SOLUTIONS FOR THE MOBILITY SYSTEM
To move people and goods, we have access to a vast network of roads and car parks, rails and stations, (air)ports and a range of transport modes. Mobility is indispensable in our society, yet it also leads to air pollution, health problems, climate change, road congestion and traffic accidents. To solve these persistent problems, a fundamental rethinking of our mobility system is required. In this chapter, we will analyse the challenges, possible solution paths and levers for the transition to an (ecologically) more sustainable mobility system in Flanders.

### 3.1 What is it about?

**Mobility: closely interwoven with other systems, but at a critical point**

The Flemish mobility system is closely connected with other societal systems such as economy, culture, spatial planning, and energy. The daily mobility of individuals is to a large extent determined by the spatial location of residential homes, businesses and facilities. Freight transport, by contrast, is closely connected with the way in which our production and consumption systems are organised.

However, due to the multiplicity and frequency of journeys, mobility in Flanders is increasingly being constrained. Congestion is worse than ever and impacts our quality of life and economic productivity. Moreover, both passenger and freight transport are expected to continue to grow. It is becoming clear that things cannot continue as they are.

**THE CHANGING MOBILITY SYSTEM IN FLANDERS: A DIAGNOSIS**

The dominant regime for passenger transport is still the fossil fuel-powered car. Its immediate availability and high level of comfort, but also a certain image that goes with it, continue to play a role in this respect. This is referred to as car-centric mobility. Freight transport, too, is mainly organised around lorries and vans running on fossil fuel.
Drastic changes in the past

Over the past centuries, our mobility system has gone through a number of transitions whose impact is still being felt today. The foundation of the current Belgian road network was laid in the eighteenth century. However, an overall road programme with a road classification was introduced only in the nineteenth century. After 1850, rail looked set to become the transport mode of the future, but around the turn of the nineteenth to the twentieth century, the first car models appeared on the market in Belgium. Throughout the twentieth century the road network was further developed to serve the needs of cars. This led to a new concept in the 1930s, the motorway: a road which is accessible only to motorised traffic and which does not have any level crossings. In the 1950s, an international network of E-roads was developed. As prosperity grew, an increasing number of Belgians were able to afford a car. The oil crises, the economic recession, the emergence of ecological awareness and the change in mentality on land use led to the first manifestations in the 1970s. Budget cutbacks in the 1980s slowed down the construction of planned roads, which, from the mid-1990s, virtually came to a standstill. Car traffic has grown steadily over the past decades. Automobility in Flanders grew very rapidly, especially until the 1990s. In 2012, almost three times as many person-kilometres were travelled by car as in 1970.

Pressure on the dominant regime: the transition impulse

Car-centric mobility causes a number of persistent problems. Traffic jams keep growing year after year. The number of lost vehicle hours for cars and vans almost doubled between 2010 and 2018. Safety, especially of more vulnerable road users, remains a major challenge. Growing public awareness of the climate issue puts pressure on the existing system from the outside. Moreover, there is growing public attention to the persistent health problems caused by particulate matter and nitrogen oxide emissions. Furthermore, questions are raised about the space that is taken up by this car-centric mobility. The dependence on fossil fuels also renders the dominant regime vulnerable to unforeseen developments in the oil market.

There are also many new niches that put pressure on the dominant system. Traffic is restricted and slowed down in play streets during certain hours for limited periods of time. Cycle streets turn the classical balance of power between car and bike upside down. Low-emission zones, and above all local mobility plans, can lead to a modal shift away from the car. The electric bike appears to give a boost to both functional and recreational cycling in Flanders. The construction of bicycle highways vigorously responds to this by providing a more appropriate infrastructure. In many other areas, however, the use of bicycles in general and electric bikes in particular is still inadequately regulated. The high speed of speed pedelecs puts pressure on traffic regulations and today’s standards for the design of cycle paths. The success of these fast electric bikes calls for solutions. These are all early signs of a cycling culture that is gradually evolving from a subordinate to an autonomous culture. The search for (combinations of) alternatives to the car has also led to the first initiatives in the field of customised mobility (Mobility as a Service or MaaS). Mobility as a Service integrates different mobility options into single efficient multimodal route planning.
Resistance of the regime to drastic changes

In spite of these new trends, car-centric mobility still constitutes the central and dominant regime. It is available around the clock, it is relatively affordable, flexible and supported by a very extensive spatial and economic infrastructure. It proves to be a highly consolidated system that is extensively connected with other societal systems such as economy (via growth), land use (via spatial planning), consumption (via spatial planning and e-commerce) and energy (via energy use).

The regime’s resistance to change manifests itself in various areas. Clearly, a substantial amount of capital is tied up in the road network. It cannot be phased out or replaced, not even in the medium term, without major financial and social costs. Furthermore, spatial planning in Flanders - dispersed settlement, ribbon development and lack of clustering - promotes car use. Widespread car use has also spatially separated activities that used to be spatially co-located (living, working, shopping, learning). Car dependency has thus become further embedded in social life. As a result, alternatives to car use are not always evident, especially for chains of journeys, such as commutes between home and multiple locations (office, school and/or daycare) and shopping trips. Also the socialisation of car use - the belief that one has to be able to drive a car in order to fully participate in social life - remains stubborn. Incorporating driving lessons into the school curriculum only seems to confirm that they are an integral part of growing up.

With the low oil prices and the limited offsetting of external costs, car use also remains relatively inexpensive, especially when taking into account the flexibility and the level of comfort offered by the car. Moreover, the status of the car was embedded in the compensation system, in the form of company cars. Originally a fringe benefit for senior positions, they quickly became regular practice throughout the labour market. Under the parking norms in urban planning regulations and the system of parking cards for residents, car owners are often also entitled to claim a portion of the public space in their residential area at no extra cost.

To withstand the internal and external pressure, the car-centric regime focuses heavily on optimisation. Real-time traffic control and rush-hour lanes, for example, are attempts at improving traffic flow. GPS allows for optimised use of the capacity of the entire road network. However, because the situation is already critical and due to the knock-on effect, the improvement is only temporary. (European) policy also actively promotes the greening of internal combustion engines. Major interests are at play in the automotive industry. A powerful lobby attempts to tone down the ambition of European policy on car emissions. From a climate and environment perspective, electric vehicles can be seen as a favourable development, but they can also help to preserve the car-centric regime.
Where does the change process stand today?

The existing mobility system is under pressure, that much is clear. However, the ever growing number of kilometres travelled by car and the very modest modal shift indicate that no fundamental change is forthcoming. There are nevertheless signals that suggest a destabilisation of the dominant mobility regime of fossil fuel-powered car, truck or van transport. Some cities and municipalities explicitly opt for quality of life, and make more radical choices in the area of mobility. Examples are mobility plans, low emission zones, or traffic-free streets in the vicinity of schools. They change the rules of play in the mobility system, thereby challenging existing practices. The recent negative perception and turnaround in policy may even lead to an elimination or phase-out of diesel technology for passenger cars. At the same time, an acceleration or even a breakthrough (emergence) gradually becomes noticeable in certain niches. One example is the growing success of the electric bike.

