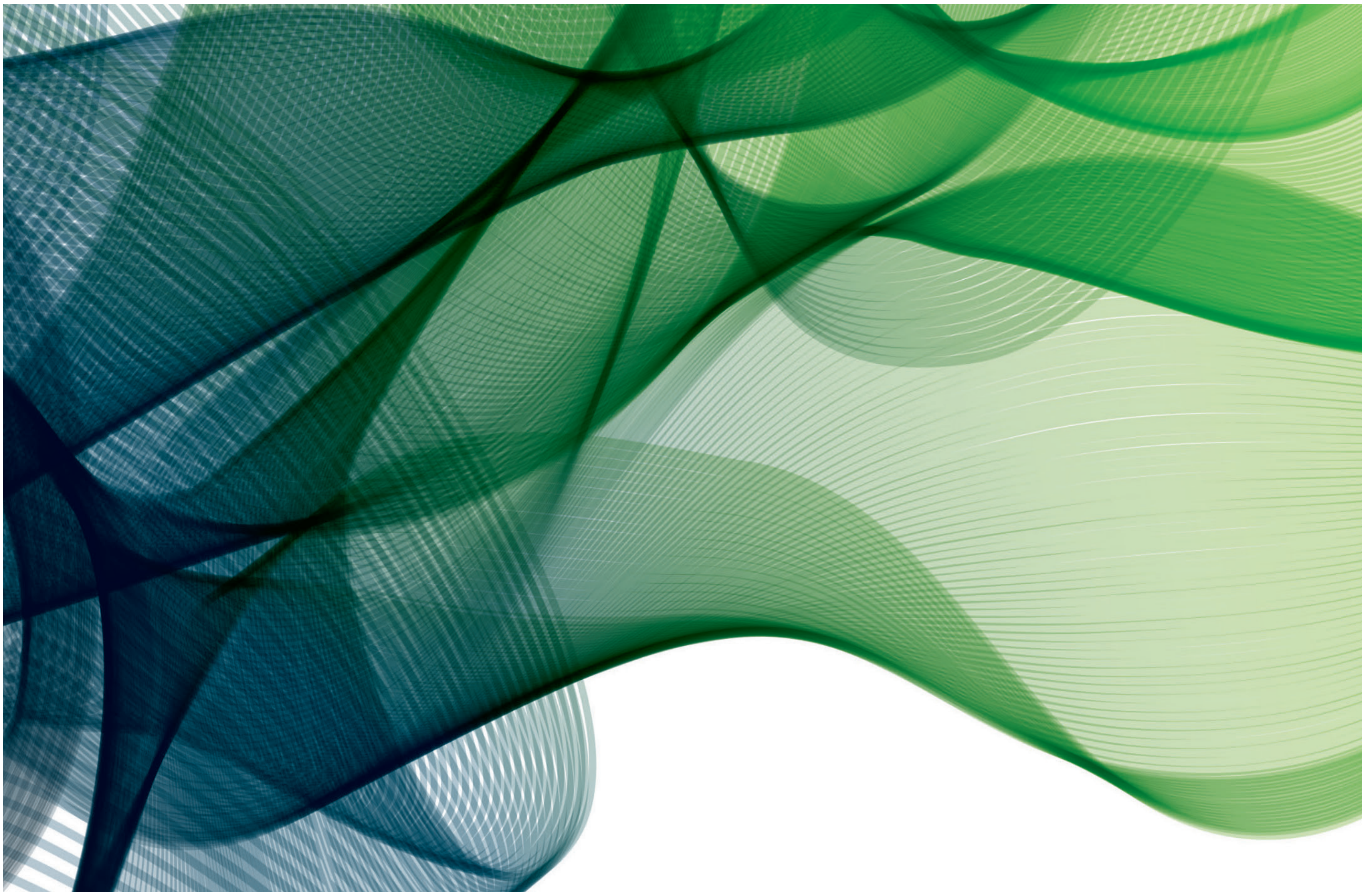
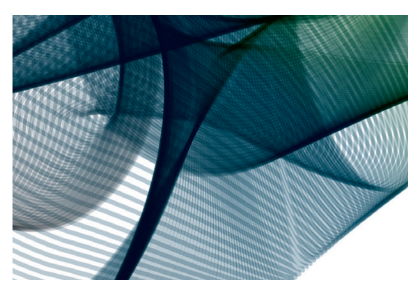
International Transport Forum



Policy Priorities for Decarbonising Urban Passenger Transport



Decarbonising Transport

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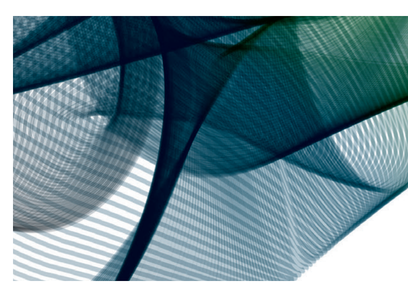

Decarbonising Transport

The International Transport Forum

The International Transport Forum is an intergovernmental organisation with 59 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. ITF is the only global body that covers all transport modes. The ITF is politically autonomous and administratively integrated with the OECD.

The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

The ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

The Members of the Forum are: Albania, Armenia, Argentina, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, China (People's Republic of), Croatia, Czech Republic, Denmark, Estonia, Finland, France, Former Yugoslav Republic of Macedonia, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Montenegro, Morocco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Arab Emirates, the United Kingdom and the United States.

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Case-Specific Policy Analysis Reports

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Executive summary

What we did

This report identifies policy priorities, megatrends and pressing issues regarding the decarbonisation of urban passenger transport. It presents the results of an expert survey on important challenges in the area and summarises the findings of a workshop with 36 experts from 12 countries regarding strategies for the transition to carbon-neutral urban passenger transport. The policy priorities identified in the workshop will be used to inform the development of policy scenarios considered in the ITF's ongoing carbon emissions projection activities published in the biennial ITF Transport Outlook and to enhance the catalogue of effective mitigation measures as part of the DT initiative.

What we found

The urban passenger transport sector must operationalise all policy levers together in order to deliver on climate change goals and sustainable development goals more broadly. Connected, autonomous, shared and electric mobility will be necessary in order to decarbonise urban passenger transport. The shared nature of this mobility will be essential to meeting urban mobility needs.

Transforming the urban transport landscape will require holistic, prospective urban planning in concert with a variety of demand management measures. Comprehensive policy portfolios will include strategic land-use policies integrated with multimodal transport planning, economic instruments, infrastructure/service measures, as well as regulatory measures that support connectivity. Successfully reducing the use of personal vehicles will ultimately depend on providing citizens with sufficiently attractive alternative mobility options. Emphasising the viability and appeal of high occupancy shared mobility services is therefore important for their widespread adoption and the full realisation of the benefits they offer.

A great multi-sector effort will be needed to make carbon-neutral urban passenger transport a reality. Innovative solutions for advancing electric mobility, managing transport demand, developing autonomous vehicle technology, and designing smart and well-integrated urban areas will involve a wide range of stakeholders. These include new technological actors, mobility operators, public authorities, infrastructure developers, city planners, electricity utilities, after-sales and end-of-life actors, the public, as well as NGOs.

What we recommend

Develop coherent electric mobility strategies for urban areas

Electric mobility strategies should be prioritised within broader urban mobility strategies. In this context, greening the grid is essential for realising the CO_2 benefits of electric mobility. Improvements in fuel efficiency are crucial but will not be able to fully decarbonise the urban mobility sector alone.

Tailor urban decarbonising pathways to the development priorities of different country groups

A single policy pathway for decarbonising urban passenger transport will not be suitable for all countries. The co-benefits from CO_2 mitigation strategies should be maximised in the design of these pathways, especially for low-income countries. Developing countries have great potential to leapfrog with respect to transport technologies, systems and policies.

Engage in holistic and prospective urban development planning that prioritises connectivity between different modes of travel

Reducing travel demand, facilitating high occupancy shared mobility and encouraging walking and cycling will require regulated expansion of cities with integrated planning of land-use and transport. Low-cost, efficient public transport and non-motorised transport investments are cost-effective strategies for reducing the carbon intensity of urban travel. Prioritising multimodal integration will be important in delivering urban mobility demand in a sustainable way. Multimodal integration can be accomplished through the strategic integration of information, fares and institutions.

