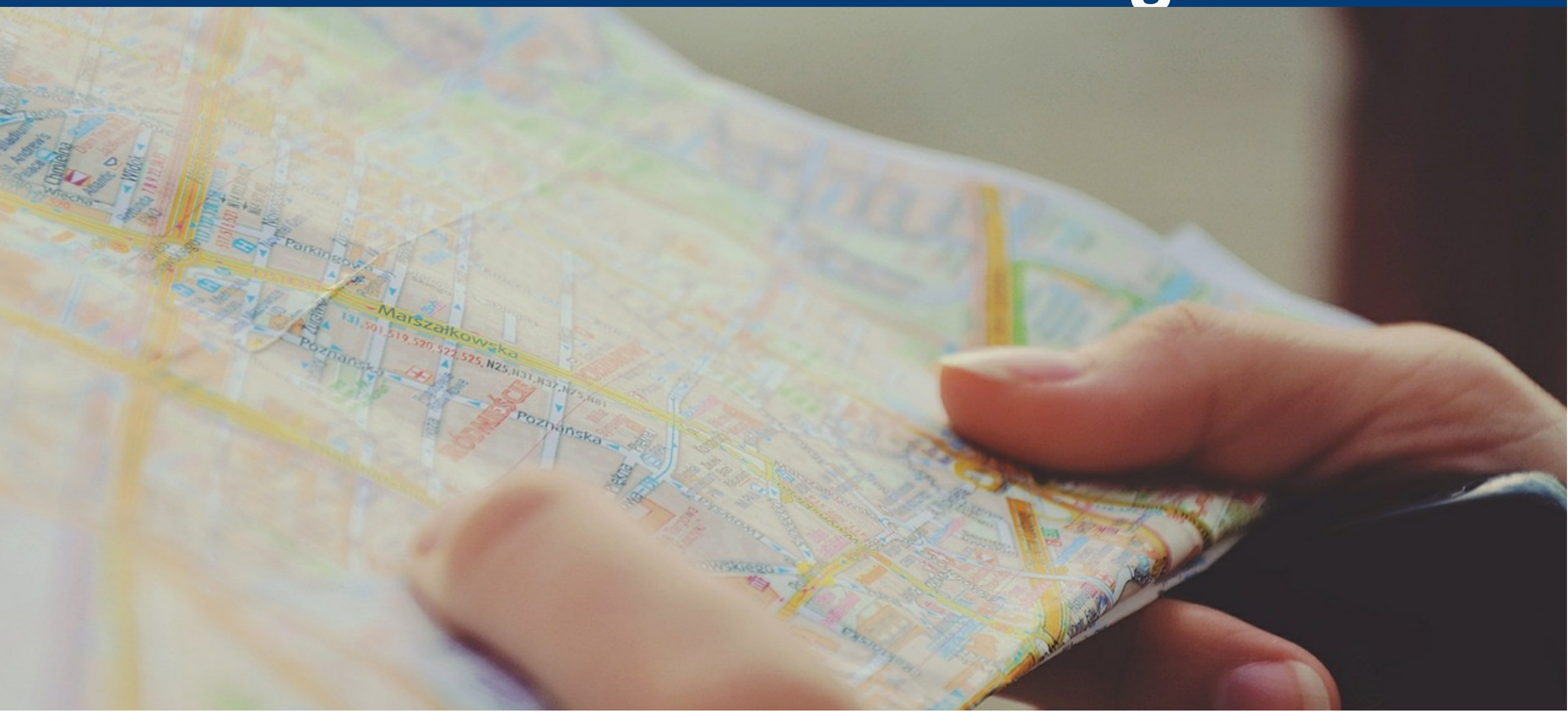
Urban Pathways

Factsheet

Implications of Autonomous vehicles on Urban Planning



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FOR A BETTER URBAN FUTURE

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The Urban Pathways project helps to deliver on the Paris Agreement and the NDCs in the context of the New Urban Agenda and the Sustainable Development Goals. It has established a facility in close cooperation with other organisations and networks active in this area to support national and local governments to develop action plans and concrete implementation measures to boost low-carbon urban development. This builds on UN-Habitat's role as "a focal point on sustainable urbanisation and human settlements including in the implementation and follow-up and review of the New Urban Agenda". The project develops national action plans and local implementation concepts in key emerging economies with a high mitigation potential. The local implementation concepts are being developed into bankable projects, focusing on the access to urban basic services to create a direct link between climate change mitigation and sustainable development goals.

