap/year or % of total passenger mobility (excluding aviation).
Calculation: [passenger-kilometres travelled per year by active modes] / [population] or [distance travelled per capita travelled by active modes] / [distance travelled per capita except air]

Introduction & indicator perimeter

Active mobility is an important sufficiency lever because of its significant potential in terms of decarbonising transport, improving health, and decongesting cities. More and more new modes of soft transport are appearing, such as the electric scooter or the electric monowheel. These categories are also to be considered in this indicator, although they represent a small share today.

Historical data was not easily accessible for many CLEVER national partners. One way to overcome this issue was to model only a growth indicator to 2050, leaving unknown historical levels constant. This would represent the new active mobility and would therefore make it possible to consider the growth of this type of mobility which will inevitably be accompanied by strong policies and incentives.

Caveat: contrary to the distance travelled per capita and share of collective mobility parts, the total passenger mobility measured for this indicator includes active mobility. It however still excludes aviation.

Historical data

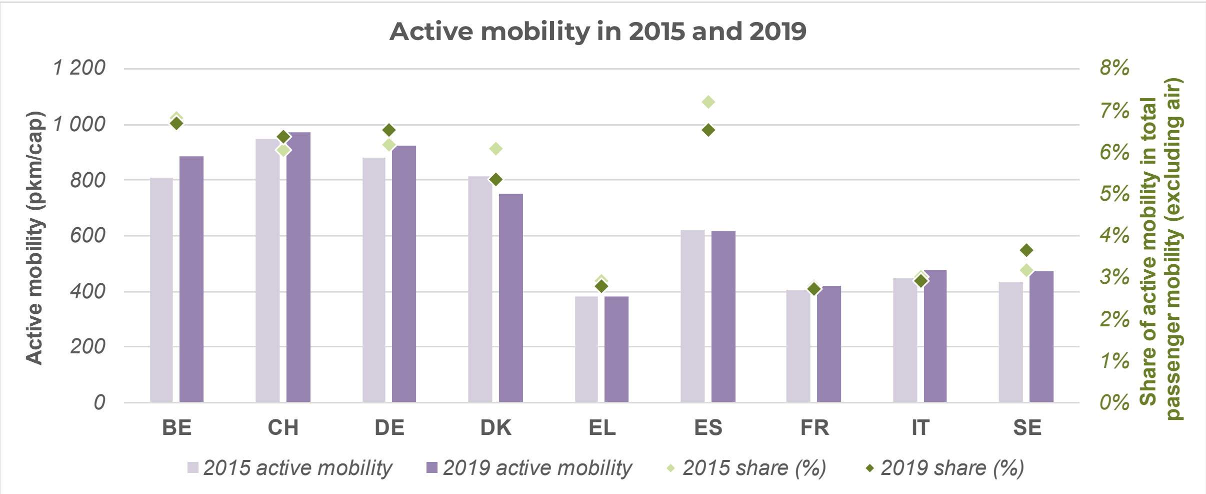

Figure 12: Active passenger mobility per capita in 2015 and 2019 according to data shared by CLEVER national partners

A disparity between the ten presented countries can be observed in 2015 and 2019. Belgium, Switzerland, Germany and Denmark reach almost 7% while France, Italy, Portugal and Greece are under 3%.

Main factors considered when defining the level of ambition

Impact of the share of urbanisation on cycling

Cycling is a key part of active mobility as it represents around 70% of this mobility.

The share of people living in cities would seem to be a factor to consider when defining the ambition rate for active mobility. However, the current example of Belgium shows that this is not necessarily the case (Figure). Moreover, IDDRI studies[75] on transport decarbonisation do not show a consensus. Indeed, in UK the potential is greater for metropolitan areas than for non-metropolitan areas, but this is not the case for France or Japan.

Still, the French negaWatt scenario defined a decreasing potential for the share of cycling in total passenger mobility following the degree of urbanisation:

- 20-25% of cycling for cities
- 10-15% for towns and suburbs
- 5% in rural areas

The extrapolation of these values to the European countries with the same rate of regular local mobility (50%) is given Figure below. Despite significant disparities in population distribution, the rates of cycling in total passenger mobility (excluding aviation) in the various countries would be close (6 to 8%) following the potentials defined by negaWatt.

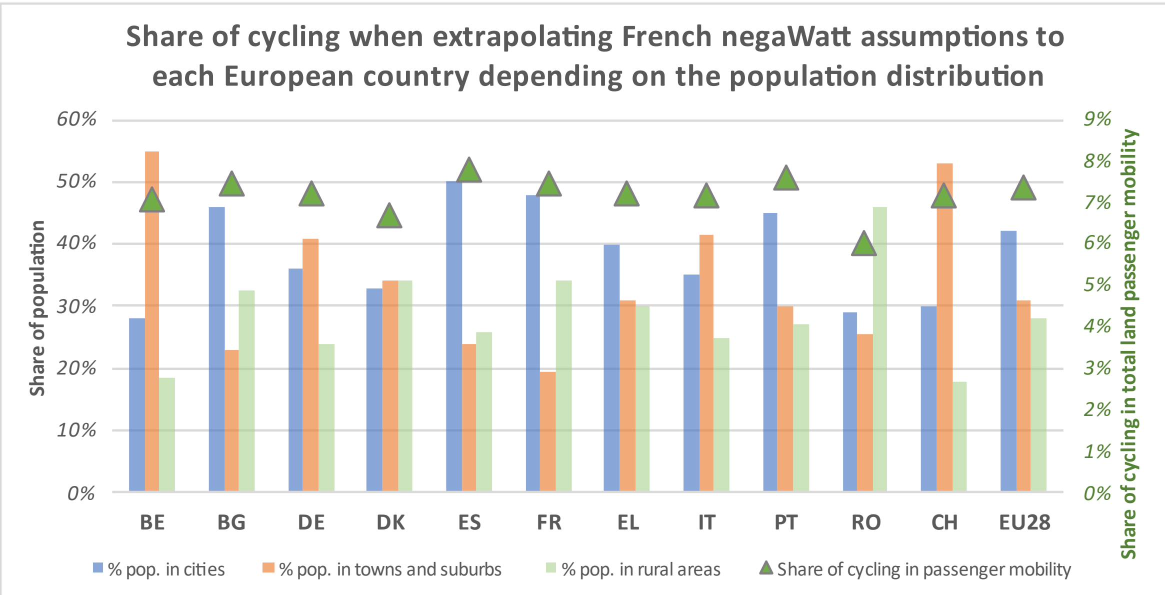

Figure 13: Share of cycling when extrapolating negaWatt assumptions on specific cycling share per type of urbanised area to European countries.

It was hence concluded that the degree of urbanisation in European countries is not a major factor to consider when defining the level of ambition for **cycling development**.

Need for key infrastructures and policies

Future policies and measures are an important factor influencing active mobility in 2050. It is not possible to have a high level of ambition without strong policies on public infrastructure and

[75] IDDRI, 2017

incentives as well as appropriate urban and territorial planning in both metropolitan and non-metropolitan areas.

This point is translated in EUCALC where public infrastructures availability is a political driver to increase the share of active mobility. The example of Copenhagen is worth mentioning, as the strong development of the cycling infrastructure has enabled the modal share of cycling to reach 49% in 2018[76].

It is also important to note that active mobility infrastructures, while requiring assessment, planning, removal of legal barriers, financing, contracting and execution, they could be deployed more quickly than rail infrastructures, for example, if there is the political will. Indeed, it consist in the redefinition of the road use and rules (create specific lanes and signalisation for instance) and to create new lanes for walking and cycling which are less expensive to create and manage than roads. Furthermore, new active mobility technologies widening the access to this type of mobility such as electrically-assisted bicycle could also spread rapidly if incentives are provided.

Eventually, a strong potential exists, but it could only be exploited by strong incentives and policies that would encourage and develop a cycling culture.

Prospective: values considered in a selection of scenarios

Most ambitious objectives

Millward-Hopkins et al (2020)[77], assumes an average non-motorized distance travelled of 4km/capita/day, which equates to just over **1,500 km/capita** annually.

National scenarios

A set of national scenarios gathered and computed in the CACTUS project[78] was considered (see Table 3). It allows to observe different prospected national variation with various base level.

Country	Pkm/cap (2017)	Pkm/cap (2050)	Share (%) (2017)	Share (%) (2050)
France[79]	410	1237	2.66%	9.31%
Germany[80]	n.a.	1641	n.a.	12.32%
Lithuania[81]	80	200	0.65%	1.48%

Table 3: Absolute value and share in total distance travelled per capita (except aviation) for active mobility in key models for four European countries

[76] European Cyclists' Federation figures

[77] Millward-Hopkins et al (2020). Supplementary data, p. 15

[78] See the project website.

[79] negaWatt scenario for France, 2022

[80] Green Supreme scenario from RESCUE report (Umwelt Bundesamt, 2019)

[81] Data from the CACTUS project, see publications available on the project website.

Proposition of a harmonised corridor

To be harmonised with the diversity of national context, it was decided to set a active mobility corridor as a share of total land passenger mobility.

Given the previous analysis and exchanges on national contexts, the following corridor for active mobility was chosen:

- Minimum level of **7%** of total passenger mobility is proposed as it represents today's best practices.
- Maximum level of **15%** of total passenger mobility, representing the highest value considered possible by CLEVER national partners.

As the active mobility infrastructure could be deployed quickly, the CLEVER network decided to set high ambitions by aiming to reach this corridor in every country by 2035 at the latest.

Trajectories of CLEVER national partners

The following diagrams show current ambition of the national partners in terms of active mobility:

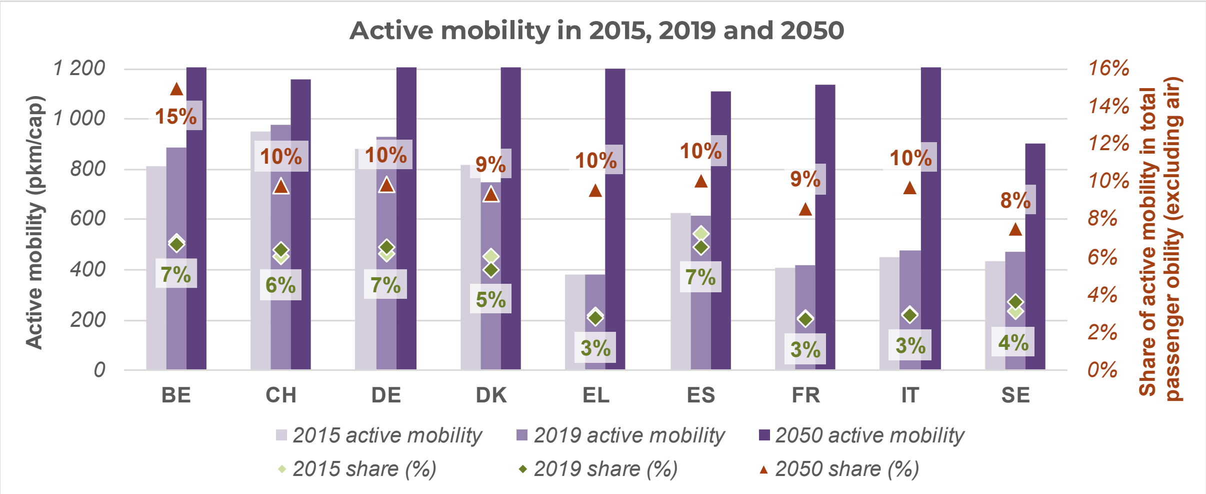

Figure 14: Share of active mobility in 2015, 2020 and 2050

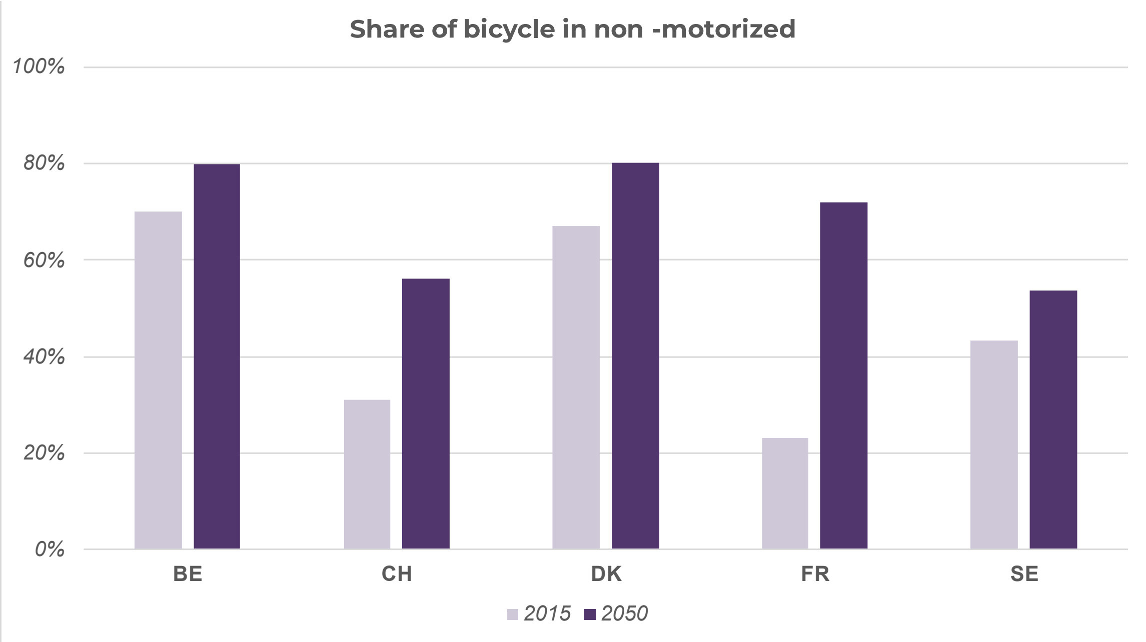

Figure 15: Share of cycling in active mobility in 2015 and 2050

For those countries whose partners have proposed a value for 2050, the rate of active mobility increases sharply to around 10%.