Forge new collaborations between relevant actors to address the sustainability challenges of urban passenger transport

Concerted efforts will best address urban mobility challenges in the face of a changing transport landscape. The roles and responsibilities of diverse actors must be (re-)defined, including those of mobility service providers, vehicle manufacturers, governments on local, regional and national levels, among others. Unprecedented co-ordination between these actors is necessary in order to achieve efficient and sustainable urban transport for all.

Continue to employ and refine demand management measures to incentivise the use of sustainable transport modes

Congestion charges, emission pricing and other financial incentives to manage demand effectively reduce the CO_2 emissions of urban travel. Non-price measures that leverage other relevant motivations (e.g. environmental, social or health-related considerations) can be effective complementary interventions.

Consider behavioural factors in both supply- and demand-side decarbonisation measures for urban transport

Behavioural factors should be an important consideration in the design of urban spaces, the implementation of new technologies, and the development of demand management interventions. It is ultimately behavioural change that will ensure the success of decarbonisation measures in the long term.

Introduction

In the 800 000 years prior to the industrial revolution, atmospheric carbon dioxide (CO_2) concentrations fluctuated between 170 and 280 ppm. In the years since the industrial revolution in the late 19th century, the concentration of CO_2 in the atmosphere has increased to 410 ppm, precipitating a 0.84°C increase in the average global temperature (NOAA, 2018). A continuation of this trend would result in CO_2 concentrations reaching between 750 and 1 300 ppm in 2100, and an average global temperature between 2.2 and 3.7°C above that of the pre-industrial period (IPCC, 2014). A wealth of scientific evidence indicates that an increase of 2°C greatly increases the risk of extreme climate events such as sea level rise, forest fires, floods, ecosystem degradation and intense droughts (IPCC, 2014), all of which pose serious threats to the natural environment and human health and long-term prosperity.

The transportation sector accounts for 23% of all global fuel-burn emissions of CO_2 (IEA, 2016), and transport-related emissions are increasing faster than emissions from any other sector (ITF, 2017a). Continued population growth and economic development worldwide will further increase transport demand in the coming years, especially in developing countries. Global populations are also expected to become increasingly urban, which will further propel the trajectory of CO_2 emissions originating from urban passenger transport. Limiting the global average temperature increase to 2 degrees Celsius above pre-industrial levels (the 2D scenario) will be a challenge, as urban passenger transport activity is projected to grow by between 60 and 70% relative to 2015 levels by 2050 (ITF, 2017a; IEA, 2016). Total motorised mobility in cities could increase by 94% between 2015 and 2050, leading to a global CO_2 emissions increase of 26% from urban activity alone (ITF, 2017a).

As a result, decoupling travel activity and its associated energy use from CO_2 emissions is an essential policy priority at all scales. Given that technological progress alone will not be able to curb the projected growth in emissions, local and national governments will need to deploy all of the resources at their disposal in order to address this untenable trend. A range of measures, including those that would shift travel behaviour, improve vehicle technology and encourage alternative fuels will need to be implemented.

The ITF Decarbonising Transport Initiative

The International Transport Forum (ITF) at the OECD acts as an international think tank that conducts research into the priorities relevant to the design of transport policies, including equity, safety, and economic and environmental considerations. Comprised of 59 member countries, the ITF seeks to identify and analyse transport issues related to these priorities and facilitate stakeholder dialogue in order to raise awareness, build consensus, and drive progress in the sector. The ITF's Decarbonising Transport (DT) Initiative seeks to increase common understanding and build capacity with respect to mitigating carbon emissions from transport activity. It accomplishes this by gathering evidence and best practices for decarbonising transport, and by generating and disseminating knowledge through original research, outreach and exchange activities. The research carried out at the ITF is based in part on a suite of in-house models and a common assessment framework. The hallmarks of the ITF's work in this regard are its quantitative approach and its inclusivity. The work is inclusive insofar as it brings together governments, private sector groups, sectoral organisations, multilateral institutions, NGOs, and research institutions in order to address transport sector challenges faced by developing and developed countries alike and to develop a global transport and climate change policy dialogue.

The objective of the DT Initiative is to identify commonly acceptable pathways that will render the transport sector carbon neutral by 2050. The work is based a comprehensive model that covers all modes of transport at multiple scales. This framework allows for rigorous, coherent analyses of policies and outcomes across the world and considers the impact of a variety of exogenous factors (e.g. demographics/urbanisation, economic development, digital connectivity) on transport emissions. The model is able to simulate technological evolution, alternative policy paths, and their expected outcomes, as well as make adjustments to scenarios of interest in order to update previous projections. It also features a common assessment method according to which alternative policy paths can be evaluated.

As part of this initiative, the Decarbonising Urban Passenger Transport Expert Workshop constituted an effort by the ITF to identify policy priorities, megatrends and pressing issues regarding the decarbonisation of the urban passenger transport sector, as well as to gather initial evidence on the effectiveness of new urban mobility options and emerging technologies. The policy priorities identified in the workshop will be used to inform the development of policy scenarios considered in the ITF's ongoing carbon emissions projection activities published in the biennial *ITF Transport Outlook*.

The workshop gathered 36 experts from the transport field, ranging from government officials, policy makers, planners, and researchers to industry experts. The workshop was conducted under Chatham House Rule in order to encourage an open discussion and exchange of views. Presentations were grouped into several thematic sessions, including vehicle technology and energy use, supply-side policy measures, demand-side policy measures, shared mobility and autonomous vehicles.

Expert survey results from the Decarbonising Urban Passenger Workshop

As part of the Workshop, the ITF designed and implemented a survey aiming to take stock of current expert opinion regarding the issues cities face in decarbonising urban passenger transport and the most promising options for addressing these issues. The survey was sent to professionals from government, industry, civil society and academia, among others. In total, 116 individuals completed the online questionnaire between February and March 2018, yielding a response rate of approximately 65%. Of those who completed the survey, 85% were European-based and 15% were non-European-based. Analysis of the survey results generates a number of key takeaways.

First, the experts surveyed indicated that the challenges regarding urban passenger transport highly depend on the developmental context of the urban area in question. Experts indicated that low-, middle- and high-income countries do not share the same policy priorities. Respondents indicated that the three most pressing urban challenges faced by low-income countries are accidents and safety issues, low equity of accessibility, and inadequate public transport services. In middle-income countries, respondents identified issues regarding environmental impacts and energy consumption, traffic congestion and parking shortages, and accidents and safety as the top three transport policy challenges. For high-income countries, the most pressing issues were considered to be environmental impacts and energy consumption, traffic congestion and parking shortages, and long commuting times. Thus, whereas environmental issues such as decarbonisation appear to be among the top challenges faced by middle- and high-income countries, this is not the case in low-income countries, where more fundamental issues continue to be of greater concern.

When asked about the urban transport policy priorities of these three country groups, respondents identified transit improvements and incentives, land-use management strategies, promoting active transport modes and adopting shared mobility services as the top priorities in low- and middle-income countries. Respondents indicated that high-income countries share the priorities of promoting active transport modes and adopting shared mobility services, as well as promoting zero-emission vehicle programmes and low/zero emission zones. When asked to evaluate the costs and relative effectiveness of different types of decarbonisation measures, those surveyed considered that car restriction schemes, low/zero emission zones, parking management and parking pricing, and congestion pricing measures were among the most cost-effective decarbonisation strategies.

The survey also sought respondents' expectations regarding future developments in the sector. Respondents expect that shared mobility services will comprise a significant share (>10%) of mode types in low-income countries between 2030 and 2050, and a significant share of mode types in middle- and high-income countries between 2020 and 2050. The top three barriers to transitioning from personal vehicle ownership to shared mobility are considered to be convenience and flexibility concerns relative to private vehicle ownership, cultural barriers to sharing rides with strangers, and regulatory barriers. New mobility service providers and public transport operators were identified as the entities in the best position to lead a transition to shared mobility services. Experts also expect that automation will increase the likelihood that the cost of on-demand bus services will become lower than the cost of regular bus services. Most respondents (70%) also indicated that shared mobility should be a public transport option that is managed by local transport authorities.