Project concept

The project follows a structured approach to boost Low Carbon Plans for urban mobility, energy and waste management services that deliver on the Paris Agreement and the New Urban Agenda. The project works on concrete steps towards a maximum impact with regards to the contribution of urban basic services (mobility, energy and waste management) in cities to global climate change mitigation efforts and sustainable and inclusive urban development. This project makes an active contribution to achieve global climate change targets to a 1.5°C stabilisation pathway by unlocking the global emission reduction potential of urban energy, transport and resource sectors. The project will contribute to a direct emission reduction in the pilot and outreach countries, which will trigger a longer term emission reduction with the aim to replicate this regionally and globally to make a substantial contribution to the overall emission reduction potential.

Project aims

This project implements integrated urban services solutions as proposed in the New Urban Agenda providing access to jobs and public services in urban areas, contributing to equality and social coherence and deliver on the Paris Agreement and the Sustainable Development Goals. This is the first dedicated implementation action oriented project, led by UN-Habitat to deliver on inclusive, low-carbon urban services. Securing sustainability and multiplier effect, the project aims to leverage domestic and international funding for the implementation projects that will follow from this initiative.

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Autonomous Vehicles

There is currently significant interest in autonomous vehicles-vehicles that are capable of intelligent motion and action without requiring either a guide to follow or a teleoperator control. Potential applications of autonomous vehicles include reconnaissance/ exploratory vehicles for space and undersea, land, and air environments; remote repair and maintenance, material handling systems for the office and the factory and even intelligent wheelchairs for the handicapped. This paper explores the effect that mass adoption of autonomous vehicles could have on the quality of life in cities, issues that urban planners need to consider in the present and proposes a sustainable path of adoption.

How do Autonomous Vehicles work?

All autonomous vehicles must navigate within an environment whether it is intended to be driven, floated, flown, or submerged. Autonomous vehicles (AVs) operate on a three-phase design known as ‘‘sense-plan-act’’ which is the premise of many robotic systems. In order to achieve this, the vehicle must be capable of sensing its environment, interpreting this sensor information to refine its knowledge of its position and the environment’s structure, and planning a route from an initial to a goal position in the presence of known or perhaps unknown obstacles. To this end, the AVs are equipped with a variety of sensors, camera, radars, etc., which obtains raw data and information from the surrounding environment. These data would then serve as input for software which would recommend the appropriate courses of action, such as acceleration, lane changing, and overtaking. Having reached its destination, the autonomous vehicle may be required to perform tasks such as manipulating objects, information gathering or sample collecting. The tasks involved are very specific to the respective application involved (Cox, Wilfong and Lorenzo-Pérez, n.d.).

Levels of Automation

According to Bagloee et al. (2016), to understand AVs, it is important to mention the levels of automation that can vary from zero to full automation. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) classifies vehicle automation in five levels :

No-Automation (Level 0): At all times, the driver has complete and sole command and control of the vehicle with respect to steering, braking, throttle and motive power.

Function-specific automation (Level 1): Some specific control function(s) such as electronic stability control or pre-charged brakes is(are) automated.

Combined function automation (Level 2): At least two main control functions such as adaptive cruise control in combination with lane centering are automated.

Limited self-driving automation (Level 3): Under certain traffic or environmental conditions, the driver cedes full control of all safety–critical functions and relies heavily on the vehicle to watch for any changes in conditions requiring transition to driver control. The driver will be required to resume control of the vehicle, but with sufficient transition time.