Moreover, the share of cycling in this active mobility is increasing with disparities between countries but reaches a level between 60% and 80%. The share of cycling is three times higher between 2015 and 2050 for France. For Belgium, Denmark and Sweden the share of cycling increases slightly during this period.

First proposals for policy measures to support ambitious objectives

Key measures

Objective: widespread of cycling by using financial, legal and educational levers:

- Make cycling the mode of urban mobility in addition to public transport.
- Increase cycle use in rural areas.

EU level: Raise the EU leadership toward the development of an EU cycling strategy as requested by the EU Parliament[82].

EU, national and local level: Unlock funding from the EU for building cycling paths in rural and urban areas, and support mechanic or electric bike acquisition. This funding could mainly come from EU national and regional programmes such as the European Regional Development Fund and the Cohesion Fund. These funds have been raised by the EU for the period between 2021 and 2027[83]. This creates a key window of opportunity for countries to unlock EU funds for cycle investments. Guides for every EU country have been edited by the European Cyclist Federation to help national and regional government to receive it for cycling development[84].

National level: Create or increase **national annual budgets**[85] for bikes to develop cycling infrastructures (cycling lanes, bike parking slots) and support bike acquisitions. There are today great disparities between countries for bike budgets: in 2017, Denmark and the Netherlands stand as good examples with 27 € /cap/year of spending allocated to cycling against 8€/cap/year in France[86]. The investments should be coupled with a re-ordering of priorities between cycling lanes and roads in dense urban contexts[87].

Local level: Establish in cities an **integrated framework of bicycle infrastructure** (dedicated lanes, parking lots, highways, bridges) that is clearly separated from car infrastructure (see an example Figure) and connected to a widespread regional framework[88]. Implementing this requires reviewing legal frameworks at national level to speed up the processes, securing financing and planning staff capacity at local level.

[82] Motion posted in February 2023.

[83] See European Cyclist's Federation, 2020 for an analysis of the EU funds available to finance cycling.

[84] These guides are available on this link.

[85] French 2022 negaWatt scenario (negaWatt, 2022).

[86] Shift Project, 2018

[87] In the German context, where priority is today given to cars rather than to cycling infrastructure, German Zero (2021) has proposed concrete legal changes needed to eliminate this barrier to the construction of cycling infrastructure.

[88] Source and further concrete examples (Dutch Ministry of transports, 2007).

Copenhagen's (Denmark) coloured bike lanes

Figure 16: Copenhagen coloured bike lanes.
Copenhagen city centre has more bikes than cars per resident (56% of residents use bike in 2016)[89]. It is assessed that the main reason explaining why people in Copenhagen cycle is that it is faster and easier[90].

<u>Local level:</u> Make it easy, make it cultural

It is important to seek a **cultural shift towards active mobility**, as this could be a barrier to its development (e.g., lack of a bicycle culture in Greece).

Appropriate urban plans could lead to a cultural shift towards active mobility. One example is the "15-minute city" concept, proposed in distance travelled per capita reduction policies which involves transforming cities in a way that makes active mobility the easiest way to get around (e.g. dead-end streets for cars[91]).
A good practice example are the "Superblocks" in Barcelona[92]. The local authority used the constitution in blocks of the city to constitute "Superblocks" of about 3x3 blocks with restricted car transit, good public transport infrastructure, greening and furbishing of streets.

Bicycle education and awareness raising is also a way to facilitate the transition when adequate infrastructure is available. Interesting policies could be the development of school bicycle transportation programs and the implementation of national and local campaigns to raise awareness of cycling and safety on the road.

Punctual car bans in city centres are a key tool to show the possibilities and comfort of a city where there is more room for active mobility in the public space. Such events are promoted annually by the EU Commission in the European Mobility Week[93]. It could pave the way to social acceptation to car road reduction, replaced by active mobility spaces.

[89] Lifegate, 2016

[90] City of Copenhagen, 2017 – p.18

[91] See the space planning of Heidelberg (Germany) to discourage car use: The Business Times, 2021

[92] City of Barcelona, 2021

[93] Car-Free City annual event (see European Mobility Week, 2022). The European Mobility Week is followed by more than 3000 cities in Europe each year.

Other measures

EU level: Increase multimodality by redesigning collective transports, especially trains, to increase dedicated space for bikes. Indeed, public transport and bicycles are complementary and could, if combined, offer an effective alternative to car use. A breakthrough has been made in 2020 in that direction: railways companies are now compelled to design bike spaces on new and refurbished trains since 2020[94].

Adequate and secure bicycle parking at public transport stations enable zero-emission multimodality. The Netherlands have shown how a consequent parking infrastructure enables the combined use of bicycle and rail transport.

EU level: Integrate mandatory bike space in new and renovated buildings in the Energy Performance Building Directive[95]. As stated above, secure bicycle parking is essential to ensure an increase in cycle mobility.

EU level: Advise and promote active mobility to national local governments. This is planned in the EU Commission new Urban Mobility Framework announced on December 2021[96]. These advises should contain the different measures propose to national and local government in this note.

EU to national level: Support bike tourism by the reinforcing the Eurovelo[97] cycle route network: give funds for infrastructures and bike-friendly facilities along the route.

National level to local level: Improve security and convenience of active mobilities through traffic regulation enforcement, infrastructure improvements to slow down traffic, space improvement (e.g., minimum size of sidewalks) and comfort (e.g., regular green areas)[98].

Local level: Invest in large scale bike public sharing systems. These systems increase the accessibility of bicycle mobility and have been experienced for a long time. First schemes of bike sharing systems were introduced in cities with historically strong bike culture such as Amsterdam in 1965 and Copenhagen in the mid-90s with a deposit-system. More important bike sharing systems were then firstly implemented in Vienna, and Lyon in 2002, then replicated in Paris in 2007. Today these schemes are spreading fast, and China stands as the biggest bike sharing systems developer worldwide (see figure 13).

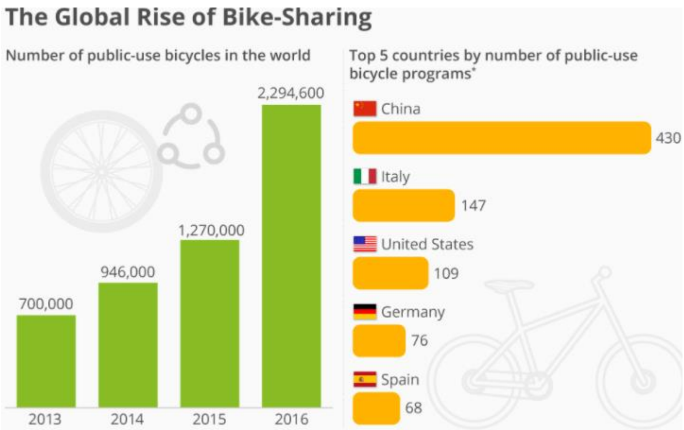

Figure 17: Global rise of bike-sharing according to Statista[99]

[94] In 2020, the "Cyclists Love Trains" campaign achieved a breakthrough in the recasting of the EU's Rail Passengers' Rights and Obligations Regulation, which now compel railway companies to provide dedicated spaces for bicycles on all new and refurbished trains.

[95] ECF, 2021

[96] EU Commission, 2021

[97] See the Eurovelo network notably founded by the European Regional Development Fund.

[98] German Zero, 2021

[99] Chart from Russel Meddin, bike sharing blog

Cross parameter measure

National level: **Introduce a mandatory sustainable mobility bonus** in national laws for commuting to work by bikes and collective transports[100]. **Make this bonus mandatory for all firms** of more than 11 employees and authorize the cumulation of this bonus with defrayal of public transportation passes. It should be possible to extend the bonus amount in cases of precarity and for rural areas. This bonus represents a cost for companies (and administrations) therefore, tax credit or aid for small companies unable to absorb the additional cost should be provided by states (through increased national budgets for active and collective mobilities or scrapping of car commuting tax allowances).

French Sustainable mobility package

France, set a currently optional package for the employer to finance sustainable mobility (bike, collective transports, and car sharing) up to 800€ per year[101].

[100] French Convention for Climate Change (CCC), 2020

[101] See the package presentation

Share of collective transports

Definition: Share of domestic distance travelled per capita (pkm), except air and active mobility, travelled by bus, coach, metro/tram, train or boat
Unit: %
Calculation: [domestic distance travelled per capita travelled by bus, coach, metro/tram, train or boat] / [domestic distance travelled per capita except air and active mobility]

Note & indicator perimeter

This indicator corresponds to the share of collective transports in passenger mobility (excluding aviation and active mobility). It therefore considers bus, train, metro/tramway, and sea transport.

This indicator is very much linked to the national context as it depends on the infrastructure available.

Historical data

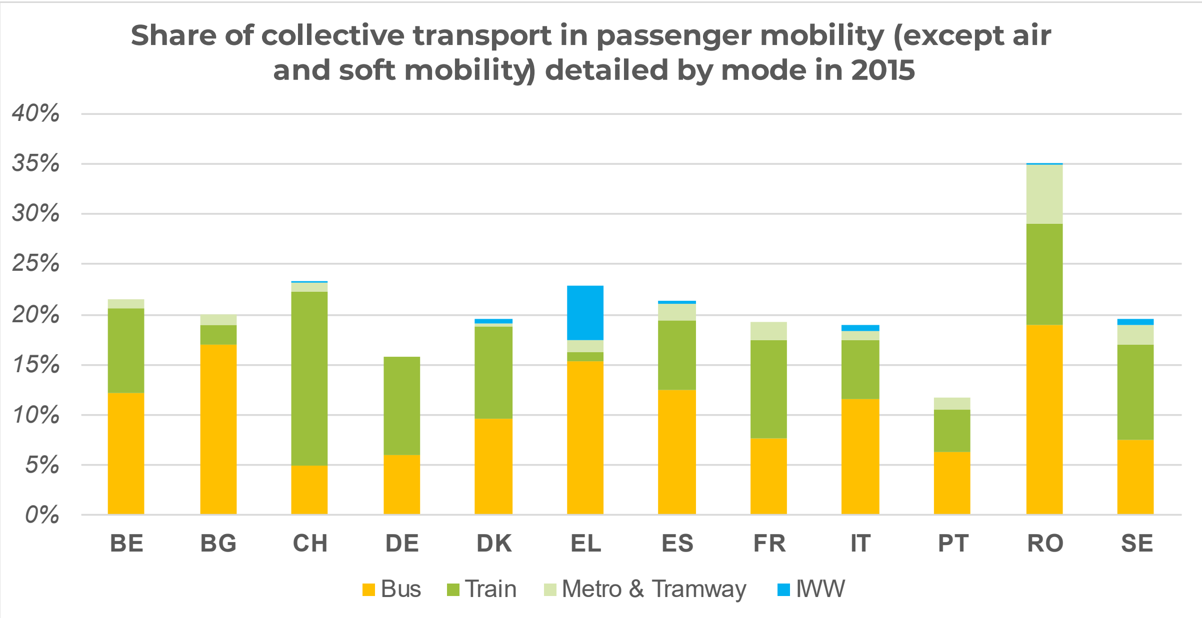

Figure 18: Share of collective transport in passenger mobility (total excluding air and active mobility) in 2015 according to data shared by CLEVER national partners.
Note: IWW means Inland Waterways