Experts believe that autonomous vehicles (AVs) will comprise a significant share (>20%) of the urban passenger car fleet between 2020 and 2050 in middle- and high-income countries. In low-income countries, most experts believe that this will occur after 2050. With respect to the impact of AVs on personal vehicles, 54% of experts believe that AVs will increase overall vehicle use, namely by reducing travel and parking costs and by providing a mobility option to those who are too young or too old to drive. Of these, most (81%) indicated that such an increase should be limited, which could be most effectively accomplished by promoting car sharing and increasing vehicle usage costs. Thirty percent believe that AV use will decrease overall vehicle use due to the fact that autonomous cars will be more efficient at completing the tasks that drivers usually perform, as well as the fact that riders are likely to engage in more car-sharing in the future. Finally, 16% of experts believe that greater use of AVs will have a negligible impact on overall vehicle use because other modes will adopt automation technologies in order to compete with AVs, thus offsetting the growth potential of the private use of AVs. The top barriers to the uptake of autonomous cars that experts identified include safety and security issues, technological challenges, and legislation and regulatory issues.

Overall, zero-emission vehicles are expected to comprise less than 50% of the passenger car fleet by 2050. Of the electric vehicle (EV) fleet, full-battery EVs are expected to comprise the highest share of vehicles by 2050. Although experts expect that the price gap between internal combustion engine (ICE) vehicles and EVs will decrease over time, they also expect that the purchase price of EVs will remain higher than the price of ICE vehicles in 2050. Respondents also indicated that cities in high-income countries are highly likely to introduce zero-emission vehicles by 2050, while most believed it is unlikely that the same will occur in low-income countries. Experts cited purchase cost, recharging time, the availability of charging facilities, and vehicle range as the top barriers to the uptake of zero-emission vehicles.

Some qualifications regarding the survey results should be noted. First, experts from European and high-income countries are overrepresented. Despite having a broad knowledge of the field, they may nevertheless be poorly suited to speak to the challenges faced by developing countries and countries in other regions. As a result, the perspectives of non-European and low-income countries are very likely to be underrepresented in this survey. Additionally, and as is the case with any survey instrument, the survey design itself also presents an inherent source of bias to the extent that the questions asked reflect the ITF's own awareness about current issues. An objective of future surveys could therefore be to put greater emphasis on seeking input regarding issues that are not raised in the survey, e.g. by inviting respondents to identify unaddressed issues, suggest research topics and propose solutions. Finally, we note that the survey can be an important source of insight regarding the potential gap that may exist between expert beliefs regarding the most effective measures and the existing evidence regarding these measures. Identifying any such gaps could shed light on the need to generate more evidence in certain areas, or alternatively, to better disseminate existing evidence.

Taking these qualifications into consideration, the results of the survey nevertheless indicate a reasonable degree of consensus among our sample of experts on a number of issues, yielding several main takeaways:

- It will be necessary to tailor decarbonising pathways to accommodate both the climate- and development-related priorities of different country groups.
- Transport planners should seek to maximise the co-benefits from CO_2 mitigation strategies, especially in low-income countries where improving the safety, accessibility and equity of transport remain high priorities.
- Fully decarbonising urban passenger transport will hinge on a transition to zero-emission vehicles that are less costly and better performing than those on the market today.
- Shared mobility must be integrated into multimodal transport planning in order to reduce emissions while still meeting urban mobility needs.
- Cities should give requisite consideration to how behavioural factors could impact the success of policies designed to promote autonomous vehicles.

In what follows, we provide a summary of the content of the presentations that took place in each thematic session, as well as a comprehensive review of the policy priorities identified.

Vehicle technology and energy use

Vehicle technology and fuel efficiency standards for cars

Technological advancements will play an important role in decarbonising personal vehicle travel. Despite the potential for increased fuel efficiency, ICE vehicles alone do not represent a viable long-term solution for decarbonising the urban passenger transport sector for two reasons. First, a significant gap remains between fuel efficiency standards and the real-world operational fuel efficiency of ICE vehicles, which ultimately limits the effectiveness of these types of standards as a measure for reducing emissions. Although fuel efficiency standards have become 30% more stringent between 2000 and 2016, actual fuel efficiency as measured by real world performance, has only improved by 11% over the same period. Thus, while fuel efficiency standards will continue to be an important norm to maintain, they alone cannot decarbonise urban passenger transport. Second, the technological options available for improving the efficiency of ICE vehicles (e.g. cylinder deactivation, direct injection, advanced diesel, mild hybrid, high compression ratio, miller cycle), can achieve at most a 25% improvement in fuel efficiency (in the case of advanced biofuel). Advanced biofuels do not represent a realistic technology for urban areas in the long term due to their limited availability, relatively high costs, unpredictable consequences for land-use change, and the added emissions that may be generated in their production (e.g. by fossil-fuel-based fertilisers and machinery). However, their low emission rates during combustion and potential for rapid uptake in vehicles worldwide make them an important alternative fuel option in the transition from ICE vehicles to EVs, as well as in long-distance transport (i.e. maritime and aviation).

EV technology (i.e. plug-in hybrid and battery EVs), in contrast, represents a more promising option for technological advancement in urban travel, offering the potential for efficiency improvements of up to 100% relative to ICE vehicles. Direct-charging electric battery vehicles, in particular, present the most attractive option long term, even compared to other zero-emission technologies. The well-to-wheel (WTW) energy efficiency of direct-charging battery EVs is 73%, versus 22% and 13% for hydrogen fuel cell and power to liquid vehicles, respectively. Electric vehicles will also be increasingly attractive from a financial point of view, given that the price of electricity is expected to fall as new solar and wind energy sources become operational. Continued technological advancements are also reducing the price of EV batteries and increasing their range, both of which increase their appeal among potential buyers.

Despite these favourable trends, public policies will need to be put in place in order to accelerate the adoption of EVs. In order to increase EV market share and meet the emissions commitments made in the Paris Agreement, mandates should set targets for the proportion of low- and zero-emission vehicle sales. For example, a mandate of 100% of new European car sales as ZLEVs by 2035 has been recommended by Transport and Environment, which would foster greater EV market penetration by: contributing to smart and renewable grid balancing, creating an incentive to build charging infrastructure, driving EU investment in EV and cell manufacturing, increasing the choice of EV models and marketing efforts, and reducing long-term compliance costs.

Impacts of alternative fuelled vehicles and electrification on urban transport

While the composition of the automobile market has historically been determined by forces affecting supply and demand, recent years have seen increasingly important roles being played by public authorities and civil society. Shared challenges on local and global scales (e.g. air pollution and climate change) have led these groups to have increasing influence regarding the operational standards and technological developments in the automobile manufacturing industry. Relative to previous decades, future directions in the industry are also increasingly shaped by consumer preferences. While there is still room for some efficiency gains to be made regarding ICE vehicle technology (e.g. with respect to their weight and inertia, energy consumption, and drivetrain efficiency), long-term solutions to decarbonising the passenger vehicle sector will involve technological breakthroughs with respect to electric and biogas mobility. The limited range, zero emissions, and low noise levels of EVs, coupled with the potential ubiquity of charging stations in densely populated areas means that electric mobility is particularly suited for use in the urban context.

