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Towards clean and smart mobility

Transport and environment in Europe

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Hans Bruyninckx
EEA Executive Director

Towards cleaner and smarter mobility

Transport connects people, cultures, cities, countries and continents. It is one of the main pillars of the modern society and economy, allowing producers to sell their products across the world and travellers to discover new places. Transport networks also ensure access to key public services, such as education and health, contributing to a better quality of life. Connecting to transport helps boost the economy in remote areas, creating jobs and spreading wealth.

Transport also plays a decisive role in shaping the way we live: our food, clothes and household waste all need to be transported; it influences what products are on offer and what we consume; and we use transport systems to go to work, school, the theatre and on holiday. Today high-speed train connections make long daily commutes possible, allowing people to live hundreds of kilometres away from their work.

There is, however, a downside to our current transport model. The transport sector causes substantial negative impacts on the environment and human health. Transport is responsible for a quarter of the EU's greenhouse gas (GHG) emissions, and causes air pollution, noise pollution and habitat fragmentation. More concretely, it is the only major economic sector in Europe where GHGs have increased since 1990 and is also the largest contributor to nitrogen oxides emissions, which harm health and the environment. Similarly, road transport is one of the main sources of environmental noise pollution in Europe.

Transport demand to rise further

Today the demand for transport in Europe is significantly higher than in 2000 and is expected to continue growing. According to European Commission estimates, by 2050 passenger transport is projected to grow by more than 50 % and freight transport by 80 % compared to 2013 levels.

Other challenges lie ahead. Europe's transport depends heavily on oil. Oil consumption not only releases GHGs and air pollutants into the atmosphere and contributes to climate change, but also makes the European economy more vulnerable towards fluctuations in global energy supplies and prices.

Moreover, despite transport's central importance to our economy and quality of life, not enough attention is paid to preparing Europe's transport infrastructure to the challenges posed by climate change. Can Europe's rail and

road infrastructure cope with higher temperatures? Disruptions in transport services — volcano ash in the air, flooded roads or damaged rail tracks due to extreme weather — can have serious consequences for travellers, daily commuters and businesses, well beyond the affected area.

The transport system also needs to adapt to changes in Europe's demographics. How can public transport be adapted to the mobility needs of an increasingly older population?

Technological improvements are not enough

In recent years, new cars and vans sold in Europe have become more and more energy efficient. For each kilometre travelled, they consume less fuel and release fewer pollutants than older models. Stricter policy measures have been instrumental in achieving these gains. Nevertheless, the number of vehicles on the road and the distances they travel continue to grow. Similarly, aircraft engines have become more efficient, but more passengers are flying and travelling further.

Incremental efficiency gains through technological improvements will fail to break the sector's dependence on fossil fuels and negate its environmental impacts. Even after recent efficiency improvements in car engines, only up to a quarter of the fuel burnt is actually used for moving the vehicle. The rest is lost as heat, mechanical inefficiencies or is used for accessories. Moreover, recent improvements in official fuel efficiency statistics have been questioned. There are significant discrepancies between fuel consumption observed in real-world driving and testing under laboratory conditions.

Ultimately, the issue is not just about cars, planes, roads, ships or fuels — the different components of the transport system — but about the need to move people and goods from one place to another in an easy, safe and efficient way. We must build a clean, smart and comprehensive 'mobility' system that caters to mobility needs by offering a service tailored to user requirements.

Defining the mobility need: essential or a treat?

The need may vary depending on the way we live. People living in compact cities where everything can be accessed on foot are less likely to rely on private cars. Fuel prices, housing and job markets, income levels and low interest rates on bank loans can all influence how much and how we travel, or how the goods we consume are brought to us. Even topography can influence our choice of transport.

Globalisation of markets (e.g. global trade and travel) would not have been possible without extensive transport networks. The world economy grew along with transport demand, each fuelling the growth of the other. In today's globalised world, consumers can buy products that only a few decades ago were not on offer, and which are now delivered to their doorsteps. Our lifestyles and consumption aspirations have changed accordingly. We expect to find cheap tomatoes on supermarket shelves and to take affordable vacations all year round. Ultimately, we should not be afraid of asking whether we actually need all this transport. The mobility need can be assessed in different ways. First, is the journey essential or just a pleasant treat? Can it be avoided? Second, can the journey be shifted to a more environment-friendly transport mode, such as opting for train travel instead of flying, or for public transport instead of driving? And last, can the transport mode be improved?


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The European Union's transport policies build on these 'avoid, shift and improve' principles, among others. Many measures in use to help curb the negative impacts of the transport sector, including fuel taxes, tolls or other road charges, are based on the 'user/polluter pays' principle. Such measures usually aim to reduce environmental impacts. Higher taxes and tolls, for example, might increase the price of using the vehicle, which in turn can lower the demand.

Unfortunately, the prices users currently pay for transport services do not reflect the full cost on the environment and public health. Carbon prices, global oil prices and passenger car prices tend to be too low to send a strong signal to users and investors.

Furthermore, the price signal can be distorted by transport subsidies, the use of which remains widespread in Europe. In some cases, subsidies are designed to promote cleaner modes, e.g. those provided to public transport. In other cases, such as tax breaks for company cars, tax exemptions on international aviation or shipping fuels and differential tax treatment for diesel and petrol, subsidies can have adverse impacts on the environment and lock the transport system in to an unsustainable path.

Mobilising ideas, policy and funds

The current mix of transport modes and fuels is simply not sustainable. The choice is ours: we can choose to build a clean, accessible, coherent, climate-resilient mobility system that greatly contributes to our quality of life and well-being.

Cleaner and smarter transport can actually meet Europe's need for mobility, and at the same time deliver many public health benefits, including cleaner air, fewer accidents, less congestion and less noise pollution. Where feasible, encouraging a switch to active mobility modes, such as walking and cycling, can also help improve other health problems such as cardiovascular diseases and obesity.

It is clear that decarbonising Europe's transport sector will take time. It requires a combination of measures, including better urban planning, technological improvements, a wider use of alternative fuels, stronger price signals, innovative research, continuous adoption of cutting-edge technology and stricter enforcement of existing rules. It also requires all investments in infrastructure and policy measures to be designed to this end.

Turning Europe's carbon-dependent transport sector into a clean and smart mobility system might seem like a colossal task. It can be done and we know how we can make it happen. It is also a must, given the current transport system's impacts on the environment and public health. I personally see it as an exciting opportunity for us to build a better and cleaner future.

Hans Bruyninckx
EEA Executive Director

EU targets to reduce greenhouse gas emissions

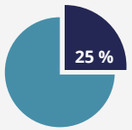
Several EU targets have been set to reduce the environmental impacts of transport in Europe, including its greenhouse gas. The transport sector's targets are part of the EU's overall goal to reduce greenhouse gas emissions by 80–95 % by 2050.

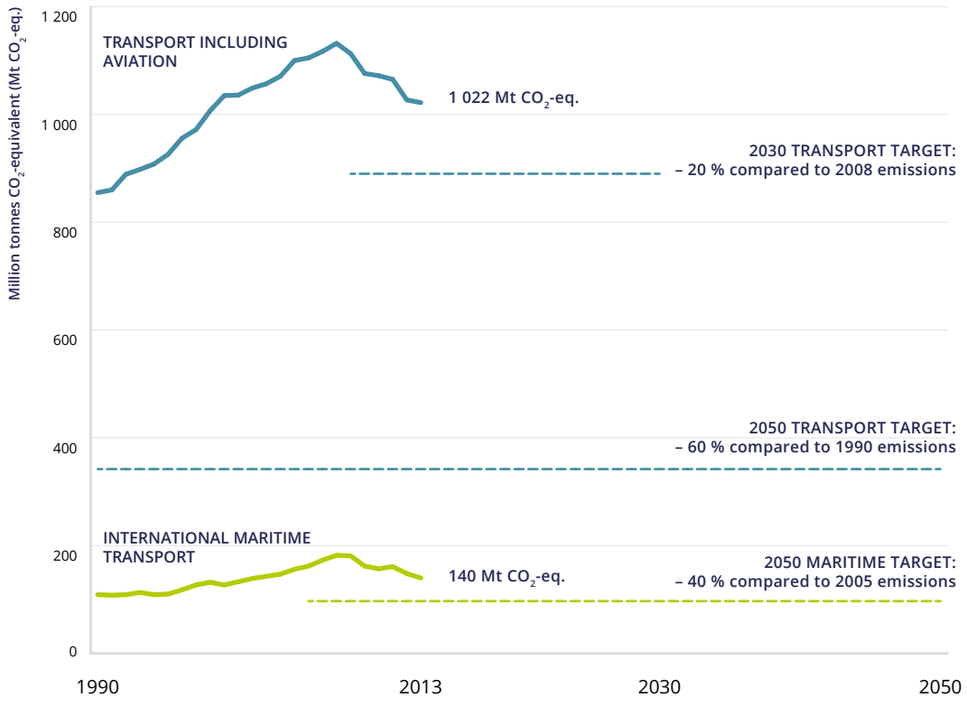
The EU's transport sector depends on oil for 94 % of its fuel, 90 % of which is imported. This makes it particularly vulnerable to instability and changes in the global energy market. A disruption in the energy supply could severely undermine the economy and hamper the quality of life in the EU.

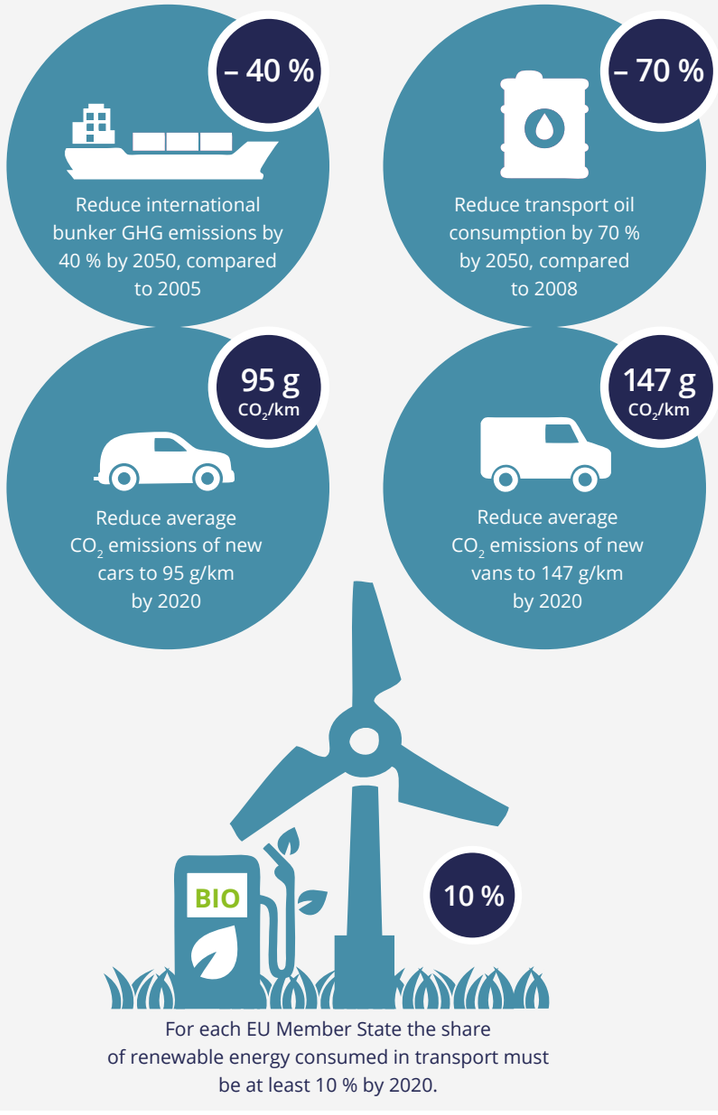
Key targets to be reached by 2050:

Reduce transport (excluding international maritime) greenhouse gas (GHG) emissions by 60 % compared to 1990 levels and reduce international maritime transport emissions by 40 %, compared to 2005.