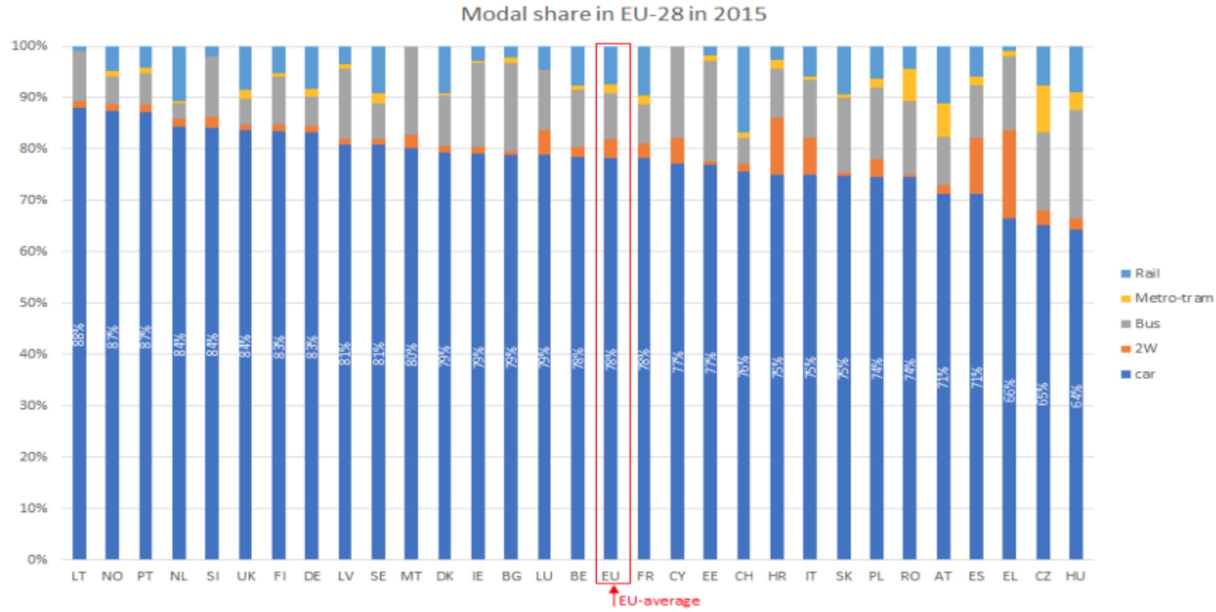

Figure 19: Modal shares in EU by country in 2015 based on Eurostat, EU-pocketbook 2017 and TRACCS[102]
Note: 2W means two-wheelers

At EU level, passenger mobility (excluding air travel) is currently dominated by the car. In 2015, public transport accounted for only 18% of the modal share (9% bus, 1.7% metro/tram, 7.3% train). However, there is a significant disparity in Europe. In some countries, the share of public transport is now more than 25-30% (e.g., Hungary, the Czech Republic and Romania), while in others it is less than 15% (e.g. Lithuania, Portugal and the Netherlands). Moreover, the share of rail varies greatly between European countries depending on the infrastructure. A low share of rail is in most cases matched by a higher share of bus (due to a compensation effect).

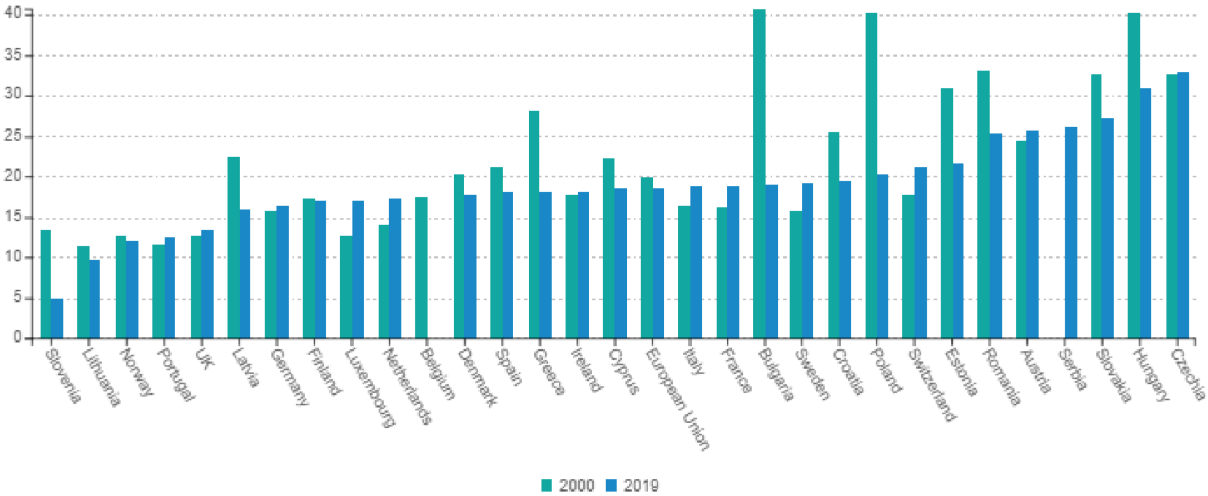

Figure 20: Share of public transport in total distance travelled per capita (excluding air and active mobility)
Source: Odyssee, Sectorial Profile – Transport[103]

According to Odyssee, the share of public transport in total distance travelled per capita has been decreasing in 14 European countries between 2000 and 2019. Moreover, the share of public transport has been decreasing rapidly in most Central and Eastern European countries (except Czechia and Lithuania), where public transport used to be dominant (especially in Estonia, Poland and Bulgaria).

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[102] EUCALC Transport documentation

[103] Odyssee, 2021 page 4.

The largest increases over the period, consisting of slight increases, are observed in Luxembourg, Sweden and the Netherlands (around +3 points since 2000) and in Italy, France and the UK (+2 points).

Main factors considered when defining the level of ambition

The lack of strong policies to promote collective transport can be an obstacle to collective transport development. However, according to Rao et Min (2017)[104], having access to public transport is a household requirement for mobility decent living. In other words, it is essential to have a functional and efficient public transport offer covering the territory to ensure a decent standard of living based on a high share of public transport.

The share of train in long distance travel is an important lever for decarbonation as it presents air travel reduction possibilities. Cheaper prices of aviation are a main obstacle for long distance travels in train. Some polices and measures to deal with this issue is presented in the last part of this indicator.

Finally, for countries with a well-developed rail network, it is possible to increase the share of rail in passenger mobility as the cost is lower: it could be obtained by increasing trains frequency without the need for new infrastructure. The past dynamics of infrastructure investments, allowing for a considerable increase in train frequency, must still be considered on a case-by-case basis.

Prospective: values considered in a selection of scenarios

European scenarios

In the EUCALC tool[105], the assumptions on collective transport share (%) at the EU28+Switzerland level for 2050 are[106]:

- Less ambitious level: the collective transport share reaches **20.6%** in 2050 compared to 18.0% in 2015 (by excluding air and active mobility from the total)
- Most ambitious level: the collective transport share reaches **43.3%** in 2050 compared to 18.0% in 2015 (by excluding air and active mobility from the total)

In the ECF/Climact scenarios, the assumptions on collective transport share (%) at the European level for 2050 are:

- **28.0%** for the "Technology" scenario (by excluding air and active mobility from the total) among which 13.1 of bus and 14.8% of rail.
- **38.7%** for the "Shared Effort" scenario (by excluding air and active mobility from the total) among which 20.0% of bus and 18.7% of rail.
- **42.9%** for the "Demand-Focus" scenario (by excluding air and active mobility from the total) among which 25.0% of bus and 17.9% of rail.

[104] Rao et Min, 2017
[105] EUCALC website
[106] EUCALC Lifestyle documentation p.49

National scenarios

A set of national scenarios gathered and computed in the CACTUS project[107] was considered (see Table 3).

Country	Pkm/cap (2017)	Pkm/cap (2050)	Share (%) (2017)	Share (%) (2050)
France[108]	2 649	3 730	17.7%	31.0%
Germany[109]	2 116	4 951	16.0%	42.0%
Lithuania[110]	1 186	2 340	9.7%	17.5%
Hungary[111]	430	1 000	31.8%	52.4%

Table 4: Absolute value and share in total distance travelled per capita (except air and active) for collective mobility in key models for four European countries

Country	Share of bus (2017)	Share of bus (2050)	Share of train (2017)	Share of train (2050)
France (nW2022)	6.2%	7.9%	11.5%	23.1%
Germany (Green Supreme)	5.7%	n.a.	10.3%	n.a.
Lithuania	7.9%	11.2%	1.2%	5.2%
Hungary	20.0%	26.7%	11.8%	25.7%

Table 5: Shares of bus and train in total distance travelled per capita (except air and active) in key models for four European countries

[107] See the project website.

[108] negaWatt scenario for France, 2022

[109] Green Supreme scenario from RESCUE report (Umwelt Bundesamt, 2019)

[110] Data from the CACTUS project, see publications available on the project website.

[111] Data from the CACTUS project, see publications available on the project website.

Proposition of a harmonised corridor

Considering the previous elements, a corridor for collective transports' share is proposed below. It could be reached in some countries by 2040:

- Minimum level of **15%**. It is considered more realistic and consistent with ECF scenarios as well as CACTUS project and EUCALC and EUCTI tools' boundaries.
- Maximum level of **40%** as it is considered more realistic and consistent with ECF Shared Effort scenario. There is an exception for countries where public transport already accounts today for more than 25% (such as Hungary, the Czech Republic or Romania, see Figure) for which a maximum of **50%** is proposed.

More precise target could be set using detailed analysis such as the negaWatt scenario 2022 for France which analysed separately local and regular mobility. Thus, the maximum modal share for metro/tram could be defined by observing the Paris metro and tramway network which is one of the biggest in Europe. It represents 20% of local and regular mobility in the city and 10% in the suburbs. Given the share of local and regular mobility (e.g., 50% in France) and the share of population living in cities towns and suburbs (50% to 80% in Europe, see Figure), an **8% modal share for metro/tram seems to be the maximum target.** Moreover, in some cases the potential of developing metro and tramway networks is already reached or would require very large investments and could provide little energy gain (or even negative) due to lower occupancy of supplementary.

Trajectories of CLEVER national partners

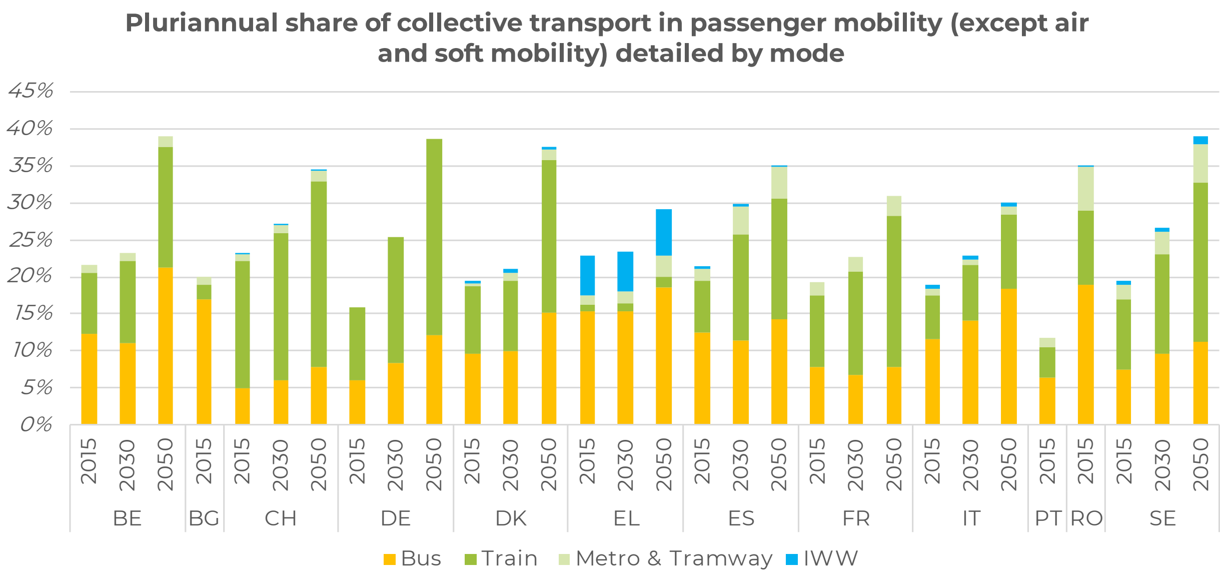

Figure 21: Share of public transport in total distance travelled per capita modelled in CLEVER national trajectories
Note: IWW means Inland Waterways

The share of collective transports increases between 2015 and 2050 for all countries whose partners provided a value ; and specially for Belgium, Germany, Denmark and Sweden which show an increase of over +15 points and exceed 35% of public transport share in 2050.For most of the countries the evolution between 2015 and 2050 is progressive; except for Denmark and Belgium where there is a high increase between 2030 and 2050. In the Danish case, this high increase of 78% between 2030 and 2050 is due to a strong development of rail during the period.

