How European transport can contribute to an EU -55% GHG emissions target in 2030

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Executive Summary

The European Green Deal may be *the* legislative trigger to spur momentous positive changes across the Union in all sectors of the economy, leading to a sustainable and net zero-emission continent. Whether future historians judge it to be so will be dependent on its scope, its ambition, but most importantly, what it delivers. This paper analyses the implications of increasing the Bloc's 2030 greenhouse gas emissions target from 40% to 55%, compared to 1990. We show how ambitious transport policy can contribute to this target, and detail measures that could drive even greater change.

The analysis draws on Transport & Environment's recent series on decarbonising transport by mid-century. This series, as does this report, focuses on the sector's largest emitters: cars, trucks, aviation, and maritime. On average, transport emissions have increased by almost 30% since 1990 (aviation emissions, for one, have more than doubled), and face varying challenges to reverse this trend and reduce them in the coming decade. To bring down transport emissions back to 1990 levels would require a 21% reduction - undoing almost 30 years of emissions growth in 10; to achieve a 55% reduction compared to 1990 would require a 65% reduction. **This analysis shows how to achieve a 28% reduction in transport emissions compared to today**, with policy measures that could go even beyond that, maximising the opportunities for European transport and its associated industries. **Most importantly, we show how to change the trend to reach decarbonisation by 2050**. Additionally, aside from the measures that directly impact the sector's emissions, we discuss taxonomy and the key policies required to move from dirty fossil fuel to renewable, sustainable and clean investments.

Passenger cars

Reversing the ever-rising emissions from the largest sector of transport emissions, passenger cars, could help Europe retain its international prowess in technology development. Thanks to the 2030 CO_2 standards, the next decade will see a shift in the current paradigm of internal combustion engine to battery electric vehicles. There are a range of policies available to achieve greater CO2 reductions, and these include:

- Strengthening the 2030 CO_2 standards from 37.5% reduction compared to 2021 to 55%, which could deliver a further 11% reductions in 2030, including annual targets to avoid stepwise reductions.
- Targeting high mileage fleets such as company cars or ride hailing services could deliver 4-24% emission reductions compared to current policy.
- Phasing out sales of internal combustion engine cars by 2035 to give carmakers a clear market outlook for zero-emission vehicle demand and to ensure 2050 decarbonisation is possible.

On top of these measures, we summarise policies that can help reduce demand and shift passengers to cleaner modes while taking away space for cars to avoid induced demand (see Table 3 for more details). With these measures combined, we project car emissions could reduce by 34% compared to 1990.

Heavy Goods Vehicles

Trucks have made no progress in their fuel efficiency for over 25 years, and the Green Deal provides an opportunity to shake the truckmakers from this inertia. The 2030 truck CO_2 standards will be an integral part of this shake-up, but it can go further. The levers available to policymakers are:

- Strengthening the 2030 CO_2 standards from 30% emission reduction for regulated trucks to a 40% reduction for all truck categories, which could deliver a further 5% reduction in 2030.

- On top of the truck CO_2 standards, a zero-emission vehicle mandate that reaches 30% of new registrations, supported by ambitious infrastructure deployment in the alternative fuels infrastructure directive (AFID), could deliver an extra 10% reduction in 2030.

- A range of complementary measures such as truck speed limitation, internalising external costs in the Eurovignette directive and through road charging, and fuel tax reform, can work to reduce vehicle kilometres and drive more efficient logistic practices and a shit of freight to rail.

Buses have escaped CO_2 regulation, but rather than imposing efficiency standards, policymakers should legislate for a zero-emission procurement strategy. A target of 100% zero-emission vehicle sales for urban buses is technically feasible and economically rational. The total reductions for heavy duty vehicles by the policy measures could deliver a 20% reduction in emissions compared to today's emissions, equivalent to levels in 1990.

Aviation

Aviation's emissions have soared, and the Green Deal can be the impetus the sector needs to get them back to earth. Reducing aviation's emissions will require investment and deployment of sustainable advanced fuels and ending its tax free fuel privileges. Unfortunately, unanimity is required to change the fuel tax exemption (therefore an unlikely political outcome), so ambitious member states will need to circumvent these legal obstacles. More explicitly, policymakers should:

- Implement carbon pricing (through ETS reforms to avoid excess allowances) and fuel taxation (through multilateral fuel taxation agreements between willing member states) that lead to at least €70 per tonne of CO_2 emitted by 2030. This could lead to a 6% reduction in emissions compared to business as usual.

- Advanced biofuel and power-to-liquid mandates. Any mandate would need to have proper sustainability safeguards in place and full impact assessments for a realistic forecast of volumes that could be available by 2030. Aviation would need to be prioritised over any other sector.

These measures would be enough to halt the rise of aviation emissions and moderately reduce them by 6% compared to today's emissions, with the long-term aim of 2050 decarbonisation in mind.

Shipping

Maritime emissions have for too long been out of sight and out of mind, and it remains the only sector to escape any regulatory measure to reduce emissions. It is a sector with perhaps the greatest diversity, ranging from water taxis carrying 12 passengers to container ships sailing around the world loaded with 20,000 containers. The MRV has provided a unique tool for EU policymakers to be able to regulate EU shipping emissions. The key policy measure for shipping is:

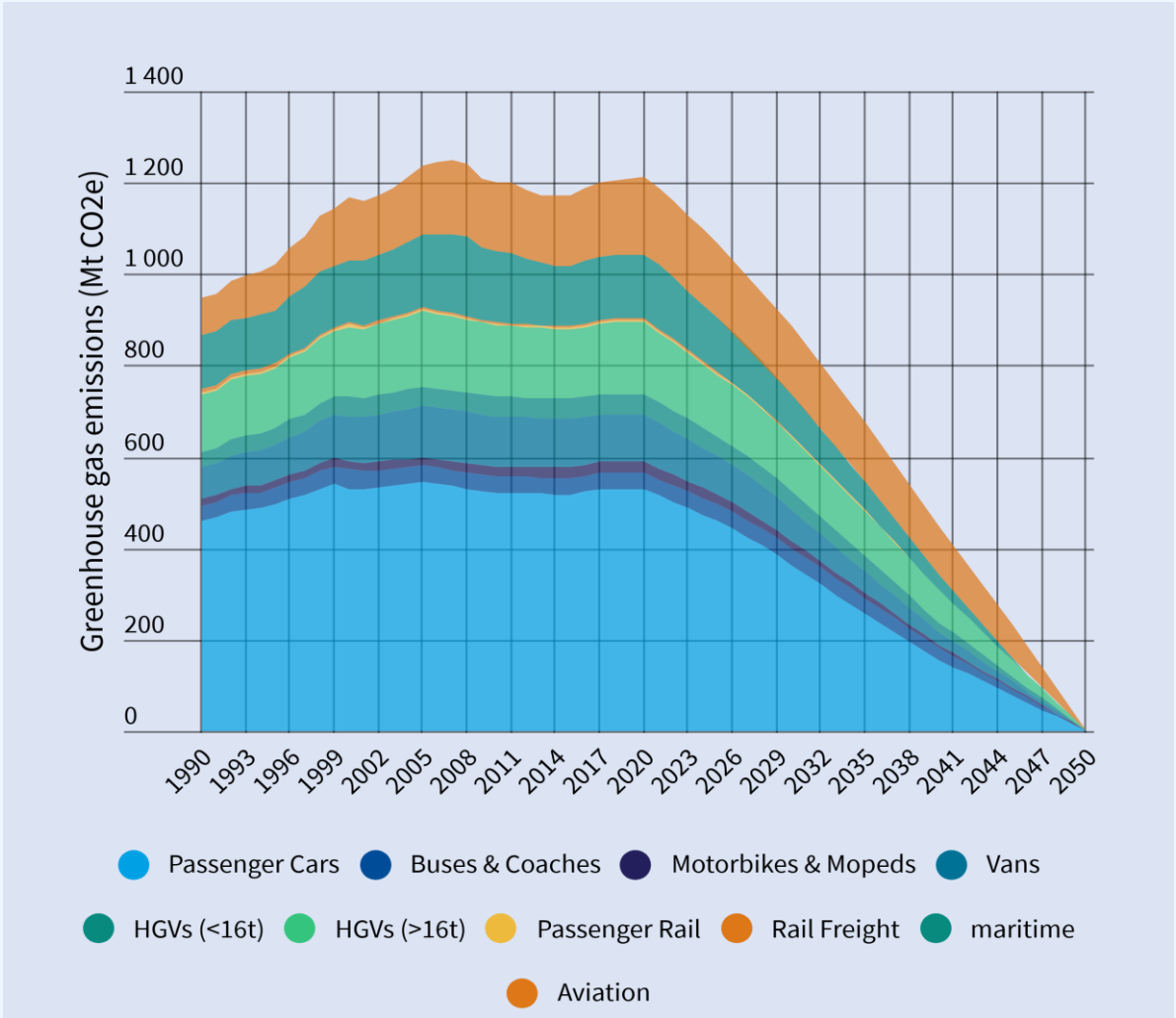
- Implement an operational CO_2 standard for ships calling at EU ports to be 40% more efficient (i.e. less carbon intensive) compared to the 2018 baseline. This could result in a reduction of emissions of 24% compared to 1990.

- Inclusion of EU shipping into the EU emissions trading system, based on the MRV scope. This will ensure that shipping pays for its CO_2 emissions.

On top of this, policymakers should implement a zero-emission berth standard at ports. Ships at berth emitted 7 $MtCO_2$ in 2018, or 5% of total emissions. These emissions could be cut from the sector and would also facilitate the infrastructure required for a zero-emission shipping future.

Green Investment

The technologies promoted as sustainable should be aligned with the technologies needed for Europe to be climate-neutral by 2050. The 18% threshold for revenues coming from Taxonomy-aligned activities to be eligible for the financial Ecolabel needs to be raised considerably. The EIB will need to update its transport lending policy to be coherent with the its objective of aligning all its financing activities with the principles and goals of the Paris agreement by the end of 2020. This will include a phase-out of lending to airports, fossil-fuel vehicles, and diesel/petrol vehicle factories. The policy should in part promote loans for restructuring plants so that they produce zero-emission vehicles and components.



Conclusions

Transport faces many challenges to stop its rise in greenhouse gas emissions and to pull its weight in enabling Europe to achieve more ambitious targets under a Green Deal. But these challenges also represent opportunities to reshape the paradigm of how we move ourselves and our products around the continent, with far reaching co-benefits including better air quality, liveable cities, and

a truly sustainable future not based on burning fossil fuels. We detail how transport can maximise its contribution towards an increased target, delivering more than the European Clean Planet for All's most ambitious scenarios, and putting transport on a track to decarbonise. In doing so, Europe can create jobs and retain its position as a leader in technical innovation. But most importantly, it may be the one chance we have to avoid catastrophic climate change.

Table of Contents

1. Introduction

1.1. Increasing the EU's climate ambition

Between 2014-2018 the European Union agreed its 2030 Climate & Energy package with targets for greenhouse gas (GHG) emissions (-40%), energy efficiency (-32,5%), and renewable energy (32%)[i]. These targets were all based on a 2014 European Council agreement that predates the Paris Climate Agreement.

After the May 2019 EU 'green wave' elections, the newly elected European Commission president Ursula von der Leyen decided to make climate her top priority. On the 11th of December the Commission presented the European Green Deal strategy that aims to make the entire EU economy climate neutral by 2050. As part of this plan Ursula von der Leyen announced the Commission would propose to increase the European Union's target for 2030 towards at least 50%, and if feasible 55%[ii]. In absolute terms, this means that 2030 GHG emissions in the Union would be capped at 2.5 Gt CO_2eq in 2030, down from 5.5 Gt CO_2eq in 1990.