Steering the mobility system of tomorrow

Our mobility is reaching its limits. The air quality in Flanders is gradually improving, but traffic remains one of the most important sources of air pollutants and greenhouse gases. In 2016, the transport sector was responsible for 51 percent of nitrogen dioxide emissions, 17 per cent of particulate matter (PM$_{2.5}$) emissions and 19 per cent of greenhouse gas emissions in Flanders. Our current mobility system further hampers the ambitions to meet the internationally agreed climate targets. Longer term forecasts by the Federal Planning Bureau estimate direct greenhouse gas emissions in 2030 to be about as high as in 2012.

A structural solution to these problems will take more than minor adjustments and further optimisations. Our mobility system is facing a fundamental reconfiguration. In other words, a sustainability transition in the mobility system is needed. Three possible approaches or solution paths play a role in this regard:

- **Avoid**
  This is possible by reducing the number of trips or the distance travelled per trip.

- **Shift**
  This implies a shift to ecologically more sustainable modes of transport (modal shift).

- **Improve**
  This is possible by converting the range of transport modes to a more environmentally friendly fleet and through better utilisation of these transport modes.

This threefold framework was designed to promote sustainable mobility in urban areas and is used by the European Environment Agency. As we will see below, some solutions contribute simultaneously to avoiding, shifting and/or improving travel.

Various solutions and innovations are addressed in the public debate on the sustainability of the mobility system. Based on literature research and expert surveys, ten groups of solutions
were selected, spread over the three above-mentioned solution paths. Innovations that are only aimed at improving the environmental performance of conventional fossil fuel-powered vehicles, were not taken into consideration because they do not contribute to, or may even slow down, an actual transition.

3.2 Avoid

Avoiding travel is the most evident way to reduce the environmental impact of mobility. Distance working, learning and meeting is therefore often cited as a solution that could lead to less travel. This is, however, not evident because both passenger mobility and freight transport are closely related to the spatial location of houses, businesses and facilities. Moreover, both freight transport streams and a portion of the passenger transport are the direct result of the way in which our production and consumption systems are spatially organised. The consumer can make a difference by choosing short-chain products that require less transport. However, developments in international trade, production processes and inventory management result in ever longer transport distances. For example, companies with only one or a few production units per continent have a great impact on logistic flows. Given today’s relatively low transport costs, it will not be easy to reverse this trend. Logistics will therefore be discussed in 3.3: “Shift (modal shift)” and 3.4: “An (ecologically) more sustainable fleet”.

Distance working, learning and meeting

The share of employees who regularly work at home or in satellite offices located closer to home, has tripled in the past twenty years, to around one in eight. The Flemish government set an example in this area: e-working or teleworking is possible for 80 per cent of all Flemish civil servants. With e-learning, pupils or students no longer need to go to school or campus. They can attend class from home or from any other location. Efficient systems already exist that enable interaction between teacher and student. E-meetings, too, can reduce the number of journeys. Many meetings can be organised without any form of physical attendance. Moreover, the technology is constantly evolving, so that e-meetings are becoming increasingly similar to conventional meetings.

These ways of working, learning or meeting have a direct positive environmental effect. Trips are either avoided or shortened. Admittedly, the environmental gain among people who already take the train or bike, is small. In the longer term, this trend could also result in smaller office buildings being erected, which has a positive environmental effect. A further increase in e-working by employees who used to travel to work by car, can reduce the congestion problem as the majority of jobs are concentrated in and around cities that also have the highest levels of congestion. Many studies are available on e-working, but fewer on e-learning and e-meeting.

There may, however, be various rebound effects. Houses and satellite offices require heating, so that overall energy use may increase. Since daily commuting is no longer necessary, people may choose to live, or continue to live, farther away from the workplace. E-working not only frees up time, but also an additional portion of the household budget that can be
spent on other activities or products (with the accompanying transport). The knock-on effect of having fewer vehicles on the road can also (partly) cancel the positive effects on congestion, the environment and energy use. Studies show that, both in terms of time savings and avoided kilometres travelled per year, almost three-quarters of the teleworking effect risks being eroded due to these rebound effects. As regards energy use, the rebound effect of additional heating in the home or at the satellite office is so great that the effect is actually reduced to zero.

Even the highly ambitious scenario where 80 per cent of employees would be e-working two days per week – even without any rebound effect – results in only 10 per cent of Flemish vehicle kilometres being avoided. When taking into account the rebound effect, it is even less than 3 per cent. Even in such an extreme scenario, the effect therefore remains quite limited.

This environmental impact is bound to change in the future, because both buildings and the vehicle fleet are evolving. Buildings are increasingly better insulated, so that the negative environmental impact of additional heating declines. When part of the vehicle fleet will be driving on renewable energy, the environmental gain will be smaller. More e-working is therefore a facilitating solution for discouraging individual car use, but apparently does not lead to a significant reduction in environmental impact.

### LEVERS FOR WORKING, LEARNING AND MEETING FROM A DISTANCE

**Better work-life balance.** Many people see commuting as a negative factor for their work-life balance. E-working has a positive image among employees. For employers, e-working could be an opportunity to save costs. On the whole, Flanders is evolving towards a service society, whereby the potential of e-working increases.

**ICT facilitating.** Distance working and meeting facilities are closely linked to the organisational culture of a company. Especially the nature of the work is an essential factor. On the one hand, ICT increasingly provides opportunities that facilitate distance working and meeting. Remote monitoring or control of machinery is also possible to some extent. On the other hand, ICT can also be used to make commuting more efficient and pleasant. This could reduce demand for e-working. A minimum of face-to-face interaction will always be required, so the possibilities of distance working and meeting are limited anyway.

**Smooth acceptance of e-learning.** For e-learning, too, ICT offers the necessary facilities for distance interaction between student and teacher. The average young age of the users implies that they have sufficient knowledge and skills to assimilate e-learning.
### 3.3 Shift (modal shift)

The solution path ‘shift’ aims to abandon existing transport modes wherever possible by switching to a more environmentally friendly mode. Various solutions are possible: (electric) bikes and light electric vehicles (LEVs), carsharing, efficient mobility services, logistics modal shift and possibly also autonomous vehicles in the longer run. Such modes deserve to be examined for their contribution to the sustainable mobility system of tomorrow.

**(Electric) bikes and light electric vehicles (LEVs)**

A modal shift from the car to the regular bike appears to be not that simple in Flanders. New technologies such as electric bikes and LEVs can give a boost to the shift away from the car. They also fit in with the drive for energy-efficient vehicles and nicely complement the short-distance options – for which the conventional bike is ideally suited – with alternatives for longer distances.