In most of the cases, the share of bus increases but less than the share of train and metro/tramway. The share of train for France and Switzerland reaches 20-25% due to a historical high developed network. This share does not exceed 5% for countries with a less developed network like Greece.

First proposals for policy measures to support ambitious objectives

Key measures

In the CLEVER European corridors of collective transport's modal share, the proportional increases in 2050 are highest for trains compared to other transport modes (car and metro/tram). This led to the high ambition of the following policies needed to substantiate this.

Objective: Massively develop European rail systems, at national and local scales to create an affordable and interconnected EU railway network.

- Ensure that train network is well developed, with good spatial coverage, for domestic and European connections.
- Ensure that rail travel is cheaper for consumers than highly emissive means of transports such as planes and cars.

EU level: Implement a European "New Deal for Rail" to help member states to massively develop trains for passengers and freight transport.

Provide financial support to member states to urgently develop this New Deal for Rail by relaunching night trains, developing regional trains, high speed trains, reactivating and creating new lines when necessary to give systematic priority to trains for transport of persons and goods at EU level. Commit to at least **30 new European Express** lines and night trains between 2021 and 2025[112].

This financial support should also enable to update or maintain train infrastructures, and to **homogenise the European network and overcome cross-border challenges,** including:

- Enhanced integration of the electrification and signalisation systems (updating the ERTMS[113]),
- Mandatory sharing of real-time data and ticketing data[114], European train timetables
- Homogenisation of technical and operating rules for all EU countries[115].

The funds could come from the European Investment Bank (EIB) along with a combination of existing EU funds such as the EU's transport Fund, the European Regional Development Fund (ERDF) and the Cohesion Fund.

Italy good-case example: development of high-speed trains

Italy is strongly developing its high-speed train network using the Next Generation EU and React EU funds[116]. One of the results of this development is a reduction of the use of domestic flight that led to the closure of Alitalia company[117].

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[112] Open letter from 36 NGOs ahead of the transport council of 3 June 2021

[113] European rail traffic management system (ERTMS): aims at promoting the interoperability of trains in the EU. There are still a number of non-homogeneity challenges remaining today

[114] Open letter from 36 NGOs ahead of the transport council of 3 June 2021

[115] Community of European Railway and Infrastructure Companies, 2021

[116] We build value, 2022

[117] CNN, 2021

National level: **Build a European affordable interconnected railway network** by making train tickets cheaper than flights. This can be partly done through **VAT tax reduction on train tickets** (depends on each current national levels) of 5.5% in all European countries. It should be done along with aviation taxes that could finance the train prices reduction (see example below and air distance travelled per capita part).

Germany good-case example: reducing VAT rate on train

In 2020, Germany increased its aviation tax on departing flights from Germany. The revenue is used to decrease the value added tax on train tickets, which has been reduced to 7 %, from the current 19% decreasing ticket prices by about 10% over 50 km[118].

National to local level: **Single prices tickets for all public transport:** offer reduced tickets allowing to use every public transport of a given region. This scheme will broadly simplify and make cheaper the use of public transport. It should be accompanied by subsidies to reduce the price of the ticket to make it accessible to all social classes and incomes.

Good case example: Austria and Germany single price tickets

Starting from end October 2021, every public transport in Austria could be taken for 3€ a day by buying a "Climate Ticket". The aim of the Austrian government is to increase the public transport share in Austria from 27% to 40% by 2040[119].

The German government followed this example with the creation of a 49€ ticket a month (1,6€ a day) starting in May 2023. It will give access to every local and regional public transport in the country[120]. This decision follows an experimentation from June to August of a similar single-price ticket for 9€ a month that has driven a reduction of car use visible in surveys[121] and to a 6 to 7 percent decrease measured in air pollution levels[122].

National level: **Legal obligations for high frequencies and availability of the rail network.** Definition of an obligation based on population flows in transport. It could be financed through EU and national funds to **strongly improve the network coverage** and supported through an optimization of the network to prevent delays[123] (especially overtaking between trains)[124].

Other measures

EU level: Reinforce the current **EU Urban Mobility package** which aims at providing targeted financial support, focusing on research and innovation to overcome urban mobility challenges and involve Member states in international cooperation.

EU level: **Revise the EU Sustainable and Smart Mobility Strategy** (SSMS) to include instruments that promote public transport, cycling, walking, shared mobility and less car use, while internal **combustion engines** (cars, vans and trucks) are **banned from city centres**.

National to local level: **Reinforce existing social prices for metro, tramways, and buses** in European cities: preferential prices *or free tickets* for students, elderly people, children, precarious workers and unemployed persons. This measure would increase collective transports share if it is accompanied by increased regulation on car use (see measures below) and is implemented in a sufficiently dense network[125].

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118 T&E, 2020

119 CNN Travel, 2021

120 Euronews, 2022

121 10% of those who bought the ticket would have used the car if this offer did not exist (DW, 2022)

122 Ghol et Schrauth, 2022

123 Which is still a pregnant problematic for instance in Germany: DW, 2022

124 GermanZero, 2021 p 239

125 Papa, 2020

Good-case example: Luxembourg's free public transport

Luxembourg is the first country in the world to offer free public transport in March 2020 to all users (residents, cross-border commuters, or tourists). The measure is part of a plan intended to reduce congestion and car use[126] while reducing financial burden of poorer citizens[127]. As in many other places where this measure has been implemented[128], it led to huge increases of public transports uses[129].

While Luxembourg's example is interesting to explore free public transport, such policy must be adapted to the specificity of the region where it is implemented (transport network congestion, actual population needs, geographic constraints…). It could also be targeted only to a specific part of the population. In addition, Luxemburg is small. A transfer of the policy to larger countries would rather be translated for local public transport.

Local level: **Progressively ban private cars from city centres**. Indeed, low public transport price should go hand in hand with measures to reduce car use. Two parts are composing these measures:

- *direct restrictions*: speed limitation for cars, regulation on car's access to city centres (or space planning to restrict their use[130]) and higher oil prices.
- *multimodality facilitations*: installation of carpark (park & ride) that should encourage individuals to use collective transports in city centres. These carparks should provide users with a public transport ticket and be installed near public transports facilities. Multi-storey parking lots with vegetation should be favoured whenever possible to avoid land artificialisation. States should financially support regional authorities in the development of such facilities.

Good case practice: Oslo (Norway) car-free city centre

Oslo implemented a gradual model to progressively from 2017 to 2019 ban cars from the city centre:

- Stage 1: all on-street parking in ring 1 of the city centre has been removed, as well as some parking in the surrounding areas, and speed limits have been reduced.
- Stage 2: several streets have been closed to private traffic (some streets remain open for delivery trucks for a couple of hours in the morning and emergency vehicles); shared space has been introduced, pedestrian network extended, and 40 miles of bike lanes built.
- Results: huge areas of the city are today completely car-free, especially around strategic places such as schools and parks. Oslo recorded 0 pedestrian and cyclist deaths in 2019[131].

Another good practice in a very large city is Paris and its ambitious policies to develop pedestrian mobility, with the Paris Pedestrian Strategy adopted in 2017, and cycling, with the 2021-2026 cycling plan.**National to local level:** **Provide financial incentives for individuals to change their mobility.**

Offer a **sustainable mobility bonus for employees** for commuting to work by collective transports (and bikes). It could be aligned with the Climate Convention in France proposal to introduce a **500 euros/year** mandatory bonus in national laws and allow extension up to 1800 euros in cases of precarity and for rural areas[132]. The proposal is to set it obligatory for all firms with at least 11 employees. This bonus represents a cost for companies (and administrations). It can be offset by a tax credit or aid for small companies unable to absorb this additional cost.

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[126] In Europe, Luxembourg has the biggest share of private car per capita: it is used for 71% of leisure trips and 41% of commuting (Eurostat).

[127] The ticket sales financed 8% of the transports costs before the policy, the shortfall is now being covered by taxes, with the burden shouldered by wealthier citizens (LAD Bible, 2021).

[128] Several EU cities also implemented free transports: **Tallinn** (Estonia's Capital) since 2013 for residents, **Dunkirk** (France, population: 200,000) since 2018 which launched a reflection in France cities (notably Paris) toward free transports (BBC, 2021).

[129] RTA, 2021

[130] As in the Barcelona example detailed in active mobility part.

[131] More information on the Olso case here and here

[132] French Convention for Climate Change (CCC), 2020

Other incentives such as **reduced public transport costs for people who give up their cars** or specific time off for worker who wish to travel responsibly.

Good case examples

Italy proposes in its National Energy and Climate Plan a **mobility voucher** (up to 1500€/a) for public transport tickets in return for old vehicle (EURO3 or older)[133].

The city of Heidelberg (Germany) provides 1-year free public transportation for resident who give up their cars[134].

A French company offers 2 days off per year targeted for responsible travel[135].

[133] See the EnSu European Sufficiency Policy database, policy 240.

[134] The Business Times, 2021 This measure in a set of measure to lead to a modal shift away from cars (along with space planning and cycle infrastructure installation).

[135] Offer made by Ubiq in February 2022.

Car occupancy

Definition: Average number of passengers per car travelling (weighted average over all segments of cars)
Unit: person/car

Note & indicator perimeter

This indicator includes all segments of cars and vans but excludes light commercial vehicles (LCV). In addition, the cars occupancy includes car rental, new car sharing initiatives and taxis.

Historical data

According to EUCALC, in 2015, average occupancy levels of transport in the EU28 + Switzerland were 1.6 person/vehicle for cars. These average hides different realities in the individual countries. Car occupancy level varies from 1,03 person/car in Czech Republic to 2.1 person/car in Poland.

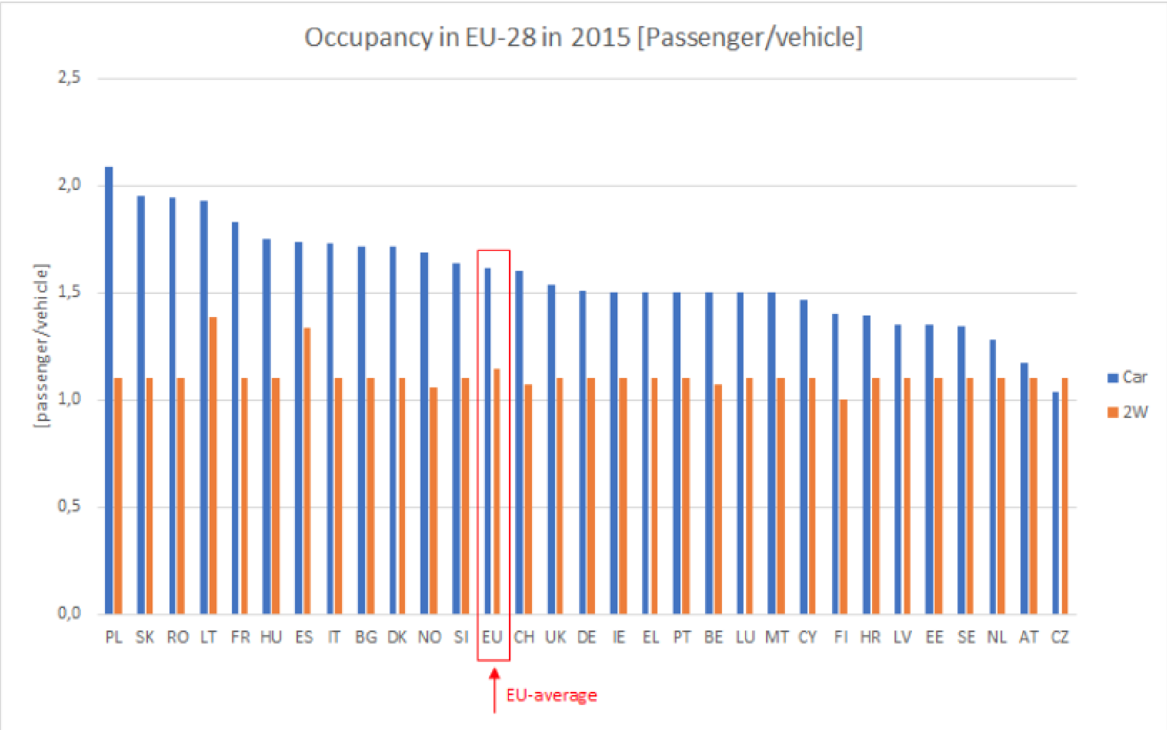

Figure 22: Occupancy in EU by country in 2015. Extrapolation based on TRACCS data[136]
Note: 2W means two-wheelers

[136] EUCALC Transport documentation

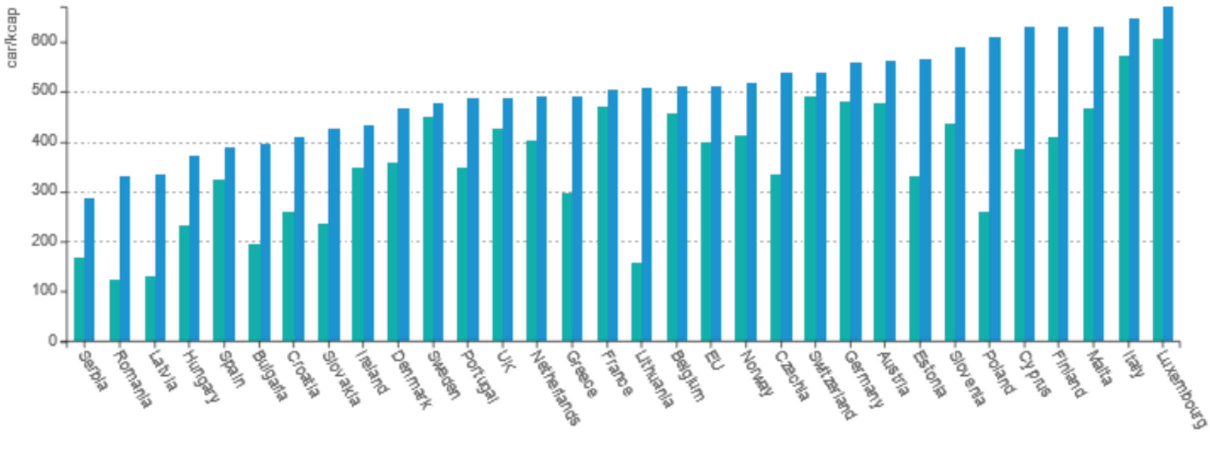

Figure 23: Number of cars per thousand of capita in the European Union[137]

There is no clear correlation between car ownership Figure and car occupancy Figure .