Transport's total share of EU GHG emissions in 2014







Sources: EEA Report No 15/2016 *Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016*; EEA Report No 7/2015 *Evaluating 15 years of transport and environmental policy integration — TERM 2015*; EEA GHG data viewer

Source: EEA Report No 7/2015 *Evaluating 15 years of transport and environmental policy integration — TERM 2015*

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Transport in Europe: key facts and trends

Despite temporary slowdowns, the demand for transport of both passengers and goods has been growing steadily and is projected to continue. As such, more and more cars are sold in Europe, the majority of which are diesel powered. And while engines are becoming more efficient, this growth means GHG emissions are a major concern.

Europe is connected through a network of roads, railway lines, inland waterways, inland and maritime ports, airports and rail-road terminals. Not counting secondary roads and railway lines, the trans-European transport network (TEN-T) alone consists of more than 138 000 km of railway lines, 136 700 km of roads and 23 506 km of inland waterways. Around 879 million passengers travelled by air in the European Union in 2014[1], of whom 73 million used London's Heathrow Airport alone. Finally, close to 3.8 billion tonnes of goods were handled in EU ports,10 % of which was handled by Rotterdam.

More freight and more passengers

The volume of freight has increased considerably since the 1990s, despite a relative decrease following the economic recession in 2008. This increase has been largely accommodated by road transport, which accounted for 49 % of EU freight transported in 2013, and to a lesser extent, sea and rail transport. However, road transport emits considerably more carbon dioxide (CO_2) per kilometre than other modes, such as rail and inland waterways.

Similarly, the demand for passenger transport (measured in passenger kilometres) also grew by more than 8 % between 2000 and 2013 in the EU, with flying experiencing the most rapid growth. Finally, EU citizens travelled approximately 12 850 km per person in 2013 — more than 70 % by car — representing a 5 % increase from 2000.

More cars on the road

This growth means that road transport now accounts for almost three quarters of the energy used in transport in the EU. Sales of new passenger cars in the EU increased by 9 % in 2015 compared to the previous year, with a total of 13.7 million new cars registered.

Recent data point to a growth in diesel consumption in road transport, up from 52 % of total road fuel consumption in 2000 to 70 % in 2014. Similarly, just over half of the vehicles sold in Europe are

diesel, corresponding to 52 % of sales in 2015. The share of diesel vehicle sales varies from country to country, ranging from 71 % in Ireland and Luxembourg to 29 % in the Netherlands and 28 % in Denmark. Larger vehicles are more likely to use diesel, and over last four decades, the average mass of passenger cars has increased mainly due to consumer preferences and improved safety standards[2]. Heavier cars tend to use more fuel and emit more greenhouse gases and pollutants.

Different types of electric vehicles are now available on the European market. Some rely entirely on an electric battery to power the vehicle, while others use a combination of electricity and petrol/diesel-hybrids.

More and more hybrid and battery-electric vehicles are being sold in the EU. Although they still represent just 1.3 % of all new cars sold, in some countries, electric cars are becoming a more common sight. According to provisional data, in the Netherlands 12 % and in Denmark 8 % of the new cars sold in 2015 were electric or plug-in hybrid[3]. In terms of purely electric cars, the largest number of registrations was recorded in France (more than 17 650 vehicles), Germany (more than 12 350 vehicles) and the UK (more than 9 900 vehicles). Electric two wheelers have also become more common, especially for journeys within urban areas.

Financial incentives, such as subsidies or preferential tax treatments (e.g. free parking in city centre, possibility to drive on bus lanes, free tolls, lower fuel or registration taxes), play a major role in the consumer's choice of the type of car purchased.

Transport and greenhouse gas emissions

Motorised vehicles need the energy generated from fuel (e.g. petrol, diesel, electricity, natural gas, biofuels) to move. But the high temperature combustion of fossil fuels in engines releases air pollutants and CO_2 into the atmosphere.

Transport demand is closely linked to economic activity: in periods of growth, economic output goes up, more goods are transported and more people travel. The economic recession of 2008 resulted in lower transport demand and, consequently, in reduced greenhouse gas emissions (GHG) from the sector in the following years following. Despite this slow down period, the EU's overall transport emissions in 2014 were 20 % higher ([i]) than their 1990 levels. In 2014, about a quarter of the EU's total GHG emissions came from transport ([ii]). According to preliminary data, passenger cars contributed to 44 % of transport sector emissions, and heavy-duty vehicles and buses a further 18 %.

Emissions from different transport modes varied substantially over time. International aviation emissions almost doubled and road transport increased by 17 % in this period, whereas emissions from rail transport and inland navigation declined by more than 50 % and almost 37 % respectively.

Reduction targets

The EU has set itself several targets to reduce GHG emissions from transport. In its White Paper published in 2011, the European Commission set a target of a 60 % reduction from 1990 levels by 2050. This means that current levels need to be reduced by two thirds.

Transport also needs to contribute to the EU's overall targets for GHG emissions reductions by 2020 and 2030. Part of the 2030 target will be achieved through the EU Emissions Trading Scheme (EU ETS). Although it includes emissions from aviation, other transport emissions are excluded. This means that with the exception of intra-EU aviation, the remaining transport modes will need to contribute to the 30 % reduction effort for the sectors excluded ([iii]) from the EU ETS.

To achieve GHG emissions reductions in these non-ETS sectors, the overall EU effort is shared among Member States. Each

([i]) Preliminary data for 2014, including international aviation and excluding international maritime GHG emissions.

([ii]) One-fifth excluding international aviation and shipping.

([iii]) Buildings, agriculture, small industry and waste

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country then decides how to achieve its national target. This is known as the Effort Sharing Decision and it will contribute to a '30 % reduction by 2030'. Currently, around one third of the GHG emissions from non-ETS sectors come from the transport sector.

The EU's transport sector depends on oil for 94 % of its fuel[4], 90 % of which is imported. This makes it particularly vulnerable to instability and changes in the global energy market. A disruption in the energy supply could severely undermine the economy and hamper the quality of life in the EU. To this end, the EU aims to reduce its oil consumption in transport (including maritime bunkers) by 70 % by 2050 compared to 2008 levels.

All these targets require reliable and effective monitoring and measuring systems to measure progress. The European Environment Agency helps evaluate progress through datasets, indicators and reports, including the annual transport and environment report TERM.

Carbon dioxide from cars and vans

To help reduce the EU's overall GHG emissions, the EU has put in place increasingly stringent mandatory targets for average CO_2 emissions for new passenger cars and vans. By 2015, new cars registered in the EU had to achieve the average emissions target of 130 grams of CO_2 per kilometre (g CO_2/km). This target was achieved two years ahead of the deadline. According to the latest EEA data, new cars registered in 2015 emitted on average 119.6 g CO_2/km. The next target is set at 95 g CO_2/km by 2021.

Similar targets are set for light commercial vehicles (vans). New vans registered in the EU must meet the average emissions targets of 175 g CO_2/km by 2017, and 147 g CO_2/km by 2020. The 2017 target was achieved four years ahead of schedule. In 2015, average emissions for new vans amounted to 168.2 g CO_2/km.

Official test results show that vehicles are becoming more energy-efficient and are polluting less. However, there are concerns regarding the way emissions are measured. The targets set in EU legislation are based on a standardised procedure, which is necessary to compare between different models over time. The testing procedure currently used in the EU — the New European Driving Cycle — was introduced in 1970 and last updated in 1997. It no longer reflects real-world driving conditions in Europe. European traffic has changed considerably since then. Cars have become heavier and faster; roads more congested. The current procedure also allows manufacturers many flexibilities in testing parameters, such as vehicle mass, tyre pressure and adjustments to brakes. As a result of all these factors combined, cars and vans tend to emit significantly higher amounts of carbon dioxide on the road than in a laboratory under the current testing procedure. According to research by the International Council on Clean Transportation (ICCT), real-world emissions of CO_2 are up to 40 % higher than emissions measured in the testing laboratory[5].

Recognising such shortcomings, in January 2016, the European Commission proposed a number of changes to the current vehicle type-approval framework. These are designed to strengthen the independence of vehicle testing, and improve the enforcement and market surveillance regimes. A new emissions testing procedure known as the 'Worldwide harmonized Light vehicles Test Procedure' (WLTP) will also be introduced in the future so that laboratory results can better represent actual vehicle performance on the road. However, the date of its introduction remains to be decided. This should help ensure more accurate reporting of emissions and fuel data, which will also provide better guidance to consumers and help them make informed decisions.

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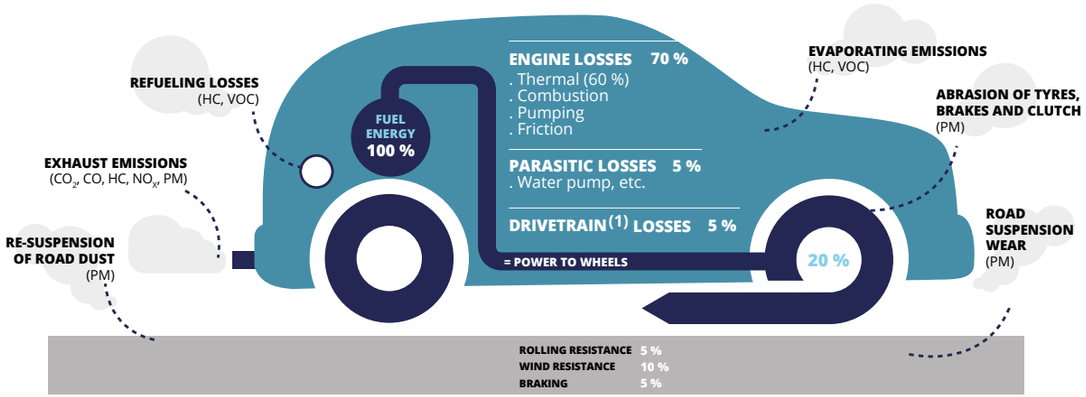
Air pollutants

In 2013, the EU transport sector contributed 13 % and 15 % of the total PM_{10} and $PM_{2.5}$ primary emissions, respectively. While exhaust emissions from vehicles have fallen since 1990, reflecting advances in vehicle technologies such as particulate filters, in contrast, non-exhaust emissions of particulate matter from brake and tyre wear have increased. Today, these non-exhaust sources make up a large fraction of total vehicle particulate matter emissions — around half of PM_{10} and a third of $PM_{2.5}$ emissions. In addition, emissions from international shipping within European seas contribute an additional 15 % of the total $PM_{2.5}$ emissions in the EU. This is notably a problem in major port cities.

Nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$) are the two main air pollutants from road transport. To limit exhaust emissions from passenger vehicles, the EU has introduced 'Euro standards' for various air pollutants, including NO_x and PM. Euro standards set different limits for petrol and diesel vehicles per pollutant and have become increasingly stringent over time. For example, a diesel car tested according to the latest 'Euro 6' technology is allowed to emit just 3 % of the particulate matter that a diesel car tested under the Euro 1 technology could emit 20 years earlier.

Vehicle emissions and efficiency

Fossil fuel powered road transport represents the most significant source of transport related air pollution. Each vehicle releases pollutants from a number of sources.



(1) The drivetrain of a motor vehicle is the group of components that deliver power to the driving wheels. This includes the transmission, the axles and the wheels.

HC - Hydrocarbons; **VOC** - Volatile Organic Compound; **PM** - Particulate Matter; **CO** - Carbon monoxide; **CO_2** - Carbon dioxide; **NO_x** - Nittrogen oxides.