Corporate average fuel economy (CAFE) regulations, bans on the sales of new ICE and diesel vehicles set to take effect as early as 2025, congestion charges, and low- or zero-emissions zones are examples of the increasing power that public authorities have in shaping the future of the automobile sector. Historically, local congestion appears to have been a main driver of the adoption of such policies in urban areas. Given that the use of ICE vehicles has mid- and long-term impacts with respect to natural resource use and climate change, as well as short-term impacts related to urban congestion and air pollution, automobile manufacturers are prioritising the development of e-mobility technologies (e.g. batteries, charging stations). The changing market also offers manufacturers an opportunity to pivot their business models by establishing themselves as original equipment manufacturers (OEMs), i.e. suppliers of specialised intermediate parts for other electric vehicle manufacturers. Industry actors are also seeking to expand the number of EV models on offer and the geographic spread of the market for their EVs. An important goal in this market expansion is increasing the capacity of EV batteries in order to reduce consumer concerns regarding range limitations. Although high battery capacity is not necessarily a priority in urban contexts, which are characterised by average vehicle trips of less than 50km, vehicle range can nevertheless be an important subjective consideration.

The way in which EVs complement other sustainability measures should also be taken into account when designing new technologies and solutions. EVs can, for example, contribute to the development of the smart grid by charging during off-peak hours, providing back-up power to the grid, and facilitating the incorporation of clean energy charging stations into grids and buildings. The former strategy would reduce ownership costs for consumers, and the latter could include, for example, battery leasing schemes and OEM activities that would be profitable for businesses. Innovative solutions for advancing e-mobility will notably involve a wide range of stakeholders, including new technological actors, mobility operators, cities and public authorities, infrastructure developers, city planners, electricity utilities, after-sales and end-of-life actors, as well as NGOs. Ongoing issues that will need to be addressed in the continued development and rollout of EVs include designing battery leasing operations, reducing the lifecycle emissions of new e-mobility technologies (e.g. EV batteries), automating e-mobility options, and adapting EV designs for shared use.

Supply-side policy measures

Better integrated urban transport systems

Reaching zero CO_2 emissions in 2050 in order to achieve the 2D scenario set by the Paris Agreement would require that emissions from cities peak in 2020 and decrease by 40% by 2030 (C40, 2016). With respect to transit, several measures will be particularly effective in mitigating emissions increases and should therefore be prioritised. Specifically, cities should focus on accelerating transit-oriented development, encouraging mass transit, walking, and cycling, and enabling next generation passenger vehicles (e.g. shared, EV-AV connected) and next-generation freight transport. It will be critically important to integrate mass transit systems in fast-growing cities where multiple systems are being planned and implemented simultaneously. Integration efforts should prioritise improving access and coverage, while avoiding duplication of service, and making trips as short as possible while minimising the number of transfers. Optimising trip length with respect to the number of transfers is an important priority in the design of mass transit systems given that users decide routes in part based on the number of transfers that must be made.

Smart integration that enhances the public transport network could be accomplished by introducing bus rapid transit systems (BRT), improving the service quality of transit systems, increasing the frequency of service, renovating major stations to improve security, and adding stations to increase access for underserved areas. In Guangzhou, China, for example, BRT has been integrated with the metro system and with cycling infrastructure, which has reduced vehicle congestion and contributed to an estimated reduction of 86 000 tonnes of CO_2 emissions. The success of this system is attributed to the holistic and forward-thinking planning that characterised its conception and implementation. In Dar es Salaam, Tanzania, the integration of walking and cycling infrastructure has fostered additional development in the city centre.

Successfully integrating different modes of transport requires providing users with real-time information that facilitates smooth connections and consolidating fare payment mechanisms. Finally, integration must also happen on an institutional level. Cities can build upon the successes and insights from other city experiences and must be able to collaborate with a variety of relevant stakeholders in the integration of forward-thinking transit options in the urban planning process. Increasing the use of electric buses and implementing zero-emissions zones number among some of the commitments that have been made thus far by C40 member cities.

How dockless bike-sharing systems are transforming and greening urban mobility

Now present in hundreds of cities across the world, dockless bike-sharing systems are becoming even more ubiquitous. In Beijing, for example, dockless bike-sharing is now the third most popular form of transport after bus and metro use. The extent to which the adoption of bike travel reduces CO_2 emissions depends on the characteristics of the shift in an individual’s transport behaviour, and in particular the mode that it replaces. Mobike, for example, has estimated that 4.4 million tonnes of CO_2 equivalent emissions have been saved globally as a result of the ridership that it has made possible.

Bike-sharing systems have seen extremely rapid growth in recent years (in the case of Mobike, services have expanded to over 200 cities in 15 countries, with 200 million registered users, 9 million bikes in daily operation, and 30 million rides per day). The fact that these systems have become so widespread so quickly attests to a demand for passenger transport that had thus far been largely unmet. This type of on-demand transportation is an example of how the Internet of Things (IoT) technology is changing transport. Such systems also collect large amounts of data on user patterns, which could potentially be used to analyse transit systems. The activity of these systems generates an enormous amount of data, on the order of tens of terabytes per day. As more and more people use dockless bike-sharing systems on a regular basis, these systems are becoming a fixture in the landscape of transit options, bringing more areas within range of public transit systems and therefore effectively increasing public transit ridership.

This new type of transit presents new challenges, however, and the solutions to these challenges may involve regulatory measures. The dockless nature of these systems, for example, means that users have the ability to park bikes in any location. Although bike share operators provide guidelines regarding best practices for parking (e.g. avoiding locations that block pedestrian travel), there are generally no penalty mechanisms by which good parking practices can be enforced. The question of who is entitled to the rights to the data generated by these systems also constitutes a novel issue for policymakers. If made available to researchers, for example, this type of data could be used for public transport blind spot analyses, biking hotspot analysis and prediction, multimode transportation analysis, and lifestyle impact analysis. Increasing mode shares of cyclists in cities also has implications for safety (ITF, 2018a), and may also necessitate infrastructure changes, such as reducing car lanes and increasing bike lanes.

Opportunities exist for apps to provide transportation as a service, bringing together information on multiple modes of transport from various providers onto one IoT platform in order to supply multi-mode, on-demand, real-time transport options. Bike-sharing companies have collaborated with social media companies in order to promote bike-sharing, as well as collaborating with and expanding to car-sharing services (e.g. in Guian, China, Mobike has partnered with FAW Group to pilot an electric car- and bike-sharing scheme). Bike- and car-sharing groups can also share customer data and collaborate in the analysis of this data. This constitutes an example of how transport providers can strategically partner with other companies to better understand and promote bike-sharing.

Measures to encourage the share of walking in urban mobility

Walking represents the most accessible and least emissions-intensive form of mobility, and arguably entails the most health benefits, as well. As cities have adapted to accommodate greater car use, however, walking has been marginalised as a convenient and enjoyable mode of transportation, exposing pedestrians to environmental risks in the form of accidents and poor air quality. A high level of walkability is defined as involving good public transit connectivity, high residential density, and the presence of many local destinations within walking distance. A critical factor for maintaining walkability in larger cities is accessibility to public transit for longer journeys. Pedestrian friendly infrastructure design also increases ridership, makes the service more equitable, and encourages more sustainable travel via mass public transit.

Of all urban trips taken, 63% are short-distance trips of under 5km in length. The distribution of resources allocated for transportation, however, is much more heavily weighted towards supporting middle- and long-range trips, which make up 30% and 7% of all trips, respectively (Sauter, 2016). This disproportionate allocation is reflective of a disconnect between actual mode shares of various mobility types and the relative importance that public authorities place on each of these modes. The motor-centric way in which cities are designed has discouraged walking by making travel by foot unsafe and unattractive, which further encourages people to adopt motorised transport as soon as they are able to do so. This type of failure in urban design and transport management can be illustrated in the case of Sydney, Australia: although 92% of trips within the city centre are made on foot, 52% of pedestrians' travel time is spent waiting to cross the road.

Although having accurate measurements of walking is important for transport planning, walking activity is currently poorly monitored. Most mode choice surveys ask respondents about their main mode of transport, even though walking (i.e. to and from this main mode) may take more travel time than the main mode itself. This implies that the amount of walking that takes place in cities is often underestimated. Furthermore, the mode share of walking depends on the type of measure in question (e.g. distance travelled, number of trips made, time spent, number of stages). In the interest of effective transport planning, it is important to measure the theoretical walkability of an environment based on geographic indicators, the amount of walking activity that is actually undertaken, as well as the perceptions that people have regarding the feasibility and enjoyment of walking, as these factors strongly influence decisions to undertake trips on foot. Another challenge for transport planners is improving walking infrastructure and encouraging greater walking at the expense of individual motorised transport specifically, while maintaining or increasing the ridership and mode share of public transit options. This means making walking spaces more enjoyable and improving the connectivity of and ease of transfers between modes.