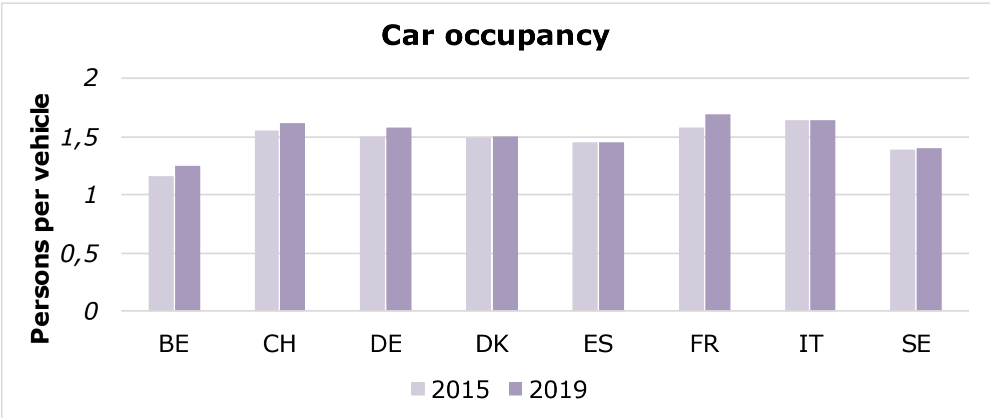

Figure 24: Car occupancy per country in 2015 and 2019 according to data shared by national partners

Important note: Car occupancy historical data provided by EUCALC (via TRACCS) is different than the one in dashboard of several countries (e.g. Belgium, France and Greece) which are based on national statistics or other databases. Car occupancy data are generally less reliable than other mobility data which can be directly measured (e.g., energy consumption, vehicle fleet, distances travelled, etc). They are often derived from calculations based on measurable data or based on surveys. This could explain differences between databases.

Main factors considered when defining the level of ambition

In the low energy demand scenario presented by Grubler et al (2018)[138], car-sharing and car-pooling increase significantly. Coupled with the development of hitchhiking (that can be supervised by local authorities - via digital platforms and dedicated infrastructures) and substantially increasing costs of car use. Those societal trends could significantly increase car occupancy.

[137] Odyssee, 2021

[138] Grubler et al., 2018

However, this increase faces a major obstacle: the lack of a car-sharing culture coupled with a historical trend of increasing number of cars per capita (linked to increased purchasing power; mainly in Eastern European countries).

Prospective: values considered in a selection of scenarios

European scenarios

In the EUCTI tool[139] (which includes some details of the hypothesis of the ECF/Climact[140] scenarios), the levers on car occupancy in 2050 are:

- Less ambitious level: "occupancy reaches **1.62** passengers per vehicle"
- Most ambitious level: "occupancy reaches **2.60** passengers per vehicle

In the ECF/Climact scenarios, the assumptions on car occupancy at the European level for 2050 are:

- **2.27** for the less ambitious scenario named "Technology"
- **2.40** for the "Shared Effort" scenario
- **2.60** for the "Demand-Based" scenario

Most ambitious objectives

Millward-Hopkins et al (2020)[141], assumes a car occupancy of **3 pers/vehicle** by 2050.

Kuhnhenn et al 2020[142], assumes a linear rise by 38% from 1.8 (in rural areas) and 1.6 (in urban areas) to **2.5 pers/vehicle** between 2015 and 2050.

National scenarios

A set of national scenarios was considered (see Table 6).

Country	Base year (2017)	Prospective (2050)	CAGR (2017-2050)
France[143]	1.72	2.03	+0.50%
Lithuania[144]	1.35	1.6	+0.52%
Hungary[145]	1.5	1.7	+0.38%
United Kingdom[146]	1,6	1,9 (metropolitan) 1,8 (non-metropolitan)	n.a.

Table 6: Car occupancy level in key scenarios for four European countries

[139] Website available on this link
[140] ECF/Climact, 2018
[141] Millward-Hopkins et al (2020) Annexes, p. 16.
[142] Kuhnhenn et al (2020), p. 33
[143] negaWatt scenario for France, 2022
[144] Data from the CACTUS project, see publications available on the project website.
[145] Data from the CACTUS project, see publications available on the project website.
[146] IDDRI, 2017

According to the NPLH ("No Place Like Home") scenario for the UK, the average occupancy per vehicle is assumed to rise from 1.6 to around 1.9 persons in metropolitan areas, and 1.8 persons in non-metropolitan area between 2015 and 2050.

Proposition of a harmonised corridor

A maximum value of 2.3 passengers per vehicle is proposed. It is slightly higher than the highest value among European countries in 2015 (see section "Historical values") and consistent with the ECF technology scenario. The upper values of ECF scenarios have been discarded as they are aligned with the most optimistic scenario of a 2009 study focused on urban transport[147] and seem beyond currently realistically achievable levels in Europe.

In addition, according to estimations made by different partners in the network, **an increase of the occupancy rate above 50% seems to be the maximum** of feasibility.

The **minimum objectives** for 2050 are differentiated according to the historical level (defined in 2015 or 2020 following data availability):

- For countries below 1.5 in 2015: **at least a 15% increase** by 2050
- For countries between 1.5 and 1.8 in 2015: reach **at least 1.8 pers/car** in 2050
- For countries above 1.8 in 2015: keep **at least a stabilisation** (which is already a sufficiency measure in Western countries where the number of cars per capita is increasing from the last years) and **do not exceed 50% of increase or 2.5 pers/car**.

To reflect CLEVER's vision in terms of sufficiency and the need to increase the EU's energy independence in the short term, it was decided to set a high level of ambition for this indicator. Indeed, as car is by far the most used means of transport (see Figure), huge energy savings could be fostered with a fast increase of car occupancy. This increase is possible because the policies and measures proposed to reach it could be implemented in the short to medium term. There are little infrastructure costs, but it requires a change in practices which accessibility should be facilitated by convenient measures. It is hence proposed in the CLEVER trajectory that **at least 50% of the current corridor is reached by 2030 in every country.**

[147] EUCTI transport sector documentation p. 18

Trajectories of CLEVER national partners

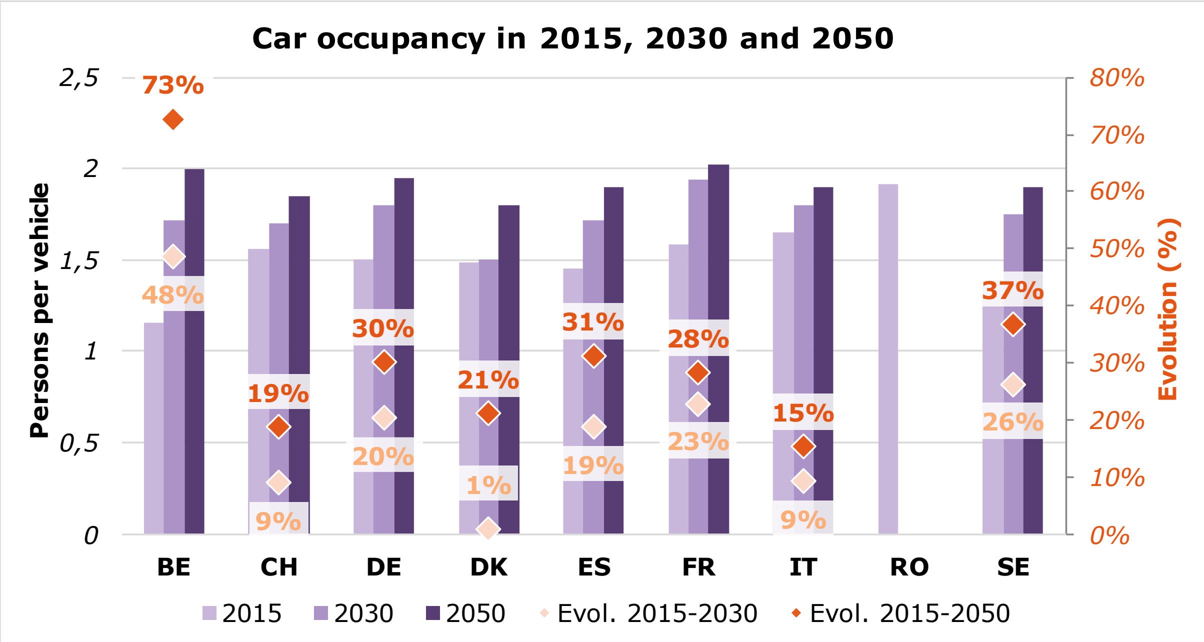

Figure 25: Car occupancy per country in 2015, 2030 and 2050 modelled in CLEVER national trajectories

The graph above shows that there is a convergence to 1.9 pers/vehicle among the partners on the assumptions of car occupancy rates in 2050. France and Belgium reach a high rate of 2 pers/vehicle. To reach this corridor, the evolution between 2015 and 2050, which represents the envisaged effort to increase car-pooling, varies strongly between partners: Belgium and Sweden reach 73% and 37% respectively; while Italy and Switzerland reach respectively 15% and 19%.

First proposals for policy measures to support ambitious objectives

Objective: bring about a cultural change towards the marginalisation of solo driving.

National to local level: Create "high occupancy vehicle (HOV) lanes" (more than 2 people) on highways and expressways and preferential parking for fully charged vehicles. This policy is well known and was already found to be one of the most effective measures in the results of the 1997 EU ICARO project (Increase of Car Occupancy through Innovative Measures and Technical Instruments)[148]. It is especially efficient on roads connecting the suburbs to centres. The positive impact of these installation on car occupancy has long been documented[149].

Good case example in Spain:

In some central high-speed roads in Madrid, Granada and between Ripollet and Barcelona, HOV lanes ("VAO carriles") allow buses and cars not exceeding 3500 kg and with a minimum of two passengers to travel preferentially on these reserved lanes. The HOV lane in Madrid, introduced in 1995 allowed in 4 years a drop of single occupancy vehicles on the given lanes from 70% of vehicles to 48%[150].

National to local level: Develop carpooling schemes:

- With the installation of infrastructures facilitating the access to carpooling (dedicated parking slots and signalisation).
- Through the creation of carpooling lines on highly frequented axis between suburbs and cities (see France best practice below).
- These actions should be made ensuring a strong collaboration between policy makers and digital platforms.

Incentives to carpooling could be made to increase the shift to these schemes. They could be either financial (through HOT or direct financial support for car-poolers) or regulatory through the installation of HOV[151].

Remark: Measures to make carpooling more attractive may draw people away from public transport[152]. Therefore, carpooling measures should be ***complementary to other measures aiming at increasing public transports*** (see previous part).

Good case examples in France

A model of carpooling line on key highly frequented axis with dedicated stops and signalisation have been developed in France. This model is spreading fast in many France cities to connect working place in the cities with habitation places in the suburbs[153].

The French government published in December 2022 a plan to triple carpooling in France by 2027. It includes financial incentives to car-poolers: a 100€ bonus to adopt carpooling and regular

[148] Link of the project official results

[149] Schjins et Eng, 2006, p.188

[150] Schjins et Eng, 2006, p.188

[151] Cohen et al., 2022 demonstrated the positive impact of the installation of HOV lanes on carpool intent in Israël.