Source: EEA Report *Explaining road transport emissions — a non-technical guide* (2016)

Such standards have been instrumental in reducing air pollution from transport. Emissions of nitrogen oxides (NO_x) ([iv]) from petrol cars have decreased significantly since 2000, although those from diesel cars have not decreased to the same extent.

Without effective after-treatment, diesel engines, in particular, are high emitters of nitrogen dioxide (NO_2). NO_2 is a significant problem at ground level in urban areas, with the transport sector the largest contributor to emissions, accounting for 46 % of total NO_x emissions in the European Union in 2013[6]. The number of diesel vehicles on the road has been increasing in recent years, impacting air quality. Without this 'dieselisation', air quality in Europe would have improved further.

Discrepancies exist between real-world and test measurements of NO_x. ICCT studies[7] estimated that real-world NO_x emissions from diesel vehicles were on average seven times higher than the limits set by

([iv]) Nitrogen oxides (NO_x) is a generic term, referring to nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x gases are formed whenever combustion occurs in the presence of nitrogen (in air and/or in the fuel), e.g. in an air-breathing engine. NO_x can also be formed naturally, e.g. by lightning.

the Euro 6 standard. To help reduce this gap, the EU has recently agreed on a 'Real Driving Emissions' test procedure for NO_x emissions from new cars starting in 2017. Public awareness of the high on-road emissions of NO_x emissions has also greatly increased following the September 2015 revelations that Volkswagen used a so-called 'defeat device' in diesel cars to lower emissions during vehicle testing in the USA. The European Union and national authorities are currently carrying out investigations on the issue of vehicle emissions including the potential use of such cheat devices in Europe.

Clean energy for transport

Transport continues to rely heavily on fossil fuels, especially petrol and diesel. The impacts of transport on human health, the environment and climate change are closely linked to the choice of fuel. Clean alternative fuels, including electricity, are already available and can constitute viable options to petrol and diesel. Trip length plays a role in determining the suitability of the fuel type. For example, electricity might be more suited to passenger cars in urban settings or those travelling shorter distances. The uptake of cleaner fuels also depends on the extent of the infrastructure and incentives offered to prospective owners (lower taxation, free tolls, etc.).

EU legislation (ʸ) requires that each EU Member State meets 10 % of its transport energy consumption from renewable energy sources by 2020. The legislation identifies certain sustainability criteria and only those biofuels that comply with these criteria are considered 'sustainable' according to this legislation.

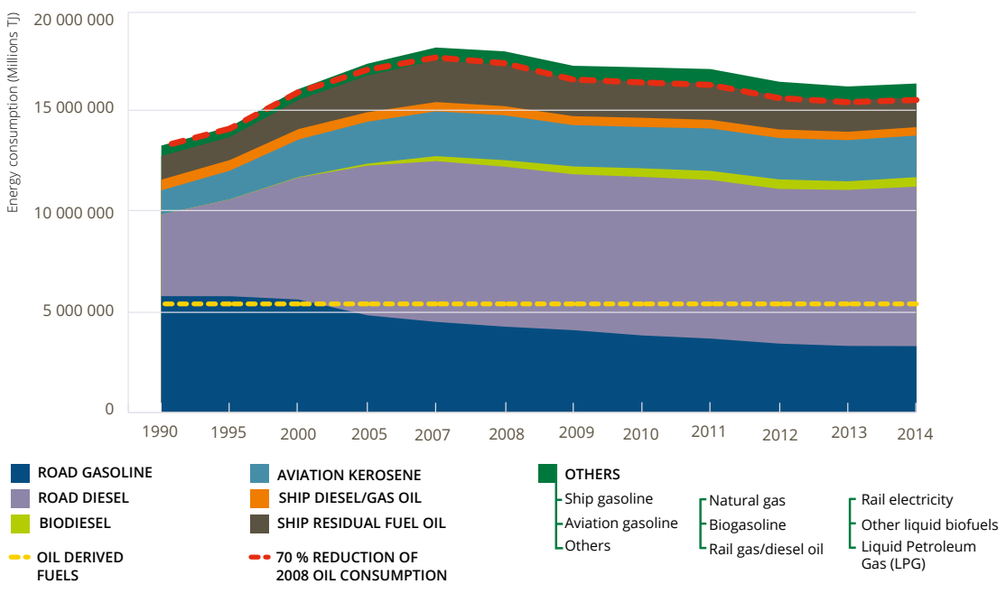
Moreover, the end product (electricity, biofuels, etc.) is not the only factor determining how environmentally sustainable a fuel is. The way the actual fuel is produced should also be taken into account. For example, electricity generated by wind power is certainly cleaner than electricity produced by coal. Transport's demand for energy can be best addressed through a comprehensive analysis and vision for the entire energy system, taking into account the demand from all economic sectors and the supply potential from a mix of energy sources.

(ʸ) Indicative target stipulated in the Renewable Energy Directive.

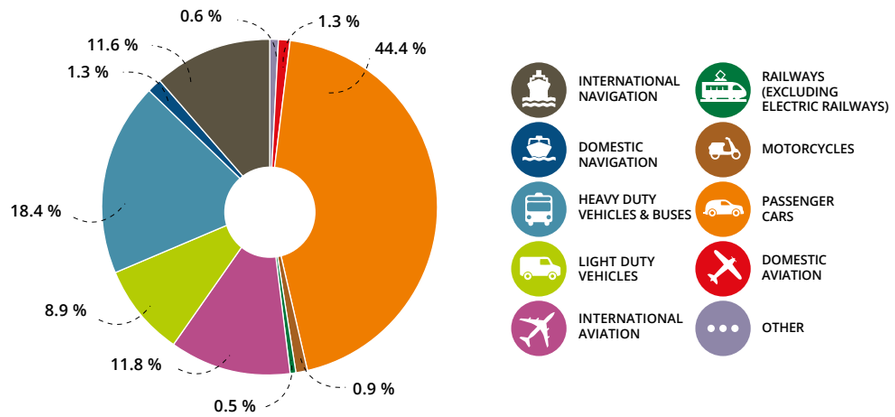
Fuel types and GHG emissions

Transport demand is closely linked to economic activity: in periods of growth, economic output goes up, more goods are transported and more people travel. The impacts of transport on human health, the environment and climate change are closely linked to the choice of fuel. Clean alternative fuels, including electricity, are already available and can constitute viable options to petrol and diesel. Trip length plays a role in determining the suitability of the fuel type.

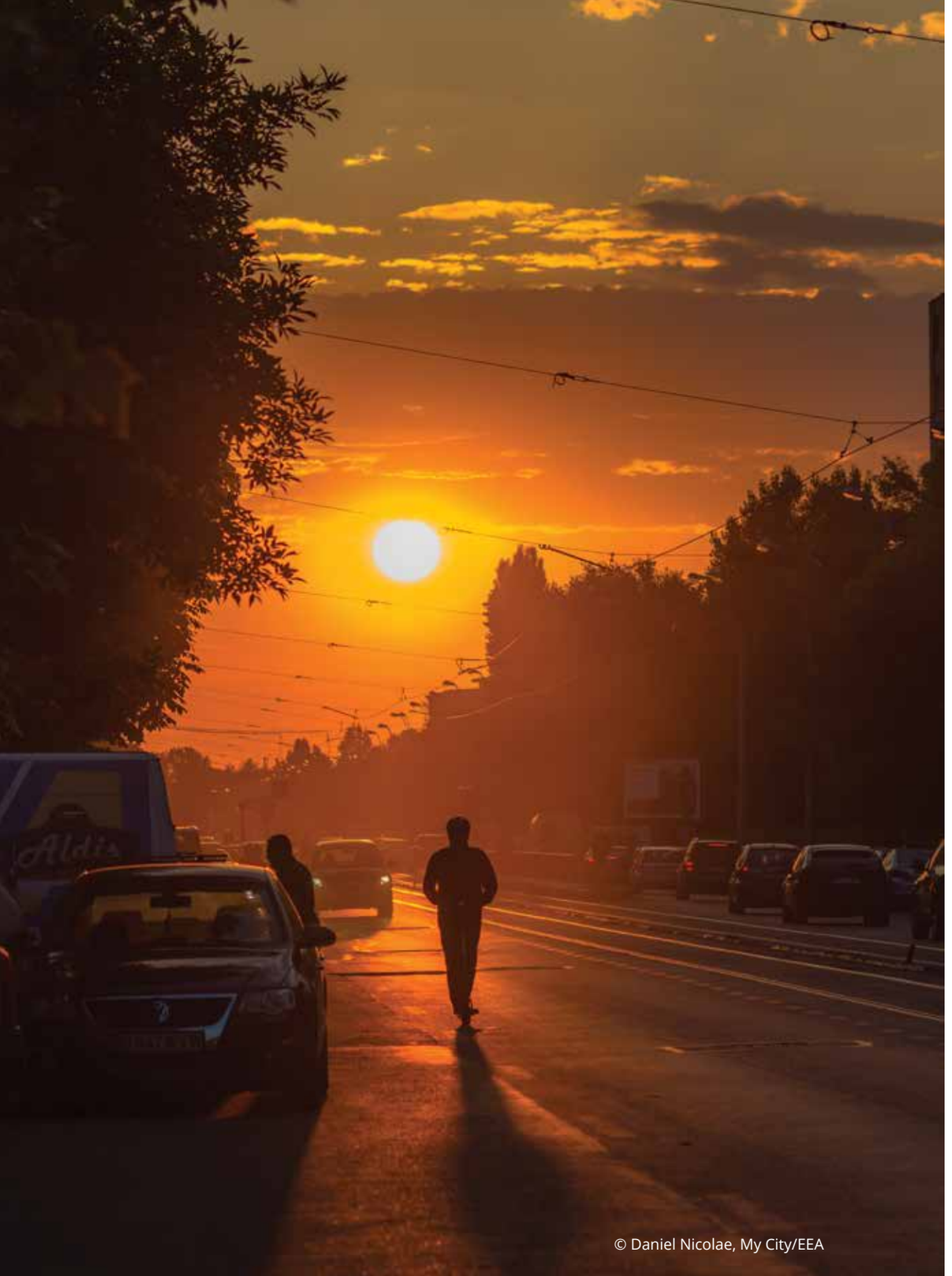
Energy consumption by fuel type



GHG emissions from transport in EU-28, 2014 (based on provisional data)



Sources: EEA Indicator TERM01; EEA data based on EEA Report No 15/2016 *Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016*



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Transport and public health

Air and noise pollution from transport cause a wide range of health problems, with road transport and diesel vehicles in particular the biggest contributors. The European Union and its Member States are taking a series of measures to reduce the impact of transport on health with some success. Innovative solutions and local action can improve the situation further.

The World Health Organization (WHO) recently warned of health-threatening air pollution levels in major cities around the world. Just days into 2016, several European cities including London[8] and Paris[9] were affected by pollution episodes. Citizens were invited to change their behaviour by using public transport networks or car sharing in order to prevent the problem from worsening. Given specific meteorological conditions coupled with high pollutant emissions and projected extreme heat events linked to climate change, we can expect pollution episodes to become more frequent.

There is clear and increasing evidence of the health impacts that exposure to a whole range of air pollutants can have. Although only episodes of high pollution might be making the newspaper headlines, long-term and continued exposure to even low concentrations of air pollutants is much more harmful to human health.

The European transport sector has achieved significant reductions in the emissions of certain major air pollutants — mainly due to the introduction of emissions standards, financial measures and, to a lesser extent, alternative-fuels and transport avoidance measures. But more work is needed to continue to reduce pollution levels and meet European Union targets for 2030 and beyond. Although it is the biggest culprit, it is not only the road transport sector that needs to reduce emissions — air, shipping and rail also contribute to air pollution and must not be ignored.