Safety, inclusivity, and enjoyableness are essential elements of walkability. It is important to recognise that greater walkability in cities will not be achieved one street at a time, but through comprehensive strategic planning in urban transport design regarding the location of places of employment, transport hubs, education sites, sports and leisure sites, health care sites, and retail locations. Urban planning activities should also prioritise density, connectivity and destinations when seeking to increase pedestrian opportunities. For public transit authorities, improving walkability also presents an opportunity to increase ridership and revenues. Walk21's International Charter for Walking outlines eight key principles and essential measures for walking communities, which include inclusive mobility, well-designed and managed spaces for pedestrians, improved network integration, pedestrian-friendly land-use and spatial planning, reduced road danger, less crime and fear of crime, more supportive authorities, and a culture of walking.

Although historically underappreciated, there are indications that walking is gaining increasing attention among policymakers as a priority in transport planning and urban design. The Institute for Transportation and Development Policy (ITDP) has contributed to this movement with Pedestrians First, a comprehensive tool for walkability in cities. Walk21 has also created the International Walking Data Standard, which has been developed through a series of workshops with experts from around the globe. The project tracks the share of people who have completed at least one stage by a specific mode on the given survey day, the average number of daily trips per person by mode, the average daily travel time per person by mode, the average daily distance travelled per person by mode, and the mode share of all modes based on trip segments, main mode, time and distance. They have also launched the Making Walking Count project, a tool for the collection, analysis and dissemination of quantitative and qualitative information to help define, benchmark and analyse walking in cities.

Demand-side policy measures

Impacts of demand management and pricing policies on urban travel demand and CO_2 emissions

While transport policies have long focused on supply-side measures in transport planning, a growing body of evidence demonstrates the importance of demand-side factors in shaping transport patterns. Transport policies that aim to affect behaviour, e.g. by altering travel routes, distance, modes, frequency, or schedules, can accomplish this through either "push" or "pull" measures. Although they do not have to be monetary in nature, most often these measures come in the form of pricing measures, involving either costs for non-compliance (push) or monetary rewards for compliance (pull). The potential for such measures to have unintended behavioural effects (e.g. rebound effects), however, should also be recognised and addressed.

An increased appreciation for the role of the demand-side effects of transport policies means that new approaches aiming to influence travel demand are becoming more and more relevant as complements to supply-side policies. The complexity of travel behaviour, however, makes it difficult to anticipate the distribution of behavioural effects of transport-related measures (e.g. across groups with different socio-economic characteristics), making it challenging to anticipate the effectiveness of potential demand management measures. The most robust approach is therefore one informed by empirical evidence and pilot studies, as well as one that is designed to be easily amended in order to react to unanticipated behavioural effects or changing conditions.

In theory, behaviour change requires three conditions: access (e.g. to transport mode, destination, relevant information), ability (e.g. confidence, operational know-how, familiarity) and acceptance (i.e. desire to change, for example in the pursuit of health- or time-management-related objectives). Policies to encourage behaviour change can therefore involve:

1. facilitating access (e.g. via supply-side measures) and ability
2. persuading users that change is desirable by motivating or incentivising them (via pull demand-side measures)
3. forcing behaviour change through coercing or penalising (via push measures).

Examples of pricing policies include road tolls, value pricing, high occupancy tolls, travel distance-based charging, travel time-based charging, road space rationing, and cordon-based charging, zonal schemes, and satellite-based road pricing schemes. These measures prioritise different aims, such as increased revenues, reduced congestion and an improved equilibrium between mobility supply and demand. Importantly, the effectiveness of these measures varies according to the context and can depend on the geographic features of a city, policy context and pervading cultural norms.

In Singapore, for example, an area licensing scheme was introduced in 1975 that aimed to reduce peak hour road traffic. The policy significantly reduced traffic by 73%, shifted personal vehicle travel to public transport and altered user departure times. It also decreased CO levels during the peak morning travel period and monthly average values of NOx, as well as redistributed the average speed of vehicle travel during the peak morning period due to changes in congestion patterns. In London, congestion charging was introduced in 2003 and extended in 2007. It involved a daily charge for driving or parking a vehicle on public roads in a certain urban zone and applied between certain areas of the day on weekdays, with reductions for residential and other purposes. Although the charging scheme was only temporarily effective, reducing congestion by about 30% after introduction, which was followed by a return to pre-intervention levels, it did increase public transit ridership and bicycle usage. Emissions of NOx, PM10, and CO_2 were, moreover, reduced by between 13 and 16% (Croci and Douvan, 2016).

In Stockholm, a toll cordon was instituted around the inner city with 18 camera-equipped toll points in 2006, which allowed the transit authority to charge users a fee when passing the cordon. Here again the measure reduced congestion by 20%, car commuting trips by 24% (of which, 99% were shifted to public transit modes), and commercial traffic by 15%. Emissions of PM10 and CO_2 were also reduced by 14% and 15%, respectively. In Vienna, a parking management scheme was introduced in 1993 in which certain areas of the city were turned into short-term parking zones only, with permanent parking permits given to residents only. The scheme effectively reduced the average occupancy rate of parking spaces by 71%, the incidence of unauthorised parking, and the number of non-residential parked cars by two-thirds. It also reduced car traffic by 26%, which contributed to a modal shift to public transport (which was further facilitated by the introduction of an affordable annual public transit pass and high quality public transport service).

Research on demand management measures continues to contribute to a better understanding of their limitations as well as how they can be best implemented. For example, there are indications that these measures can be more effective if they target the “superusers” who are responsible for the majority of congestion. Case studies in San Francisco and Boston have shown, for example, that shifting the behaviour of 25% of the top 1.5-2% of the highest contributors to congestion can decrease overall congestion by 14-18%. As with any type of behaviour change intervention, its effectiveness is also naturally impacted by the attractiveness of the alternative travel modes available. There is also evidence for perverse effects associated with monetary push measures (Gneezy et al., 2011), such as the possibility that drivers will find ways to avoid penalties. For this reason, policymakers should have a comprehensive and nuanced understanding of the varied behavioural impacts, such as rebound effects, that monetary demand management measures may entail. In contrast to monetary demand management measures, non-monetary measures leverage non-financial motivations (e.g. health or social-image concerns) and cognitive biases.[1]

Effectiveness of urban demand management policies in reducing CO_2 emissions

As part of its Roadmap to Decarbonisation, the city of Copenhagen has developed a portfolio of CO_2 reduction measures that will be implemented between 2017 and 2020. Of the total amount of CO_2 reductions projected, however, only 8% will arise from changes taking place in the mobility sector. In cities that are already fairly decarbonised, the scope for reducing carbon emissions in the transport sector is therefore limited. The proposed city ring metro in Copenhagen, for example, will not yield a significant reduction in CO_2 emissions, demonstrating that increasing the supply of public transit in the city will not generate a significant amount of demand. It should be noted, however, that, insofar as it reduces congestion and liberates road space, any shift away from car transport increases the marginal benefit of traveling by car. Mitigating a shift back toward personal vehicle travel as more road space becomes available will only be possible if increases in the supply of public transit are accompanied by additional disincentives to travel by car.

In another example, a proposed toll-ring road in Copenhagen is expected to reduce car traffic by an estimated 18%, and CO_2 emissions by an estimated 12%. The economic value of the project can be broken down into the values associated with reduced congestion (DKK 9.6 billion), fewer accidents (DKK 5.1 billion), lower noise levels (DKK 1 billion), less air pollution (DKK 0.5 billion), and reduced CO_2 emissions (DKK 0.3 billion). As is evident, policy measures can have ostensible economic benefits without necessarily having a significant impact on CO_2 emissions. In Copenhagen, the long-term challenge for decarbonising urban passenger transport is to shift surface transport from reliance on fossil fuels to reliance on renewable energy sources. For this, national measures such as carbon taxes and subsidies will be necessary (at least initially) in order to help e-mobility achieve sufficient market share.