The electric bike (e-bike) with pedal assist or pedelec is a hybrid vehicle that combines human power and electric power. In the ‘slow’ variant, pedal assist is limited to 25 kilometres per hour; in the ‘fast’ electric bikes or speed pedelecs, a speed of up to 45 kilometres per hour can be reached. Electric bikes are booming in Flanders. Cargo bikes, which are suitable for carrying extra luggage, goods or passengers, are an interesting option when fitted with an electric drivetrain. In some places they are already being used for urban distribution.

In 2016, the (electric) bike was used in Flanders as principal means of transport for 25 per cent of trips up to 5 km and for 7.6 per cent of trips between 5 and 15 km. In total, this represents 15.5 per cent of the number of rides and 4.5 per cent of the number of kilometres travelled. These numbers pale when compared to the Netherlands, where a quarter of all trips are made by bike. However, bicycle use is also becoming increasingly popular in Flanders. Illustrative in this respect is the creation of Fietsberaad Vlaanderen (2014) by the Flemish government, which acts as a knowledge centre and promotes the development, dissemination and exchange of practice-oriented know-how. In this way, Fietsberaad Vlaanderen wants to support cities and municipalities in accelerating and improving their cycling policy.

Any type of bike can also be used in BiTiBi services (Bike-Train-Bike) as an alternative to the car for longer distance trips. BiTiBi stands for the intermodality between bike and train, and is named after a European project. By using the bike for travelling both to the station of departure and from the terminal station to the final destination, the train (or bus) can more often serve as an alternative to the car. To also have a bike at the place of arrival, there are sharing systems such as Blue-bike.

LEVs are situated somewhere between the conventional bike and a small car. They vary in type from reclining bikes with pedal assist to lightweight electric cars. LEVs are still quite scarce and, as a niche, they are still primarily in an experimental phase among a small segment of the population. An overview of the different types is available on the website created by KU Leuven (University of Leuven), VUB (Free University of Brussels) and ASBE (an association that promotes the use of electric vehicles and supports scientific and technological developments) on behalf of the Environment Department of the Flemish government (iiw.kuleuven.be).
In general, (electric) bikes and LEVs are light and their lower speeds make them over thirty times more energy-efficient than conventional cars. The environmental impact obviously depends on the form of energy used to produce electricity for the drivetrain, and on the type of vehicle which the electric or LEV replaces. Based on available statistics and reasonable assumptions, a shift to (e-)bike, LEV and BiTiBi would allow for a 29 per cent reduction in the number of passenger kilometres by car by 2030. Moreover, the additional societal health gains appear quite substantial, even more substantial than the already significant environmental gains. It is important to note that significant policy support is required to make the use of these alternatives more attractive and to discourage individual car use.

In addition to short distance trips by car, where a shift to the (electric) bike or LEV is possible and desirable, longer distance trips by car (more than 40 km) must also be borne in mind. These account for nearly half of the number of car passenger kilometres. Here, too, the bike-train-bike combination can offer an alternative with significant environmental gains.

**LEVERS FOR (ELECTRIC) BIKES AND LEVS**

**Trendy image and health effects.** In Flanders, cycling already had a positive image as being particularly suitable for recreational purposes, but now more and more also as a functional transport mode. The emergence of the electric bike provides an additional impulse. In combination with growing awareness of the importance of exercise for health and the health impact of air pollution, (electric) cycling is showing an upward trend in Flanders.

**Flexibility and coupling to other modes of transport.** An obvious asset of bikes and LEVs is their great flexibility (‘door to door’). The promotion of cheap park-and-ride facilities in combination with the provision of (shared) bikes can contribute greatly to the quality of life in cities.

**Low cost.** An electric bike costs significantly more than a regular bike, but far less than a car. LEVs contain much less material than conventional cars and are therefore cheaper to produce. Larger production volumes could lead to a significantly lower cost.

**Suitable and sufficient infrastructure.** Flanders still has an insufficient number of bicycle highways that allow safe and optimal use of (e-)bikes. A feeling of road unsafety could impede the market breakthrough of electric bikes and LEVs. It is, however, significantly cheaper to further develop the infrastructure for bikes and LEVs than to build new motorways. In addition to a riding infrastructure, suitable charging and parking facilities (especially for LEVs) are important.
Effective policy choice in several areas. Flanders will need to drastically reduce CO₂ emissions from the mobility system by 2030 if it is to meet its international climate commitments. A shift from the car to the bike, the electric bike and the LEV can substantially contribute to this. The significant health impact of additional exercise is an important bonus. Policy incentives in this respect can therefore be particularly effective.

Need for consistent policy. Policy financially supports both cycling (tax-exempt bike allowance) and driving (company car, free (second) resident permit and parking spaces). As a result, the electric bike does break through, but often not as a replacement for the private car. Car use should be further discouraged, for example, by introducing road pricing. There exist also differences, that are difficult to objectify, between support measures for electric cars or mopeds and the lack of such measures for LEVs and electric bikes.

Carsharing

The sharing of cars, but also of other vehicles such as scooters, has grown strongly in recent years. In conventional carsharing, the vehicles have a fixed location. In one-way carsharing, the shared car can be dropped off at a different location than the pick-up location at the end of the trip. This can be a location for shared cars but also a freely chosen location within a defined area, as in free-floating systems. The latter are very flexible, but also more complex to manage.

Car-sharing companies can provide the fleet themselves, but it is also possible to share privately owned cars via an online community, with a company being responsible for the practical and legal arrangements. Scooter sharing, carpooling in companies, sharing of company vehicles between companies, or the use of car-sharing systems for business trips, also fall under these forms of shared mobility. In addition, there are systems where cars can be shared with neighbours, friends or acquaintances (peer-to-peer) for non-commercial purposes. As can be seen, there is a great diversity of systems. Membership of car-sharing organisations in Flanders has more or less quintupled to over 35,000 over the past five years. The supply of peer-to-peer cars is growing rapidly, but sometimes outstrips demand. Many people actually offer a car, but it is not clear whether it will also be used. It is as yet unclear what the societal importance of shared mobility will be in the future. It is perceived primarily as an option within a mobility ‘service package’ (Mobility as a Service). Results of studies on the impact of car sharing also vary greatly according to the area and period under study. It is also difficult to compare the studies because of differences in methodology.