[152] EU ICARO project

[153] Scheme developed described by its developer in the following website. On the lane where it was experimented, it was calculated that 23% of car pkm by car could be done through carpooling with 2.6pers/cap in average. If generalised with a strong political will, it was estimated that 5% of this potential could be reached in just 2 years (see negaWatt 2022 sufficiency proposals for the French government, p.131).

incentives. It also develops several measures to increase the accessibility of car-pooling (communication and infrastructures)[154].

<u>EU to local level:</u> Define an EU wide tolling scheme targeting a raise in car occupancy[155]. A move in that direction have been made in 2021 in an agreement to modify the Sustainable and Smart Mobility Strategy[156]. This scheme could give a framework to set two key measures increasing car occupancy:

- High Occupancy Toll (HOT) into highways that are free or cheaper for vehicles with 2 or more occupants[157].
- Congestion charges into cities and highways with differential charges for private and shared cars and exemptions for public transports[158]. This measure could also have a positive effect on the collective transport share.

The revenues from those additional charges could be used for the benefit of sustainable transport.

Good example in the US, London, Stockholm and Milan:

Many HOT have been set in the United States with positive results on congestion[159].

In Europe, 3 cities (London, Stockolm and Milan) have been experimenting for a long time HOT with very clear positive results on congestion, pollution and car accidents[160].

<u>National to local level:</u> Develop car sharing systems[161]. These systems should be optimised to provide adapted cars following the user needs (small cars in city centres, bigger cars for holidays or commercial purchase, etc.). Support of roll-out also to suburban and rural areas.

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[154] See the <u>French government's communication</u> on the plan.

[155] Recommendation from <u>T&E, 2017</u> to guide national tolling implementation. This tolling scheme could be wider than congestion charge by also focusing on vehicles emissions to trigger a faster car rollout.

[156] The EC <u>proposed an agreement</u> in June 2021 to extend road charging to all heavy and light vehicles in its Sustainable and Smart Mobility Strategy. It also introduces the option to charge for congestion and charge more for travel in sensitive areas,

[157] <u>Hall, 2020</u>

[158] Examples of congestion charges available in <u>ICCT, 2010</u>

[159] <u>Hall, 2020</u>

[160] <u>Croci, 2016</u>

[161] There is still a lack of evidence and transparency on the efficiency of car sharing systems even if the overwhelming majority of conclusions of independent studies generally show that car sharing reduces car ownership and increases car occupancy.

Cars: Share of motorisation

Definition: Share of car traffic (pkm) by motorisation
Unit: %

Note & indicator perimeter

This indicator represents the share of motorization of the cars (in % of pkm) used for passenger mobility. It therefore differs from the composition of the vehicle fleet (in number). Indeed, these two indicators differ since vehicles are not always used for the same purposes. Indeed, these two indicators differ since the motorizations vary according to the trips. For example, for long distances which represent more pkm per vehicle (also because the occupancy rate is higher), diesel engines have in the past been largely favoured over petrol engines. Similarly, an electric micro-car with a autonomy of about 100km that would be used in for short distances should represent a lower share of motorization than its share of the vehicle fleet.

It is important to note that this indicator doesn't include LCVs.

In addition to the issues related to energy consumption, GHG emissions and co-benefits (e.g., on health), this indicator on the share of motorisation also integrates issues related to materials and in particular to critical metals such as lithium or cobalt for the electrification of mobility. Historical data

In 2015, liquid fossil fuels (petrol and diesel) were the most used energy carriers (>90%) in all European countries (Figure).

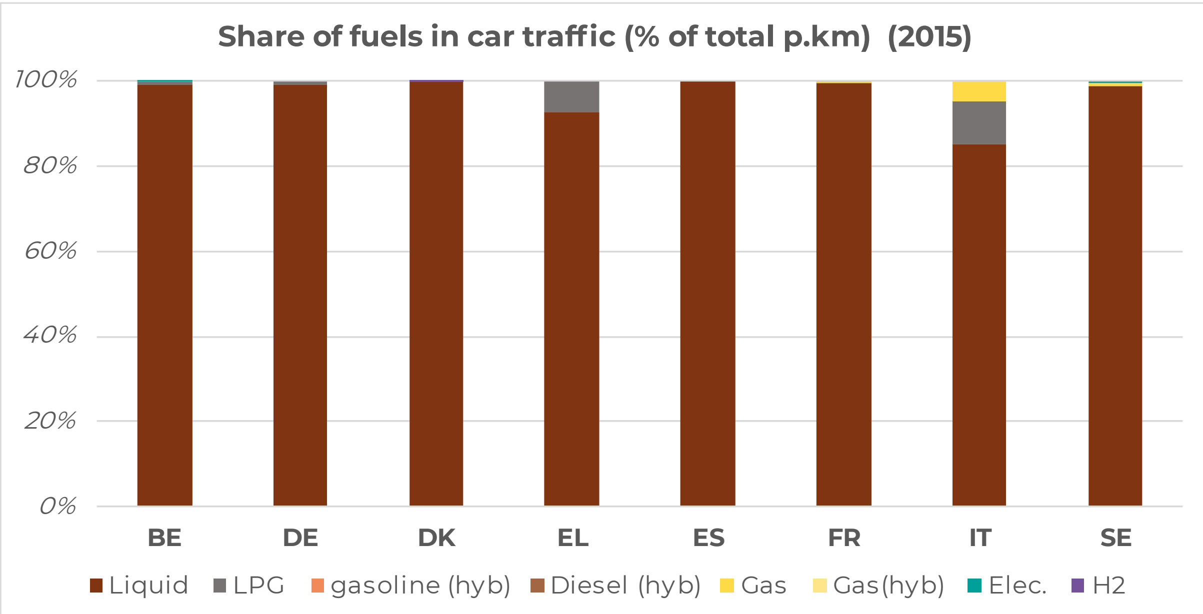

Figure 26: Share of carriers in car traffic in 2015 according to data shared by national partners

Main factors considered when defining the level of ambition

Car motorisation options in 2050

To meet climate targets and build a 100% renewable scenario, a radical transformation of the mobility sector is needed. There are different types of low-carbon technologies for private vehicles that can meet this objective:

- **Electric cars** represent the most efficient motorisation (see next part) and a low-carbon mobility (in the case of a 100% renewable electricity mix). It emits fewer fine particles than thermal vehicles. Electric car construction however poses constraints in terms of raw material consumption (mainly lithium, cobalt, class 1 nickel and copper) and significant surplus of CO2 emissions during batteries manufacturing and specific metals metallurgy. The material issues related to electric mobility are various, often related to resource extraction sites: strong geopolitical and social constraints for cobalt, non-substitutability and significant environmental and social risks for lithium, deforestation and short-term supply constraints for class 1 nickel, in addition to the impacts that accompany the extraction and refining of other metals such as copper or aluminium. Furthermore, the need for lithium, cobalt and nickel from mines for electric mobility is such that it calls into question the availability of reserves (although incorporating very ambitious recycling assumptions) and the fair distribution of these reserves between countries[162].
- **Thermal cars using biogas** could replace electric vehicles for long distances to allow to reduce the need for electric vehicles. It could also be used in countries where the biogas resource is important. However, care must be taken to ensure the sustainability of the resource and avoid fine particle pollution in cities.
- **Thermal cars running on (liquid) biofuels or e-fuels** could be an interesting lever but there is a conflict of land-use with food and fuel needs of international transports (air and maritime) that strongly limits their development for car mobility.
- **Plug-in hybrid (biogas) cars** combining both electric and biogas engine is an interesting way to allow the use of the electric motor for short trips (and in cities, avoiding a significant portion of fine particle pollution) and the biogas for long trips. This allows an optimisation of the battery size to avoid its production amenities (raw material and CO2 emissions).
- **Fuel cell cars using green hydrogen** is also a low carbon lever, but it has not yet reached maturity and does not necessarily appear to be competitive with the others (limited efficiency, see efficiency part; conflict of use of green hydrogen as it is needed for other sectors such as freight and industry, high costs). Furthermore, these vehicles will be at a disadvantage compared to electric and gas vehicles which benefit from well-developed national networks. Finally, their massive development could be an issue in terms of platinum consumption. Unlike the critical metals in lithium-ion batteries[163], the issue of platinum has not been specifically studied in the CLEVER partner network.

The discussion within the CLEVER network to define 2050 car mobility focused on electric, biogas, plug-in hybrid engines and to a lesser extent on fuel-cell cars.

Drivers for a change in car motorisation

Electric mobility is favoured in many transition scenarios (see next part). There is however a socio-economical obstacle to allow a shift to this mobility: electric vehicles are more expensive than other thermal vehicles. To allow a quick shift to this mobility, policies and measures such as promoting car-sharing, reducing vehicle prices through incentives and facilitating cars retrofitting[164] should be put in place to help households overcome this price barrier. The renewal time for transitioning to a

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[162] Detailed analysis of the material footprint of electric car (in French) in negaWatt (2023) for lithium and negaWatt (2022), part 4 ; pp.65-69.

[163] Ibid

[164] Allowed recently in France.

new type of car motorization is a crucial factor to consider, as it impacts the timing of phasing out GHG high emitting vehicles. Depending on the country, a fleet is updated every 15 to 20 years, and this duration needs to be considered when estimating the year when such vehicles will no longer be on road. To achieve the goal of replacing all liquid fuel vehicles by 2050, it is necessary to plan for an end to the sale no later than 2035.

As a summary, EUCALC lists the main drivers for passenger mobility decarbonisation[165]:

- Technological drivers: Maturity of new technologies, availability of alternative fuels
- Economical drivers: Costs of new technologies, etc.
- Political drivers: Availability of adapted infrastructures (i.e., charging stations), incentives, etc.

Prospective: values considered in a selection of scenarios

European scenarios

The composition of the car fleet in the ECF/Climact and European Commission scenarios is presented Figure below. It is important to note that the composition of the car fleet may differ significantly from car mobility (in pkm) depending on the type of engine. Indeed, the different engines can be used for different purposes (long journey or daily commute).

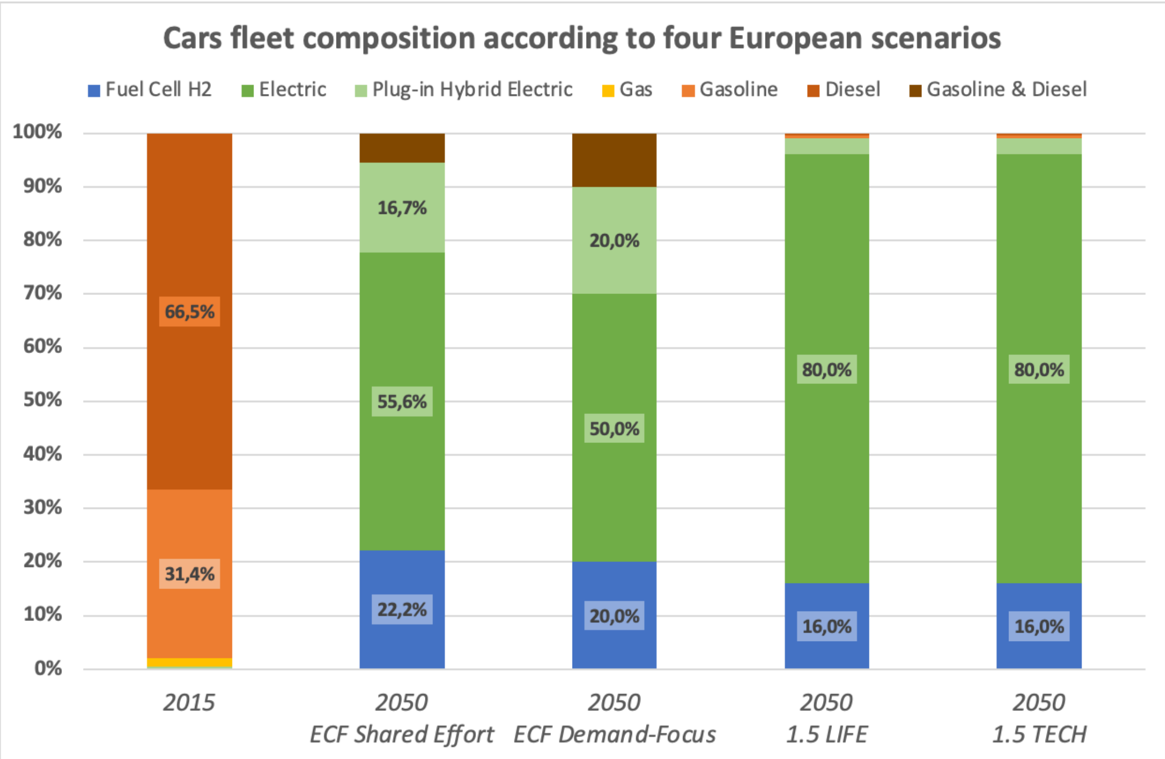

Figure 27: Share of carriers in car traffic in 2050 of ECF scenarios (from EUCTI tool[166]) and European Commission scenarios (from EU publication[167] based on TIMES)

[165] EUCALC Transport documentation

[166] Consulted in early 2022, the new regulation on CO2 and cars should lead to changes in the following scenarios. Website available on this link

[167] European Commission, 2019. p.119

In these scenarios, there is a broad use of electric vehicle (up to 80%) complemented with H2 vehicles and, for ECF scenarios, liquid fuels motorisation. It is important to note that these scenarios are older than the EU ban on the sale of new petrol and diesel cars from 2035. This should have an impact on future prospective studies at the EU level.