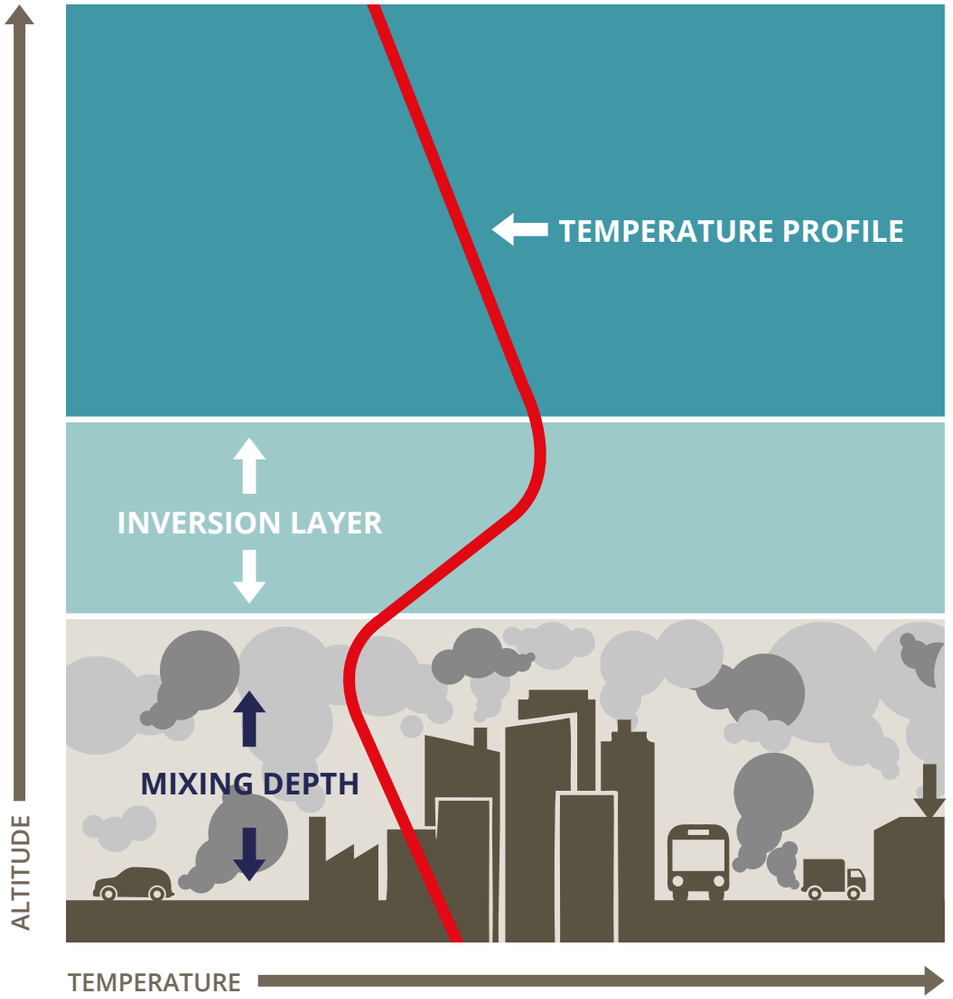
Similarly, noise pollution threatens human health and wellbeing, with road traffic again the most widespread contributor. While there have been reductions in air pollutants from transport, exposure to noise levels above accepted limit values has remained constant across European urban areas in recent years.

Health impacts of transport

The most recent figures for Europe show that, despite considerable emissions reductions in the last decade, more than 400 000 premature deaths[10] per year can be attributed to air pollution from all sources.

Temperature inversion traps pollution at ground level

Pollution events are more likely to occur under temperature inversion conditions. During extended periods of high pressure in winter months, solar radiation reaches the ground, warming it up. At night, the lack of cloud cover means the ground loses heat rapidly and the air in contact with the ground becomes colder. The warmer air rises and acts as a lid, trapping the colder air close to the ground. Pollution, including that from road traffic is also trapped, so the air layer closest to the ground becomes more and more polluted. This continues until the prevailing meteorological conditions change.



Source: Clovis Online School, Lesson 7-03 Temperature Inversions; cosscience1.pbworks.com

Individual air pollutants can cause a variety of health impacts. Nitrogen oxides, particulate matter (PM_{10} and $PM_{2.5}$), sulphur oxides, carbon monoxide, and various heavy metals such as cadmium, lead and mercury are all emitted from the exhausts of vehicles. In addition, precursor chemicals in exhausts may react in the atmosphere giving rise to the formation of ozone. Finally, particulate matter and heavy metals are also released into the air as a result of tyre and brake abrasion and, once they have been deposited on the pavement may be 're-suspended' in the air by passing cars.

Exposure to these pollutants can have very specific health impacts, but in general, the organs, nervous system and blood are affected, causing or aggravating ailments such as lung disease — leading to respiratory problems — heart attacks, asthma, anxiety, dizziness and fatigue[11].

Noise also has significant health impacts. Exposure during the night can cause sleep disturbance, leading to adverse health effects. Long-term exposure during an average day period can result in increased blood pressure and cardiovascular disease among other illnesses. As many as 80 % of Europeans are expected to be living in urban areas by 2020, with a large number of these near busy transport infrastructure and hubs such as airports and motorways.

An estimated 125 million Europeans (or one in four) are affected by noise levels from road traffic that exceed an average annual day, evening and night level of 55 decibels (55 dB L_{den}). Due to incomplete reporting, these numbers are likely significantly higher.

Recent figures suggest that such exposure leads to 20 million Europeans experiencing annoyance from noise, as well as 8 million suffering sleep disturbance, 43 000 hospital admissions and at least 10 000 premature deaths. In addition, noise from aircraft movements in and around airports affects a considerable number of people, including school children — at least 8 000 of whom suffer reading impairment in Europe as a result of exposure to high noise levels.

Tackling air and noise pollution

Current European transport, air quality and noise legislation deals with air pollution and environmental noise, with a view to improving human health and the environment. European emissions standards (Euro standards) regulate emissions of pollutants from different types of vehicles. For example, the current Euro 6 standard, in force for new vehicles since 2014, sets emissions limits of particulate matter from petrol and diesel cars at 5 milligrams per kilometre (mg/km), a fivefold reduction compared to 2005 levels[12]. Similarly, NO_x emissions limits are set at 80 mg/km for diesel cars and 60 mg/km for petrol cars, again, marking a considerable reduction since 2005.

Euro standards include specifications for vehicle testing but there are significant differences between official vehicle emissions (i.e. those recorded under test conditions) and real-world emissions. Measures are being taken to rectify this, including the development of new test specifications and the roll-out of Portable Emissions Measurement Systems (PEMS), which can be fitted to cars to measure on-road conditions.

To reduce harm from noise pollution, the EU has put in place different measures, including technical standards to limit noise emissions at source (e.g. EU tyre labelling to help consumers identify 'quieter' tyres). The Environmental Noise Directive complements such standards. It aims to improve the quality of data collected with a view to better managing the relationship between residents and traffic. The directive requires action plans to be drawn up[13] for major transport sources and the largest urban areas, the aim of which is to reduce the impact of noise on the affected population — and reduce noise itself if necessary — as well as to protect quiet areas, i.e. those areas free from noise pollution. These action plans are currently in a third five year cycle, running until 2018.

In parallel with EU efforts, many local and regional initiatives are looking for innovative solutions to transport-related air pollution and noise problems. The 'Ljubljana Step-by-Step Approach' and Seville's Big Bang'[14], which ran between 2006 and 2013, are two such initiatives that favour cycling infrastructure development. Both have successfully reduced traffic congestion, improved air quality and lowered GHG emissions. In Seville, while the number of daily car journeys into the town centre dropped from 25 000 to 10 000 over the duration of the project, a 29 % drop in NO_2 and a 19.5 % drop in PM concentrations were measured. Meanwhile, in Ljubljana, the modal share of cycling as a proportion of total traffic rose by 20 % during the project. These figures indicate impressive results. Regarding improvements in health or noise reduction, there are no official data, although anecdotal evidence suggests noise levels dropped significantly in both towns.

Looking at the future

Given these legislative frameworks and innovative solutions, emissions of air pollutants from transport are expected to continue their decline across Europe, with positive impacts on human health. However, 87-90 % of city dwellers in the EU are still exposed to levels of air pollutants[15] deemed harmful by the WHO. In fact, by meeting these levels for $PM_{2.5}$, it is estimated that some 144 000 premature deaths[16] could be avoided. In the longer-term, Europe will need to further integrate policy measures and actions to reduce air pollutant emissions and create the conditions for better health and wellbeing of European citizens, and avoid the effects of pollution episodes such as those in London and Paris. Reducing pollutant emissions from transport could certainly help improve air quality, in urban areas in particular.

The situation for noise is even more challenging. Noise is a pervasive pollutant in Europe and continued economic growth, increased industrial output, expanding urbanisation and related transport needs will continue to threaten the quality of Europe's soundscape. This will have an impact on the health of Europeans. Noise from road traffic will remain the biggest threat, while noise from airport activities will continue to affect those living nearby. Improved noise reporting is essential to build a more complete picture of the health impacts it brings about. Countries are encouraged to continue to develop their noise action plans, but the focus should also be on noise reduction at source — a far more efficient way of solving the problem.

Measuring annoyance from noise

L_{den} is a descriptor of noise level based on an energy equivalent noise level averaged over a whole day. It is designed to assess annoyance. The Environmental Noise Directive sets L_{den} at 55 dB for noise mapping assessments and action planning. For assessing sleep disturbance in an exposed population, the directive recommends the application of an L_{night} indicator, with a threshold of 50 dB.

Noise pollution in Europe

Noise pollution is a growing environmental concern, arising from a number of sources. The adverse effects of noise pollution can be found in the well-being of exposed human populations, in the health and distribution of wildlife, as well as in the abilities of children to learn at school.

To reduce harm from noise pollution, the EU has put in place different measures, including technical standards to limit noise emissions at source. The Environmental Noise Directive complements such standards.

Noise levels from road traffic that are greater than 55 dB L_{den} affect an estimated **125 million people — one in four Europeans.**

> 55 dB L_{den}

ANNOYANCE

20 000 000

Almost 20 million Europeans are annoyed by environmental noise.

SLEEP DISTURBANCE

8 000 000

At least 8 million Europeans suffer sleep disturbance due to environmental noise.

HEALTH IMPACTS

43 000

Noise pollution causes 43 000 hospital admissions in Europe per year.

PREMATURE DEATHS

10 000

Noise pollution causes hypertension and cardiovascular disease, leading to an estimated 10 000 premature deaths annually in Europe.

Source: EEA Report No 10/2014 *Noise in Europe*; www.eea.europa.eu/themes/noise.

Helle Søholt
Gehl Architects

'People-first' for green, liveable cities

Our cities are under pressure like never before from increasing populations, traffic gridlock and climate change. How can we make them easier to get around, more liveable and sustainable? One urban design firm is helping transform the way we plan cities. We talked to Helle Søholt, founding partner and CEO of Gehl Architects, Copenhagen, to find out.

What does an ideal city look like and is such a model realistic?

It is difficult to create the perfect green city, but we do have an overall vision. Our key guiding principle can be summarised as 'people first'. We are making cities for people — to support their ability to have a better quality of life in a sustainable way, while ensuring social inclusion both in the short and long term. We have to understand people's physical and social requirements and their need to have access to work. In addition, cities must have a well-integrated mobility system and the capacity to deal better with climate change. We see cities struggling globally on these issues, but putting in place practical solutions to these issues is realistic.

In terms of mobility, well-built transport networks need to be put in place to ensure that the city is walkable and 'bikeable'. People should be able to get around very easily, not only in their local neighbourhoods but also over distances between 5 and 10 kilometres away.