In cities that are already relatively decarbonised, such as Copenhagen (IEA, 2017), urban transport planners could do well to target other types of politically palatable externalities (e.g. congestion, safety, noise) in order to improve the liveability of cities. Insofar as they address issues that are related to the immediate quality of life among urban populations, such measures are likely to generate greater public interest and support than policies whose primary aim is to reduce CO_2 emissions alone, and any CO_2 benefits that accompany the implementation of these types of measures would be considered as climate co-benefits.

Vehicle charging schemes: The case of London

In London, the first congestion charge was launched in 2003, a low-emission zone was launched in 2008 and tightened in 2012, an ultra-low emission zone was implemented in 2015, and the T-charge was implemented in 2017. Congestion charging had become necessary because vehicle traffic was a major problem in the city centre despite high public transit ridership, the cost of which was estimated to be approximately GBP 4 billion. The aim of the charge was to reduce traffic and congestion and to raise revenue that would be re-invested in transport. The congestion charge has had several impacts, including a 30% decrease in congestion, a reduction in the total number of vehicles entering the zone per day, a 15% reduction in circulating traffic per weekday, and an 11% mode share shift away from cars and towards public transit, walking and cycling. The additional road capacity liberated by the measure was also associated with an improvement in cycling and walking conditions and traveller safety. Furthermore, congestion charging was directly responsible for a 16% reduction of travel-related CO_2 emissions inside the charging zone.

In contrast to the congestion charging scheme, the low-emission zone (LEZ) is an environmentally-motivated measure that charges travellers based on emissions. Under this scheme, vehicles that don’t meet specified emissions standards (Euro IV PM for HGV and coach, and Euro III for vans) pay a substantial daily charge in order to be able to drive within the low-emission zone. Compliance rates have responded to public announcements and other publicity efforts, and currently remain very high. In the first four years of implementation, the LEZ in London prevented the release of 28 tonnes of particulate matter, and increasingly stringent regulations have continued to yield significant additional reductions to particulate matter levels.

The T-charge, an emissions surcharge, was launched in 2017 and is characterised by the same boundary and time frames as the congestion charge. It operates in tandem with the congestion charge, adding an additional fee based on the emissions rating of the vehicle in question. This is the first emission control scheme in the UK to target individual vehicles, and represents an important stepping stone towards an ultra-low emission zone (ULEZ). The T-charge has resulted in a 30% reduction in the number of non-compliant vehicles in the congestion charging zone. In London, the ULEZ is now set to replace the

T-charge. It will apply 24 hours per day, seven days a week, and will include fewer exemptions. It will also require most every vehicle in London to meet emissions standards or pay a surcharge on top of the congestion charge in case of noncompliance.

The objective of the ULEZ is to encourage frequent users of the zone (and therefore those who contribute the most to its pollution) to switch to emissions-compliant vehicles. As such, the objective of the zone is not to ban carbon-intensive travel entirely, but to allow low levels of infrequent travel at a cost. The amount of the charge to be used in the ULEZ was selected so as to make buying a compliant vehicle the cost-effective choice for frequent users of the zone. The 2019 ULEZ is expected to reduce road emissions by 20%. London is targeting zero emissions by 2050, and future policy proposals include expanding the ULEZ to a wider area. In the closer term, the city aims for 80% of trips to be taken by soft modes or public transit by 2041. In designing these demand management measures, it is important for the government to be able to anticipate how people will respond to such regulations. Those who own non-compliant vehicles, for example, may decide to either buy a compliant vehicle, pay the charge, or alter their travel behaviour by diverting their route, changing their travel mode, or forgoing the trip altogether.

Shared mobility: How can cities benefit?

ITF's work on shared mobility, policy implications from four cities

Shared mobility can be defined as the optimal routing of vehicles that minimises vehicle kilometres driven through the use of a centralised dispatch system. The ITF's work on shared mobility began in 2015 and sought to assess how shared mobility can help address the current challenges in urban mobility, including emerging technologies, governance and recent trends. To this end, the ITF has carried out an analysis of shared mobility systems, specifically shared taxi and taxi-bus services in conjunction with public transport, in four cities: Lisbon, Helsinki, Auckland and Dublin. The analysis uses an agent-based simulation framework that involves three components: 1) a dispatcher, or a central entity that has information about clients and vehicles and optimally matches them so as to maximise mobility and minimise vehicle kilometres travelled; 2) the users, who have preferences regarding attributes and scheduling constraints; and 3) the vehicles that move within the network. The simulations are published in a series of reports, as well as a Corporate Partnership Board report, detailing how cities can transition to shared mobility (ITF, 2017b; 2017c; 2017d; 2018b).

An important task in this analysis is understanding the current state of mobility in cities (e.g. mode shares, the characteristics of transport supply, land-use patterns and CO_2 intensity per inhabitant) in order to better anticipate the impact of potential policies. Indicators of transport supply provide information about the range of mobility options available to users in the system, and include heavy public transport infrastructure service provision (in seat-kilometres of heavy public transport infrastructure per 1 million inhabitants), transit connectivity, and the ratio of public transit to private car transport time for trips greater than 1km. Land-use patterns are characterised using measures of study area size, population density, land-use mixture and the central business influence radius (i.e. the distance required in order to reach a population size of three-times the number of those employed in the central business district). Finally, CO_2 intensity per inhabitant is also used as an indicator.

Simulating different urban policy scenarios involves assessing the impacts of each adoption scenario, exploring the factors that affect the outcome and testing targeted policies. The scenarios used for the analysis were developed through focus groups and stated preference surveys in order to determine the most realistic policy options in each city. In a more ambitious, full-adoption scenario, simulations indicate that replacing private car use completely (the full-adoption scenario) results in reductions in CO_2 emissions of 62%, 34%, 54%, and 31% in Lisbon, Helsinki, Auckland and Dublin, respectively. In this scenario, the size of the motorised fleet drops by 96%, 96%, 93% and 97% in these cities, respectively, and heavy public transport ridership increases by 47%, 30%, 681% and 54%, respectively. Accessibility to employment increases by 589%, 111%, 254%, and 183%, respectively (ITF, 2017d; 2017c; 2017b; 2018b). Simulations also indicate that this scenario decreases the costs of mobility and the CO_2 intensity per inhabitant. In a less optimistic, 50% adoption scenario, CO_2 emissions are reduced by 12%, 23% and 27% in Helsinki, Auckland and Dublin, respectively. The size of the motorised fleet falls by 37%, 32% and 42%, and heavy public transport ridership increases by 12%, 530% and 27% in each of these cities. Factors that affect these outcomes include the current mode share, the quality of existing public transport, the density of the area under study and existing travel patterns.

Scenarios involving lower shared mobility adoption rates of 20% and 50% were also tested, indicating that in Auckland and Dublin, significant reductions in congestion can be achieved even at adoption rates up to 20%. In Helsinki, which is characterised by a lower congestion reduction elasticity, reductions in congestion only become significant beginning at an adoption rate of around 50%. The work also investigates alternative implementation strategies, namely replacing vs. preserving existing bus rapid transit (BRT) networks. In Auckland, simulations indicate that preserving BRT corridors is always more advantageous than replacing them. In areas characterised by low frequency bus services, however, existing performance appears to be worse than that which could be achieved by shared mobility services. In the case of Dublin, the recently developed portions of the bus network perform better than shared mobility, while the older, non-urban portions of the network do not perform as well as shared mobility. In Helsinki, replacing current bus feeder services with heavy public transport and replacing low frequency services with shared mobility both improve outcomes. All scenarios modelled reduce costs and increase connectivity and access.