National scenarios

The negaWatt scenario 2022 for France propose a different car motorisation mix than the European scenarios detailed in Figure . Indeed, it propose a trajectory using in 2050 a mix of **electric vehicles** (**48%** and **plug-in electricity-biogas hybrid vehicles** (**52%**). This results in more than 80% of passenger km by private vehicle in France in 2050 being powered by electricity (Figure 25).

The choice in the negaWatt scenario to limit electric mobility is mainly motivated by a mapping and prospective modelling study (called MODEIRE carried out by negaWatt for ADEME) on the raw material footprint of the French economy and its evolution in the context of the energy transition. In the mobility sector and in connection with its electrification, the metals identified as the most critical are lithium and cobalt (with class 1 nickel and copper). The aim of the negaWatt approach was to avoid France consuming more than its "raw materials budget" defined as the ratio between the proven reserves[168] for each material in proportion to the country's population. Following this analysis, and despite strong assumptions on recycling and sufficiency (on the reduction of car travel, on the number of vehicles per household and on battery autonomy), rechargeable hybrid biogas proved to be an essential lever in this scenario to avoid exceeding France's lithium and cobalt budgets[169].

Finally, the choice in this scenario of a marginal use of fuel cell cars using green hydrogen is made considering that this technology has not yet reached maturity and does not necessarily seem competitive with other types of motorisation.

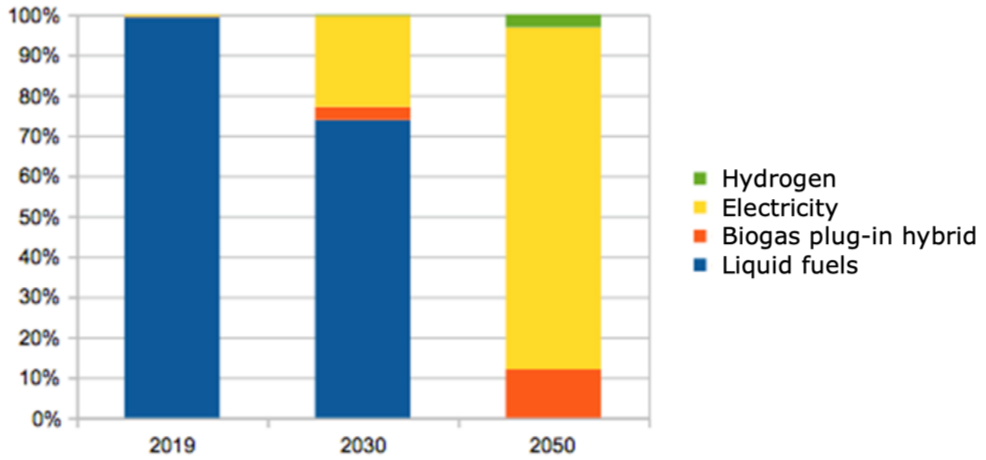

Figure 28: Evolution of the share of energy carriers used in private vehicles (calculated in passenger-km) according to negaWatt scenario 2022[170]

Proposition of a harmonised corridor

The harmonisation of car motorisation represented a major challenge within the CLEVER network. There were divergent positions between 2 types of trajectories:

- trajectories using a mix of electric vehicles and biogas plug-in hybrids, driven by raw material concerns, guided by raw material consumption analysis such as the negaWatt scenario for France.

[168] USGS, 2021

[169] See the detailed analysis of the material impact (in French) in negaWatt (2023) for lithium and negaWatt (2022), part 4 ; pp.65-69.

[170] negaWatt, 2022

- 100% electricity trajectories by 2050, driven by concerns about efficiency and sustainability of biogas resources, and following the general line of other energy transition scenarios.

A **target of 100% electric cars by 2050** have finally been chosen, while considering ambitious assumptions on car-sharing, very high recovery rates of critical materials and high reincorporation rates in new batteries, and reinforcing previous sufficiency assumptions (car-pooling, reduction of car passenger km, etc.) to limit as far as possible the European critical material footprint. **A detailed stock-model based analysis of the critical material footprint of electric mobility and freight is planned in the CLEVER scenario to further examine these issues**.

In addition, this target includes a **flexibility to consider up to 5% pkm via hydrogen car**.

Different constraints lead to this choice:

- There is a political will aiming at a 100% electric and hydrogen motorisation at the EU level traduced by the CO2 and Cars directive recently adopted[171] that forbid the sale by 2035 of any new vehicles emitting CO2 at the tailpipe. This measure automatically forbids the sale of rechargeable biogas hybrids in 2035. However, it may be possible for the case of biogas plug-in hybrids to be reconsidered in the European Commission's assessment of progress in 2026 if it includes an LCA approach rather than a tailpipe approach. Although full electrification of cars seems to be well established in Europe, it is fundamental to highlight the role of sufficiency and the role of bio-NGV in road freight. Aligned with this political will, the automotive industry is focusing on full electric mobility.
- As CLEVER is an EU wide trajectory, gathering a network of EU organisations, it is necessary to find a consensus. In the case of a dissensus causing some country to modelise a 100% full-electric trajectory while others use biogas plug-in hybrids, exchange between these countries in the 2050 Europe envisioned by CLEVER will be complexified. Indeed, in that case, plug-in biogas hybrids won't be able to travel in countries with 100% electric motorisation.
- The CLEVER network will carry out an analysis of the raw material consumption of its scenario at the European scale as it was done for the 2022 French negaWatt scenario. This will guide the modelling choices for the freight sector.

Following a target of 100% full-electric cars by 2050 in the CLEVER scenario suppose several precautions to respect the CLEVER ambition to propose a deeply sustainable trajectory for Europe in the 30 next years. As CLEVER prevails an offer of 100% decarbonised electricity by 2050, the key unsustainability of the use of full-electric car is in its production and the resource consumption. As mentioned above, the negaWatt scenario for France shows that the raw material footprint of the 100% electricity vehicle could very quickly exceed the budget available in the case of a fair share of these resources. Thus, **direct replacement of the current available fleet of liquid fuel vehicles (see Figure) by full-electric vehicles would be unsustainable**. Several strong sufficiency measures listed below have been considered and modelled in every CLEVER national trajectory.

- **A reduction of car ownership** through a quick raise of the car occupancy (see the previous indicator part) and an increase of car sharing schemes. A reduction of car ownership leads to a reduction of the need for electric cars (and even more in the short-medium term). The combination of these 2 levers is key to reduce the amount of battery produced between 2020 and 2030. This would reduce the rush to primary lithium, cobalt or class 1 nickel, which could cause major socio-environmental impacts, but also avoid the use of raw materials from mining at a time when a recycling industry (focused on recovery for re-integration of materials into new batteries and not on other diffuse or destructive forms of valorisation) is not yet well established.
- **A reduction of the size and the weight of vehicles** and **a limitation of the battery capacity with a range adapted to the travel needs**. This integrates sufficiency in the vehicle design and the emergence of micro-cars (500kg) and an optimisation of their efficiency to use as small batteries as possible.
- Finally, **a reduction of the need for car travel and car ownership** thanks to an ambitious increase of other travel means (collective and active mobility) and a general decrease of the need of travelling as detailed in three previous parts of this note.

[171] See the council press release on the agreement on this directive.

These strategies need a strong and effective policy framework enabling and guiding a respective development. To ensure the raw material sustainability of its trajectories, the CLEVER network decided in addition to these sufficiency measures to consider biogas in both LCV and trucks trajectories[172].

Following this target, the end of the sale of internal combustion engine cars is considered to be at the latest in 2035 and earlier if possible, depending on the national circumstances. As the CLEVER scenario is aiming to reach carbon neutrality as soon as possible and given the replacement rate of the car fleet, incentives should be provided to scrap the last fossil fuel vehicles before 2050.

Trajectories of CLEVER national partners

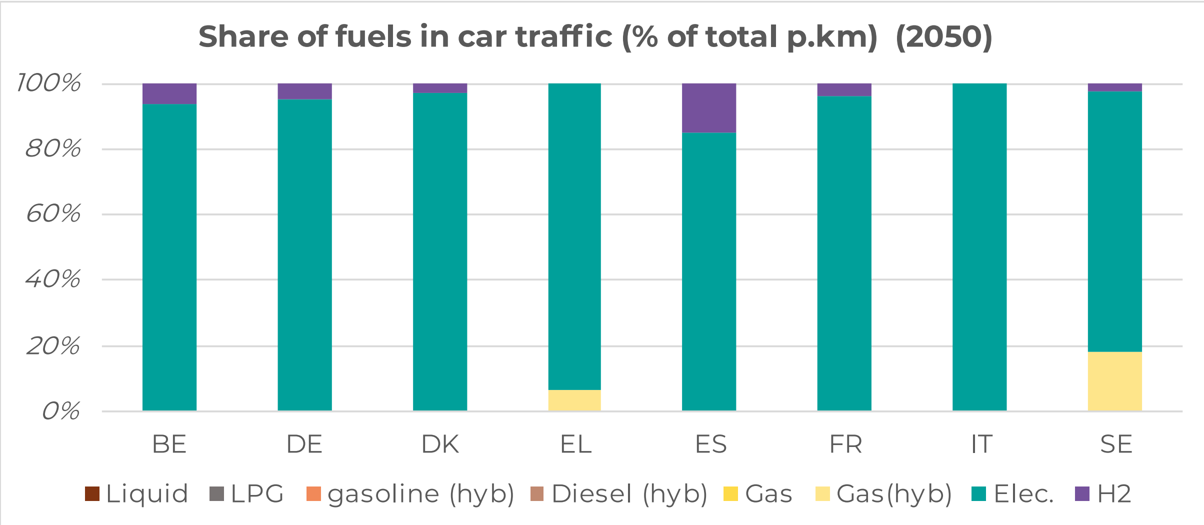

Figure 29: Share of carriers in car traffic in 2050 modelled in CLEVER national trajectories

Figure 29 shows a convergence on the leading role of electric mobility among the partner countries. Indeed, electric motorisation represents in all countries more than 80% of the passenger.km. The role of hydrogen motorisation is limited due to its lower maturity and the prioritisation of green hydrogen for other more priority uses. Only Spain presents a very ambitious assumption to reach 15% of pkm by car. Some countries, such as Sweden and Greece, are considering a relatively large share of NGV motorisation in 2050 (18% and 8% respectively) for economic reasons (more reliable purchase price) or for use in remote locations or locations where the very low temperature could compromise the efficiency of the battery (or force it to be oversized).

[172] A dedicated note on fret in the CLEVER trajectory, detailing the trajectory for trucks and LCV, will be published in Winter 2023

First proposals for policy measures to support ambitious objectives

EU Context:

Zero emission vehicles target: *The European Commission aims to have* ***at least 30 million zero-emission vehicles on its roads by 2030***[173] *and hope for "almost 100% of cars emissions free by 2050"*[174]*.*

The European Clean Vehicle Directive: The European Union validated in October 2022[175] the European Clean Vehicle Directive which proposed to:

- *reduce the CO2 emissions of new cars by 15% by 2025 and 55% by 2030 from 2021 level,*
- *ban the sale of* ***new cars and vans that produce tailpipe CO2 emissions by 2035****.*

Key measures

Objective: Shift from a fleet of fossil-fuelled cars with a high degree of individual use and increasing size to a shared fleet of small electric cars.

- Design new cars as efficient as possible and adapted to the needs to monitor the use of resources (fair sharing of resources, especially lithium and cobalt resources, worldwide). It should be complemented by a reduction of the need for cars thanks to the policies of the previous parts on distance travelled reduction, modal shift and car occupancy.
- Support modest household during the transition via car-sharing promotion or progressive incentives to buy an electric car depending on revenue.