Public and green areas are also essential. They enable us to meet others and feel connected but also give us a sense of freedom and space beyond our private homes. A city needs a wide variety of accessible public spaces in local neighbourhoods like playgrounds for kids and families, local parks and calm areas that bring us closer to nature. People who have access to nature feel less stress in urban environments.

A city should also have other types of public spaces, such as plazas or squares, where people can gather and enjoy commercial or cultural activities. Such diversity of space in a city helps meet people's social needs. Similarly, the buildings should consist of a mix of old and new, offering residential opportunities for all income groups and integrating work places. All these places should be easily reachable by public transport to encourage people to adopt sustainable behaviour.

New Road, Brighton, UK

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How do you assess mobility problems?

We have developed a data-driven approach; what we call the 'public life/ public space method'. Many cities already assess economic performance, public transport use, and current and future vehicle use. But the more social and cultural elements of the city are often not assessed. Here at Gehl Architects, we try to map these elements and make them visible. Who are the people using the city? How do they move? What public activities take place in the city? Who attends them? What can we do for those groups not using the city? We try to get to the root of certain behavioural patterns and use this knowledge to develop the city.

For example, in one of our projects, we conducted a public space/public life survey to understand why New Road was failing to attract people — pedestrians, shoppers — although it was located in the popular core of Brighton in the United Kingdom. Our analysis showed that the road would be a perfect link between the inner city and the nearby university and library. We proposed to open it up towards the park nearby and designed it for pedestrians, but allowed vehicles to pass at low speed. The street became very quickly the fourth most used space in the city.

Who contributes to a city's design?

We work closely with community groups, local NGOs, business improvement groups and local government. When we upgrade a city, we have to make sure the spaces we create benefit people living and working nearby. We do a lot of before and after surveys. This feedback often encourages political leaders to move forward.

People who live in the city also need to be involved. For example, we often face reluctance or opposition when pedestrianising commercial districts. Based on our data, the number of pedestrians walking in front of shops increases massively in newly created car-free areas. By sharing the data, we can convince people and businesses of the social and economic benefits. We actually invite people to vote with their feet.

It is important to have a focus on what we call software (the culture or use of the city) — and hardware (the roads, streets and buildings and the physical environment) because these two things have to go hand in hand.

Are there any trade-offs to attain urban equality, quality of life and mobility?

It's not about trade-offs. It's about flexibility and being more balanced in designing cities. Rather than pedestrianising one street, the focus should be on having a much more integrated network where all streets are walkable, bikeable, and nice places to live and work. Our current silo approach has to change. We have to work on many different levels to ensure cities are safe and comfortable to move around in so people feel that they can still go where they want without owning a car. Cities should develop multiple and well-functioning transport systems to give people a choice.

To strike that balance between mobility needs and quality of life, some cities have restricted car access to certain areas. Cities like Copenhagen, London, Stockholm and others have done this by introducing congestion charges or increasing the cost of parking downtown. This makes other transport options like cycling or public transport more appealing.

Are European cities adapting to a greener transport model?

I think Europe is leading the way. Many European cities have well-functioning public transport and have also pedestrianised parts of their urban areas over recent decades. Copenhagen and Amsterdam are the two top cities for cycling while Berlin also has quite high numbers of cyclists.

There are challenges when it comes to other cities. Paris was a pioneer when it introduced a public bicycle system. It became a global example. But it has not been as brave in implementing infrastructure more concretely, i.e. taking space away from cars and making a more connected cycling network. Many cities have similar issues and unfortunately cycling accidents do happen. This stops people seeing cycling as a safe alternative.

Many cities consider their streets too narrow for bicycles. I would say they're too narrow for cars! People don't take up as much space when moving on foot or by bicycle.

We also need to connect city centres with outlying areas better. This involves a focus on the journey and an understanding that public transport, be it trains or buses, can act as a continuation of our public spaces from home to work and back again.

What future challenges do we face in terms of mobility and the city?

There are many challenges ahead: increased urbanisation, climate change, transport, food production, energy consumption, social inclusion... Security has also become a real issue for public spaces. When people perceive public spaces as unsafe, they might prefer to use cars instead.

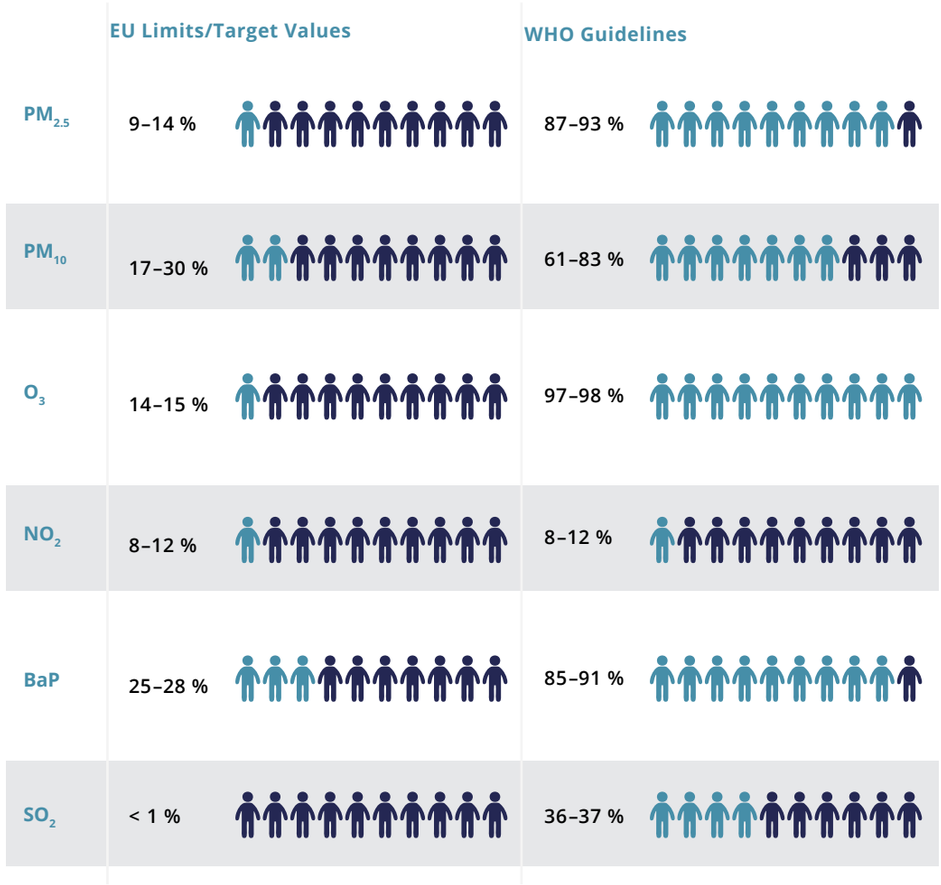
Urban mobility also touches upon public health. We are collaborating with Novo Nordisk to tackle diabetes in cities as 80 % of the world's diabetic population lives in cities. We see that government health budgets are growing enormously and designing cities differently could certainly help combat diabetes.

An aging population is another challenge. We are working in Tokyo and in parts of Europe where the age demographic is changing rapidly. Our cities need to be designed in a way that makes it easier for an aging population to get around. The key here is to understand that for all of these challenges the city is part of the solution and the design of the city can help us change people's behaviour.

Air pollution exposure in cities

Many Europeans are exposed to harmful levels of air pollution. Up to 30 % of Europeans living in cities are exposed to air pollutant levels exceeding EU air quality standards. And around 98 % of Europeans living in cities are exposed to levels of air pollutants deemed damaging to health by the World Health Organization's more stringent guidelines.

EU urban population exposed to harmful levels of air pollution in 2010-2012, according to:



Notes: PM: particulate matter; O_3: ozone; NO_2: nitrogen dioxides; BaP: Benzo(a)pyrene; SO_2: sulphur dioxide
Source: EEA Report No 5/2015 *Air quality in Europe — 2015 report* and EEA Report No 5/2014 *Air quality in Europe — 2014 report*

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Feeding the hungry city

Ingredients for the meals we eat at home or in restaurants come from near and afar. In an increasingly urbanised and globalised world, the food produced in the countryside needs to be transported to the city. Much focus has been put on reducing 'food miles', which can be a relevant but sometimes limited concept. A smarter and cleaner transport system would solve only part of the issue. A wider systemic analysis of the entire food system is in order.

Even if we live on a farm, most of the food we eat needs to be transported in one way or another. As three in four Europeans live in cities, the supply of food is highly dependent on transport, which is currently heavily reliant on burning fossil fuels. This of course has negative impacts on the environment and the climate.

Globally, more than half of the world's population lives in urban areas and, according to the United Nations[17], this share is projected to increase to about two-thirds — more than six billion people — by 2050. Many of these urbanites are projected to be in the growing and relatively affluent middle class, so the demand for transporting all kinds of food to cater both to our needs and tastes is likely to increase.

Distance travelled does not tell much about the journey

Transporting food, people and goods has many environmental impacts, including air pollution, noise, landscape fragmentation and greenhouse gas (GHG) emissions. Concern for these impacts has led to the concept of 'food miles', which usually means the distance the food has travelled to reach homes, supermarkets or restaurants.

Calculating 'food miles' can, in some cases, be a useful way to estimate your meal's environmental impacts. But it also has a number of important limitations: only a part of the environmental impacts related to food come from its transport. In terms of GHG emissions, how the food is produced (e.g. in heated greenhouses or in open fields in its growing season) is usually much more important than the distance transported. In fact, most of the environmental impacts of what we eat are linked to the production phase[18], which involves cutting down forests for agricultural use, irrigation, using chemical fertilisers, feeding animals and so on.

Looking just at 'food miles' not only ignores the way the food was produced, but also the type of food we are buying. Going vegetarian[19] or simply reducing meat consumption, switching type of meat and cutting food waste[20] might cut your food-related GHG footprint by a quarter.

Moreover, 'food miles' typically look at the journey from the point of production to the supermarket or restaurant. However, transporting large quantities of food from one point to another can actually be highly efficient. Your own choice of transport mode — by foot, bicycle, car or bus — to the supermarket and back home may be much more important when estimating your meal's environmental impact.

Determining who sells what

'Food miles' are probably of minor concern compared to how food is brought to consumers. There is no single, common food supply chain at European level. In recent years, logistics providers have been trying to form alliances and provide services across Europe. Despite this trend, cost pressures faced by pan-European logistics providers mean that many rely on subcontracting small operators. As a result, a significant share of road freight is still subcontracted to, and transported by, a myriad of small enterprises and driver-owners[21].

At the same time, according to a study by the European Commission, food retail has become more concentrated in the EU because of the penetration of supermarket chains, hypermarkets and discounters with a centralised distribution system involving modern logistics[22]. In other words, fewer players are operating in food retail. This has resulted in more efficient logistics and cost savings, but has arguably affected the selection of food items available to consumers and made it harder for smaller producers to enter wider distribution systems.

These centralised logistics systems can also be subject to failures, leaving supermarkets and consumers vulnerable to disruptions in food supply. For example, fuel protests in the United Kingdom in 2000 led supermarkets in some cases to ration food until supply lines were re-established[23].

Basing our food system on large-scale transport also has implications on the type of food we eat. As food needs to stay fresh — or at least edible — during and after transport, much fresh produce has to be plucked raw, and for many types of food using conservatives becomes a necessity.

Age of the pizza drone?

Online grocery shopping is growing rapidly in Europe[24] and this may mean a major transformation of how food reaches consumers. However, it's not very clear if this would be good or bad for the environment.