Nevertheless, a number of important findings can be drawn from them. For example, with carsharing one becomes more directly aware of the costs of car use, which puts a brake on excessive use. The possession of a car means that at the time of using the car, the costs for purchase, insurance and the like are considered to be sunk costs. As a result, one tends to underestimate the average cost per kilometre by focusing mainly or only on the operational cost. This will lower the threshold for the use of one’s own car. Consequently, the comparison with the cost for the use of a shared car is not always made correctly. Moreover, the shared car is located at a certain distance, so you will be less inclined to use it for just about anything, which could lead to fewer trips (‘avoid’).
The fact that carsharing allows you to choose the appropriate type of car (rightsizing), leads to improved energy efficiency and lower emissions. Due to the more intensive use of shared cars, the car fleet can also be rejuvenated faster to more efficient types with lower emissions. This will also contribute to an ecologically more sustainable fleet (‘improve’). Electric cars are in fact particularly suited for many relatively shorter trips in areas with a dense network of charging infrastructure. This is often also the case in the typical urban environment, where shared mobility is most popular. In such an environment, carsharing can also reduce the need for parking spaces, which can have a noticeable impact on land use. If carsharing leads to reduced car use, it could also help solve the congestion problem. However, there is also a risk of possible increased car use. Furthermore, it could induce people who did not have a car to start using one. Carsharing can, however, also lower the barriers to a shift towards public transport, by providing a flexible solution for pre- and post-transport. It is therefore essential to create the right framework conditions to achieve the desired positive impact.

According to studies, members of car-sharing organisations are increasingly prepared to dispose of one or more cars or to postpone the purchase of a private car. In addition, members travel fewer kilometres than they would with their own car. The direct confrontation with the costs of car use appears to be an important factor in this regard. Users of carsharing systems are generally young and their lifestyle is comparatively less dependent on the car. Studies suggest that the average Flemish citizen would be far less inclined to abandon individual car ownership. On the other hand, the positive experience of these young urban frontrunners could inspire others and lead to further growth due to imitation effects.

### LEVERS FOR CARSHARING

**Further experiments needed.** There remain quite a few challenges in the fields of communication technology, business models and cultural barriers. It would be appropriate to organise additional experiments. Competition appears desirable, so that various forms of shared mobility can be integrated into a total package of transport modes.

**Low entry cost.** The financial benefits – no high acquisition cost or maintenance – and user-friendliness of carsharing are a strong motivator, especially for a younger audience.

**Availability at short distance.** An important factor for users is that a shared car is readily available at relatively short distance. More urban areas are therefore particularly suited for shared mobility.

**Rightsizing.** Carsharing provides rightsizing options. For example, the user can choose a smaller car that is cheaper per kilometre travelled. However, where appropriate, the user can also have a car that is suitable for carrying several passengers or larger loads.
**Stimulating policy.** A more dissuasive policy in respect of car ownership and individual use, such as the phase-out of benefits for company cars and the introduction of road pricing, would favour shared mobility. Cities and municipalities could assign specific priorities to shared cars, such as a sufficient number of reserved parking spaces. Such measures strengthen the position of carsharing and promote a sustainable and progressive urban image. Some car makers could also be encouraged to participate more actively in shared mobility initiatives.

**Objective information and awareness raising.** The user of a carsharing system is more directly confronted with the cost per kilometre travelled, giving him the impression that carsharing is expensive compared to driving his own car. Tools that allow an objective and fair comparison to be made between the actual cost of car ownership and the use of shared mobility may have an awareness-raising effect.

**Part of Mobility as a Service.** Shared mobility can become a major option within a mobility service package (Mobility as a Service). The necessary communication technologies are in place, but to further increase user-friendliness and flexibility, matching request and offer should be further optimised.

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**Efficient mobility services or Mobility as a Service**

Today, mobility is still largely based on having one’s own car. Mobility services or Mobility as a Service (MaaS, see figure opposite) seek to offer similar user comfort that is no longer based on individual car ownership. This concept is based on the user’s specific mobility requirements. The available mobility options are customised to the user’s needs. A central role is reserved for state-of-the-art communication media. Mobility as a Service assumes the integration of current public transport services in terms of use and tariffs. Consumers can access all information via an online ticket booth and make payments using a single card or transparent pricing system. Public transport services are supplemented with individual solutions for pre- and post-transport.

Recently, there have been a number of tentative developments towards such customer-oriented solutions. For example, public transport is supplemented with new peripheral facilities such as shared bikes or shared cars. Better communication media allow different transport services to be better harmonised and users to be informed in real time. Online route planners already combine certain forms of intermodal information for users. Moreover, commercial platforms are being created that go one step further. These relatively new economic players, so-called mobility integrators, inform users about the available mobility services and the best possible combination of such services. They assume the role of brokers offering door-to-door customised mobility solutions. This includes not only a comparison of time and costs, but also the necessary reservations, payments and support in case of real-time changes. Based on knowledge of the user’s previous mobility choices, personalised proposals can be made.
MOBILITY AS A SERVICE

ALL YOUR TRANSPORT SOLUTIONS

- bundling
- routing
- service
- payment
- customer experience

TRANSPORT PROVIDERS

INFRASTRUCTURE

Transport & Mobility Leuven, HIVA - KU Leuven, Background document Oplossingsrichtingen voor het mobiliteitssysteem (to: Crow 2017)
Studies show that it is crucial for public transport to remain the core of the proposed mobility solution. Only then can the environmental potential of Mobility as a Service be maximised. Furthermore, the environmental gain is only clearly positive if Mobility as a Service is used as an alternative to travel by conventional car. In all other cases, the environmental impact is limited or possibly even slightly negative.

Comfortable public transport that is an integral part of efficient mobility services can also ensure that travel time is perceived less as lost time. Promoting (electric) (shared) bikes in combination with public transport will also make the latter more attractive. Reliable information will lower the threshold for the use of mobility services, especially among the younger generation which is familiar with ICT applications. With the breakthrough of Mobility as a Service, digital literacy will become even far more important than it is today, which may pose a problem for certain disadvantaged groups. Privacy considerations are also an important factor in the context of Mobility as a Service. Business models focusing primarily on profit margins might reduce the available transport capacity, make it more comfortable and raise prices. This could lead to the exclusion of socially vulnerable groups of transport users. As with shared mobility, monopoly positions should preferably be avoided. Efficient mobility services and vehicle sharing can lower the cost and threshold of occasional mobility, thereby allowing also people from low-income groups to have access to full-fledged mobility options.

**LEVERS FOR MOBILITY AS A SERVICE**

**ICT developments.** The most important lever for the emergence of Mobility as a Service is without any doubt the further evolution of real-time communication technology. Information can thus be readily shared and linked, and be made available in a user-friendly manner.

**Deterring car use in urban areas.** When it becomes difficult, or even impossible, to reach certain parts of the city by car, this will lead to choices for other forms of transport. Mobility as a Service can play a facilitating role to make the most efficient choices based on the user’s travel profile.

**Efficient public transport.** The government will have an important steering and facilitating role to ensure that public transport constitutes the core of Mobility as a Service. The provision of efficient pre- and post-transport is an important accompanying measure. Public transport can also be made attractive for local use within the city. There is still a lack of alternatives to the car outside peak periods and/or in non-urban areas.