Full self-driving automation (Level 4): The vehicle is intelligently designed to monitor roadway conditions and act solo, performing all safety–critical driving functions for an entire trip (a fully driverless level).

Urban Mobility

By 2030, it is expected that 60 percent of the world's population will live in cities, up from about 50 percent today. Over the same period, more than two billion people are likely to enter the global middle class, with the majority of them living in cities in emerging markets. They will aspire to buy cars: automobile sales are expected to increase from about 70 million a year in 2010 to 125 million by 2025, with more than half forecasted to be bought in cities. Some automotive analysts have gone as far as predicting that on the existing trajectory, today's 1.2 billion strong global car fleet could double by 2030.

The existing urban infrastructure cannot support such an increase in vehicles on the road. Congestion is already close to unbearable in many cities and can cost as much as 2 to 4 percent of national GDP, by measures such as lost time, wasted fuel, and increased cost of doing business. Transport creates emissions of greenhouse gases which presents serious public-health concerns. The World Health Organization estimated in 2014 that seven million premature deaths are attributable to air pollution, and a significant share is the result of urban transit (Bouton et al., 2015).

Sustainable Urban Mobility is designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life taking into consideration their safety, security, health and environment.

Shared Mobility principles

According to the Shared Mobility Principles (2017), sustainable, inclusive, prosperous, and resilient cities depend on transportation that facilitates the safe, efficient, and pollution-free flow of people and goods, while also providing affordable, healthy, and integrated mobility for all people.

The pace of technology-driven innovation from the private sector in shared transportation services, vehicles, and networks is rapid, accelerating, and filled with opportunity. At the same time, city streets are a finite and scarce resource. The principles below were produced by a working group international NGOs, and are designed to guide urban decision-makers and stakeholders toward the best outcomes for all.

1. Plan cities and their mobility together.
The way our cities are built determines mobility needs and how they can be met. Development, urban design and public spaces, building and zoning regulations, parking requirements, and other land use policies shall incentivize compact, accessible, livable, and sustainable cities.

2. Prioritize people over vehicles.
The mobility of people and not vehicles shall be in the center of transportation planning and decision-making. Cities shall prioritize walking, cycling, public transport and other efficient shared mobility, as well as their interconnectivity. Cities shall discourage the use of cars, single-passenger taxis, and other oversized vehicles transporting one person.

3. Support the shared and efficient use of vehicles, lanes, curbs, and land.
Transportation and land use planning and policies should minimize the street and parking space used per person and maximize the use of each vehicle. We

discourage overbuilding and oversized vehicles and infrastructure, as well as the oversupply of parking.

4. Engage with stakeholders.
Residents, workers, businesses, and other stakeholders may feel direct impacts on their lives, their investments and their economic livelihoods by the unfolding transition to shared, zero-emission, and ultimately autonomous vehicles. We commit to actively engage these groups in the decision-making process and support them as we move through this transition.

5. Promote equity.
Physical, digital, and financial access to shared transport services are valuable public goods and need thoughtful design to ensure use is possible and affordable by all ages, genders, incomes, and abilities.

6. Lead the transition towards a zero-emission future and renewable energy.
Public transportation and shared-use fleets will accelerate the transition to zero-emission vehicles. Electric vehicles shall ultimately be powered by renewable energy to maximize climate and air quality benefits.

7. Support fair user fees across all modes.
Every vehicle and mode should pay their fair share for road use, congestion, pollution, and use of curb space. The fair share shall take the operating, maintenance and social costs into account.

8. Aim for public benefits via open data.
The data infrastructure underpinning shared transport services must enable interoperability, competition and innovation, while ensuring privacy, security, and accountability.

9. Work towards integration and seamless connectivity.
All transportation services should be integrated and thoughtfully planned across operators, geographies, and complementary modes. Seamless trips should be facilitated via physical connections, interoperable payments, and combined information. Every opportunity should be taken to enhance connectivity of people and vehicles to wireless networks.