According to a study by Massachusetts Institute of Technology on shopping for electronics, clothing and toys, online shopping was the most environmentally friendly option. There were two main reasons for this: the buyer's journey to the store was avoided and maintaining a retailer website generates significantly fewer emissions (and uses less energy) than a physical retail store[25]. However, if you already live next to a grocery store, the calculation may provide different results. Several factors can be at play: How close is the nearest grocery shop? Do you walk, bike or drive there? Are you buying food for an entire week or just for one meal?

Another question is how our shopping habits keep up with changes in transport technology. Self-driving electric trucks and pizza-delivery drones may become a reality much sooner than we think. In long-haul transportation, more efficient container ships — possibly slow steam ships coupled with sails — could change the game.

Similarly, our diets might change in favour of vegetarian choices. Or our protein need might be largely met by aquaculture or insects. In terms of logistics, it would also be much easier to transport highly nutritious, concentrated powders or pills, but these dry solutions might not match the image most of us have of a delicious dinner, not yet at least.

Other innovative solutions, such as growing food in cities, for example on vertical farms and rooftops, can both reduce the transport need and also help cities to adapt to the impacts of climate change.

Looking at Europe's food system

The EU 7th Environment Action Programme sets an ambitious goal of 'living well, within the limits of our planet'. It also identifies both food and mobility, together with housing, as key sectors where the overall life-cycle environmental impact of consumption should be reduced. Together, these sectors are responsible for almost 80 % of the environmental impacts of consumption[26].

Tackling food waste, which amounts to some 179 kg for an average EU citizen per year[27], seems like a good place to start as it should also reduce the need for food transport. However, to tackle unsustainable consumption, we need to address the entire food system, including production, consumption and governance.

This understanding has been at the heart of recent assessments by the EEA, including the 'Greening the Common Agriculture Policy (CAP)' paper[28] and the agriculture briefing in the 'European environment — state and outlook 2015' report (SOER 2015). Systemic analyses address food in a wider sustainability context, linking it not only to its current environmental impacts, but also to issues such as food security in a globalised world, growing demand for food linked to global population growth, raising income levels, impacts of climate change on food production, changing diets with obesity on the one hand and malnutrition on the other.

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Aviation and shipping in the spotlight

Flying off for a weekend break, cotton t-shirts made in Bangladesh, roses from Kenya… These are some of the products available to us in a well-connected, globalised world. Aviation and shipping contribute to economic growth, but they also lead to impacts on human health, the climate and the environment. Faced with future projections of growth, these two sectors have started to explore ways to reduce their impact.

Aviation and international shipping have helped to dramatically reduce distances and increase our access to cheaper holidays and goods. They have also helped to create millions of jobs at home and abroad due to increased trade and tourism.

Demand for the two sectors is expected to grow globally for more leisure, convenience and access to goods in the years ahead. Between 1995 and 2050, passenger transport in the EU, including aviation, is expected to grow by around 70 % and freight transport by 100 %[29]. According to the International Transport Forum (ITF) at the Organisation for Economic Cooperation and Development, world freight volumes will also increase. This is partly due to projected growth in global trade. The ITF also foresees geographical shifts in trade patterns around the world, where growth in trade in emerging economies will lead to longer haulage distances[30].

While such growth is good for the economy, the upward trend in passenger flights and shipping poses an increased threat to the climate, the environment and human health. The aviation and maritime transport sectors are expected to see a rise in emissions of greenhouse gases (GHG) and air pollutants such as carbon dioxide (CO_2), nitrogen oxides (NO_x) and sulphur oxides (SO_x), as well as noise pollution. Carbon dioxide emissions from the sectors currently represent 5 % of global emissions and, according to a European Parliament study, aviation and maritime transport will be responsible for up to 22 % and 17 %, respectively, of global CO_2 emissions in 2050[31].

Up in the air

Flying is seen as a safe and convenient mode of transport. The number of flights in Europe in 2014 was about 80 % higher than in 1990. And after a drop due to the economic recession from 2008 onwards, the numbers are picking up again[32].

Increased numbers are partly due to a general trend towards longer flights and aircraft with more seats. Most of the growth is due to increased business by low-cost

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flights, which have lured passengers away from traditional carriers and opened new routes contributing to growth in the sector. This trend is expected to continue as low-cost carriers expand their fleets and start offering trans-continental flights, giving travellers more choice and more destinations. The International Civil Aviation Organisation (ICAO), the UN agency which regulates the sector, projects that the world's commercial aircraft fleet will jump to around 47 500 by 2036, from around 26 000 in 2016[33].

According to 2014 preliminary data compiled by the European Environment Agency shows that GHG emissions from international aviation increased by 22.7 % between 2000 and 2007, and then fell by 3.5 % between 2007 and 2014. Excepting the recent decline, emissions have been increasing steadily. They doubled since 1990 and were 18.3 % higher in 2014 than in 2000. And the upward trend is expected to continue. The ecological footprint of a single person taking a long-haul flight causes as much pollution as a motorist does in two months according to one study[34]. In other words, a one-way transatlantic flight from Paris to New York in economy class generates around 381.58 kilograms of CO_2, according to the ICAO's emissions calculator[35]. This is equivalent to emissions generated by the energy use of an average house for 10 days[36].

The extra noise created with increased numbers of take-offs and landings at airports also has a negative effect on health, creating more than just annoyance and sleep disturbance for people living nearby. Recent research on children's exposure to aircraft noise found evidence of reduced academic achievement and health damage[37].

The aviation sector has addressed some of these issues by boosting fuel efficiency through improved engine and plane designs. However, the uptake of sustainable alternative fuels is very slow, and the recent collapse in global oil prices has eased the incentive on airlines to develop biofuel-based renewable fuels. Moreover, jet fuels used on international flights are also exempt from national taxes. Compared to fuels used in other heavily taxed transport modes such as road transport, this tax exemption makes the cost of flying relatively cheaper and the user does not pay for most of the negative impacts on the environment and climate.

Airlines are continuously upgrading their fleets. New planes are much more fuel-efficient and have quieter engines, but replacing the entire fleet by more fuel-efficient aircraft will take time. Newer aircraft fleets have led to reductions in emissions per passenger kilometre, but the pace of growth in recent years and projected growth in the years ahead mean that technological efficiency gains fall short of reigning in the absolute increase in total emissions from aviation.

Tourism and transport

The tourism sector depends on transport, while the demand in the tourism sector contributes to the growth in the transport sector. With raising income levels and decreasing holiday travel costs, more and more people aspire to 'discover new places'. Globalisation and extensive transport networks potentially turn every location into a holiday destination. More than half of the international tourist arrivals in the world are for holidays and leisure trips[38].

Although the aviation and cruise sectors are growing, the largest share of trips by tourists is made by car[39]. However, air transport accounts for the largest share of tourism-related GHG emissions, while cruises remain the most GHG emissions-intense mode of transport per kilometre travelled. Furthermore, most cruises start with flights to reach harbours, adding between 10 % and 30 % to the total emissions caused by the cruise[40].

Europe is a major tourist destination. In 2007, the number of air passengers in Europe was estimated to be around 600 million, 400 million of whom was leisure passengers[41]. In 2030, Europe is expected to have international tourist arrivals corresponding to almost 90 % of its population.

Highways of the sea

Thousands of cargo ships routinely travel long distances on the high seas to move millions of tonnes of goods between continents — everything from fresh fruits and television sets to grain or oil. The maritime transport sector plays a key role in Europe's economy. Almost 90 % of the EU's external freight trade is transported by sea making European businesses and consumers heavily dependent on goods imported from the rest of the world. Shipping is seen as the cheapest way to move goods around the world, but the sector remains a highly volatile one, prone to boom and bust economic cycles.

While the sector's share of GHG emissions is lower than those of road transport or air freight, its environmental impact is nevertheless growing. The shipping industry is estimated to emit around 1 billion tonnes of CO_2 per year and this is projected to rise to 1.6 billion tonnes by 2050[42]. The International Maritime Organisation's (IMO) latest figures show that if no action is taken, GHG emissions from shipping will increase by up to 250 % by 2050, representing 17 % of global emissions.

The sector is heavily dependent on fossil fuels to power its engines, in particular bunker fuel, which is a less refined, more polluting and cheaper mix of oils, including diesel oil, heavy fuel oil and liquefied natural gas.

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As ships spend most of their time out at sea, the reporting and analysis of their emissions have been less precise. However, when sailing close to the coast, the impacts of the emissions are clear. The burning of bunker fuels emits sulphur dioxide and nitrogen oxides, causing acid rain and generating fine particles. These pollutants are dangerous for both human health and ecosystems.

Air pollution is only one of the environmental impacts of maritime transport. The sector has faced pressure over recent decades to do more to prevent oil spills, and dumping of waste and other pollutants at sea. Passenger cruise liners have come under increased scrutiny for their environmental impact. Demand for cruises continues to rise, resulting in the construction of megaships, which can carry more than 5 000 passengers and more than 1000 crew, making them floating cities at sea. These ships create large amounts of sewage, garbage, wastewater and air pollution, which critics say poses increased risk to the environment.

Most harbours are not yet equipped to supply electrical power to ships. Consequently, ship engines or on-board generators are always kept running even when moored to meet the ship's internal energy needs, which in turn worsens air quality in harbour cities. Furthermore, sensitive ecosystems, such as the Arctic and Antarctic or coral reefs, are facing the risk of damage due to increased tourist traffic via cruises.

Although there are no agreed and binding targets, the industry and the IMO have taken some steps to reduce GHG emissions and pollution. New operational measures like slow steaming, sulphur emission control areas, better routing and banning discharges in and around sensitive marine areas are being adopted, and new hull designs to improve fuel efficiency and safety are being embraced. They are also looking at the use of cleaner fuels, including biofuels, as well as electric hybrid propulsion. A new global cap on the amount of sulphur permissible in fuel will be introduced from 2020, limiting the amount of sulphur in fuel to 0.5 %. The EU already restricts sulphur from commercial shipping to 0.1 % in a zone that extends from the English Channel to the Baltic Sea.

Time for change?

Airlines and shipping companies acknowledge these measures will not be enough. The objective of the 'Paris Agreement' to limit global average temperature rise to 2 °C above pre-industrial levels, and if possible to 1.5 °C, is not achievable without the full engagement of the international aviation and maritime sectors. Some of the stakeholders in these sectors are already taking action. For example, recognising the concerns linked to their ground operations, some airports are putting in place a series of measures not only to curb noise pollution and GHG emissions, but also to prepare the airport for climate change impacts. Currently, 92 European airports participate in the Airport Carbon Accreditation Programme, 20 of which are carbon neutral[43].

For sector-wide action, however, the onus is now on the international regulatory bodies. For aviation, the focus has been on

Carbon offsetting

Carbon offset programmes, introduced over a decade ago, allow consumers to buy carbon credits to 'neutralise' their travel emissions, or emissions produced by shipping. The initial public interest around carbon offsetting seems to have faded. Currently only 2 % of international flights are offset by passengers and this is not expected to rise in future[45], despite the fact that many airlines and cruise lines continue to offer the service.

the ICAO, members of which are working to reach a climate deal this year. ICAO member states have already agreed to a goal of carbon-neutral growth by 2020 and the ICAO is currently working to bring a 'global market-based mechanism' (GMBM) or a global carbon-offsetting scheme online by 2020 to achieve the carbon-neutrality goal. The plan also includes the use of more efficient engines and biofuels. However, access to market instruments is not expected to lead to significant direct emissions reductions from the sector; it will rather enable aviation operators to off-set their increasing GHG emissions by making reductions in other economic sectors. In this case, emissions of air pollutants and noise are expected to continue to increase.

Similarly, the IMO is leading talks between shipping nations on limiting emissions. Several initiatives are on the table, including the creation of a global data collection scheme to improve information on emissions from maritime shipping, an emissions reduction target and a market-based system to achieve the target.