Increasing the 2030 GHG emission reduction targets for the EU is necessary for the EU to achieve a climate neutral economy by 2050 and limit global warming to "well below 2°C" compared to pre-industrial levels, ideally to 1.5°C[iii]. The Paris Agreement includes a 1.5°C target due to the evidence showing the catastrophic effects of a 2°C increase. A recent IPCC report concluded that the difference between 1.5°C warming and 2°C is significantly more droughts, heavy precipitation events, heat waves and severe storms with large human populations no longer able to survive in their current location[iv]

1.2. Clean Planet for All

In November 2018, the European Commission published its Clean Planet for All report[v]. The report presents several scenarios detailing rapid electric, hydrogen, power to liquid/gas (PtX), and circular economy scenarios along with a cost effective combination of these. The so called 1.5TECH and 1.5LIFE scenarios[1] are the most ambitious, and achieve mid-century decarbonisation. Discussion in the remainder of this report will only refer to these two scenarios taking the average of their emissions. The aim of this section is to determine what the reduction for transport emissions is in the Commission's modelling, and how this may guide what a transport sub-target may be.

Figure 1 shows a reproduction of the results of the 1.5TECH and 1.5LIFE scenarios[vi]. The average cumulative emissions and removals from these scenarios between 2018 to 2050 are approximately 67 Gt CO_2eq (including LULUCF). The total emissions in 2030 are 3.1 Gt CO_2eq, representing a 46% reduction from 1990. As for the contributions for the Emission Trading Scheme (ETS) and Effort Sharing Regulation (ESR) sectors, in 2030 the reductions are 51% for power and industry (the bulk of ETS emissions) and 31% for transport and residential emissions (the bulk of ESR), compared to 2005. By 2040 the power sector is close to being fully decarbonised. Transport[2] is projected to reduce emissions to 868 Mt CO_2 in 2030, essentially reaching parity with 1990 emissions, or a 20% reduction compared to 2005. The PRIMES-TREMOVE model is a partial equilibrium simulation tool[3], thus it aims to reduce emissions in the most cost-effective way. In this paper we argue that transport can, and should do more to reduce its emissions by 2030.

[1] So-called as it is not clear how they have been deemed as 1.5°C compatible

[2] Does not include international shipping emissions

[3] For more detailed analysis of PRIMES-TREMOVE, see T&E (2018) The future of transport in the European Commission's 2050 strategy. Available: https://www.transportenvironment.org/publications/modelling-future-transport-european-commissions-2050-strategy

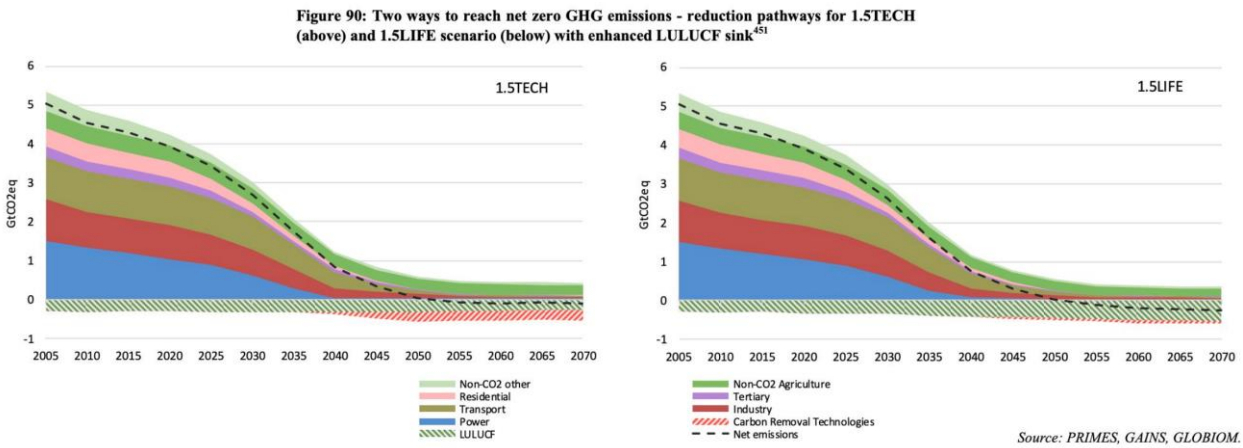


Figure 1: Reproduction of *Figure 90* from Clean Planet for All: In-depth Analysis in Support of the Commission Communication COM(2018) 773[vii]. Both 1.5TECH and 1.5LIFE scenarios reach net-zero emissions by 2050, however 1.5TECH relies on more carbon removal technologies in the second half of the century.

1.3. Transport's contribution

As will be detailed in this report, increasing the EU's 2030 targets to 55% would create opportunities such as reduced energy dependence, cleaner air and new jobs, but is also an unprecedented challenge. This applies to many sectors in the economy but in particular to transport. First, it's the only sector to have increased its emissions since 1990; a 55% target would therefore require a rapid and steep change in its emissions (Figure 2). Second, as new sales amount to a fraction of the fleet (in the case of passenger cars, around 5%), there is a significant lag between the clean vehicles coming to market and an improvement seen in the fleet emissions. For this reason ships will have to be retrofitted, as they stay in the fleet for a lot longer. A 55% target would require a reduction of 65% compared to 2017 emissions, compared to public electricity and heat's 36% cut. Thus the transport sector will need a rapid and drastic overhaul to help the EU achieve a 55% reduction. A key question this report answers is: how and by how much can transport reduce its emissions to help the EU reach this new climate target?

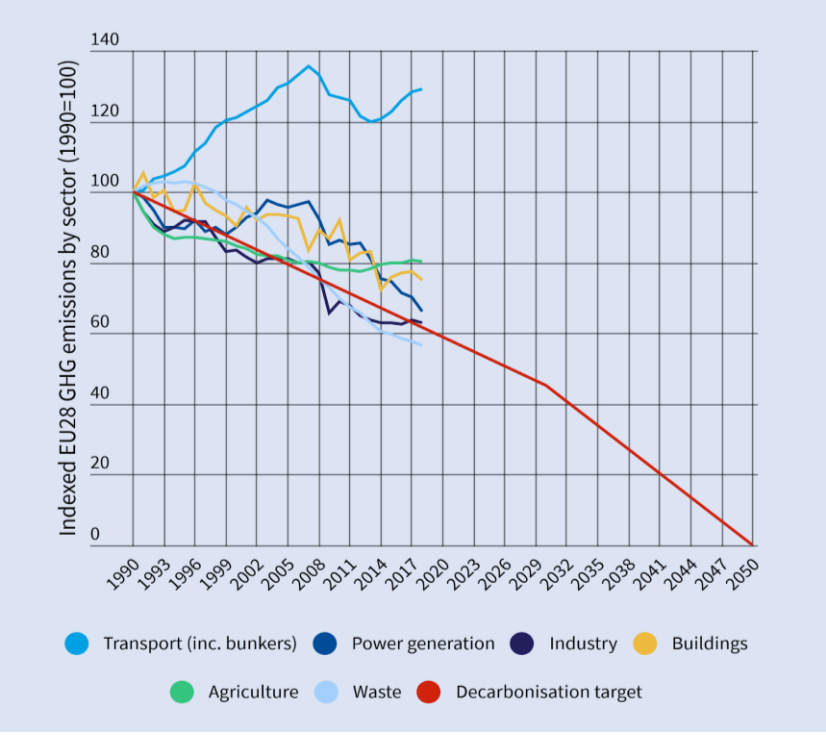


Figure 2: European Union emissions indexed at 1990 levels. The decarbonisation target line includes a 55% reduction in 2030 and assumes full decarbonisation by 2050. Transport (including international aviation and shipping) in 2018 was almost 30% above 1990 levels[viii].

2. EU climate legislation - state of play

2.1. The EU ETS and the ESR - an overview

The EU's Climate Laws are built on two main pillars: the Emission Trading Scheme (the EU ETS) and the Effort Sharing Regulation (ESR), recently renamed Climate Action Regulation. The ETS is a cap and trade system, with companies buying emission permits (or allowances) for every tonne of CO_2 that they emit. The ESR covers the emissions not covered by the ETS, with the notable exception of international shipping, which is currently not included in EU climate legislation. For the ESR, the onus is on the member states to reduce emissions. The current -40% economy wide target for 2030 (equivalent to 3.3 Gt CO_2eq by 2030) compared to 1990 is thus achieved with targets (with a 2005 baseline) of -43% for the ETS and -30% for the ESR.

Annex I takes a closer look at the abovementioned policy instruments. The difference in targets between the ETS and ESR sectors is a reflection in part of the techno-economical potential to reduce emissions. Ramping up of the ETS and ESR targets will require consideration of these aspects.

2.2. The European Green Deal

Sworn in on the promise of greater climate ambition, the new Commission president unveiled the EU strategy on climate neutral Europe, the European Green Deal, in her second week of office. The Green Deal strategy promises to ensure that there are no net GHG emissions by 2050, including increasing the EU's 2030 GHG reduction target to at least 50%, and towards 55% "in a responsible way". This is a strong shift in emphasis away from incremental improvements towards zero emission technologies and economy-wide change. The strategy will be the foundation of most of the laws, regulations, funding and innovation in early 2020s, starting with an all-encompassing review of most of the EU's climate legislation in mid-2021.

The strategy announces an ambitious plan to revamp transport and to set all sectors and modes towards a zero emission path. The overall direction for each sector will be elaborated in a new strategy on sustainable and smart mobility in 2020. The Green Deal commits to put light duty vehicles on a pathway towards zero emission mobility after 2025, as well as ramping up the necessary infrastructure and fuels to underpin the transition. After years of lacking progress, the Commission finally commits to tackling emissions from aviation and shipping, notably via the reform of the ETS and the Energy Taxation Directive. All this represents an opportunity to put transport on track to achieving zero emissions and years ahead are crucial to put in place regulations that would realise the ambition of the Green Deal into enforceable measures.

2.3. Following the money - Taxonomy

Vast sums of money are currently invested in fossil fuel companies and associated industries, perpetuating a lock-in of the sectors that rely on them. The average annual investment required for transport to achieve the EU's 2030 climate and energy targets is €685bn[ix] and €847bn over the 2031-2050 period, in order to be aligned with the EU's "1.5 Life" 2050 target. The EU adopted a Sustainable Finance Action Plan (SFAP) in 2018 to reorientate private capital flows towards sustainable investment to boost the insufficient public funds, which is set to be updated in Autumn 2020. A key pillar of the SFAP is the Taxonomy Regulation, which establishes the legal framework for the EU to develop clear criteria to determine when an investment is classifiable as "sustainable". The European Investment Bank (EIB) is updating its transport lending policy in 2020 to align its financing activities with the principles and goals of the Paris agreement by the end of 2020. The current transport policy allows for lending to fossil-fuel vehicles, airports, and biofuels and will therefore need to be significantly updated.

2.4. The 55% target by 2030 and the carbon budget

The EU is currently responsible for around 9% of Global GHG emissions[x]. One way to calculate how much of the carbon budget should be allocated to the EU would be to take present day shares of emissions and divide the carbon budget up based on these shares, otherwise known as a grandfathering approach[4]. This would mean that for a 66% chance of limiting warming to 1.5°C, the EU has a carbon budget of 38.4 Gt CO_2eq. For a 66% chance of limiting warming to 2°C, the EU has a carbon budget of 97.7 Gt CO_2eq, in both instances following the grandfathering approach. From the trajectories shown in Figure A1, we can see where the current targets and the proposed 55% target may put us in terms of the CO_2 budget (Table 1). As can be seen, the 55% reduction target is the only means to enable the EU to do its fair share of climate action, yet still exceeds the 1.5°C by 49%.