Other policy strategies tested included different variations of LEZs in each city. In the case of Auckland, simulations indicate that a small LEZ may lead to greater congestion near the LEZ area (given limited points of entry). A wider area, in contrast, would yield much greater benefits. Implementing the LEZ during peak periods only also appears to achieve similar CO_2 performance as a full-day restriction. In Dublin, LEZ systems were largely beneficial, but a smaller LEZ was associated with some local congestion effects. Traffic inside the LEZ is reduced under this scenario, and adequate transit services outside of the LEZ appear to be crucial in reducing the congestion that occurs at the transfer points between personal cars and shared mobility and public transport. In Helsinki, the LEZ significantly reduces congestion to a degree that is comparable to the scenario of full adoption of shared mobility over the whole study area. Adequate integration with the existing public transport system also mitigates local congestion effects.

Electrification was also tested as a policy scenario. In Auckland and Helsinki, the electrification of the vehicle fleet is associated with a significant reduction in costs, whereas in Dublin this reduction is limited. In Auckland, the increase in vehicle fleet size that would be required due to limitations with respect to range and charging time are largely compensated for by a reduction in energy costs. In Dublin, the fact that the regional shared mobility service covers large distances means that vehicle range is frequently a constraint in a shared mobility service. As such, replacing the BRT with shared mobility would necessitate significantly larger fleets in order to satisfy mobility needs, a problem that is intensified at lower adoption rates. In Helsinki, there is a large potential for electrification to deliver benefits due to the small fleet increases that would be necessary, along with the relative infrequency with which range becomes a mobility constraint. Cost savings become less significant with smaller fleets due to the necessity of recovering the additional investment costs.

The ITF work on shared mobility also investigates the impact of a scenario that involves the proliferation of self-driving technology. This is generally found to yield significant reductions in mobility costs, on the order of 50% for shared taxi and taxi-bus costs per kilometre. In some cases, this reduction even leads shared taxis to be cheaper than current public transport. Finally, the work tests the impact of a change in the market structure regarding the dispatcher of shared mobility systems. Specifically, having three centralised dispatchers and no interaction between shared taxis and taxi-buses causes a 15% drop in the performance of shared mobility services. This suggests that it is important to implement shared mobility dispatch services that are well-integrated with existing public transit systems.

This work implies that, in the transition to decarbonised transport, strategic land-use policies will be very important, as well as implementing economic instruments, infrastructure/service measures that foster connectivity, as well as regulatory measures that support connectivity. Overall, the ITF work on shared mobility points to the benefits that can be obtained by implementing shared mobility as part of a wider policy package. Other insights emphasise the importance of introducing these services at a sufficient scale, adequately feeding them to existing mass transit systems, targeting potential early adopters (particularly car users), and ensuring that public transit systems will be able to accommodate the additional capacity that will result from the increased ridership of shared mobility users.

The contribution of shared mobility services to low-carbon transport

Current app-based shared mobility services provide on-demand, point-to-point mobility that offers two-way flexibility for both suppliers and users (i.e. both can enter and exit the platform at will). A fundamental objective of such services is to reduce the number of empty passenger seat kilometres driven in urban areas by using a single car to carry out trips for multiple people, rather than using one car per person per trip. The shared mobility services offered by point-to-point providers are innovative insofar as they transform personal vehicles into shared vehicles, and personal journeys into shared journeys. These two developments imply different impacts and present new opportunities for driving efficiency. Transforming personal vehicles into shared vehicles increases the utilisation of these vehicles, which increases the importance of running costs and makes more efficient technologies, such as electric vehicles, more relevant over time.

Greater utilisation also increases the turnover of the vehicle fleet, which serves to accelerate replacement, making the fleet newer and more fuel-efficient as a whole. The optimisation of trip routes can also be better accomplished through a connected network, and since mobility can be anticipated more easily on a shared network, infrastructure can also conceivably be allocated in an optimal way based on expected demand patterns. Some preliminary data indicate that the percentage of miles driven by hybrid electric vehicles (HEVs) in shared mobility networks is higher than the percentage of new HEV sales, suggesting that shared mobility drivers may indeed favour more efficient technologies.

The carbon intensity of shared mobility services depends on the capacity utilisation and fuel efficiency of participating vehicles. As such, carbon intensity decreases to the extent that a service enables the movement of more people in fewer and fuller cars, and more efficient trips. As with other transport providers, shared mobility platforms can measure capacity utilisation as passenger-kilometres per vehicle-kilometre. This indicator provides information regarding how efficiently people are being transported and is a common metric for measuring the efficiency for mobility systems. Some research also indicates that the efficiency of shared mobility services at optimising the movement of users while minimising that of vehicles is greater than previous point-to-point, on-demand mobility services (i.e. taxis). The capacity utilisation rate of UberX vehicles, for example, has been found to be an average of 38% greater than traditional point-to-point services in two large North American cities (Cramer and Kreuger, 2016). Preliminary indications also suggest that capacity utilisation in shared mobility networks is markedly higher in dense urban areas, indicating that higher density (of supply and demand) is correlated with higher efficiency. A greater uptake of shared mobility platforms implies a decrease in carbon intensity only if new shared mobility users are those who had previously relied on personal vehicles for their transport needs. However, if new shared mobility users are primarily those who switch from non-auto modes of transport (e.g. walking, cycling or public transit), then shared on-demand mobility can in fact contribute to increased congestion (Schaller, 2018).

Given the increased utilisation of vehicles in shared mobility networks, shared mobility service providers are exploring the potential for greater EV use in their networks. There are indications that it is indeed possible for fewer (electric) vehicles to cover the mobility needs of a city than previously imagined under personal car ownership scenarios. In one success story in London, for example, 60 EVs operating in a shared mobility network delivered 40 000 rides over the course of a four-month period. Barriers to greater EV use remain, however, including vehicle affordability, inadequate urban EV infrastructure, the lack of EV charging infrastructure designed for shared mobility, and the fact that drivers can face an opportunity cost penalty associated with driving EV vehicles in shared mobility networks. First, and particularly applicable to the peer-to-peer vs. licensed markets, is the fact that EV owners tend to be more affluent than ICE vehicle owners. Although the cost of EV ownership becomes more attractive as the number of kilometres driven increases, it is typically the less affluent drivers who are likely to be driving the most miles. It is therefore problematic that there are few mid-market, all-around performing, and affordable EVs on the market.

Second, current EV technology was never intended for shared use, and this is reflected in the challenges faced by EV drivers in shared mobility networks. Namely, EVs are designed to sit parked (and therefore charge over long periods), rather than drive, for the great majority of their time, which makes them less suited for high utilisation. The available charging infrastructure, moreover, was not originally designed for shared use. Given their long charging times, their locations outside of city centres, inside garages and lacking access or amenities, it is clear that EV charging infrastructure was designed for customers and commuters rather than for shared use purposes. As a result, it is not surprising that some shared vehicle drivers, for instance, report that the biggest obstacle to driving an EV in the network is a lack of rapid charging stations in areas of high mobility demand (e.g. downtown centres or airport queues).

This contributes to a third issue, namely that drivers can face an opportunity cost penalty associated when using an EV versus a conventional fossil-fuelled car in a shared mobility system. The need for time-consuming charging, often multiple times per day, for example, reduces drivers' availability for offering rides and earning fares. Drivers report that range anxiety can lead them to decide to cancel trips. Between looking for a charger, spending time traveling to that charger, waiting for the charger to become available, and then waiting for the car to charge – drivers who drive EVs lose a significant amount of time that could otherwise be spent transporting users. For instance, a study of EV drivers on Uber's network in London reported that drivers wanted to spend 10 more hours driving per week than they were able due to charging requirements (Energy Saving Trust, 2017).

It will take a great multi-sectoral effort to address these challenges, and some shared mobility services are working with NGO experts and others in order to bring these challenges to the attention of government agencies (e.g. Energy Saving Trust, 2017). While a greater use of soft modes and a lower urban carbon footprint are desirable, the convenience of car transport constitutes a very attractive characteristic of personal vehicle travel, one that makes this transport mode very difficult to give up in the absence of similarly attractive mobility options. There are new efforts among ride share companies to increase the options available to riders and create viable alternatives to car ownership. In pursuit of a seamless transport service, some are collaborating with technology providers in order to enable riders to schedule their entire multi-modal trips on an integrated payment platform. Promisingly, a number of different surveys indicate that transport users, especially younger ones, believe that mobility apps could be a feasible alternative to owning a car, which is an encouraging sign for the future of shared mobility.