The European Union has already taken measures to slow the growth of emissions by airlines and shipping companies. The EU and EUROCONTROL (the international organisation managing pan-European air traffic) have also been pushing for a more efficient use of European airspace and air traffic management through the Single European Sky initiative. The EU has also worked with the industry on research programmes to make jet engines more environment-friendly in terms of noise and other pollution.

Starting in 2012, GHG emissions from flights within the European Economic Area ([vi]) have been included in the EU's Emissions Trading System (ETS). The EU exempted flights to and from non-European Economic Area countries up until the end of 2016 to give time for the ICAO to negotiate a global deal.

([vi]) European Economic Area consists of the 28 Member States of the European Union, Iceland, Liechtenstein, and Norway.

Similarly, the EU has pushed hard for the IMO to come up with a global approach to reduce pollution. The European Commission is pushing the IMO and industry to adapt new operational measures to improve the energy efficiency of existing ships and the design of new ones. Under a new EU monitoring, reporting and verification regulation, from 2018, large ships (over 5 000 gross tonnes) using EU ports will have to report their verified annual CO_2 emissions and other relevant information. The ships will have to monitor and report the amount of CO_2 emitted on journeys to, from and between EU ports and also when in EU ports. This reporting system is estimated to cut carbon emissions from journeys covered by up to 2 %.

There are also EU rules in force to tackle sulphur emissions in Europe's coastal waters and harbours. A European Parliament report[44] has also suggested the maritime transport sector look at finding alternative fuels and other renewable energies to power ships.

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Transport and ecosystems

Transport networks have become a commonplace feature of the European landscape. They connect people, boost economic activity and provide access to key services, but they also introduce barriers between natural areas, while their use emits pollutants and introduces non-local species to ecosystems. Strong policy measures and a network of green spaces can help preserve and protect Europe's natural wealth.

The European continent is connected by an extensive transport network, comprising motorways, roads, rail tracks, navigable rivers, cycle paths, flight routes and sea routes. In addition to bringing goods and services to people, transport networks shape and impact the environment around them.

Less space for nature?

Transport is often associated with economic development. Connecting a city or region to major transport networks can give an initial boost to the local economy and create new jobs. However, once a region has reached a certain level of connectivity, additional transport infrastructure does not give comparable benefits. It can, however, generate substantial environmental impacts. Transport networks can also facilitate the spread of urban areas and other built-up areas into relatively rural and sparsely populated parts of Europe, exerting pressure on natural habitats. For example, connecting remote mountain regions or islands to the European transport system could attract more tourists to the area, resulting, for example, in a boost to accommodation and food-catering services. However, increased economic activity also often comes with the negative impacts of human settlements — more wastewater, more solid waste etc.

Similarly, an increasing demand for biofuels can also result in additional demand for land and freshwater resources in Europe. When combined with land required for food production, it can lead to more natural areas being converted to agricultural land.

Air and noise pollution in nature

Transport also leads to releases of pollutants, which can spread beyond the reach of transport networks. They can contribute to background concentrations of particulate matter, ozone and nitrogen dioxide, affecting people, plants and animals. Some areas, including mountainous regions, coastal zones and seas, can be particularly vulnerable to pollution from transport. Transport corridors through Alpine valleys or along large rivers like the Danube are essential for the European economy, but also exert pressure on unique ecosystems. Certain pollutants, such as ground-level ozone, are known to lower crop yields, affect tree growth and cause acidification in lakes.

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Similarly, oil spills or the release of hazardous substances at sea can cause considerable damage to marine life. Recognising these risks, many measures have been put in place at European and international levels.

Noise pollution from transport is another concern and its impacts are not limited to land ecosystems alone. Large ships generate significant amounts of noise. Their hulls tend to amplify the mechanical noise from the engine and propellers. Due to its low frequency, this type of noise propagates very far in water and disturbs marine life. Research indicates that whales and other species that communicate and orient themselves through sound are particularly affected. Potential impacts suffered by small fish and marine invertebrate populations are also becoming clearer thanks to ongoing research[46].

Some solutions are already available and are quite effective in reducing noise pollution at sea and on land. For example, ships can be designed with their engines placed further from the hull (e.g. electric propulsion motors in pods outside the hull) to minimise noise amplification. Similarly, car engines and parts (e.g. tyres) could be redesigned to reduce noise levels at source, or noise barriers along motorways could be extended.

Unwanted free riders on board

In addition to pollution, transport can also bring non-local species into new habitats, risking significant harm to local species. Construction of large transport projects, such as the Suez Canal, can alter the key characteristics of an entire ecosystem. Since the building of the canal, more than 500 non-indigenous marine species were introduced to the Mediterranean Sea, contributing to 'a catastrophic anthropogenic ecosystem shift in the Mediterranean Sea'[47]. In the case of maritime transport, large ships, especially those used in freight transport, take in water to stabilise the vessel. Depending on their cargo load, they release this ballast water, which often carries in it many bacteria, microbes, small invertebrates, eggs and larvae of various species. If introduced in sufficient quantities and in the absence of predators, the impact of alien species can be devastating.

The case of the comb jellyfish, *Mnemiopsis leidyi* — a species native to the American Atlantic coast — is well known and well-documented. *Mnemiopsis* was introduced into the Black Sea through ballast water in the early 1980s and had devastating effects on local marine life, affecting fish populations and fishing communities. Recognising the ecological risk posed by ballast waters, a number of international measures and guidelines have been set by the International Maritime Organisation, including the Convention on Ballast Water Management.

Ballast water is only one of the ways alien species are transported. Fruit seeds thrown from passenger cars, bacteria or insect eggs in the discarded soil found in imported flowerpots, and exotic fish or bird species released into nature can all impact local ecosystems.

Investing in green infrastructure

All man-made infrastructure networks — road, rail and inland water canals — connect urban areas, rural areas and people. But they also build barriers and divide the natural landscape into smaller areas. A multi-lane motorway cutting through a forest represents a physical barrier for animal and plant species. In addition to reducing the total area available for wild life, a lack of connectivity between different habitats makes their populations more vulnerable. Animals need to move around to find food and mate, and risk being injured or killed while trying to cross roads or rail tracks. Even fences around transport networks could isolate the population of a particular species such that their genetic pool is limited, making them more vulnerable to diseases, and ultimately dying out.

Better connectivity through tunnels or bridges would certainly reduce the pressure on Europe's biodiversity and ecosystems. In fact, these initiatives could be better planned on a much wider scale than a single infrastructure project, involving a multitude of different stakeholders (planners, investors, citizens, public authorities at various governance levels etc.).

A 'green infrastructure' consists of a strategically planned network of high-quality green spaces. It requires a wider look at all green spaces — in remote, rural and urban areas, and beyond national borders — connects between them so as to facilitate movement of species. To this

end, the European Union adopted a Green Infrastructure Strategy[48] aimed at providing a vision for a trans-European green network, as well as facilitating coordination among stakeholders, and exchange of ideas and information.

Better connectivity is not the only positive outcome of green infrastructure. In addition to improving public health, it is increasingly seen as a cost-efficient way of reducing current (or future) weather- and climate-related natural hazards[49]. For example, instead of building sewerage systems to transport extreme rainwater, cities can create green areas to absorb excess water.

Planning with nature in mind

Transport infrastructure projects, including those related to the Trans-European Network, have contributed to enhancing quality of life across Europe, bringing services and public goods to remote parts. Several studies[50] partly link the Trans-European Transport Network (TEN-T) to the EU's failure to meet its target to halt biodiversity loss. Other studies[51] highlight the potential impacts of TEN-T projects on protected areas.

The EU's recent transport policy has significantly strengthened nature and biodiversity considerations. Now, these concerns need to be taken into account from the planning phase. Moreover, Member States need to carry out environmental impact assessments for such projects. EU legislation[52] also covers the potential impacts of infrastructure projects taking place outside protected areas, but which can still affect them.

This approach could translate into various measures on the ground. For example, in the case of rail and road networks, the route proposal could be changed to leave larger areas untouched and to avoid landscape fragmentation. Similarly, tunnels or nature bridges could be planned and built to increase connectivity between protected areas, and facilitate the movement of animal populations. If the project does not comply with these rules, EU funding can be withdrawn.

Stricter environmental protection rules have already led to changes in several projects. An inland navigation project, aimed at deepening the Weser River in Germany, would allow ships to easier access to the Bremerhaven harbour. An environmental NGO challenged the project plans, arguing that the deepening the river would change the salinity level and create stronger tides, posing a threat to animal species dependant on the river as well as to people living on its banks. The European Court of Justice ruled that the project would deteriorate the water quality in the Weser and constitute a breach of the EU's Water Framework Directive[53]. Consequently, the project was cancelled.

Similar to transport and energy networks bringing economic wealth across Europe, a trans-European network of green infrastructure could actually help foster healthy and rich nature.

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Green choices: policymakers, investors and consumers...

From walking and electric cars to massive freight vessels and high speed trains, a wide range of transport options exist. Many factors, including price, distance, availability of infrastructure and convenience, can play a role when selecting a transport mode. Car rides are the preferred mode for passenger transport in Europe. But even then, some options are cleaner than others. How can we opt for greener choices?

The transport sector provides an essential service to today's society, contributing significantly to quality of life. In some cases, transport meets a vital need such as food distribution, commuting to work or going to school. In other cases, it facilitates leisure time. Depending on the transport mode selected, the journey might generate varying impacts on the environment and human health. In many cases, we have a choice.

Consider a commute of 5 kilometres. There might be several options available: ride our bicycle, drive alone in our diesel SUV (sport utility vehicle), carpool with co-workers or take public transport. Some of the options will always be more environment friendly than others. At the same time, not all options will be available to everyone. For example, a very rough terrain without bicycle paths on a stormy day will only appeal to adventurous cyclists in good form. Similarly, car-pooling in an electric car is more likely to happen when certain conditions are met, such as the availability of re-charging stations and a community of car-poolers.

The transport sector involves a wide range of stakeholders from urban planners and vehicle manufacturers to passengers. To facilitate the transition towards a green and sustainable transport system, they all need to be involved and unafraid to question every aspect of the current transport system. Some of these questions might actually force us to reconsider our consumption patterns and lifestyle choices — what we consider as essential and what is just nice-to-have.

European support for carbon-free transport

At the moment, transport in Europe remains very dependent on oil, with an increasing number of new passenger cars sold, the majority of which use diesel. Europe's goal is to move away from this reliance on fossil fuels.

The future of Europe's transport sector is shaped by a number of EU policy documents, including the Europe 2020 strategy, the Roadmap for moving to a competitive low carbon economy in 2050 and the Roadmap

to a single European transport area — towards a competitive and resource-efficient transport system (referred as the 2011 Transport White Paper).

They clearly identify the challenges the transport sector faces: developing a competitive transport system, reducing Europe's dependence on imported oil and reducing carbon emissions from transport by 60 % by 2050 (compared to 1990 levels), while supporting growth and employment.

The EU has earmarked funds to this end. More precisely, close to 20 % of the EU's Cohesion Policy funds (around EUR 70 billion over the period 2014–2020) is expected to support transport investments. More than half of this amount will support the transition towards an energy-efficient, decarbonised transport sector.

To drive or not to drive?

Although Europeans across Member States and age groups prefer a wide range of transport modes, cars appear to be the most popular option. According to a Eurobarometer survey on urban mobility[54], half of Europeans use a car every day as a driver or a passenger. However, car use varies significantly across EU countries. While eight out of ten survey respondents in Cyprus use a car every day, less than a quarter do so in Hungary.

The daily use of public transport is quite high in Hungary, the Czech Republic, Estonia and Latvia. In Cyprus, three quarters of respondents never take public transport. The Netherlands, Denmark and Finland have very high cycling rates with 43 %, 30 % and 28 % respectively of respondents cycling every day.