Table 1: How the EU 2030 targets can change the course of long term climate performance.[#]Based on linearly extrapolating 2018 emissions through the 2030 target (See Annex 1). [§]Average of both TECH and LIFE scenarios presented in Clean Planet for All.

Scenario	40% target and decarbonisation in 2072	40% target and decarbonisation in 2050	55% target and decarbonisation in 2046[#]	LIFE & TECH scenarios[§]
Cumulative emissions (Gt CO_2eq)	107.9	79.0	57	74.7
Percentage difference from 1.5°C budget (38.4 Gt CO_2eq)	+181%	+106%	+49%	+95%
Percentage difference from 2°C budget (97.7 Gt CO_2eq)	+10%	-19%	-42%	-23%

The previous sections have summarised the historical emissions in the EU and the importance of intermediate climate targets to not only achieving timely decarbonisation, but to achieving cumulative emissions that are as close as possible to the 1.5°C carbon budgets. What follows is a detailed analysis of what transport can and should achieve in the EU to help achieve the climate targets. We detail the policies required and enabling frameworks to achieve them. We also show the implications of these measures in the context of long term implications.

3. Emission reduction potential from transport by 2030

3.1. Historical emissions

Figure 3 shows how each mode of transport emissions have been evolving since 1990. Emissions from cars, heavy duty vehicles, 2-wheelers, and navigation (maritime) emissions have all increased by around 20%, whereas van emissions have increased by 56% and aviation emissions have more than doubled. Only emissions from trains have reduced since 1990. Emissions from cars and vans make up just over half of the

[4] Other methods include dividing the remaining carbon budget up per person to then be allocated to countries, or to take into account historical emissions and try to balance budgets across countries across longer time periods. Measured from the mid 18th century, the 28 European Union Member States are responsible for 22% of historical emissions. See: https://ourworldindata.org/contributed-most-global-co2

EU's transport emissions, a fifth is from heavy duty vehicles and a seventh from each of international maritime and international aviation.

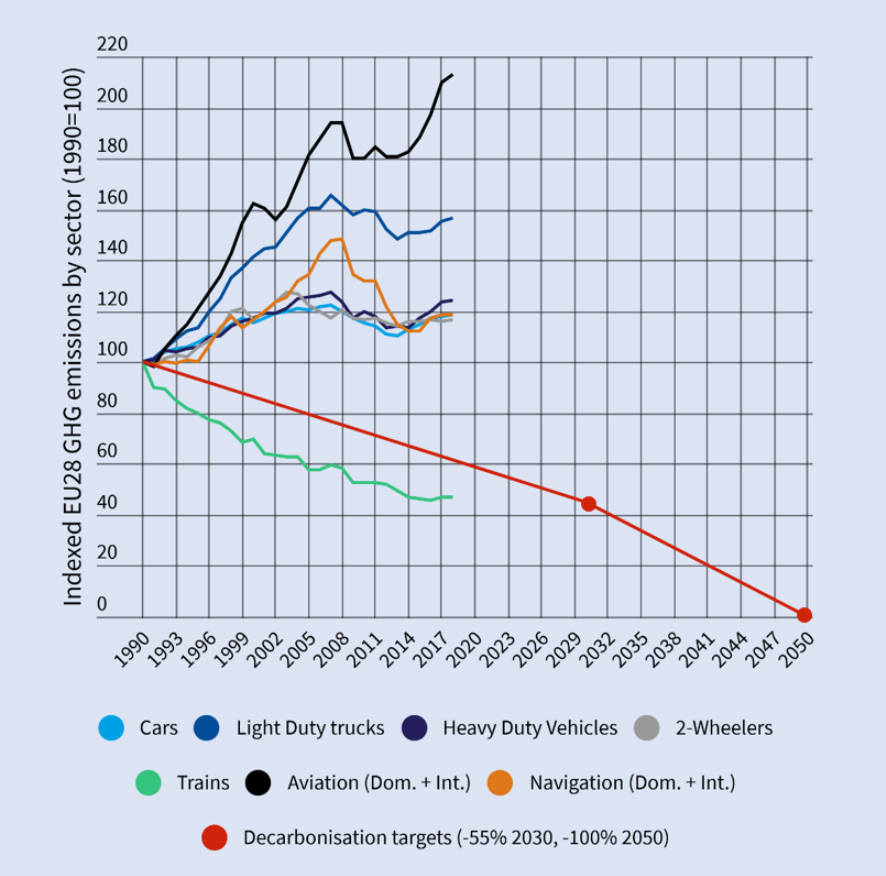


Figure 3: Only trains on track to meeting a 55% reduction in emissions by 2030 compared to 1990.

3.2. Overview and modelling approach

In November 2018, Transport & Environment published its vision on how European transport can decarbonise by 2050[xi]. The guiding philosophy behind the strategy was to first analyse how much transport energy could be reasonably reduced through shifting to cleaner modes and reducing demand by some extent through economic levers such as environmental taxes and pricing. The remaining transport activity would then need to be decarbonised by switching powertrains to zero emission technology, with direct or indirect electric propulsion. The speed of technology uptake strikes a balance between what is deemed to be technically and economically feasible (based on manufacturer announcements, total cost of ownership, technology readiness) in the early 2020s but then becomes driven by the necessity of reaching a 2050 decarbonisation binding target.

Direct electrification (through batteries or catenary lines, for example) are favoured where possible owing to higher efficiency and thus a reduction in total renewable electricity consumption[xii]. Direct electrification is not always possible, however, the salient examples here being deep sea shipping and aviation. For these modes, indirect electrification is required to decarbonise. Hydrogen produced by electrolysis can be used directly as an energy carrier (used in fuel cells or combusted directly in internal combustion engines) or with further energy inputs its derivatives (for example synthetic hydrocarbons or e-fuels) can act as drop-in fuels to replace fossil fuels and unsustainable first generation biofuels, the predominant energy sources in the sector today. Additional sustainability safeguards will be needed to ensure that production of these fuels is the cleanest possible. One key caveat of these energy carriers is the requirement that they be produced from *additional* renewable energy for them to be clean.

As discussed in greater length in the decarbonisation reports, most road transport - namely cars, buses, vans - has a clear (but by no means simple) decarbonisation pathway: battery electric. We have analysed the infrastructure requirements[xiii], life cycle emissions[xiv], the car models[xv], the battery price and technology, the total cost of ownership business case for vans, and how the market has been evolving in these sectors. The outcome is clear - battery electric will be the dominant powertrain for these modes.

For heavy duty trucks, several options exist: battery electric, catenary line (or electric highway systems), and perhaps hydrogen fuel cells in and around key transport hubs such as ports where the infrastructure will likely be available. It is too early to say which technology, or mix of technologies will dominate in 20 years. In the maritime sector, green hydrogen will need to be available at ports for deep sea shipping, as it is a necessary energy carrier for decarbonisation. Short sea shipping routes can be powered by battery electric drivetrains, as is currently the case for several ferries operating in Norway and Denmark.

Finally, aviation is arguably the most difficult to decarbonise. Should Europeans continue to fly, it will require a rapid uptake in synthetic kerosene - electric or hydrogen planes won't have the capacity or range required to make a significant dent in the sector's emissions by 2050. Likewise, sustainable advanced biofuels can only make only a very limited contribution. However efuels won't be available in meaningful quantities until the 2030s, meaning that the 2020s require a strong focus on immediate measures that can rein in and cut emissions from the sector, such as demand management and taxation.

In the following sections, we detail and quantify the reduction potential of each mode and the policies required to get there. The emissions projections to 2050 were computed with our in-house transportation model, the EUTRM[xvi]. The following sections are based on the decarbonisation strategies for cars[xvii], heavy duty vehicles[xviii], aviation[xix] and maritime[xx]. Further information and in depth analysis can be found therein. Policy makers at all levels of governance have the mechanisms to meet the types of emission reductions that we have presented in this study, while a lot of these are in the realm of the European Green Deal. More explicitly, the modelling undertaken to attain these projections rely on the robust and ambitious implementation of the policies proposed in this paper - without them, European transport will not meet the reductions envisaged in this study. This section will highlight the most effective policies available and, where possible, quantify the impact of a policy.

A key table from the series of reports worth reproducing here is the sales uptake of zero emission vehicles in each category of transport (Table 2). What these ambitious zero emission vehicle sales hide, however, is the slow turnover of the fleet. Consider a simplified case[5]: The European passenger car fleet is around 270 million vehicles[xxi]. With annual sales of around 15 million, in a hypothetical case where we could make them *all* zero emission next year and from all years on, it would still take around 18 years for the entire fleet of vehicles to be replaced. In reality, cars last in the fleet for up to 30 years, particularly in Central and Eastern European countries. The turnover rate of the truck, van, and aircraft fleets are even slower. For 2025 new vehicle sales, assumptions were based on cost analysis and CO_2 regulation driving a technology shift[6].

[5] In this case we do not consider the survival rates of vehicles (that dictate how many leave the fleet prematurely due to accidents or exports to third countries outside the EU) nor the fact that the car fleet is growing, nor that the *average* age of vehicles in some countries is greater than 15 years. This is of course taken into account in the transport model.

[6] Since the publication of the series, market analysis has shown that the offer of battery electric passenger cars will increase to nearly 350 models in 2025, while the van market, despite being favourable from a total cost of ownership perspective (and business owners being more rational economic agents compared to car buyers), the van market has unfortunately not moved as quickly. This would make the 20% sales figure for vans in 2025 more difficult, but not necessarily impossible, to achieve.

Table 2: Assumption of zero emission vehicle sales for each mode. [§]Rail is by activity, not sales.

Sales of Zero emission vehicles	2025	2030	2035	2050
Motorcycles & mopeds	50%	100%	100%	100%
Passenger cars	15%	40%	100%	100%
Vans	20%	50%	100%	100%
Urban buses	50%	100%	100%	100%
Coaches	10%	25%	50%	100%
HGVs (<16t)	10%	30%	80%	100%
HGVs (>16t)	5%	30%	80%	100%
Rail (passenger and freight)[§]	70%	80%	90%	100%

3.3. Passenger Cars

3.3.1. Emission reduction potential

The decarbonisation of the European fleet of passenger cars will require a joint effort from multiple players. The EU needs to set ambitious emission targets for cars placed on the market, European and international car manufacturers will need to manufacture the zero-emission cars and develop supply chains of key components, member states will need to help roll out the infrastructure in key corridors and cities, and policy makers at all governance levels will need effective policies to enforce and incentivise the uptake of zero emission vehicles (ZEVs).

From Table 2, it can be seen that the required sales of zero emission passenger cars in 2030 is 40%, on top of which there is an assumed 20% plug-in hybrid electric vehicle (PHEV) sales. 60% of vehicle sales having a plug by 2030 is a fundamental shift compared to sales today, which amount to around 3% in 2019[xxii] but on course for around 5% in 2020 and 8-10% in 2021 . In order to meet the current 2030 CO_2 standards, around 35-40% EVs in 2030 will need to be sold. A 60% market share would thus require a significant ramp up beyond 2025, but it is achievable. For one, the battery technology is already available and increasingly affordable, with cell makers such as Northvolt, LG, Samsung, Saft, CATL and others currently building gigafactories to supply the European market on a large scale. T&E estimates that with increased volumes expected in early 2020s, EVs will reach purchase price parity with fossil-run cars for most segments by the mid-2020s. This means that the market uptake beyond 2025 can be significantly accelerated compared to the current 2030 framework. The impact of the uptake of these sales could be amplified with policies targeting high mileage vehicles. This is the subject of more detailed analysis, but a qualitative and high level quantitative analysis is provided in the info boxes on company cars and taxis below.