10. Support that autonomous vehicles (AVs) in dense urban areas should be operated only in shared fleets.

Due to the transformational potential of autonomous vehicle technology, it is critical that all AVs are part of shared fleets, well-regulated, and zero emission.

Shared fleets can provide more affordable access to all, maximize public safety and emissions benefits, ensure that maintenance and software upgrades are managed by professionals, and actualize the promise of reductions in vehicles, parking, and congestion, in line with broader policy trends to reduce the use of personal cars in dense urban areas.

Urban planning principles

The following urban planning principles were borrowed from the City of London (2010) illustrated urban design principles.

Legibility

A clear and simple development pattern within a city and neighbourhood enables residents and visitors to understand how an area is organised and to make their way around. This type of development pattern is generally delivered through a grid or modified grid network of streets. The 'grid' allows for easy navigation and provides a block pattern that creates increased connectivity, which also encourages alternative transportation modes to the car. In turn, the block pattern sets the parameters for the type of built form that can be achieved. It is highly desirable that the built form be both transit and pedestrian oriented.

Character

A recognisable image can identify a city or neighbourhood to its residents or visitors. This image can include, historic buildings, village precincts, buildings with a distinct architecture, public art and public spaces to name a few. Also, a development pattern created by a regular grid of streets and blocks reinforced by buildings that form a continuous, enclosing streetwall, creates a strong foundation for establishing such a recognisable image.

Diversity

Successful neighbourhoods within a city provide for diversity and choice through a mix of compatible housing and building types and land uses. Through these measures residents of a neighbourhood have the opportunity to age in place; going through all of their various life cycles without having to leave their original neighbourhood and breaking the social networks they have formed.

Continuity and Enclosure

A continuous built form street frontage is needed throughout an area of the city or neighbourhood to allow users to easily understand where they are, directions to where they need to go and the purpose of the street (ie is the street a village mainstreet or is it a residential arterial). In doing this, development will assist in creating the proper enclosure of space and delineate the private and public realms.

Ease of Movement

Older neighbourhoods within cities are usually configured for maximum convenience as the area has high connectivity and it is a place for pedestrians. A compact urban form, a legible urban structure (ie grid network of streets), short blocks, pedestrian priority and a built form that is transit and pedestrian oriented ensures an area has maximum convenience for movement. In newer neighbourhoods, the street systems are usually curvilinear in nature with larger blocks, which reduces overall convenience and frustrates ease of movement for pedestrians.

Adaptability

Cities and neighbourhoods are constantly changing. The success of these places are directly related to the ability of the form and pattern of development to adapt over time to changing social, technological and economic conditions.

Quality Public Realm

The public realm is one of the most important components of any city or neighbourhood. As such, the built form and streetscape treatments should provide an attractive, safe and comfortable pedestrian environment, while maintaining the overall visual cohesiveness of the area. This can be achieved through a variety of design responses, which include, but are not limited to, ground level facade treatments (ie transparent glass that shares the interior activities with the street), architectural details, paving patterns, shade, seating, adequate sidewalk widths and other features.

In action

AV implications on Urban Planning: Opportunities and Challenges

Car Ownership

Car Ownership

Fully autonomous cars will allow people who do not have driving licences or those with limited ability or opportunity to be as mobile as those who drive. AV technology could induce additional travel and energy demand with people taking more car trips further burdening an already congested network. This may in turn encourage an increase in private vehicle ownership, a decrease in the use local public transport and lead to urban sprawl .

O'Toole (2014) argues that car sharing may become more widespread as people who own cars will rent them out rather than park them when they aren't using them themselves. The expansion of car sharing may change the way people view the cost of auto travel. Much of the cost of owning a car is fixed, so once someone owns a car, the marginal cost of taking a trip is low. But people renting shared vehicles will have to pay the average cost, which may depress travel.