It is not surprising that in the countries with a high rate of daily car use, public transport and bicycles are used less often. It is also not surprising that Europeans aged 15–24 are by far the most likely group to use public transport at least once a day.

So the question is how to encourage Europeans to opt for greener transport modes.

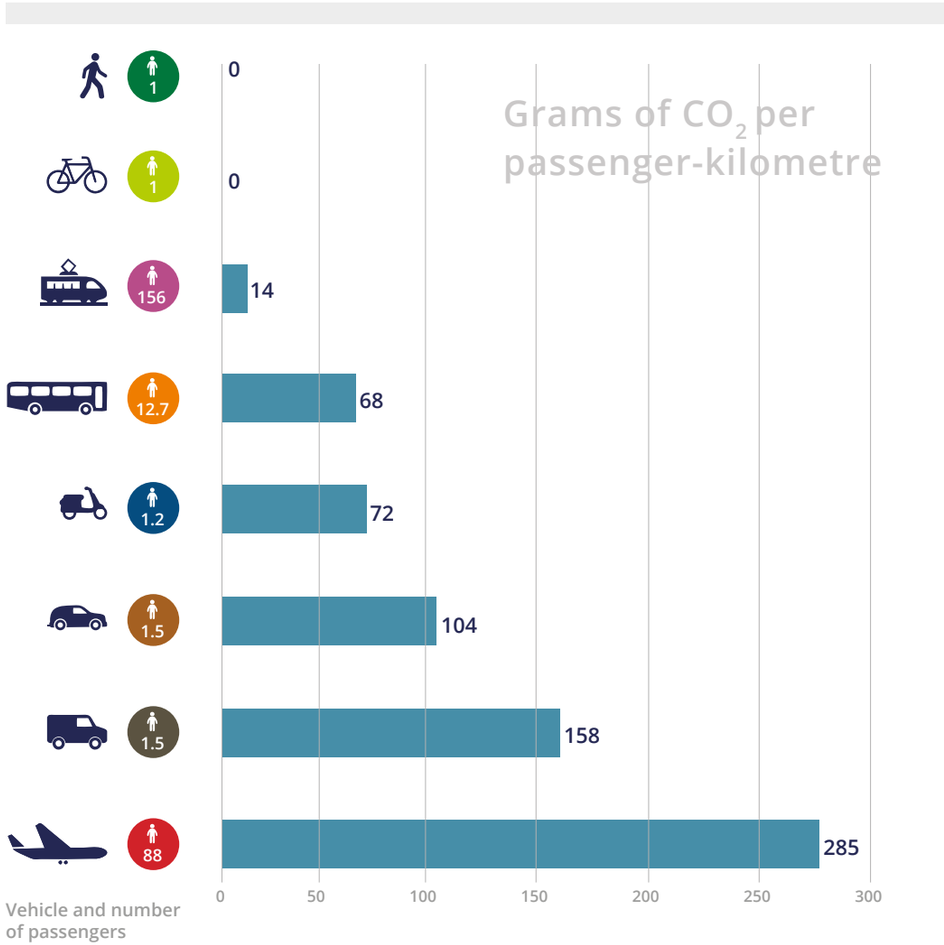
Future of passenger cars: shared and electric?

Cleaner fuels and higher fuel efficiency can help reduce the environmental and health impacts of transport to some degree. EU and national funds have long supported research into alternative fuels, leading to many improvements in fuel efficiency and engines. However, common standards and an extensive fuelling infrastructure also need to be developed to encourage a wider uptake of cleaner fuels. Car buyers/users are more likely to choose alternative-fuel vehicles when they feel confident that they can easily recharge or fuel their car without the risk of running out of fuel on the road.

To facilitate the build-up of infrastructure (e.g. recharging points across Europe) and common technical specifications (e.g. a common plug standard for recharging), the EU has set out a comprehensive alternative fuels strategy covering all modes of transport in its communication on 'Clean Power for Transport'[55].

Carbon dioxide emissions from passenger transport

A wide range of transport options exists, but choosing the one with lowest emissions is not always straightforward. One way to measure your environmental impact is to look at the CO_2 emissions per passenger kilometre travelled.



Note: CO_2 emissions are calculated using an estimate of the amount of CO_2 per passenger-kilometre. Different modes of transport are considered, with an average number of passengers per mode used for the estimates. As the number of passengers in a vehicle increases, the total CO_2 emissions of that vehicle increase, but the emissions per passenger are fewer. The inland ship emission factor is estimated to be 245 g CO_2/km, but data availability is still not comparable with that of other modes.

Source: Estimates are based on the TRACCS database, 2013, and the TERM 027 indicator.

Depending on the distances to be covered, a large vessel has a very different energy need than a compact electric car designed for short trips in the city centre. Given these differences, it is clear that a comprehensive mix of alternative fuels is needed.

The development of the alternative-fuels market, including investments in their infrastructure, is also expected to boost the economy and create new jobs. According to research by the European Climate Foundation, greening cars could create 700 000 extra jobs in the EU by 2025. Moreover, the alternative fuels market could also significantly reduce the EU's dependence on oil and thus the economic risks linked to fluctuations in supply.

Renewing existing fleets with more efficient models will take time. Given their longer lifespan, replacing aircraft, train and ship fleets, will take more time than for cars and trucks. For passenger cars, car-sharing schemes could actually offer an interesting alternative to the 'one household-one car' model, especially for urban residents, and speed up the renewal of the fleet. Car-sharing could also mean savings for the user as the costs of owning a car (purchase, maintenance, insurance, etc.) would be shared by a group of users. It could also reduce the number of cars parked in cities. What used to be a symbol of social status — car ownership — should no longer be perceived as such.

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Higher taxes for the more polluting transport modes?

Pricing can provide another push for the user towards greener transport. Taxes applied to more polluting transport modes make them more expensive and are likely to reduce the demand. The opposite is valid for cleaner options: reducing taxes can lure more users to cleaner transport. More than half of Europeans believe that lower prices and better public transport are the best ways to improve urban travel.

Road transport fuel is already heavily taxed across the EU compared to other transport modes. Nevertheless, different types of road fuels are taxed at different rates, influencing the composition of the vehicle fleet. For example, lower taxes and other incentives on diesel in many EU countries resulted in a significant increase in the number of diesel vehicles sold. Although diesel vehicles might have helped lower GHG emissions, their indirect promotion and growing uptake have contributed to air pollution in Europe.

Subsidies and tax breaks are common in the transport sector. Some promote greener options, such as public transport, while others, such as preferential tax treatment of company cars or tax exemptions on the fuel used for international plane and ship travel, result in higher car use or increased consumption of fossil fuels. The overall influence could again be significant. For example, in Germany, Europe's biggest market for cars, around 64 % of all new cars were registered to companies in 2014.

The high uptake of electric cars in the Netherlands and Norway has been closely linked to a number of incentives offered to potential buyers. However, consumers can easily revert back to combustion-engine cars when such incentives are discontinued. Tax rules for plug-in hybrid and hybrid cars were changed in the Netherlands, effective as of 1 January 2016. This change resulted in a huge and immediate drop in electric car sales[56]. Similar consumer reactions were also observed in other countries, including Denmark.

Making the user pay for infrastructure

Charging for infrastructure use is another effective tool for influencing the price of transport and, hence, the demand. There are different ways to charge for road infrastructure in Europe. Tolls often consist of a price paid for the distance travelled, whereas vignettes allow the vehicle to use a country's road infrastructure for a given period of time.

In 2015, 27 of the EEA's member countries had some type of road charge for heavy-duty vehicles (e.g. trucks and buses). The EU's Eurovignette Directive foresees road-user charges for such vehicles. Regional and national authorities can improve infrastructure charging through a further shift from vignettes to electronic tolls. A wider and more systematic use of fair and efficient tolls based on the polluter/user pays principle will steer users towards more sustainable transport choices.

Public authorities also play a key role in ensuring that different transport systems are connected (e.g. rail to air) and interoperable (e.g. no need to buy separate tickets), and that price signals are consistent. Through their regulatory and funding power, public authorities also help shape the mobility system of the future. For example, they could make sure that decarbonisation and climate adaptation concerns are always taken into account in all infrastructure plans. Public authorities can also facilitate cooperation among different stakeholders, enhancing exchange of know-how and innovative ideas, as well as helping different operators prepare for and cope with climate change impacts. Greater interoperability between European railway services could provide an opportunity to channel larger volumes of freight towards this more environment-friendly mode.

Transport is a complex sector with many different public and private sector stakeholders such as infrastructure and service providers across different modes, vehicle producers, regulators and, finally, users. Many stakeholders only have a partial perspective of the system. Moreover, transport requires many costly and long-lasting investments in infrastructure, aircraft, trains, ships and other transport equipment. A large part of these investments comes from public funds.

Decarbonisation of the transport sector will affect all Europeans and the whole economy. The energy sector in the EU will need to adapt to changes in demand. For example, increased use of electric vehicles will generate extra demand for electricity. In addition, decarbonisation of the transport sector is expected to impact the oil-refining sector, while offering new opportunities in alternative fuels. It can also boost Europe's competitiveness by enabling European manufacturers to develop and export cutting-edge transport technology.

Smart and innovative mobility

A part of the demand for mobility stems from lifestyle and habits. With rising income levels, more and more Europeans travel to different parts of the world for work and leisure. Air travel, which used to be a memorable experience enjoyed by few people just 50 years ago, has become quite ordinary. The same goes for car ownership, even if that means a private car spends most of its time unused. Consumption patterns have continuously evolved and will continue to change. New holiday destinations such as the Arctic might appear on the tourism menu as a result of climate change. We may, however, decide to opt for greener choices.

Innovative solutions can actually challenge some of these consumption patterns while still meeting the need for mobility. Innovation does not involve engine designs and energy efficiency only, but also covers new business and ownership models. In a world of highly packaged tours, businesses can explore eco-tourism alternatives, such as cycling-camping vacations across Europe, for example.

A network of cycle paths is more likely to convince commuters and leisure drivers to cycle. Some EU countries are already introducing bicycle networks that go beyond urban centres. Germany has recently opened the first stretch of what will become a 100 km cycle 'autobahn', connecting 10 cities and four universities in the Ruhr region. The cycle-highway will be completely traffic-free and will mainly use converted disused rail tracks. According to some estimates, the cycle highway is expected to reduce traffic load in the area by up to 50 000 cars every day when completed[57].

Innovation could also help improve freight logistics and road transport in general. Many trucks are not fully loaded on their return journeys, so improving operational logistics could reduce the number of 'empty runs' and consequently the number of trucks on the road. A fleet of self-driving trucks has just driven 2000 km across Europe[58]. Self-driving cars might also be in the pipeline. By regulating speed, they are expected to reduce fuel consumption. They can also enhance the mobility needs of some social groups, such as children and the elderly. Smart transport systems could be built to prevent accidents, and reduce fuel consumption and congestion.

Smart mobility can combine different modes and options (public transport, car-sharing, car rental services, taxis and a bicycle system) to cater for mobility needs by using IT, apps, and smart invoicing.

Innovation and research will certainly be one of the driving forces behind the transition towards smarter and cleaner mobility. So what should we explore next — solar powered tricycles, sails and solar panels on vessels, or first-aid assistance through drones?

Further reading

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For your notes

EEA Signals 2016

The European Environment Agency (EEA) publishes Signals annually, providing a snapshot of issues of interest to the environmental debate and the wider public. Signals 2016 focuses on transport and mobility.

Transport connects people, cultures, cities, countries and continents. It is one of the main pillars of the modern society and economy. At the same time, it is responsible for a quarter of the EU's greenhouse gas emissions, and causes air pollution, noise pollution and habitat fragmentation. Signals 2016 looks into how Europe's carbon-dependent transport sector can be turned into a clean and smart mobility system.

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