On top of this rapid uptake of ZEV and PHEV sales, we combined very ambitious and holistic demand reduction strategies through pricing (e.g road charging) and parking policy, a shift to cleaner modes (buses, trains, walking and cycling), and more efficient use of vehicles (through sharing). The inputs to the modelling amount to a 21% reduction compared to a business as usual scenario by 2030[xxiii]. As detailed in the report, this is rather an aspirational target: since the year 2000, car activity has increased 600 billion pkm while for the cleaner transport modes the change has varied. Bus and coach activity reduced by 35 billion pkm, tram and metro activity increased by 36 billion pkm, and railway activity increased by 93 billion pkm[xxiv]. Only in some member states (e.g. the Netherlands) has the rise of car use plateaued over this time,

but they are the exception. Policies to achieve this reduction will need to be rapidly deployed and overarching, a particular challenge being to avoid inducing car demand by freeing up road space by shifting motorists to other modes.

The combined technology and demand measures in place would result in a curb of passenger car emissions from a maximum of 535.5 Mt CO_2eq in 2007 to 363.6 Mt CO_2eq in 2030. **Compared to 1990, this represents a reduction of 21%**.

Transport & Environment conducted a study on automated, electric, and shared cars coupled with a revolution in urban planning and city design to analyse the potential impact of these four revolutions. Embracing and adopting the best practices of city planning to further encourage multimodality and a shift to cleaner modes and active transport (walking and cycling), the passenger car sector could be on a steeper trajectory towards decarbonisation, however by 2030 we don't envisage a significant difference in emissions compared to the T&E decarbonisation strategy series. Most of the impact will be in the longer term.

3.3.2. Policies needed

The early revision of the EU wide CO_2 standards for cars announced for June 2021 is the key opportunity at EU level to increase car emission reductions by 2030 (and beyond). The current standards - agreed in late 2019 among industry's scaremongering & diesel decline - are not fit for the EU Green Deal ambition and must be strengthened in a number of important ways:

- Move to annual CO_2 reduction targets from 2026 onwards rather than targets that kick in every 5 years, as is currently the case in Europe. This is important to ensure gradual fleet improvement throughout 2020s and to avoid step wise compliance with targets observed in the last years: no progress on fleet average new car registration emissions[xxv] from 2016 as carmakers postpone selling clean models to the last minute, ie 1 January 2020.
- Increase the 2030 new cars CO_2 target in line with the 2050 trajectory and increased 2030 climate ambition, to at least 55% reduction. This should be accompanied by setting an EU-wide phase-out of fossil fuel and CO_2 emitting technologies, so that only new cars that are zero emission can be sold from 2035.
- Consider setting separate ZEV purchase mandates for private fleets - where electric cars are already better on the total cost of ownership bases - such as large commercial fleets, large lease companies and high-mileage vehicles such as taxi & ride-hailing services. These parts of the market should have all new sales zero emissions no later than 2030. This will accelerate their introduction into new fleet and CO2 emission savings, and as a result, earlier availability in the second hand market to benefit all consumers.

To enable smooth and seamless transition to zero emission mobility, infrastructure roll out should keep pace with EV sales. The alternative fuel infrastructure directive (AFID) is a mechanism that mandates provision adequate number, quality, and coverage of public charging infrastructure. The legislation should be reviewed and turned into a harmonised regulation setting binding targets for public charge points and focusing on covering all EU main roads, charging hubs in cities and home and workplace charging[xxvi]. The support under the many Green Deal funding mechanisms should be aimed at cabling all private and public buildings and upgrading grids where necessary, following smart charging principles.

But increased ambition in the next decade leading to 2030 cannot be achieved without the necessary shift in climate as well as industrial policies. This includes capturing the battery value chain and modernising

EU's car manufacturing and workforce so no region is left behind. Crucially, shift to electromobility must benefit all Europeans and be inclusive, so that disadvantaged regions or neighbourhoods benefit from targeted incentives and zero emission mobility services. EU regional funds should be used to e.g. provide publicly owned fleets of shared electric vehicles or roll-out of electrified public transport.

Info box - Company Cars

Corporate cars, i.e. those not purchased by an individual, make up 58% of new vehicle registrations in Europe[xxvii] (rising above 70% in some markets). A subsection of corporate cars are company cars, the vehicles given to an employee as part of their salary package. They tend to be higher mileage than privately owned vehicles (particularly as fuel is often paid for), have a higher turnover, and are typically provided by lease companies, who are rational economic operators and thus consider the operational/ownership costs of the vehicles rather than just the up-front cost. These makes electric vehicles perfect for that market segment already today. Company cars end up in the second hand vehicle market after only several years rather than around 7 years for privately owned vehicles. This means that any policy that targets company cars has the potential to have a significant impact on the whole fleet and speed up its renewal to zero emissions models. Although company cars fall under the EU post-2020 car CO_2 standards, **national governments** can accelerate penetration of EVs by changing company car taxation to favour ZEVs (as was done in Germany and the UK recently), and even set ambitious mandates for businesses. Companies should be incentivised to also provide charging at their office premises, while stopping free fuel cards. This is already discussed in Belgium where a rapid shift of the company car fleet to electric cars would result in up to a 50% reduction in the fleet emissions compared to 2005[xxviii].

The effect of a policy targeting fleet cars is the subject of future work. However, for this report a simple analytical model was developed to get an appreciation of how effective such a policy could be. Compared to a situation where most fleet cars are ICEs (10% sales in 2030), a policy that enforces fleets to uptake most of the ZEV sales (40% by 2030) could cumulatively save 5% emissions over the decade for new vehicles, equivalent to a 4% reduction on 2030 emissions. If there was a policy to mandate ZEV for fleets to 100% sales in 2030 while private cars still reach the current 2030 target, then the cumulative savings in emissions could be 27%, equivalent to 24% savings in 2030.

At the country level, tax regimes are the main tool to boost the uptake of clean vehicles. While zero emission models should be supported, CO_2 emitting cars should be disincentivised with financial penalties: The French and Italian bonus-malus systems are a good example of self-perpetuating scheme whereby buyers of the most polluting vehicles pay for the subsidies for electric cars. Countries should reform company car rules to force companies offering vehicles to switch to a green fleet by reducing benefit-in kind contributions for EV users and allowing generous VAT deductibility for companies offering EVs. . The announced phase out of internal combustion engine (ICE) vehicles in the 2030s, as announced by several EU countries[xxix] should be properly implemented (and EU rules adjusted to allow that), as it sends a clear sign to consumers and OEMs about the future direction of the market.

Info box - Taxis and private hire vehicles (PHVs)

Taxis and PHVs are high mileage vehicles and like car leasing companies, are rational economic operators when making investment decisions on vehicles. While these vehicles also fall under the EU post-2020 car CO_2 standards, **local and city level governments** should go further and ensure all taxi-like operations are zero emissions before 2030, inter alia by:

- changing taxi and PHV licensing laws to favour zero emission vehicles,
- introducing zero emission zones and road charging, and
- setting ambitious mandates for businesses.

All levels of government will need to help facilitate this change with a roll out of a fast public charging network strategically placed around the city, at taxi ranks, and dedicated rest areas. The rapid transition of the taxi and PHV fleet to electric vehicles and the deployment of recharging infrastructure to help achieve it has the advantage that the public chargers will also be available for private and shared vehicle owners, an enabler for electric vehicle uptake.

Cities can and must play an important role in the transition to zero emission mobility[xxx]. Introducing bans on diesel and petrol cars alongside reducing space and accessibility for cars are key to drive modal shift to zero emission modes such as buses and trams, shared electric fleets or metros in cities. Zero emission zones, congestion zones, and removing lanes for cars to provide dedicated infrastructure for cycling, micro-mobility services and buses will help reduce demand for private transport in cars. Cities can change taxi and private hire vehicle (PHV) licensing laws to drive a high mileage fleet to decarbonisation (see info box on taxis and PHVs). Eco-driving and C-ITS may help reduce in-use fuel consumption and improve traffic flow, but they have limitations, particularly in very heavy traffic, and would require regular driver training.

Table 3: Quantification of policy measures for passenger cars. Relative reductions given in percentages; absolute CO_2 saved will depend on the baseline it's compared to. Most policies are intrinsically linked. For example, an increase in fuel tax may lead to some people to take another mode, and some people to avoid driving all together.

Policy	Change in 2030	Description
Strengthening of CO_2 target from 2025 to 2030	11% reduction in emissions compared to business as usual	Compared to the existing 37.5% CO_2 standards. This leads to a higher uptake of EVs and is effectively a target of 55%. This includes annual targets between 2026 and 2030.
Prioritising ZEVs in high mileage fleets	4-24% reduction compared to business as usual	See Info Box for more details. Keeping with the current CO_2 standards, but forcing company cars to take a higher proportion of ZEVs, could save 4% emissions. By setting a 100% sales mandate for company cars by 2030, while private cars meet the standards, up to a 24% reduction compared to business as usual could be expected.
Modal shift from private car to bus, train, metro, cycling and walking	6% reduction of pkm in cars compared to business as usual	This metric is based on passenger activity, i.e. in terms of passenger kilometres (pkm). Passenger activity (and thus emissions) is skewed heavily by longer commutes. This will result in many fewer trips taken by car, particularly in cities, and large increases in passenger activity for buses and trains (28% and 35% increases EU wide respectively). Investment is required to build dedicated cycle and bus lanes, new metro lines, increased rail services, and better pedestrian infrastructure. This type of shift is only possible with demand reduction measures (table row below) while also avoiding induced demand.

Fuel tax harmonisation and increase, low emission zones, congestion zones, toll roads, public parking restrictions	5% reduction of pkm in cars compared to business as usual	The reduction is an approximation of EU wide implementation of one or a combination of these measures on passenger (and thus vehicle) activity. The effectiveness of each policy is dependent on the region or city where it is implemented.

3.4. Vans

3.4.1. Emission reduction potential

The van sector has been the fastest growing road transport sector in the EU, where emissions have grown 56% from 1990. In a study[xxxi] commissioned by Transport & Environment and undertaken by consultancy CE Delft, the European van market was analysed and the total cost of ownership (TCO) potential of battery electric vans quantified. As vans are predominantly owned or operated by businesses, they tend to act as more economically rational operators than for passenger cars. TCOs affect the bottom line of a business, and therefore play an important role in purchasing decision making. Based on the analysis in this study, we assume ZEV sales of 50% by 2030, resulting in 2030 emissions of 69 Mt CO_2eq in 2030, equivalent to a 1% *increase* compared to 1990. Despite very high zero-emission sales in 2030, all of the reduction effort has only been able to offset the high growth in emissions since 1990.

3.4.2. Enabling policies

Vans often slip through the passenger car and heavy duty vehicle gap of European legislation[xxxii] in terms of prioritising emissions reduction and operator licensing. This is one reason why vans' emissions are almost 60% higher than they were in 1990. Vans also fall into broad usage criteria, from small and medium enterprises (such as plumbers, builders, tradespeople), delivery, passenger transport. Appropriate road charging, particularly on the highway systems, is an important mechanism to internalise the external costs and can counter a growing trend of large vans replacing small segment trucks (that transport goods more efficiently). The EU CO_2 standards for vans are not ambitious in terms of target and required effort to meet them[xxxiii], which has resulted in a lack of adequate offer of electric van models despite the business case and industry demand already there (particularly from urban and regional delivery operations). The upcoming review of CO_2 standards announced in the European Green Deal strategy is a unique opportunity to strengthen the 2030 target and drive the uptake of more zero emission vans. It should:

- As part of the June 2021 review, enforce annual targets from 2026 to redress the ineffectiveness the 2025 van standard
- Increase the inadequately weak 2030 CO_2 target to ensure timely investment into zero emission van manufacturing
- Introduce zero emission mandates for vans (up to 3.5t), often used in cities and urban areas for delivery, where electrifying already makes economic sense today[xxxiv]. Consider sub-targets (for both CO_2 reductions and ZE sales) for the three N1 sub-classes[7]. At a minimum, however, ZE vans need to make up 50% of average van sales, weighed by emissions, by 2030.