Car sharing provides an opportunity to offer travelers services based on the mobility needs, Mobility as a Service (MaaS). MaaS could decrease costs to users since it obviates the need for annual fixed costs, maintenance and parking, improve utilization of MaaS transit providers, reduce city congestion as more users adopt MaaS as a main source of transit, and reduce emissions as more users rely on public transit components or electric, autonomous vehicles in a MaaS network.

There currently exist arguments for both an increase and a decrease in private car ownership as an impact of the adoption of AV technology, urban planners and policy makers need to vigilante to the trends in car ownership in order to adapt policies accordingly.

Safety and Crashes

The most thorough analysis of crash causation, the Tri-Level Study of the Causes of Traffic Accidents published in 1979, found that "human errors and deficiencies" were a definite or probable cause in 90-93% of the incidents examined (Treat et al., 1979).

A downward trend in the number of crashes in the United States is significantly indebted to the adoption of new technologies such as airbags, anti-lock brakes, electronic stability control, head-protection side airbags, and forward collision warnings. These are features that will be adopted in AV technology. In particular, some studies estimate the reduction of crashes could be as high as one-third if all vehicles are equipped with adaptive headlights, forward collision warnings, lane departure warnings, and blind spot assistance which are attributed to Level 0 or Level 1 vehicle automation (Bagloee et al., 2016). Therefore, there is an opportunity for AVs to prevent an appreciable number of these crashes, in turn eliminating the vast majority of all traffic delays.

Liability

Self-driving car liability is a developing area of law and policy that will determine who is liable when an automated car causes physical damage to persons, or breaks road rules. When automated cars shift the control of driving from humans to automated car technology, there may be a need for existing liability laws to evolve in order to fairly identify the parties responsible for damage and injury, and to address the potential for conflicts of interest between human occupants, system operator, insurers, and the public purse (Anderson et al.,2014). Increases in the use of automated car technologies (e.g. advanced driver-assistance systems) may prompt incremental shifts in this responsibility for driving.

A well-advised person who is not controlling a car at all (Level 5) would be understandably reluctant to accept liability for something out of their control. And when there is some degree of sharing control possible (Level 3 or 4), a well-advised person would be concerned that the vehicle might try to pass back control at the last seconds before an accident, to pass responsibility and liability back too, but in circumstances where the potential driver has no better prospects of avoiding the crash than the vehicle, since they have not necessarily been paying close attention, and if it is too hard for the very smart car it might be too hard for a human. Since operators, especially those familiar with trying to ignore existing legal obligations (under a motto like ‘seek forgiveness, not permission’), such as Google or Uber, could be normally expected to try to avoid responsibility to the maximum degree possible, there is potential for attempt to let the operators evade being held liable for accidents while they are in control.

Legislation

The 1968 Vienna Convention on Road Traffic, subscribed to by over 70 countries worldwide, establishes principles to govern traffic laws. One of the fundamental principles of the Convention has been the concept that a driver is always fully in control and responsible for the behavior of a vehicle in traffic. This requirement is challenged by the development of technology for collision avoidance systems and autonomous driving. This principle does not adequately cover the advancements in automatic vehicle technology where a programmed machine has the possibility of taking over the functions of a driver.

Infrastructure

AVs work best under specific circumstances. For example, if lane demarcation is unclear or worn off or signage is blocked, the vehicle has difficulty driving safely. Without the ability to navigate in adverse conditions, AV deployment could be limited to urban areas with consistently clear weather. Policy-makers will have to take a new look at how infrastructure is to be built and how money will be allotted to build for automated vehicles. One way to overcome this hurdle would be to use smart highways. Smart highway and smart road are terms for a number of different proposals to incorporate technologies into roads for generating solar energy, for lighting, for monitoring the condition of the road and could help AVs navigate landscapes by connecting the vehicle to the surrounding infrastructure. Smart Highways could also reduce the need for traffic signals since the AVs and the infrastructure can be connected.