EU level: Introduce a **life-cycle analysis (LCA)** that apply to all types of cars (electric, fuel-cells, plugin-hybrids and thermal vehicles). Several key components should be considered:

- *CO2 emissions* at the tailpipe and the embodied emissions linked to the manufacture, supply and end of life,
- *Raw material footprint* of the vehicle with a focus on the critical raw material composing the batteries (lithium, cobalt, nickel class 1 and copper).
- *Energy consumption* for all types of motorisation, the *weight* of vehicles and batteries, and their supply and end of life.

EU level: Set policy framework to guide, incentivise and regulate a design and sale of new cars as efficient as possible and adapted to the needs allowing to succeed an ethic transition to low-emissions vehicles:

- *Limitations on energy consumption of every type of new cars:* revise the European Clean Vehicle Directive to put limitations on the energy consumption (in kWh/km) on every type of new cars, especially electric and fuel-cell cars[176]. This should provide incentives for car efficiency as the current regulation for thermic cars does.

- *Weight monitoring*: there is a current trend to build heavier vehicles such as SUVs[177] that are oversized to the current needs and require more resources (steel, plastics and critical raw materials) to build and more energy during driving. This trend is alarming when considering a transition to low-emission vehicles with scarce resources. Removing the mass

[173] Euractiv, 2020

[174] Euractiv, 2021

[175] See the agreement between the Council and the Parliament

[176] German Zero, 2021 p.204

[177] Which consume around 20% more energy than a medium-sized car and sees record sales (IEA, 2021).

utility parameter for the 2025 and 2030 standards[178] is key to incentivize lighter vehicles. It could be replaced by a vehicle footprint parameter[179]. Increasingly stricter limits of kWh/km can also limit growing vehicle size. Sales tax rates progressive in size may also incentivise manufacturers to produce smaller vehicles.

Good case example: LISA car project

The LISA car project aims to promote at the EU level the building of cars that are lighter, less powerful (smaller engine, lower maximum speed) and more aerodynamic. The target of this project is to reduce environmental (less CO2 and pollution) and health (less accidents and respiratory problems) impacts of the car industry[180].

National level: **Support affordable and environmentally friendly mobility for all** by creating a rigorous **bonus-malus system** to provide incentives to consumers for choosing the least environmentally damaging car solutions. An efficient bonus-malus system should[181]:

- Define a criterion on both CO2 emission per kilometre and consumption per kilometre (independently of cars segments).
- **Indexing the bonus-malus** on a measurement of emissions, no longer at the tailpipe, **but on the whole life cycle analysis (LCA)** of vehicles, including electric vehicles (complementary to the LCA measure above).
- **Put a weight criterion** in the bonus scheme by applying it **to cars over 1.2 tones** and add a bonus below that. This criterion could be followed by a criterion on the size of batteries for electric vehicles.

This reinforcement will pursue the previous policy to change the trend of car design. It could be reinforced by a ban on advertising for highly polluting vehicles (see other policies below).

Good case example: France bonus-malus system

A bonus-malus system is already implemented in France[182]. It provides financial assistance for purchasing vehicle with CO2 emissions inferior or equal to 20g/km (electric, hydrogen, or rechargeable hybrid[183]) and imposes a tax for the purchase of most polluting cars. This measure incorporates an ethical dimension as a higher bonus is granted to modest households as well as zero interest loans at the purchase.

Other policy measures

EU to national level: **Ban fossil fuel cars advertising:** impose a ban on advertising for private transports powered by fossil fuels, it could be extended on any fossil fuels powered tool/activity[184].

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[178] Currently, the heavier a manufacturer's car fleet, the higher the permitted CO2 emission value (ICCT, 2018).

[179] ICCT, 2018: the vehicle footprint is the utility parameter used for the US GHG vehicle standards.

[180] See the open letter of the project.

[181] Current pledge of negaWatt association to strengthen the bonus-malus system in France.

[182] Green bonus (Service Public, 2022a) and malus (Service Public, 2022b)

[183] And include information campaigns targeting drivers to principally use the electric mode rather than the thermic mode.

[184] This policy was the topic of a European Citizens Initiative launched by Dutch Citizens' that fell short to reach 1 million people (see the website of the initiative and it's official EU registration).

Cars: efficiency

Definition: Car energy efficiency assessed through the energy consumption per unit of distance travelled.
Unit: l/100km or kWh/100km

Note & indicator perimeter

Car efficiency corresponds to a weighted average over all segments of cars including vans but excluding light commercial vehicles (LCV).

This indicator assesses **the tank-to-wheel efficiency of cars** (in kWh/km) and not just the engines that make them up. The tank-to-wheel approach was made without any distinction of car segment. The impact of sufficiency on car size is therefore well reflected in this indicator. Thus, the evolution of the average speed or the spreading of eco-driving are reflected.

This indicator is **defined at a European scale**, by setting the same efficiency trajectory for every national trajectory as explained the following parts.

Historical data

The relevant carrier to be analysed in historical data is the efficiency of liquid fuel cars which represent by far the most used carrier in 2015, see Figure . For this vector, energy efficiency varies little from one country to another (see Figure 30). This situation could be explained by a globalisation of the automotive industry: there is little variation in the energy efficiency of vehicles (inside each segment of motorisation) between different manufacturers.

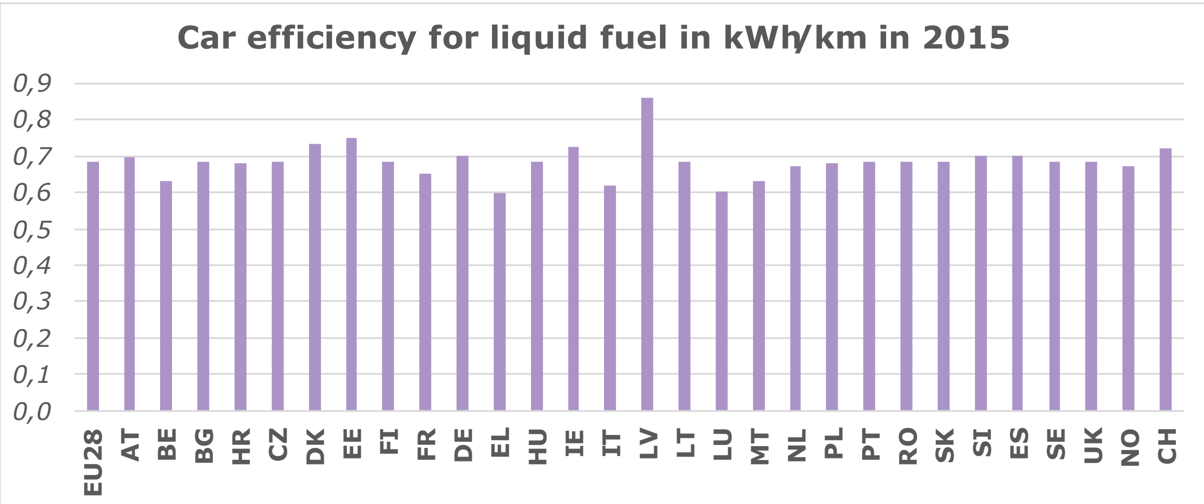

Figure 30: Energy efficiency for liquid fuel cars in kw/km in 2015 (source: Odyssee)

As this indicator entails the overall energy efficiency, the remaining variations between countries visible in the previous figures could be explained by variations in the fleet renewal rate but also on size and national speed limitation.

Relatively few data is available on the efficiency of the 3 motorisations (electricity, gas and fuel-cell) that compose the car fleet in 2050 in the CLEVER scenario (Figure 29) as these technologies are not currently widespread in Europe. The current average efficiency values observed in different statistic and prospective analysis are the following:

- Electric: 0,23 kWh/km (source: EUCalc and negaWatt, 2022).
- Fuel-cell (powered by hydrogen): 0,39 kWh/km (source: negaWatt, 2022) and 0,49 kWh/km (source EUCalc).
- Gas (only biogas motorisation has been considered in CLEVER): 0,49 kWh/km (source: negaWatt based on Odyssee)

Main factors to consider when defining the level of ambition

Car efficiency is an important lever for decarbonisation because, despite sufficiency efforts to reduce distances travelled and modal shift, the proportion of trips made by car will remain high in 2050. In addition, there is a socio-cultural context that pushes for an increase in the size and weight of cars (e.g. SUVs) that could offset the gains in overall energy efficiency.

The CLEVER approach proposes a harmonised vision among countries on the size of cars (see previous indicator's policy part) and on the generalisation of eco-driving and reasonable speed limitation going for 110km/h in highways (see the policy part). Thus, a **European target for tank-to-wheel efficiency was proposed for each type of motorisation by 2050**.

Many different factors could lead to an improvement of the tank-to-wheel car efficiency:

- There is a huge disparity of vehicle efficiency following the motorisation. Electric mobility is by far the most efficient motorisation. The electrification of car mobility will automatically improve the average efficiency for cars[185].
- The size, weight and in a lower measure optimisation (aerodynamism) of cars could broadly improve cars efficiency.
- The average speed limitation and the driving behaviours (spreading of eco-driving) is key.
- A continual technological progress of engine efficiency between today and 2050[186].

Prospective values considered in a selection of scenarios

Prospective values for the 2050 car fleet efficiency from 2 scenario were considered.

Motorisation	Final efficiency for Europe in EUCalc tool (kWh/km)	Final efficiency in negaWatt scenario for France (kWh/km)
Liquid fuels	0,45	0,31
Gas - NGV	0,43	0,33
Electric	0,15	0,13
Fuel-cell		0,22

Table 7: Final car efficiency values in 2050 according to several studies

[185] T&E, 2020

[186] An interesting evaluation of the possible efficiency evolution is done in T&E, 2020.

These final values could be reached before the 2050 milestone as it is the case in the negaWatt scenario for France. In this last scenario no liquid fuel vehicles are sold after 2030.

Proposition of a harmonised target

In the CLEVER scenario, a **European target for tank-to-wheel efficiency** (without any distinction on car segment) **was proposed for each type of motorisation by 2050**. Thus, all European countries reach by 2050 the same overall energy efficiency by motorisation. Linear trajectories have been set between 2020 and 2050 for the majority of the levers, with the exception of the gain (which depends on each country) associated with the speed limit (110km/h on highways) applied in 2023.

Liquid fuel: an efficiency of 0, 43 kWh/km reached in 2035, latest year before the ban on the sale of this type of vehicle.

Gas-NGV: an efficiency of 0, 45 kWh/km, a value already reached today for new gas vehicles as this technology is little spread today and should be also ban in Europe after 2035. A more ambitious trajectory could be envisaged if plug-in hybrid biogas technology is included in the European Commission's 2026 progress assessment of the 2035 ban on all new tailpipe CO2 emitting vehicles.

Electric: an efficiency of 0,13 kWh/km which is aligned with the ambitious level of the negaWatt scenario that include sufficiency assumptions. This value is reached in 2045 as the ambition of CLEVER scenario is to aim for carbon neutrality before 2050.

Fuel-cell: an efficiency of 0,22 kWh/km, also aligned with the negaWatt level of ambition. This value is also reached in 2045.

To reach these ambitious efficiency values, in addition to the planned technological gains, several sufficiency measures (detailed in the policy part below) have been integrated to reduce the final real efficiency: (i) size and weight reduction, (ii) speed limit to 100 or 110 km/h in high-speed roads, 80 km/h in country roads and 30 km/h in cities, and (iii) eco-driving generalisation.

Speed limitation have been integrated in the very short term (by 2023) to answer the current energy crisis. This requires political will and pedagogy to make this measure popular, but needs very limited investment (limit signs, information display and possibly speed cameras).

First proposals for policy measures to support ambitious objectives

Objective: widespread vehicles as efficient as possible.

Most policies presented in this section are those from the previous section on car motorisation. Especially, policies aiming to guide a design of new cars adapted to the needs (weight criteria, absolute energy consumption criteria) which is also in line with reaching high levels of overall energy efficiency.

Two specific measures on car efficiency are presented below.

EU to national Level: Reduce road speed limitation. The CLEVER scenario considers 3 key maximum speeds observed in many EU countries:

- 110 km/h in motorways.
- 80 km/h outside built-up areas
- 30 km/h in built-up areas.

Speed road reduced have significant impacts on car efficiency[187] (20% energy saving on motorways if the speed is reduced from 130 km/h to 110 km/h) along with positive impact such as an increase of read safety[188]. It could be implemented very fast in order to answer the energy crisis created by the Ukraine war context[189].

Good case example: Netherlands

Since March 2020, the Netherlands set a maximum speed of 100 km/h on motorways during the days (between 6:00 and 19:00). Maximum speed outside built-up areas is set at 80 km/h and 70% of urban roads have a maximum speed of 30 km/h[190].

EU to local level: Provide information, training (e.g., WeNow in France) and incentives for eco-driving.

[187] As enlighten conjointly in 2022 by the IEA and the EU commission

[188] ETSC, 2022

[189] IEA/EU Commission, 2022

[190] ETSC, 2022

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