Cities can take the lead in pushing the electric van market (particularly in advance of new van standards). Low and zero emission zones enforced by cities are enablers that ensure that early adopters of clean vans

[7]N1 subclasses are: class I, up to 1305kg; class II, 1305 to 1760kg; class III, 1760 to 3500kg

are incentivised. In addition, the upcoming EU urban mobility package should give cities support and funding necessary to implement zero emission logistics operations and the depot charging infrastructure necessary.

3.5. Road freight - Trucks

3.5.1. Emission reduction potential

Never before has the foundations of European trucking seen such rapid and far-reaching developments. Not long after our report on decarbonising road freight was published, we published an addendum on battery electric trucks after several OEM announcements. We then analysed whether or not the truckmakers' claims were credible, and we found that they were[xxxv]. The sales projections of 30% of zero emission trucks by 2030 considers the current operational profiles in the EU, the speed of the market, the potential opportunity costs for reduced mass or volume carrying capacity in the short term. For example, around half of truck activity (measured in vkm[8]) are taken up by trips less than 300 km. We couple these sales with more efficient internal combustion engine trucks (and their more aerodynamic cabs and trailers) logistics improvements, increasing rail market share (from 18% to 23%, resulting in a potential doubling of total rail freight carriage), and demand reduction through road pricing. We project that truck emissions in 2030 emissions of 160 Mt CO_2eq in 2030, representing a 3% increase compared to 1990.

3.5.2. Enabling policies

Truck makers will need to meet CO_2 standards on new truck sales. A 30% reduction in 2030 is certainly a step in the right direction and will ensure that Europe has the most fuel efficient trucks in the world. The standards cover the sale of 4 truck categories that are responsible for 75% of emissions. The review of truck standards in 2022 will include trailers, ensuring that, by 2030, all main trailer types are regulated together with all new trucks. A ZEV mandate for trucks on top of existing fuel efficiency standards would also be a key tool to deliver emission reductions.

The EU is currently reviewing the Eurovignette directive that regulates road charging. We project that the new legislation will be finalised by the end of 2020. Likely from 2023, member states will need to vary the infrastructure charge based on a vehicle's CO_2 performance, unless they opt to introduce a CO_2 external cost charge (or choose to do both). The variation of the infrastructure charge includes a 50 to 75% toll reduction for zero emission trucks. For high-efficiency ICE trucks and hybrids, toll reductions range from 5 to 50%.

Infrastructure roll-out should be delivered and guided by the EU (see info box below for more discussion). Coverage of the Ten-T network should be prioritised starting with urban and regional delivery. Positioned strategically, high capacity truck re-chargers will also be useful to long haul distance haulage as the market develops. In addition, a European Investment Fund should be used to support small and medium enterprises (SMEs) to install private charging infrastructure. Finally, speed limitation could play a role in reducing emissions (and fuel/energy use) from trucks in some European countries where this limit currently does not apply or isn't enforced.

Limit the speed of all freight vehicles (existing and new) to 80 km/h. In previous sections, it is assumed that a cohort of new vehicles will be limited to 80 km/h to save emissions and fuel. A more radical measure is that 80 km/h becomes the speed limit for all freight vehicles in the EU (above 3.5t), with a comprehensive pan-EU retro-fitting programme adopted. The measure, based on 2013 estimates, would cut emissions from 4% to 6%[xxxvi].

[8] It is around 43% in terms of tkm.

Info box - Truck charging infrastructure

The outlook of the truck market has rapidly changed in the last few years. Most European truck manufacturers have now announced battery electric heavy duty trucks up to 28 tonnes. Pilot projects of electric road systems (highways with overhead catenary lines or electric rail) are demonstrating the feasibility of zero emission long haul technology. European policy makers have a key role to play in determining how fast the uptake of electric trucks are. Studies have shown that they are competitive with the incumbent diesel trucks on a total cost of ownership, let alone on environmental grounds. However, charging infrastructure is key. T&E has released a study[xxxvii] on how Europe can best deploy charging infrastructure to give greater guidance to member states on the best way to accelerate the transition to zero emission trucking. In a first step, the 88 urban nodes on the Ten-T network should have coverage by 2025, and the most significant gaps in the network filled by 2030.

Table 4: Quantification of policy measures for trucks. Relative reductions given in percentages, as total amount of CO_2 saved will depend on the baseline it's compared to.

Policy	Change in 2030	Comments
Strengthening the 2030 CO_2 standards	5% reduction in emissions	Compared to the currently legislated standard of at least 30%, increasing the 2030 CO_2 target to 40%.
Inclusion of trailers in CO_2 standards	--	More efficient trailers can reduce fuel use and emissions of the tractor-trailer combination; however, it will be after 2027 as new trailers are taken up when this cut will be most felt. This is an enabling policy for a strengthening of CO_2 standards to 40%.
ZEV mandate on new truck sales	10% reductions on top of strengthened CO_2 standards	As per the sales assumptions in Table 2, resulting in 30% new truck sales in 2030, and dependent on AFID and road charging policies (see following policies).
Alternative fuels infrastructure directive, AFID	High uptake of electric trucks	Allows the uptake of zero emission urban delivery envisaged in the decarbonisation strategy. In the longer term allows the uptake of zero emission heavy duty and long haul trucks
Speed limitation to 80 km/h	4%-6% reduction in emissions	Old vehicles would need to be updated to new speed limitations, and all new trucks equipped with them.
Eurovignette, road charging, fuel tax reform.	2-5% reduction in emissions compared to business as usual[9]	Toll reductions for ZE trucks are expected as early as 2021 with reduced tolls from low-CO_2 trucks following after 2023. Higher charges for other external costs (e.g. air pollution, noise) will also improve logistics efficiency, load factors of trucks, and reduce demand.

[9] Overall, a maximum reduction of 5% could be achieved once trucks are charged based on their CO2 emissions in combination with additional ambitious measures such as reducing or eliminating the fuel rebate for hauliers and a

Mode shift to rail	5% reduction in emissions compared to business as usual	Accounting for the anticipated increase in surface freight, this shift represents a doubling of rail freight transport. This is also in the context of a reduction in the transport of fossil fuels such as coal, which makes up 22% of EU rail freight activity. This modal shift would only be possible with demand reduction policy measures.

3.6. Urban buses and coaches

3.6.1. Emission reduction potential

Urban buses are perfect candidates for direct electrification[xxxviii]. They have set routes and operations, allowing procurement of right-sized batteries or appropriate on the go charges. The stop start nature of bus journeys also favours electric powertrains, as energy can be recuperated during deceleration which is otherwise lost as heat with internal combustion engines. Aside from GHGs, the impact on air quality is also significant, as buses tend to operate in densely populated urban centres. Similarly, coaches can have relatively predictable operational profiles (for well serviced routes), and with strategic placement of fast charging infrastructure, they can also reach full zero emission sales. We project that urban bus and coach emissions in 2030 of 37 Mt CO_2eq in 2030, representing a 4% reduction compared to 1990.

3.6.2. Enabling policies

Policy makers should lever the clean vehicle directive for the public procurement of 'clean' buses only (i.e. not natural gas buses). 100% sales of urban buses is technically feasible and economically rational by 2030. The benefits to cities will come from reduced noise and pollution, not just a reduction in greenhouse gas emissions. The EU should create a fund to help small cities to procure electric buses, and cities should use best practices to procure buses to reduce costs, for example by partnering with other cities to increase bus orders and negotiate better prices. Cities will need to work closely with bus makers to determine the best strategy for the deployment of chargers, either at the depot or for opportunity charging at or along the routes. Finally, policy makers should push to allow for a temporary weight allowance for electric buses so that the passenger capacity of buses is not reduced.

3.7. Aviation

3.7.1. Emission reduction potential

Aviation is one of the fastest growing transport sectors in Europe. Intra-EU flights have increased on average 5% year-on-year since 2013. Central scenarios of all departing EU flight emissions project a rise of 21%-37% by 2040[10]. When it comes to modal shift, the stark reality of the aviation sector is that emissions are heavily skewed towards long distance flights. Figure 4 shows the aircraft departures and associated emissions for departing aircraft in Europe. We can see that around 45% of flight departures are 1000km or less, however the CO_2 emissions associated with those departures is only 15%. This implies that modal shift to rail or replacement of short flights by electric aircraft will only have a limited impact on emissions and fuel

harmonisation of diesel and petrol excise duty rates. Note that Baseline scenario when taking into account current Eurovignette revision is not more than -0.5% See page 145 of EC (2017) Support Study for the Impact Assessment Accompanying the Revision of the Eurovignette Directive (1999/62/EC) Available: https://ec.europa.eu/transport/sites/transport/files/docs/2017-05-support-study-ia-revision-eurovignette-dir.pdf

[10] European Aviation Environmental Report 2019. Available: https://ec.europa.eu/transport/sites/transport/files/2019-aviation-environmental-report.pdf

consumption. As a result, emissions from long-haul aviation will have to be addressed through measures which more directly restrict demand: through for example limiting and reducing airport capacity, and increasing taxation.

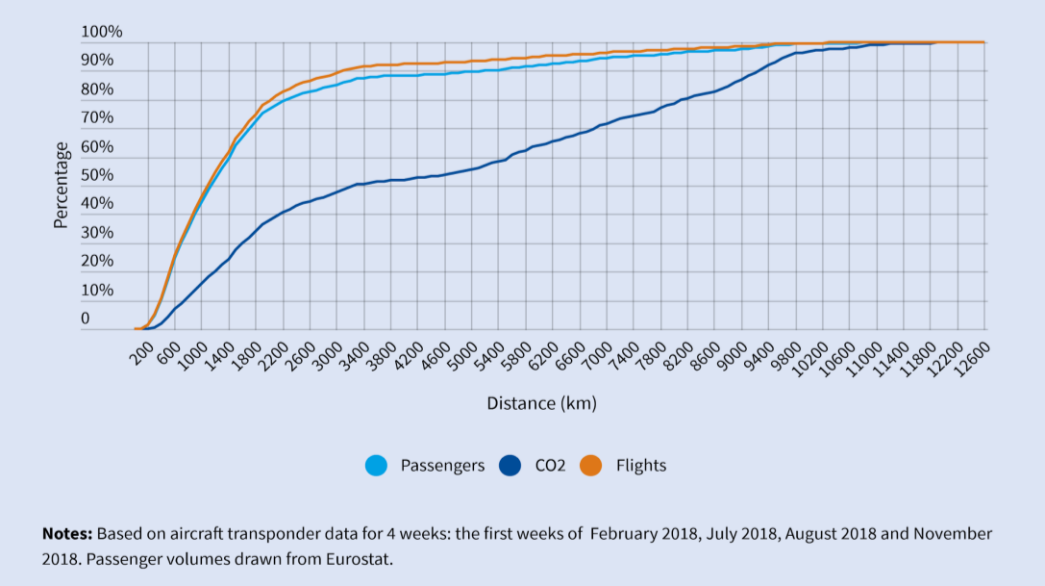


Figure 4: Cumulative CO_2 emissions associated with aircraft departures in the EU.