**Collaboration between public transport companies.** The most appropriate solutions for mobility often run across different transport networks. In many cases, however, collaboration and coordination between transport companies, cities and regions is not yet optimal.
Properly working market. There is as yet no final business model for Mobility as a Service. If one party were to become dominant in the Mobility as a Service playing field, this could impede further improvements. Society and environment benefit from a policy that prevents the creation of a monopoly position.

Logistics modal shift

The bundling of flows from different consignors and/or consignees will allow larger volumes to be handled per transport operation. Also transport by rail and ship can then become a cost-effective option because these modes require larger volumes for profitable operation. However, a modal shift to rail or waterways does not seem evident. The main reason for this are the rather limited transport distances. Rail and waterways are particularly interesting over longer distances (several hundreds of kilometres), because it enables the transshipment cost and the additional time loss to be reduced. The average transport distances in Europe are relatively short compared to Russia or the United States, for example. The limited potential for a modal shift is also illustrated by the modest effect of the European incentive policy. It appears that it will be quite difficult to achieve the objective of organising 30 per cent of all freight transport over 300 km by water or rail by 2030.

Exchange and management of real-time data could (eventually) facilitate synchromodality. This mobility is based on the combination of different transport modes for the carriage of goods, whereby it is possible to readily switch or transship between the different transport modes. An example can be found in the Netherlands, on the Rotterdam-Venlo transport connection. On this axis, four freight transport operations by rail are organised every day. In addition, there is a waterway and a motorway. It is therefore possible to always choose the most optimal transport mode depending on the circumstances, the available capacity, and the customer’s needs and requirements. Based on detailed information about the different transport modes and the goods to be carried, the ideal transport choice is made.

The comparison of such methods to optimise logistics with the operation of the internet has even led to a futuristic vision of a possible ‘physical internet’. This would be a profoundly optimised logistics network where cargoes are distributed in standard packages and forwarded via a network of hubs and transport modes. It implies an extensive standardisation of the packages used, so that they can easily be combined. This requires a system without any separate transport companies, but instead with generic transport modes that are optimally used by different logistics parties. It is questionable whether such a visionary system can and will be realised.

The potential environmental benefits of shifting part of the freight transport to rail and/or inland navigation are obvious. A modal shift on such a significant scale is, however, quite unlikely in the short to medium term.

The still theoretical concept of a physical internet could lead to significant reductions in greenhouse gas emissions. City distribution could provide a smaller-scale testing ground, which would allow for a better assessment of the potential environmental impact.
LEVERS FOR LOGISTIC MODAL SHIFT

Coordinated logistic hubs. Transshipment and bundling of flows can be organised in regional logistic hubs. Strategic choices for the location of such hubs and their embedment into spatial planning can benefit the modal shift.

ICT and synchromodality. Collaboration between providers of transport and mobility solutions can lead to ICT-driven platforms that enable synchromodality. This allows different transport modes to be used optimally on the basis of a real-time comparison of information relating to the availability and characteristics of both freight and various modes. Modern communication technology and real-time information play a key role in this regard.

Logistics as a Service. A logistics third party or broker who has access to all relevant information and provides logistics services (Logistics as a Service or LaaS) can play a powerful facilitating role. He ensures that the goods reach their destination as efficiently as possible by allocating them to modes of transport, thereby optimally bundling goods flows.

Autonomous vehicles

Vehicles have different levels of autonomy, ranging from no to full autonomy. Cars with adaptive cruise control and lane support, which have already made their appearance in Flanders, belong to one of the lower autonomy levels. The higher levels are still under development and pose not only technological but also ethical and legal challenges. For example, questions are raised as to the choices to be made by autonomous vehicles in crisis situations and who is liable if they fail.

Self-driving vehicles with a high level of autonomy can be relevant to both passenger transport and freight transport. The transport of certain goods to the customer, for example, could to a large extent be automated. Or goods could be delivered via small self-driving vehicles from central storage facilities in the city, as an autonomous form of city distribution. A number of trial projects on autonomous vehicles are currently ongoing in Flanders. Flemish partners are also involved in international research projects.

The environmental potential of autonomous vehicles is, however, dependent on their impact on the number of kilometres travelled, the emissions technology and their impact on the traffic flow. Vehicles with a high level of autonomy would allow users to read, work or rest during the journey. Such a high level of comfort might make people less inclined to live closer to their workplace. Also non-work-related journeys over longer distances can thus be made more attractive. If autonomous vehicles lead to less congestion and therefore higher average speeds, this effect can even be reinforced. In the case of connected autonomous vehicles, for example, the overall flow will improve. Autonomous vehicles are expected to have higher energy efficiency because they allow the driving pattern to be optimised. If autonomous vehicles prove to be safer, they could possibly also be made lighter, thereby further increasing their energy efficiency. Autonomous vehicles could make alternative powertrain technologies more attractive. The lower weight of the vehicles coupled with a higher level of road safety could increase the driving range of batteries.
The impact on the emissions of greenhouse gases and air pollutants is therefore the combined result of a variety of factors and is not necessarily positive. Mainly the use of sustainable powertrain technologies, rather than the autonomous character of the vehicle itself, will make the difference. A high level of autonomy is expected to improve road safety. This could lead to a reduction in non-structural congestion caused by accidents. However, the positive effects will depend on the mix between autonomous and non- or semi-autonomous vehicles and also on the level of autonomy. At a later stage, they can also improve the mobility of people with restricted (car) mobility, such as the elderly or people with a disability.

**LEVERS FOR AUTONOMOUS VEHICLES**

**Convincing demonstration projects.** The technology is still too immature to allow for higher levels of autonomy in the short term. Further investments in research and development are required. A high level of ICT security for (online) control will also be crucial.

**Complement to public transport.** Autonomous transport is particularly interesting as a complement to public transport and Mobility as a Service. Self-driving private vehicles are not meant to replace public transport, but they can be used as part of the public transport system. Autonomous vehicles can offer opportunities in the longer term, above all in those areas where the development of conventional forms of public transport entails significant costs.

**Cost.** The cost of a fully automated vehicle is currently estimated to be a multiple of the price of a conventional car. On the other hand, individual ownership is not required and the vehicles can be used for mobility services (Mobility as a Service).

**Ethical and legal framework.** The government will have to create a consistent ethical and legal framework as to who is responsible in case of accidents or glitches in the system. The co-existence of non-autonomous, semi-autonomous and autonomous vehicles could also give rise to challenges in the field of road safety. Comprehensive regulation of such aspects is crucial in order to create support for the fact that driving is taken over by a system.
3.4 An (ecologically) more sustainable fleet

‘Improve’ points at solutions and innovations that enhance the environmental performance of means of transport through technological innovation or better utilisation. Reducing the environmental impact appears to be possible through the use of battery electric vehicles, fuel cell or hydrogen-powered vehicles, or through the use of advanced biofuels. In addition, ridesharing and logistic improvements are considered as solutions to improve the efficiency of means of transport.