Due to smart highways and with the assistance of smart technological advances implemented by policy change, the dependence on oil imports may be reduced because of less time being spent on the road by individual cars which could have an effect on policy regarding energy. On the other hand, automated vehicles could increase the overall number of cars on the road which could lead to a greater dependence on oil imports if smart systems are not enough to curtail the impact of more vehicles (Litman, 2019). However, due to the uncertainty of the future of automated vehicles, policy makers may want to plan effectively by implementing infrastructure improvements that can be beneficial to both human drivers and automated vehicles.

AVs could potentially require less area to park, reducing the amount of land dedicated to parking uses and allowing for alternative uses to occupy the space, including green space in urban areas (Walker Consultants, n.d.). There is potential for an urban environment in which MaaS transit providers utilize AVs, and daily commutes could become seamless trips which incorporate multiple modes of transportation.

Urban Landscape

Congestion

Anderson et al. have attributed three main factors related to AVs that affect congestion positively and sometimes negatively: (i) reducing traffic delay due to a reduction in vehicle crashes; (ii) enhancing vehicle throughput; and (iii) changes in the total vehicle-kilometer traveled (VKT). An anticipated reduction in vehicle crashes would result in fewer delays and, in turn, higher reliability of the transport system. VKT in fact could increase due to a combination of factors such as self-fueling and self-parking, increased use of AVs by those unable to drive, an increased number of trips (both unoccupied and occupied), a shift away from public transport and longer commutes.
In a situation where travel demand increases, policy makers can maintain travel demand at the same levels as prior to the emergence of AVs by tapping into congestion pricing. The pricing can be set to the level at which the induced demand dissipates.

The fact that AVs are connected may also provide an opportunity to mitigate the congestion burden. Dresner and Stone propose a reservation-based system for alleviating traffic congestion, specifically at intersections when the vehicles are connected. The results show that the reservation-based system designed for connected AVs can perform two to three times better than traffic lights. As a result, it can smoothly handle much more congested traffic conditions.

Economic Implications

Mass adoption of AVs could lead to a decline in the use of public transport if the focus is not kept on making AVs sharable. Moreover their mass adoption could lead to loss in employment for people who work as drivers in all sectors of the economy. Self-driving vans have the potential to make home deliveries significantly cheaper, transforming retail commerce and possibly making hypermarkets and supermarkets redundant. It was found that industries that could experience losses, in terms of “societal savings”, from AVs were insurance, personal transportation, auto manufacturing and repair, medical, construction, traffic police, and legal professions.

Another risk is that AVs could cater to a privileged class of people if their cost and accessibility is determined by the private sector thereby increasing social exclusion of poor people. National and local governments need to develop policies that ensure that AV use and adoption is inclusive to all citizens and residents.

Public Acceptance

Members of the public must trust technology completely to ride in or purchase a fully AV, and must be willing to forgo a level of convenience to agree to share rides on a regular basis. For mass adoption to happen, people will need to trust that the program controlling the car is making similar or better driving decisions than they would. This will call for car manufacturers to create different driving profiles to cater for different styles of driving incase a user prefers a slower pace compared to a faster driving speed. Secondly for members of the public to adopt widespread car sharing instead of individual car ownership, the convenience of sharing their personal space in a shared car needs to outweigh the convenience of owning their own AV.

AV Impact on Urban Travel Scenarios

A report titled “Three revolutions in Urban Transport” developed by University of California, Davis, and the Institute for Transportation and Development Policy expands upon the scope of the previous studies by considering the role of electrification, automation, and ride sharing (more people per vehicle) in developing future scenarios. Three urban travel scenarios were developed, elaborated from the base year of 2015 through 2050: a business-as-usual scenario, a technology-dominated 2 Revolutions scenario, and a technology + high shared-mobility 3 Revolutions scenario. Below is a summary of these scenarios:

Business-as-usual (BAU) scenario – This scenario assumes few changes from 2017 travel patterns and current trends through to 2050. No major revolutions occur. It assumes internal combustion engine (ICE) light-duty vehicles (LDVs) remain dominant or grow in dominance, depending on the country, through 2050, and applies population and growth projections with these assumptions in mind.