By 2030, with the right policies in place, we could expect an exceptional and continued improvement in the fleet efficiency of aircraft (of 1.2% per annum), demand reduction resulting from higher ETS CO_2 allowance prices and kerosene taxes, an uptake of advanced sustainable second generation biofuel and a small uptake of synthetic fuels. By 2030, we project aviation emissions could be 149 Mt CO_2eq, representing a 79% increase on the 1990 levels which were 83 Mt CO_2eq and roughly equivalent to 2015 emissions.

This is well short of aviation decreasing emissions by 55% by 2030. As it will be challenging to scale up fuels before then, and doing so too rapidly may cause negative consequences as has been the case in the past, the focus for the coming decade will have to be on limiting demand growth from the sector.

3.7.2. Enabling policies

The growth of aviation is facilitated by several tax exemptions that other modes of passenger transport do not enjoy. The primary exemption is fuel taxation. A tax on kerosene is unfortunately unlikely to be applied EU wide, as it requires unanimity to change the tax law in the energy taxation directive (ETD). A coalition of ambitious member states could multilaterally or bilaterally agree to tax flights between them, and this can be an effective way to end aviation's tax holiday. Policy makers should as a priority work to tax kerosene for flights in Europe. Tickets for flights are exempt from VAT, another fiscal advantage that the aviation industry has over all other modes of transport and mobility. In order to address the growth in emissions from long-haul aviation, taxation will have to be especially targeted at such journeys, which could include progressively increasing ticket taxes until demand growth is reversed.

The EU should study the possibility to regulate fuel supplied to aircraft and have a mandate for sustainable advanced biofuels and efuels. This should encompass renewable synthetic fuels and exclude crop biofuels as well as their co-products. Sustainable advanced biofuels derived from wastes and residues produced within Europe could also be part of a fuel blending mandate, provided robust definitions are in place and the targets are aligned with availability at sustainable levels. This will enable to channel specific advanced fuels to the aviation sector but the required volumes need to remain within sustainable boundaries, taking

into account competing uses and existing targets in the Renewable Energy Directive II. A thorough impact assessment will be needed before deciding on the form and level of a potential mandate.

Info box - Safeguards for advanced e-fuels

The 10% renewables in transport target for 2020 has resulted in an unprecedented increase of unsustainable crop biofuels in the EU. A direct consequence of this policy is that drivers are the largest consumers of palm oil in Europe, a crop that has caused immense deforestation. The target was set without the right safeguards in place from the beginning, in particular regarding land use impacts. It is crucial to avoid repeating the same mistakes with advanced fuels, whether advanced biofuels or sustainable e-fuels.

This is why a robust sustainability and accounting framework is imperative at EU level, especially the requirement to produce e-fuels with additional renewable electricity. In addition, these fuels should be produced with CO_2 captured from the air and be subject to specific criteria regarding land use, water, and social impacts. These, together with an impact assessment of potential production at EU level, are prerequisites for a potential mandate on sustainable electrofuels in the sector. If a mandate is studied, it will have to start at a very low level and be increased only progressively, depending on availability.

Governments should not expand current airport capacity, such as at London Heathrow and Schiphol. Airport expansion enables more aircraft slots, and enables more flights. Investments in new airport capacity will be a lost money if aviation were to follow a path to decarbonisation, as passenger demand cannot continue to increase but must at worst stabilise and also begin to fall.

Table 5: Quantification of policy measures for aviation. Relative reductions given in percentages, as the total amount of CO_2 saved will depend on the baseline it's compared to.

Policy	Change in 2030	Comments
CO_2 standards for aircraft	2% reduction in emissions	This policy will drive the fuel efficiency of the EU aircraft fleet and lead to the uptake of more advanced planes in the 2040s
Carbon pricing and ending tax exemptions on fuel	6% reduction in emissions	In 2030, equivalent to €70/tCO_2. This should be principally be achieved through reforms to the ETS to ensure there's no excess of ETS allowances, but can also be through a coalition of countries implementing multilateral fuel taxation on kerosene. This can also be achieved with ticket taxes or aircraft taxes.
Advanced biofuel blending mandate	tbd	As discussed, any advanced biofuel blending mandate would need to have full safeguards in place. In 2030, we assume that 2.5 Mtoe of the total 7.5 Mtoe European potential could be available for aviation. This is equivalent to a mandate of 5% on fuels supplied to aviation. Importantly, as these are the same feedstocks required for road transport, countries would need to meet their REDII targets in road transport with renewable electricity. Every country will need a specific assessment of the sustainable potential for advanced biofuels.

Power to liquid blending mandate	tbd	A proper impact assessment will be needed for a realistic forecast of sustainable volumes of e-fuels. The mandate could start in early 2020s and be ramped up towards 2030 depending on sustainable potential. As an example, a mandate of 5% would deliver 2.5 Mtoe, and at a cost of €3700/tonne of fuel (around 6x the assumed price of fossil kerosene) would increase fuel costs by 25%.

3.8. Maritime

3.8.1. Emission reduction potential

The shipping sector is unique in many ways. No other mode can claim to the changes in scale, from 12 person water taxis[xxxix] to the largest container ships which can carry more than 20 000 containers and with carrying capacity exceeding 200 000 tonnes (or deadweight tonnage, DWT)[11]. Ships can have a lot more freedom to bunker, or refuel, wherever they choose, particularly those embarking on intercontinental trade. Ships will be one of the few sectors where new powertrains can be retrofit onto existing hulls. Our analysis looked at various categories of ships and performed a techno-economical analysis of the different zero emission technologies available. It found that most inland shipping could be run on battery electric propulsion, while deep sea and intercontinental shipping would most likely operate on liquid hydrogen or liquid ammonia.

Our analysis for shipping was not prescriptive in a trajectory to reach zero, rather it showed the technological options to use to get there by 2050. Part of the reason for this is that only until recently has there been publicly available data on the detailed operations of these ships. Transport & Environment recently published an analysis of the monitoring, reporting and validation (MRV) scope emissions[xl]. For the sake of this analysis, we assume that shipping emissions could follow a linear trajectory from 2020 to 2050. This implies that shipping emissions could be 89 Mt CO_2eq, representing a -38% reduction compared to 1990 levels.

3.8.2. Enabling policies

The monitoring, reporting and verification of ship emissions has for the first time enabled a detailed analysis of Europe's contribution to global shipping emissions[xli]. It also defines a scope which can be used for regulation. Policy makers should as a priority legislate that the emissions that fall under the MRV to be included in the European ETS. Like aviation, the maritime industry benefits from tax-free fuel. Ending this exemption could generate substantial funds (a combined €28 billion)[xlii] for the EU that could be rapidly reinvested into ports and into the EU shipping industry to develop the clean ships of the future.

A key metric now available to policy makers is the energy efficiency operational index (EEOI), which gives an accurate representation of the operational efficiency of ships, rather than the energy efficiency design index (EEDI), which has been shown to be inadequate[xliii]. We have analysed the operation efficiency standards necessary to decarbonise shipping by mid-century based on the MRV scope for identifying EU maritime emissions. This will require **ships calling at EU ports to be above 40% more operationally efficient (i.e. less carbon intensive)** in 2030 compared to the 2018 baseline. This can be achieved by mandating an operational EU CO_2 standard for ships using EEOI as a metric. When implemented in 2022, this would result in a reduction of absolute emissions of 18% by 2030 compared to 1990[12].

[11] For example, the MSC GÜLSÜN

[12] As the MRV emissions are only available from 2018, 1990 MRV scope emissions were estimated to be 117 $MtCO_2$ by scaling the change in emissions reported in the UNFCCC greenhouse gas inventories.

Member state governments have a big role to play in terms of zero emission enabled ports. Ships emitted around 7 Mt CO_2 in European ports while at berth, emissions that could easily be avoided a European zero emission berth standard. This capacity also feeds into the electrification of ferries and ro-ro ships, which have set routes and schedules, and could be feasibly electrified, as has been proven in Norway and Denmark. Zero emission ports can also help provide the necessary infrastructure for hydrogen which in the short term could enable zero emission auxiliary engines, responsible for almost 40 Mt CO_2 in the EU MRV scope.

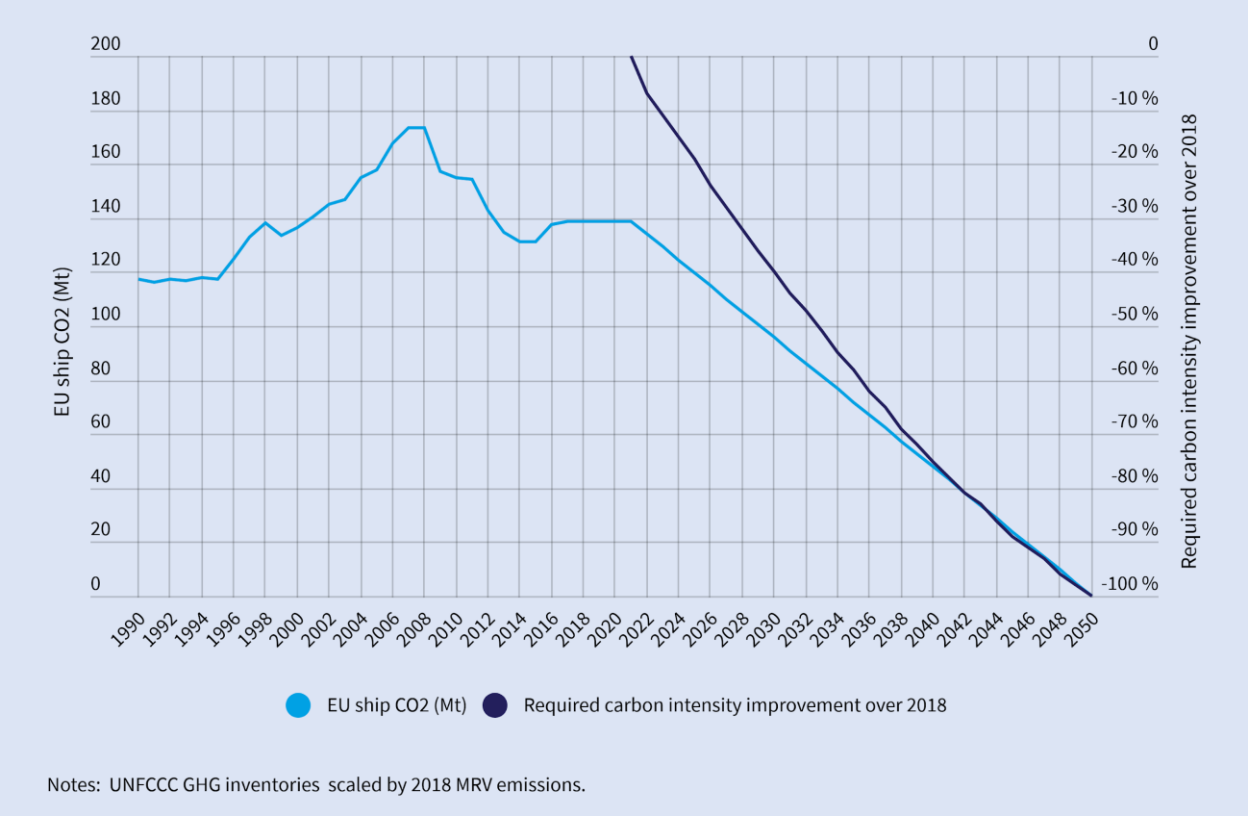


Figure 5: EU shipping emissions on a 2050 decarbonisation trajectory, accomplished with an EEOI standard.

Finally, zero emission assistive technologies (like wind propulsion) and measures such as speed reduction, are necessary to ensure that a traditional laggard in climate heating mitigation becomes more ambitious. In the case of speed reduction, emission reductions would be observed instantly. This could also help address the over capacity of freight transport in the industry to incentivise greater efficiencies. Operational CO_2 standards is the most efficient regulatory tool to practically implement speed reduction for ships, as slow steaming is the most immediate option available for ships to improve their carbon intensity.