Battery electric vehicles

Recent technological innovations, especially in battery technology, have made the electric drive an alternative to the conventional internal combustion engine. A switch to electric vehicles is now seen as a promising strategy to significantly reduce emissions of greenhouse gases and other pollutants. In that case, emissions are limited mainly to the generation of the electricity used to charge the batteries. Particulate matter emissions from wear and tear of brakes, tyres and road surface, however, remain unchanged or may even increase due to the weight of the battery. There is, however, a 100 per cent gain in terms of NOx due to the absence of combustion processes. The air quality gain is therefore smaller than the avoided exhaust gases. This is certainly the case when comparing them with diesel and petrol cars that meet the most stringent Euro standards. For those vehicles, wear and tear in fact represents the bulk of particulate matter emissions.

Various types of electric vehicles have been put on the market in recent years. In many cases these are hybrid vehicles equipped with both an electric drive and an internal combustion engine. In the basic variant, the battery is only charged during braking. If the battery can (also) be charged by connecting it to the electricity grid, the term ‘plug-in hybrid vehicle’ is used. We will only discuss this type of hybrid vehicle because it offers greater environmental potential. An electric vehicle that has no internal combustion engine is referred to as a battery electric vehicle (BEV). In that case, the driving range is an important variable. Some car makers overcome this problem by incorporating an internal combustion engine, only for the purpose of recharging the battery in case of emergency (extended-range electric vehicles or EREV). The optimism about the potential of electric vehicles is apparent from the fact that even the electrification of (lighter) freight transport is no longer dismissed as utopian. It does, however, remain a challenge: heavy batteries go at the expense of extra freight and there is also the potential loss of time due to the charging times.

Electric vehicles still make up less than one percent of the vehicle fleet in Flanders. About two-thirds of these are plug-in hybrid vehicles. In 2017, the percentage of new electric vehicle registrations amounted to 3.5 per cent, indicating a sustained increase. If innovations in the field of battery technology continue, the limited range of BEVs will be much less of a problem by 2030. Moreover, quicker charging times should also become possible by then.
The environmental potential of a transition to electric vehicles with battery depends mainly on how the electricity for charging the batteries is generated. For hybrids, the emissions released during use of the combustion engine must also be taken into account. In general, electric propulsion, also with the current European energy mix, can be said to be significantly cleaner than the propulsion system of traditional vehicles. It allows greenhouse gas emissions to be reduced by around 40 per cent. Especially the expected longer-term developments in sustainability of the energy mix suggest great environmental potential in the (more distant) future.

The higher weight of BEVs, however, still remains a drawback for non-exhaust particulate matter emissions. The production of an electric vehicle currently also requires about 70% more primary energy than that of a traditional vehicle. There are as yet no efficient recycling cycles. However, the environmental gains during the use phase compensate for the other effects, the more so if the electricity comes from renewable sources. Another advantage is that electric vehicles are much more silent at low speeds, especially in urban areas.

Electric vehicles can make a contribution to more sustainable mobility provided their potential is correctly assessed. They are not a universal solution as such. Problems like congestion, road accidents, and pressure on land use continue to exist. Moreover, sustainably generated electricity is a key condition and the additional demand for electricity represents a challenge for the energy system.

**LEVERS FOR BATTERY ELECTRIC VEHICLES**

**No major adaptation.** The transition to an all-electric transport system requires only a relatively limited cultural change. Consequently, from a societal perspective, this solution is simpler than modal shift alternatives, but it does not solve the congestion or road safety problem.

**Rapid technological evolution.** The limited driving range and the long charging times for batteries prevent a broader breakthrough for the time being. Lithium-ion battery technology is evolving rapidly, and this evolution is expected to continue for quite some time. This can reduce the costs and lead to significant improvements in terms of driving range and charging time, thus making the transition also practically feasible for a larger share of the population. The production of batteries does, however, require critical resources, which raises questions from a sustainability perspective.

**Growing charging infrastructure.** The number of charging stations for electric cars is growing. Collaboration between the government and private players could ensure that the number of charging stations grows at a sufficiently rapid pace.
**Potential key function in climate policy.** A relatively swift transition to electric vehicles can contribute significantly to meeting the international commitments in the field of greenhouse gas emissions.

**Growing attention to air quality and health.** Air quality as a social issue has gained in importance in recent years. The positive impact of electric vehicles on local air pollution and health - especially in relation to diesel vehicles - can promote legitimacy.

**Correct information about the total cost of ownership.** Even if a portion of the cost is recouped through lower energy and maintenance costs and subsidies, electric vehicles still cost significantly more than conventional vehicles of comparable size. A better awareness of the lower energy and maintenance costs could promote the breakthrough of electric vehicles. Additional knowledge, such as a method to correctly calculate the total cost of ownership via a tool or app, could have a threshold-lowering effect.

**Stimulating policy.** Policy can play an important role by introducing a favourable tax regime for electric vehicles. Such a regime would include lower road tax rates, higher tax deductions, or road pricing based on emission factors. Also other measures, such as the reservation of parking areas for electric vehicles and the introduction of low-emission zones, could have an incentive effect.

**Matching electricity demand and supply** The impact of a swift transition to electric cars on overall electricity demand is significant. This will have to be taken into account when matching demand and supply. The growth of private PV panels can play a role in this.

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**Hydrogen fuel cell electric vehicles**

In addition to batteries, electric vehicles can be equipped with hydrogen-based fuel cells (fuel cell electric vehicles of FCEVs). The electric current generated in the fuel cell is used to power the electric motor. Water is the sole by-product that is generated, due to the reaction with oxygen from the air. This type of vehicle is not recharged, it is refuelled just as an LPG vehicle. In Flanders, there is only a very small number of hydrogen-fuel cell powered electric vehicles. In 2017, only one new car was registered. There is also only one filling station for private consumers, which is located in Zaventem.

Just as with vehicles that are (fully) powered by an electric battery, direct emissions are limited to particulate matter due to wear and tear of brakes, tyres and road surfaces. FCEVs do, however, cause indirect emissions due to the production of hydrogen. Today, by far the most cost-effective method to produce hydrogen is a process based on fossil fuels such as natural
gas, which gives rise to greenhouse gas emissions. With production via electrolysis, it would eventually become possible to produce hydrogen gas by means of renewable energy. In view of the high process cost, it is questionable whether this is realistic within the time horizon to 2050. Much will depend on developments in the market of battery electric vehicles. Indeed, if costs continue to fall in this area too, whilst the energy density of batteries continues to grow and charging times keep coming down, this would neutralise the advantages of FCEVs. Fuel cell powered vehicles could eventually (only) prove interesting for niche markets such as (very) long distance freight transport.