2 Revolutions (2R) scenario – This is a technology focused scenario that includes rapid vehicle electrification along with – but starting later – rapid automation. Electric vehicles (EVs) achieve a significant share of vehicle sales by 2025 in leading countries, with automated EVs reaching this stage about five years later. Both are dominant around the world by 2050. This scenario contains no significant increase of shared vehicle trips through new technology; it preserves the BAU trends toward a private-car-dominated world.

3 Revolutions (3R) scenario – This scenario includes widespread vehicle electrification and automation, and adds a major shift in mobility patterns by maximizing the use of shared vehicle trips. This scenario includes all three revolutions, and is a strongly multi-modal scenario, with increased availability of vehicles for shared trips, increased public transport availability and performance (including on-demand small bus services, larger buses and rail), and significant improvements in walking and cycling infrastructure and therefore in travel by these modes.

The report found all three revolutions together could cut the cost of vehicles, infrastructure and transportation system operation by more than 40 percent. Ride-sharing and renewable energy sources critical to this.

Sustainable Mobility Outlook on AV

According to the shared mobility principles (2017), in order to satisfy the mobility needs of people and businesses and improve the quality of life, AVs will need to be shared, automatic and electric.

In a world in which every individual in dense urban areas owns their own car, AVs would distort land use and other behaviors and dynamics in ways that would be severely detrimental to cities. When an individual owns an AV, the decision to make a particular trip is dictated by the marginal cost of that trip (refueling charge, at a minimum). When a vehicle is shared, the decision to make a trip now includes the full costs (depreciation, insurance, maintenance, as well as refueling) and therefore sets a higher cost hurdle rate to make a trip. Through sharing AVs will cater for multiple users at a time therefore minimizing congestion on the roads and reducing the need for parking spaces which can be converted to green spaces by municipalities. Shared AVs have the ability to improve access to all and increase mobility options for vulnerable people like disabled, but also an expanded range of services for the elderly and children.

This more inclusive and easier travel may lead to increased AV adoption which may in turn lead to an increase in vehicle related emissions unless electric mobility is adopted. In order to reverse the existing trends in air pollution from vehicle transportation and achieve zero emissions, AVs will need to be electrical. According to a research by UC Davis and ITDP (2017), a scenario that involves electrification and automation but with a private car dominated world, may provide significant energy and CO2, mostly after 2030, and only with large scale decarbonization of electricity production. If the world's electricity production is not completely decarbonized by 2050, this scenario may produce more CO2 emissions in 2050 than is consistent with targets to limit global temperature rise to 2°C (or less) compared to preindustrial levels.

A sustainable scenario is one in which there is widespread vehicle electrification and automation, and adds a major shift in mobility patterns by maximizing the use of shared vehicle trips, that incorporates a strongly multi-modal scenario, with increased availability of vehicles for shared trips, increased public transport availability and performance (including on-demand small bus services, larger buses and rail), and includes significant improvements in walking and cycling infrastructure and therefore in travel by these modes. This scenario, referred to as the 3 Revolutions (3R) Scenario, performs significantly better on energy and CO2 , as well as on livability. This scenario has the potential to deliver an efficient, low-traffic, low-energy, and low-CO2 urban transport system around the world. In this scenario, the widespread adoption of on-demand travel with substantial ride sharing, along with greater use of (high-quality) public transport, cycling, and walking reduces car travel by well over half in 2050, and the number of cars by nearly three-quarters compared to continuing to operate with the current travel trends all through to 2050. It would reduce traffic congestion and parking needs dramatically, opening up tremendous amounts of urban space for walking, cycling, and other uses. This scenario – with energy use and CO2 emissions in 2050 less than one-third of the BAU and about one-half that of the 2R scenario, and with fully decarbonized electricity production – yields a very low CO2 picture worldwide.

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