3.9. Green Investment

The European Commission will publish Delegated Acts before December 2020 that include the criteria to determine whether an investment contributes to climate change mitigation or adaptation. Insofar as these criteria relates to transport, the technologies promoted as sustainable should be aligned with the technologies needed for Europe to be climate-neutral by 2050. The late inclusion of “transition” and “enabling” activities to the Regulation opens the door for suboptimal technologies to be labelled as “green”. Such “transition” activities must only be for economic activities where no zero-emission equivalent exists and such activities should also be complemented with a deadline that determines when they cease being eligible.

The draft Ecolabel for financial products must be updated to reflect the needs of sustainable investment in the coming years. Allowing a fund with only 18% of revenues coming from Taxonomy-aligned activities to

be eligible for the label would do little to reorient capital flows to sustainable finance or stem greenwashing in the financial sector. The EIB will need to update its transport lending policy to be coherent with the bank's own objective of aligning all its financing activities with the principles and goals of the Paris agreement by the end of 2020. This will include a phase-out of lending to airports, fossil-fuel vehicles, and diesel/petrol vehicle factories. The policy should in part promote loans for restructuring plants so that they produce zero-emission vehicles and components.

3.10. Transport summary

Our decarbonisation strategy reduces emissions to 892 Mt CO_2eq in 2030 compared to 1990 (-5%); by way of comparison, the average of the 1.5TECH and 1.5LIFE scenarios in Clean Planet for All is 868 Mt CO_2 excluding international shipping, equivalent to a 0% reduction on 1990 emissions. This implies that the rest of the economy will have to reduce its emissions by 65%. Table 3 gives a breakdown of these findings for each mode.

Table 6: Summary of historical and projected transport emissions in the EU on an ambitious decarbonisation pathway. *Shipping emissions are those reported in 2018.

Mode	Historical emissions [Mt CO_2][13]			Decarbonisation pathway [Mt CO_2]		
	1990	2017*	2017 vs 1990	2030	2030 vs 1990	2030 vs 2017*
Passenger cars	461	543	+18%	364	-21%	-34%
Vans	68	106	+56%	69	+1%	-37%
Trucks and Buses	197	235	+23%	194	+2%	-19%
Aviation	83	174	+110%	149	+79%	-1%
Shipping[14]	117	140	+19%	96	-18%	-31%
Total Transport (inc. 2W, rail)	944	1232	+29%	892	-5%	-28%

4. What else could be done?

The ambitious technology changes, pricing, and modal shift measures would put EU transport on a path to zero emissions by 2050 but would deliver a modest 5% reduction on transport emissions by 2030 compared to 1990 (or a 28% reduction from today's emissions). Achieving bigger emission cuts before 2030 would require additional measures.

This section takes a qualitative look at more radical measures to decarbonise transport faster, with a brief discussion on what the implications of such measures could be.

Before discussing the additional measures, it is necessary to consider three important underlying assumptions of the transport modelling undertaken in the T&E's 2050 decarbonisation strategies:

[13] Member State reporting of greenhouse gas inventories to UNFCCC.

[14] MRV 2018 data backcast to 1990 based on change in UNFCCC emissions for domestic and international shipping

- Exogenous inputs of GDP and population. A key assumption used in this modelling work is that Europeans will become more numerous and continue their historic trends of becoming wealthier. Projections of population and wealth don't tend to take into account the effects that climate change shocks will have on the economy or demography.
- A continuation of the historical trend of increasing wealth driving demand for both personal mobility and the consumption of goods, driving up freight demand. This assumption cannot hold indefinitely while planetary boundaries are exceeded.
- The measures modelled apply a philosophy of *not* reducing mobility by simply pricing it out of reach of the masses or to stymie the growth of mobility of Member States where it is under developed. Rather, more holistic approaches are considered.
- Different spatial planning and transport infrastructure policies could end the trend of suburbanisation and encourage a shift to dense urban areas with lower transport intensity that can more easily be decarbonised. This policy area has not been considered although its emissions impacts are likely to overlap with savings from modal shift to cleaner modes of travel.

Aside from showing the limitations of this modelling exercise (and those of many others), this also shows that there are other ways to reduce emissions that have not been discussed in this paper. These measures are typically beyond the remit of policy makers in the transport sector, but worth broader discussion here. That includes to apply a societal or individual limit on mobility and trade; to drastically increase the price of transport; to radically change spatial planning policies. Such policies and the way they are designed could have important social implications. For example, in the UK, 70% of flights are taken by 15% of the population[xliv]. Increasing the price of these modes may not stop or dissuade the frequent flyers or drivers from their disproportionate pollution, but measures like limiting airport expansion or reducing access to cities by car be more equitable if done through non-fiscal measures such as taking away car spots or reducing car lanes.

4.1. Other measures and higher ambition

This paper assesses what transport's contribution could be to achieving a target of -50/55%. But there have also been calls by some for a 65% [xlv] [xlvi] reduction by 2030 which is deemed necessary for Europe to contribute to keeping global warming below 1,5°C. Whilst the highest possible ambition should in principle be pursued the full consequences of doing so need to be considered. First, there would need to be strictly enforced safeguard mechanisms to avoid those emission reductions being a mere accounting trick (e.g. offsets or more bio-energy). This is a risk at any level of ambition but it may increase with higher ambition. Accelerating (real) emission reductions to such high levels would also require a huge and rapid change to the socio-economic structure of most countries. For example, it is theoretically feasible to end the sales of combustion engine cars earlier than 2035 for example in 2025. But it would be all but impossible to retrain the people, build the battery factories, develop the infrastructure or deal with the social consequences of shutting down the combustion engine industry by that date.

4.2. Cars and personal mobility

To achieve bigger and faster CO_2 reductions from cars before 2030, more radical measures would need to be taken on the cars lifetime and usage side. This could include:

- Reducing vehicle speed is one of the simplest, quickest and cheapest ways to achieve quick emission reductions from the entire vehicle fleet. Reducing highway speed limits from no limit, 130 or 120kph to 100kph whilst lowering rural road speed limits to 70 and urban speed limits to 30kph

would result in significant and immediate GHG savings. Reducing speed limits has no important fairness implications but is usually very unpopular.

- All EU member states banning diesel, petrol and fossil gas (CNG) cars from entering their cities and urban areas by 2025. This would require banning the still rather new cars bought today, so would entail forcing people to get rid of or replace their relatively new cars.
- Doubling or even tripling fuel taxes and road charges to make driving cars more expensive and therefore cut their use. While this may bring significant CO_2 cuts, if not implemented carefully, this could be the most unjust measure as it would hit those that rely on cars to commute to work and cannot yet afford the up-front cost of electric cars - often less wealthy and disadvantaged families living in cheaper and not well connected suburbs. To counter these effects would require wealth redistribution and massive investment into public transport or alternatives, such as providing shared electric vehicle fleets. Politically, this measure is the least fair or acceptable and, without the aforementioned caveats, could cause unrest.
- Limiting the type approval validity of existing cars on EU roads. Not dissimilar to the city bans, this would be a country-wide measure (mandated by national vehicle authorities) to shorten the type approval of existing cars on the road (for example, 10 years). This would remove old cars from circulation and force an accelerated fleet renewal to low and zero emission models. This requires strong political resolve from governments to be put in place, and without adequate funding support would again hit those less wealthy parts of society (or less wealthy Member States) disproportionately. It would also require proper environmental safeguards to ensure sustainable recycling.
- Applying considerably higher taxes on vehicle ownership and parking charges of single occupancy vehicles to push a much faster uptake of electric car sharing.
- Applying a cap or increased charge for vehicle miles that exceed a threshold.

4.3. Trucks and freight

On top of the fuel efficiency standards for trucks, a zero emission vehicle mandate on top of these standards could deliver a 15% reduction in emissions by 2030. A number of additional measures - not included above - could be contemplated by policy-makers. These are typically challenging in nature, and political feasibility has not been considered:

- Banning ICE trucks from all EU cities would lead to the rapid development e.g. zero emission urban freight solutions, including electric delivery vehicles or cargo bikes.
- Significantly increasing diesel taxes and road charges, banning the use of ICE trucks during weekends and at night would likely lead to a significant reduction in truck kilometres travelled and provided additional rail capacity is provided, modal shift. However, it could be economically disruptive and would be portrayed as economically disadvantageous for remote regions.
- Impose high minimum charges on next day deliveries and on returns. In other words, customers opting for next-day delivery would be subject to a minimum charge, with similar provisions for return of goods.

4.4. Aviation

In order to scale back emissions from the sector in line with progress achieved in for example the power sector, taxing fuel, slowly increasing zero emission aviation fuel uptake and restricting growth in air travel will not be sufficient. Whilst in the long run zero emission aviation is conceivable, in the short run radical

action would be needed to cut emissions from the sector mainly focusing on reducing the number of flights, in particular the number of long-haul flights which is disproportionately responsible for aviation's climate impact.

The aircraft fleet and the distances it flies would have to shrink by 2030 in order to rapidly reduce emissions from the sector. This could be achieved by imposing high taxes on kerosene (higher than the current diesel/petrol tax), requiring airlines to purchase multiple ETS allowances, by banning certain flights (night time, short or long haul) or by reducing the number of slots available at airports.

4.5. Shipping

The proposed CO_2 standard could have several measures combined with it to increase the rate of decarbonisation. They include:

- Mandating zero-emission operation for new luxury cruise ships starting from 2025. This could initially be implemented in the EU/member state territorial waters (12 nautical miles from the coast) and then extended to the EU/member state economic exclusive zone (EEZ, which is 200 nautical miles from the coast). Such a mandate can then be extended to all luxury cruise ships from 2035.
- Mandating zero-emission operation for new cargo ships starting from 2030. This could initially be implemented in the EU/member state territorial waters (12 nautical miles from the coast) and then extended to the EU/member state economic exclusive zone (EEZ, which is 200 nautical miles from the coast). Such a mandate can then be extended to all cargo ships from 2040.
- Very high carbon prices in the range of several hundreds of euros a ton, or even a thousand euro a ton would likely have a significant and immediate impact on shipping GHG emissions by suppressing demand. However, as this is not a T&E recommendation, we have not assessed the exact emissions impact of this measure, nor have we considered the socio-economic impact of sudden and sharp increases in shipping costs.

4.6. Fuels and infrastructure

This report, and others produced by T&E, have given guidelines on the necessary charging infrastructure required to meet an ambitious electrification of the fleet. Besides the uptake of new infrastructure, the following measures could be pursued to expedite the phase out of fossil fuels from the transport sector.

- A ban on fossil fuel sales at fuel stations, requiring fuel bowsers to be updated to fast chargers.
- A ban on all new gas refuelling infrastructure for transport.
- A ban on fossil fuel extraction across Europe.

5. Conclusions

The European Green Deal could be revolutionary for Europe[xlvii]. Transport has many challenges, but so do most other sectors of the economy. Policy makers must be as ambitious as possible so that transport can do as much as it can and is not given a free pass. This paper has shown that the Green Deal represents an unprecedented opportunity to fundamentally change the paradigm of the transport sector from fossil fuel dependent to renewable and sustainable. The paper details the policies and the laws that should be enacted to realise this change.