**LEVERS FOR HYDROGEN FUEL CELL ELECTRIC VEHICLES**

**Higher driving range, easy refuelling** The driving range and the refuelling time are similar to those of conventional combustion engine vehicles. Developments in electric battery technology could reduce this relative advantage of hydrogen-fuel cells in the medium term. For longer distances (outside the city), FCEVs are currently more suitable than battery-powered electric vehicles. They may also be an interesting alternative to long-distance freight transport.

**Development of charging infrastructure.** Hydrogen infrastructure is as yet virtually non-existent in Flanders. This situation is not expected to change in the short term due to the cost of the large storage tanks and the associated safety facilities.

**Lower vehicle and fuel costs.** Today's FCEVs are expensive, due in part to the small production volumes. The price of hydrogen is also relatively high. Production is not always energy-efficient.

**No need for rare earth metals.** The production of electric vehicles requires critical metals such as cobalt for the batteries. Hydrogen is produced without any rare mineral resources. Therefore, there are no issues regarding the use of sustainable materials.

**Advanced biofuels**

Three forms of biofuels should be distinguished:

**First-generation biofuels** are derived from rapeseed oil, soya bean, sunflower or palm oil for biodiesel production, and from sugarcane, sugar beet, wheat or maize for bio-ethanol production. The production of these fuels therefore competes with food production.

**Second-generation biofuels** are made from agricultural and forestry residues, suitable waste streams and crops grown specifically for biofuel production. They are produced mainly using (thermo)chemical processes and new fermentation technology, aimed at full exploitation of the biomass.

**Third-generation biofuels** are made from algae specially cultivated for this purpose.
The term ‘advanced biofuels’ refers to second- or third-generation biofuels. In Flanders, they do not yet play any role of significance in the total energy demand for transport. Several research projects are ongoing in which Flemish research institutions participate.

The carbon footprint (greenhouse gas emissions per energy content) of second-generation bio-ethanol and biodiesel is still uncertain. It is, on average, lower than for petrol and diesel, and therefore also better than the footprint of first-generation biofuels. However, water consumption during production is significant. The carbon footprint of third-generation biofuels currently still far exceeds that of diesel.

### LEVERS FOR ADVANCED BIOFUELS

**Customised solution.** Advanced biofuels can be an alternative to fossil fuels for transport modes where electricity is not an obvious alternative, such as heavy construction or agricultural machinery, aircraft and ships. These last two modes are a major challenge in this regard.

**Further research into environmental impact.** In recent years, the breakthrough of biofuels in Europe was hindered by uncertainty regarding the sustainability of these fuels. Also in the case of advanced biofuels, there is still some level of uncertainty about the environmental impact.

**Availability of raw materials.** For advanced biofuels to break through as alternative fuels, a sufficient availability of raw materials must be guaranteed. In addition, they must meet technical and sustainability specifications.

**Efficient production.** Further research is necessary to improve the technical efficiency and cost effectiveness of the different conversion processes. The challenge will be to scale up results from laboratories and demonstration projects to commercially profitable production processes.

**Support.** Compared with the first generation biofuels, the production of advanced biofuels requires more complex technologies. The capital costs are therefore also much higher. In combination with other risks, this makes biofuels less attractive for investors. In the absence of public incentives, these biofuels are unlikely to compete with fossil fuels in the short or medium term.
Ridesharing

Carpooling or ridesharing means that people jointly complete (part of) their trip by car, thereby maximising the occupancy of the vehicle. Recent ICT developments facilitate the search for potential carpool partners. New trends are so-called dynamic or real-time ridesharing systems where drivers and passengers can receive carpool proposals while en route.

In 2014, the share of carpooling in commuter traffic amounted to 3.3 per cent for business establishments located in Flanders, a percentage which, based on diagnostics on commuter traffic by the Federal Public Service Mobility and Transport, has dropped over the past decade. Flanders has eighty or so carpool parking areas (with a total capacity of over 5800 vehicles). Ridesharing is mainly associated with home-work trips, but is also applied for other trips.

The environmental impact of ridesharing depends on the means of transport that would have been used in the absence of ridesharing. If ridesharing replaces a journey by car where one rides alone, the average occupancy of cars increases whereby the environmental impact decreases. To participate in ridesharing, the passenger may be required to first travel a small distance to the meeting point. Or the passenger is picked up and dropped off, in which case the distance travelled increases for the driver. This means that the net impact on the number of vehicle kilometres travelled, the financial cost and the environmental cost – especially with shorter carpool distances – will be smaller. Assuming the average occupancy per car in commuter traffic would rise from 1.06 (according to the Travel Behaviour Study) to 1.25, then the total number of car kilometres is estimated to drop by 3.9 per cent in 2030. The money saved by ridesharing may, however, give rise to a rebound effect. If ridesharing is applied on a sufficiently large scale during peak hours, and used mainly by people who would otherwise use their car alone, it can have a positive effect on the congestion problem.

**LEVERS FOR RIDESHARING**

**Adequate policy.** Car use costs in Belgium remain low. Consequently, the potential financial savings for participants in ridesharing are currently rather limited. Moreover, ridesharing comes at the expense of some degree of flexibility. Coordinated policy choices and incentives are crucial to further encourage ridesharing, such as additional parking facilities for carpooling and tax incentives for commuter ridesharing. Companies could also be stimulated to promote or even organise ridesharing themselves.

**ICT and new forms of service provision.** ICT developments and the growing amount of available data make it increasingly easy to match people’s transport needs. New service providers can come up with innovative solutions in the ridesharing market. Flexible real-time systems do, however, require sufficient scale, so that ridesharing requests are also answered effectively and quickly enough.
Logistics improvements

In a densely populated region like Flanders, it is important that the available transport capacity for goods is used as efficiently as possible. In Flanders, the current load factor of lorries is on average around 40 per cent. Improvement can be achieved in various ways. For example, the volume or tonnage per lorry can be increased by stacking loads more efficiently. Bundling of cargo flows from different consignors and/or to different consignees is also crucial.

Bundling can lead to an increased cargo volume per journey. For cooperation between companies, ICT can be used for rational routing or matching of loads (complementary flows or return freight) or to optimise the frequency of deliveries. Possible opportunities for a logistics modal shift, whereby bundling of certain goods could cause transport to shift to rail or waterway, were already discussed earlier in this document.

City distribution could reduce congestion in the city and improve quality of life. Goods destined for the city are delivered at distribution centres on the outskirts of the city. They are then forwarded to their final destination by smaller, optimally loaded vehicles. The drop density per vehicle increases, resulting in the reduced presence of delivery vehicles in the city. City distribution appears to be promising to improve urban quality of life.