Autonomous vehicles: A potential game changer for urban mobility

Public transport at the centre of the autonomous vehicle revolution

Fully autonomous vehicles (AVs) are expected to be available in the early 2020s. While they have enormous potential to fundamentally change urban mobility, the widespread adoption of AVs will only occur if they are successfully integrated into public transit networks. The International Association of Public Transport Authorities (UITP) has detailed the challenges of developing AV use and has offered several insights regarding their introduction. The UITP's SPACE project places public transit at the centre of the AV revolution, aiming to give members the tools and knowledge that will enable them to provide higher quality and more efficient services. The project's objective is also to assess the impacts of automated road transport systems, develop operational concepts and new business models, and advocate for a harmonised framework that would foster the safe operation of AVs as a mode that is integrated with other mobility modes.

Most local authorities, however, are not willing to co-operate in AV pilot studies, instead preferring to observe the outcomes of other pilot studies. Given the potential impact of widespread AV use in urban areas, e.g. in terms of congestion, environment, road safety, user behaviour and infrastructure development, it will be important for cities to assume a more prominent role regarding AV policies. If this does not occur, the promised impacts of AV adoption may not materialise, or even generate negative impacts, e.g. if people shift from walking and cycling to personal AV use. It is therefore important to judiciously frame the introduction of AVs in order to ensure that this technology benefits, rather than hinders, mobility in urban areas.

One pathway for the intelligent development of AVs is through integration with public transport systems. Accomplishing this represents a significant challenge: while AVs are an attractive choice for users, their attractiveness could in fact lead to over-purchasing, low utilisation capacities, congestion, urban sprawl, loss of public space, as well as the decreased use of public transit, walking, and cycling (along with the accompanying health implications). The attractiveness of AVs as a solution to urban mobility issues therefore hinges on convincing individuals to make a shift to shared, rather than individual, AV use.

Insofar as public transit facilitates pilot operations in a limited area, e.g. through dedicated service lanes, it represents the quickest development path to full autonomy. Furthermore, AV use that is initiated by public transport authorities would create more public space and liveable cities, less congestion (aided by interconnectivity and road pricing), and lower emissions. As a result, AVs have great potential to revolutionise urban mobility, specifically in conjunction with public transport systems that continue to provide high capacity core networks with fixed line services. AVs can also play a role in low-density areas, as feeder lines, and even as private mobility in appropriate contexts. In urban areas, AV taxis and other car-sharing and area-based on-demand autonomous mini-bus vehicles could also complement public transport in urban areas, as well.

Currently, AV use is limited to several pilot projects. However, there are steps that can be taken to prepare for the AV revolution. One such step is encouraging shared mobility, which younger generations appear relatively more open to. Other steps pertain to putting in place adequate regulation and governance. The current regulatory landscape, characterised by a certain degree of inflexibility and difficulty to navigate, hinders the introduction and putting into practice of new types of mobility. Making regulatory provisions for pilot projects and promoting innovation will therefore be key in fostering further AV development.

Piloting new autonomous vehicle mobility solutions

The mobility market is facing a major transformation. Connected, autonomous, shared and electric mobility will be essential, and the shared nature of this mobility in particular will be essential to meeting mobility needs. Pilot projects regarding shared autonomous vehicles have sought to sequentially increase the complexity of the systems. AV developers are providing an increasing number of services across the world. Keolis, for example, currently operates 10 autonomous shuttles and has transported 90 000 passengers in seven countries. It has also conducted five long-term trials regarding the use of AVs in urban areas, the first trial was carried out in Lyon in September 2016. A mobile app for the service was launched in September 2017 that offered key service information and real-time shuttle locations. From June to December 2017, a second automated shuttle service pilot was launched in Pari--La Défense, which resulted in more than 6 000km driven. In September 2017, another project was launched, in partnership with a number of companies, for a 1km-long autonomous shuttle service in London. In November 2017, the first public, open road AV service (i.e. operational in traffic) was launched in Las Vegas, USA. In February 2018, another automated service was launched at Roissy-Charles de Gaulle Airport in France that uses V2X technology to co-ordinate two AVs crossing each other in open traffic. The service is also available on-demand for use in off-peak hours via an application. The first fully electric and autonomous robo-taxi on the market is now planned to be released in Lyon in late 2018 to early 2019.

In order to become operational on a large scale, however, AV developments must move from experimentation to regular service. Industry actors, riders and city planners will need to be involved in developing new urban policies in order to limit the usage of personal vehicles and to provide equally attractive alternative mobility options to passengers. Public transit represents the preferred method for introducing AVs into open road conditions, namely due to the lower speed that is characteristic of public transit services, the greater amount of information regarding the environment in which an AV will operate, and the lack of an expectation regarding its ability to operate in all conditions (e.g. snow). While progress is being made with respect to regulations, bringing AVs to market will hinge on being able to adequately test potential AV systems. Regulations should therefore facilitate opportunities to experiment, but also provide a framework to ensure the safety of this experimentation, as there is much still to be learned with respect to AV use, especially regarding behavioural considerations, such as how pedestrians and passengers related to AVs.

Conclusion

Consensus was reached on the necessity to operationalise all policy levers together to not only deliver on climate change goals, but also on the sustainable development goals for the urban passenger transport sector. Several key takeaways can be identified.

First, while improvements in fuel efficiency are crucial, they will not be able to fully decarbonise the urban mobility sector alone. Given that decarbonising targets are achievable in the urban mobility sector in a high electrification scenario, coherent electric mobility strategies should be prioritised within broader urban mobility strategies. Greening the grid is clearly essential for realising the CO_2 benefits of electric mobility. Second, given the diversity of country contexts, single policy pathway for decarbonising urban passenger transport will not be suitable for all groups. The co-benefits from CO_2 mitigation strategies should be maximised in the design of these pathways, especially for low-income countries. Developing countries have great potential to leapfrog with respect to transport technologies, systems, and policies. Third, regulating the expansion of cities and integrating land-use and transport planning will be critical in reducing travel demand, facilitating high occupancy shared mobility and encouraging walking and cycling. Low-cost, high-impact public transport and non-motorised transport investments are cost-effective strategies for reducing the carbon intensity of urban travel. Multimodal integration will be critical for delivering mobility demand in a sustainable way, and can be accomplished through the strategic integration of information, fares, institutions, etc. Fourth, addressing the mobility challenges that cities face in the midst of a changing transport landscape will require concerted efforts to define the roles and responsibilities of diverse and previously disparate actors, including mobility service providers, vehicle manufacturers, and local, regional, and national governments, among others. Unprecedented co-ordination between these actors will be necessary in order to achieve the ambitions identified herein. Fifth, monetary demand management measures, such as congestion and emissions charges, have proven to be effective in reducing the CO_2 emissions of urban travel, and the strategic use and limitations of these measures are becoming better understood. Measures that leverage non-monetary motivations and cognitive biases can also be effective interventions. Finally, the importance of behavioural factors in the design of urban spaces, the implementation of new technologies, and the development of demand management interventions was frequently raised as an important consideration in ensuring the ultimate success of these decarbonisation measures in the long term. It will be particularly important, for instance, to emphasise the viability and attractiveness of high occupancy shared mobility services if shared mobility is to be widely adopted and its benefits fully realised.

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Note

1 Although they have shown promise in a range of policy areas (OECD, 2017), they are largely underexploited in the transport sphere (Gaker et al., 2010).

Policy Priorities for Decarbonising Urban Passenger Transport

This report identifies policy priorities, megatrends and pressing issues regarding the decarbonisation of urban passenger transport. It presents the results of an expert survey on important challenges in the area and summarises the findings of a workshop with 36 experts from 12 countries regarding strategies for the transition to carbon-neutral urban passenger transport.

This report is part of the International Transport Forum's Case-Specific Policy Analysis series. These are topical studies on specific issues carried out by the ITF in agreement with local institutions.

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