In order to reach a 55% reduction in transport emissions in 2030 requires a 65% reduction on today's emissions. The policy options presented in this report show an overall reduction of 28% from today, or 5% reduction compared to 1990, for all transport modes. This is considerably more than the European

Commission's Clean Planet for All LIFE scenarios which deliver a 20% reduction. The mid- century decarbonisation pathway that we have presented implies that other sectors will have to deliver more reductions than transport or alternatively, more measures will need to be put in place to stop the relentless growth of transport demand. Although achieving these reductions will be a formidable challenge, it will allow for unprecedented opportunities to overhaul the transport sector and in doing so, for Europe to lead the world in this field. Emissions aside, this pathway will help create jobs[xlviii], make Europe a hub of innovation, improve air quality in cities and at ports, improve quality of life, and facilitate more active transportation.

In terms of changing the technology of vehicles, vessels, aircraft, and the way they are fuelled and charged, this paper details a pathway that would be an unprecedented rate of transition in the sector. We have discussed (and where possible quantified) the policies that can stem transport demand, particularly in aviation and trucking, and policies that are required to both facilitate and encourage cleaner transportation.

The other side of the equation is transport demand, and this is a policy area where more effort can be realised. We had a deep dive into five countries in our Emission Reduction Strategy series of papers under the EUKI project[xlix]. It is clear that rising transport demand makes the challenge of decarbonisation more difficult, if not impossible if people continue to use the most inefficient or energy intensive means of travel (such as in single occupant cars or in planes). Modal shift from cars to cleaner modes such as buses, trains, cycling and walking is critical, but also has practical limits based on efficiency, cost, and distance. Likewise, shifting freight from trucks to trains can deliver significant GHG reductions, but this would also come at significant cost and has many practical constraints. Thus there will also need to be gradual downward pressure on travel demand in total. This can be achieved through fiscal and non-fiscal policies, for example by increasing transportation prices or reduce access particularly to the most polluting vehicles, but will also require more thought-out systemic change in the way we transport ourselves and goods around the continent and with cities and regions. Aside from systemic changes such as these, people will need to realise or be made aware of the pollution that their activities cause, and aim to reduce them or be legislated to do so.

There is a window of opportunity to avoid the most severe effects of climate change that is closing. The Green Deal, if done right, will shape the EU climate legacy. Transport has a vital role to play in that.

Annex I: The EU ETS and ESR and their targets explained

The EU has two cornerstone policies for reducing GHG emissions: the Emission Trading Scheme (the EU ETS) and the Effort Sharing Regulation (ESR), recently renamed Climate Action Regulation. The ETS is a cap and trade system, whereby companies must pay for permits (or allowances) for every tonne of CO_2 that they emit. Over time, less permits become available and that scarcity drives emission reductions. In reality however the scheme has suffered from an overallocation of allowances, and instead emission reductions in these sectors have been the result of more effective measures adopted at European and national level.

The EU ETS mainly covers major power plants and the largest industrial facilities. Alongside these installations, the ETS also covers all departing aviation flights from EEA airports. Since 2013 however, the ETS is currently only implemented in a limited scope called Stop the Clock, an exemption from departing flights leaving EU territories. In 2018, the EU ETS emissions were 1753 Mt CO_2, of which 67.5 Mt CO_2 (or 4%) were from intra-EU aviation. Aviation's share belies its 26.3% growth since 2013, compared to the 12% reduction in stationary emissions. The ETS currently has a 2030 sub-target of 43% compared to 2005 emissions.

The ESR covers the emissions not covered by the ETS, with the notable exception of international shipping, which is currently not covered by any EU emissions reduction regulation. For the ESR, the onus is on the member states to provide policies and incentives to reduce emissions. Targets are based on the country's gross domestic product per capita coupled with the cost effectiveness of the reductions[i] ranging from 0%-40%. Member states that don't meet their targets will need to buy allowances from countries that exceed them, or use 'banked' allowances that may have been accumulated during times of over achievement. The absolute reduction achieved at EU level is equivalent to 30% compared to 2005. The current 40% economy wide target for 2030 (equivalent to 3.3 Gt CO_2eq by 2030) compared to 1990 is thus achieved with 2030 targets (compared to 2005) of 43% for the ETS and 30% for the ESR.

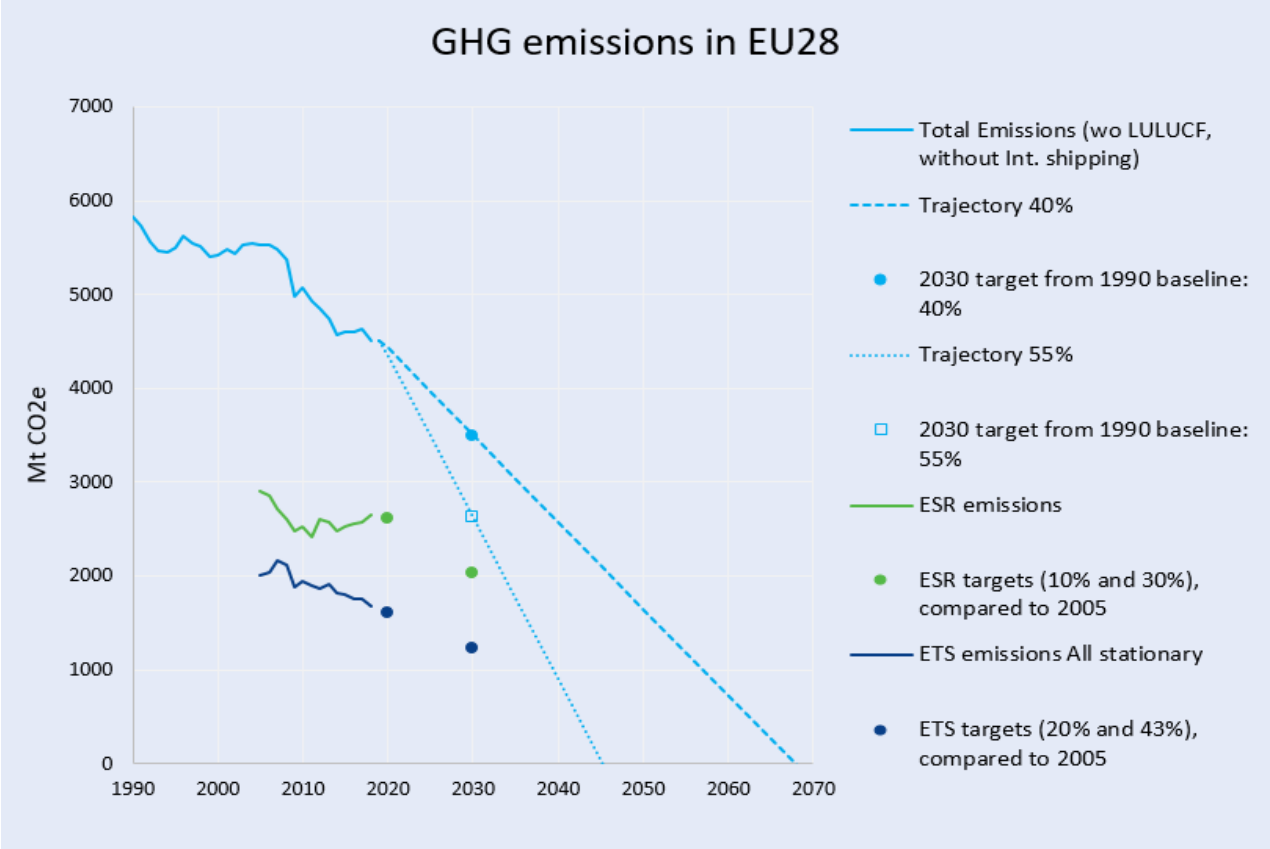


Figure A1: Total EU emissions and linear trajectories from 2019 with 40% and 55% reduction targets. From 2005, the ETS and ESR emissions are shown with their respective 2020 and 2030 targets. 2019 emissions assumed to be equal to 2018.

Figure A1 shows the historical evolution of EU GHG emissions from 1990 to 2018. In 1990, emissions were 5.8 Gt CO_2eq. From 2005, the ETS and ESR sector emissions are shown, along with their respective 2020 and 2030 targets. Linearly extrapolating 2018 emissions through a 40% or 55% 2030 target can give an indication of the effect of the target on cumulative emissions. A trajectory towards a 40% target indicates sector wide decarbonisation by 2068 and cumulative emissions of 107.9 Gt CO_2eq. If ambition were to be ratcheted up after 2030 to achieve 2050 decarbonisation, this would result in 79.0 Gt CO_2eq of cumulative emissions. Finally, extrapolating through a 55% target would result in 57 Gt CO_2eq cumulative emissions and would result in a decarbonised EU by 2045. In reality, the emission reductions are unlikely to be achieved linearly, with more challenging to abate emissions tending to tail off.

Figure A1 also highlights an important consideration: if the economy wide target is increased to 55%, how much should the sectors covered by the ETS and ESR reduce their emissions? Figure A2 shows how increasing overall ambition can come by increasing the reduction efforts in either the ESR, the ETS, or in both. As discussed, the current 40% reduction target (light blue line, Figure A2) is currently set at 43% target for ETS and 30% for ESR (as shown by the red dashed lines). It follows that a 55% economy wide reduction could be achieved with a 55% ETS target, and a 48% ESR target, for example.

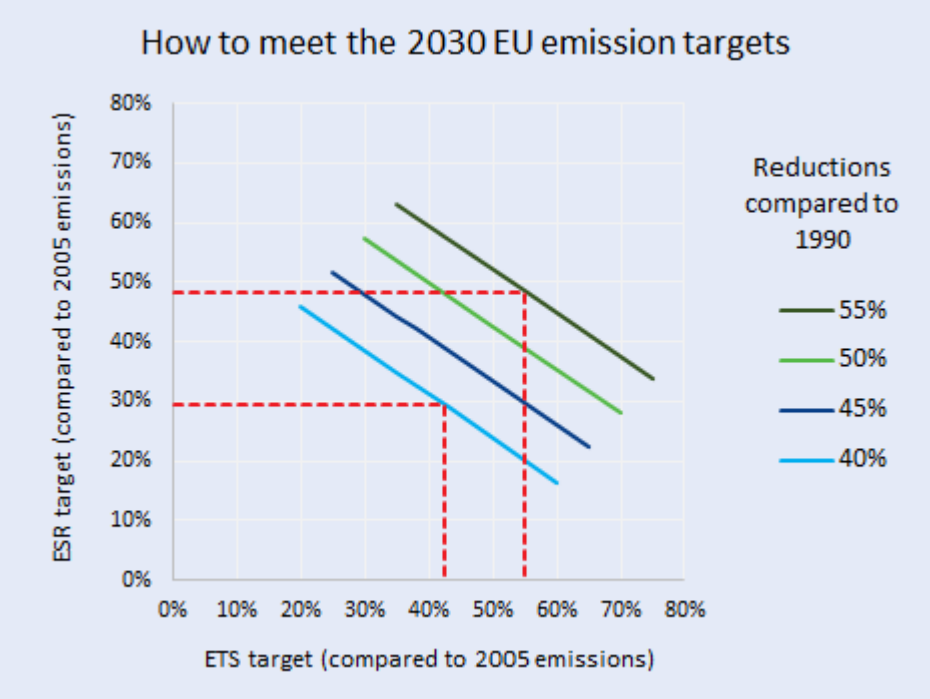


Figure A2: How the ETS and ESR sector reduction targets contribute to economy wide reductions. Red dotted lines show both the current split for the 40% target, and a hypothetical split for a 55% target.

Determining the cost-effective split between the ESR and ETS is not as trivial as reading it off the graph, unfortunately. Cost aside, there are many political and policy drivers at play too. For instance, in Ireland where agriculture emissions dominate, there will likely be a strong lobby to seek a higher reduction target in the ETS sector, whereas in member states such as Poland, where coal power plants are a significant share of national emissions, there could be a push in the other direction. What is clear however, is that all sectors will need to increase efforts in the near term to reduce emissions.

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