The environmental potential with a better logistic organisation, especially by bundling, is estimated at a reduction in the number of journeys by 10 to 15 per cent. While significant, this reduction should be set off against the expected growth in freight transport by 30 per cent for the period 2012-2030. Logistic improvements will therefore only limit the growth of transport, and the associated rising environmental impact. Moreover, logistic improvements will lead to lower transport costs, which could generate additional transport demand.

LEVERS FOR LOGISTICS IMPROVEMENTS

**Regional logistics hubs.** Bundling and transshipment of flows becomes more evident through the provision of regional logistic hubs. They should preferably be included and embedded in the Flemish spatial planning policy.

**City distribution.** A guiding government policy that discourages (road) transport and restricts access to cities, can lead to sustainable logistic adaptations. Good examples in the field of city distribution may prove contagious. The resultant improvements in quality of living can contribute to generate legitimacy and support from residents.

**Third parties (brokers).** The efficiency benefits that can be achieved by bundling will allow the market to evolve towards collaborations between logistics players. Third parties (brokers) can play an important facilitating role between parties by lowering the transaction costs. Specific requirements related to delivery or collection times for different recipients could be a challenge in the case of bundling.
3.5 Conclusions

Towards a sustainable mobility system

Several modes and alternatives will contribute to the transition towards an (ecologically) more sustainable mobility system. For a number of them, however, future (technological) developments and their potential environmental impact are still uncertain. There are also real risks of rebound effects or other indirect effects that could undermine the environmental potential. Furthermore, the expected population rise, declining family size and increase in the number of passenger and freight transport operations will put additional pressure on the mobility system.

The majority of solutions are expected to affect also other external costs of transport, such as congestion and road safety. Clear health gains can also be expected with increasing use of the more active transport modes. Furthermore, a number of broader societal impacts have implications for a number of innovations and solutions. These concern aspects such as inclusion, privacy, the market power of providers and the broader economic and social implications connected with the emergence of new technologies and the extraction of mineral resources.

There is no single solution for a sustainable mobility system. We are looking at a combination of solutions, spread over three approaches: avoid, shift and improve. New sustainable niches can be supported and break through. At the same time, however, existing components such as the public transport system need to be optimised and expanded. For public transport will continue to play an important role as the backbone of a future sustainable mobility system.

The interwovenness with other societal systems is significant and likely to increase further. The sustainability of solutions also often depends on developments in other systems, such as the energy system. Fortunately, there is a growing number of people and businesses that are eager to contribute to a more sustainable mobility system. However, habits in our travel and consumption behaviour prove to be particularly persistent. A change appears to have been initiated, but the acceleration in the transition to a sustainable mobility system is still ahead of us.

Levers for the transition

Specific levers that can make the difference for certain solutions have already been discussed in greater detail elsewhere in this report. There are, however, also more generic levers that are relevant for sustainability transitions within the entire mobility system, or large parts thereof.

A clear, consistent, stable and credible longer-term policy framework is needed. This will not only reduce the risks for potential investors, but will also allow behavioural patterns to adapt sustainably. One of the most important policy levers is the social correction of the relative prices of transport choices, taking also external costs into account. In this way, the consumer can and will also take into consideration the (ecological) sustainability of the
options. At present, the price of passenger and freight transport does not reflect these external costs at all, or only to a very limited extent. As a result, the organisation of the logistics economy, for example, is too much based on relatively cheap fossil fuel-powered road transport. Price incentives can also play a key role if companies are to be encouraged to take environmental considerations into account in their mobility decisions. It is not the task of a government to advance a specific technology, but rather to impose environmental standards and to ensure a pricing policy that allows (ecologically) more sustainable mobility solutions to find their way to the market.

The need for integrated policy among the many relevant areas (space, living and working, industrial policy and mobility) is stressed. This is perfectly illustrated by the teleworking example. This topic can also be found in various other innovations and solutions. Mobility is therefore also directly linked to location choices, networks and how they operate. Spatial strategies geared towards sustainability can play an important facilitating role in this process. Policy makers obviously have a range of objectives that extend beyond purely environmental considerations. This only highlights the crucial importance of policy alignment and integration. A given organisational culture, in itself a part of a social situation or evolution, has a great influence on the various solutions for the mobility system. The values and norms that belong to a given culture, fundamentally determine our mobility behaviour. A sustainability transition therefore also requires changes in mentality. Within a given culture and set of values, every individual will make mobility decisions that result in a specific mobility behaviour. These decisions are rationally motivated in some cases, but emotions and habits also play a role that should not be underestimated. The challenge is to install a choice architecture that also allows the integration of non-rational motivations. For example, 'joy of ownership' appears to be particularly persistent in the context of car ownership. Information or education alone is not effective enough. Sustainable examples, by contrast, could prove contagious and lower the threshold to try out a particular behaviour. A properly balanced combination of 'persuading' and 'seducing', but also of obliging and enforcing, is necessary. In this context, it is also found that the effects of public transport improvements on car use remain limited. Car and public transport remain essentially separate markets. A modal shift will only be possible if the travel time of public transport approaches that of the car. The challenge will therefore be to achieve a competitive travel time for public transport. Making car use comparatively less attractive through pricing will be a significant lever in this respect. Both are needed simultaneously: making public transport more attractive and deterring car use.

Technological developments in information and communication are crucial for virtually all solutions and innovations. However, technology alone will not be sufficient to change also our behavioural patterns. User friendliness and a distinct advantage of specific choices that are facilitated by technology, will be crucial in convincing people to make the switch. There is broad consensus that electric transport can in future contribute significantly to an (ecologically) more sustainable mobility system. However, this is obviously closely linked to the energy mix. A high percentage of green electricity is a crucial prerequisite. Here, too, the challenge lies in the energy transition and the associated technological developments. The
shortage of raw materials also raises questions as to the sustainability of the battery technology itself. The transition to electric cars is in itself not the technological solution for a transition to a sustainable mobility system, but it does have a role to play in the process.

It is particularly important for policy interventions in the field of mobility to pay sufficient attention to all the effects involved, including undesired **indirect effects and rebound effects**. These appear to be a real risk in many solution paths. Teleworking, for example, could lead to people living farther away from work, thereby resulting in (slightly) fewer but also longer journeys. The additional free time (and budget) may also generate additional recreational trips. Policy measures or incentives should therefore preferably take into account the rebound effects, which are less favourable in the environmental field. Autonomous vehicles for their part could lead to new induced traffic and longer commute distances. On the other hand, fewer parking spaces are needed, resulting in space savings. But the search for new customers or parking spaces can lead to additional kilometres travelled. In several solutions, various indirect effects come into play that can mutually reinforce or (partially) cancel each other out. Policy-supportive research is essential to proactively counter these effects.