

JUNE 2017



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SUSTAINABILITY & RESOURCE PRODUCTIVITY

The future(s) of mobility: How cities can benefit

Autonomous vehicles, electric powertrains, vehicle sharing, and other advances are transforming urban mobility. Planning ahead can help cities capture the benefits of the shift, from cleaner air to easier journeys.

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The way that people get around cities is changing dramatically. Technological advances and new transportation services are making it possible for city dwellers to cross town ever more efficiently and safely. These shifts could have profound economic and social effects. McKinsey analysis indicates that in 50 metropolitan areas around the world, home to 500 million people, integrated mobility systems could produce benefits, such as improved safety and reduced pollution, worth up to \$600 billion.

Because each city is unique, the transition to integrated mobility will also play out differently, and produce different results, from one city to the next. The pace and extent of change will depend

on factors such as population density, household income, public investment, the state of roads and public-transit infrastructure, pollution and congestion levels, and local governance capabilities.

The private sector will exert important influences, too, as companies adjust to new consumer behaviors. Utilities, for example, will need to manage possible increases in electricity demand resulting from the wider use of electric vehicles. Automakers can expect the automotive revenue pool to grow and diversify as the mix of vehicles sold tilts toward electric and autonomous vehicles. The trend toward connected cars will affect technology companies and insurers, causing

disruption and creating opportunities in areas such as data analytics.¹

With all these forces at work, the transition to integrated mobility will be complicated, even challenging at times. Some cities can get an early start, while others will need to work on developing the right conditions. No matter how ready a city is to move toward advanced mobility models, municipal officials can already begin developing a vision for what integrated mobility ought to look like and how their cities might evolve accordingly. More important, they can consider how to manage the transition so that its benefits are maximized in line with local priorities for improving residents' quality of life.

To help city leaders structure their thinking, we have created scenarios for how mobility might change in three types of cities: dense cities in developed economies, dense cities in emerging economies, and sprawling metropolitan areas in developed economies. Each scenario accounts for present-day conditions and highlights both opportunities and challenges. In this article, we lay out these visions for the future of mobility, along with ideas about how municipal officials and other urban stakeholders can help their cities navigate toward positive outcomes.

Trends influencing urban mobility

Fast-moving trends are influencing urban-mobility systems around the world. Some trends, like vehicle electrification and the development of autonomous-driving technology, relate directly to mobility. Other, broader trends will also have important implications. The decentralization of energy systems, for example, will make a difference as modes of transportation come to rely more and more on electricity as an energy source. The following trends are likely to have the biggest

impact on the development of integrated mobility in cities.

Shared mobility. Ride-hailing services have grown rapidly over the past few years and now compete not only with traditional car-sharing and car-pooling providers but also with public transit and private vehicle ownership. Investments in ride-hailing companies have taken off, too, more than doubling to \$11.3 billion in 2015 from \$5.3 billion in 2014.

Autonomous driving. Advances in autonomous-driving technology promise to resolve road-safety concerns, reduce the cost of transportation, and expand access to mobility. Autonomous vehicles (AVs) should turn driving time into free time. AVs could also lead to higher overall vehicle mileage, as people take advantage of their convenience by making more trips or even sending AVs to run errands for them.

Vehicle electrification. Global electric-vehicle (EV) sales have risen quickly, from 50,000 in 2011 to nearly 450,000 in 2015. Purchase subsidies, falling battery costs, fuel-economy regulations, and product improvements have contributed to the increase. Bloomberg New Energy Finance estimates that battery costs will drop below \$100 per kilowatt-hour in the next decade. If that happens, EVs should achieve cost competitiveness with conventional vehicles.²

Connectivity and the Internet of Things. The spread of IoT applications into vehicles and infrastructure will generate data with a variety of uses. For city dwellers, software systems can facilitate trip planning and guide AVs based on real-time conditions. Transit authorities could use the same data to analyze the movement of people and vehicles, identify bottlenecks, adjust services, and make long-term transit plans.

Public transit. Cities around the world are expanding and improving their public-transit networks. Adding autonomous features to transit vehicles may reduce operating costs, while new deployment models such as fleets of shared vehicles can make transit more flexible and accessible. Using data from IoT-enabled infrastructure can help planners to add capacity and improve reliability so that mass transit remains competitive with private vehicles and mobility services.

Infrastructure. The United Nations Population Division projects that the world's urban population will increase by more than two-thirds by 2050.³ Such an influx of people could put more strain on city roads, bridges, and tunnels that are already struggling to keep up with increases in vehicle miles. But infrastructure upgrades that favor public or shared transit and bicycling could reinforce a shift away from car ownership.

Decentralization of energy systems. If the cost of renewable power generation continues to fall, then intermittent distributed generation will produce a notable share of the world's electricity over the next 15 years. These trends could accelerate EV uptake by making electricity cheaper, cleaner, and more reliable. Residential solar and energy-storage systems let EV owners recharge their vehicles without buying electricity at retail rates. (In some places, it is already less expensive to power a vehicle with electricity than with liquid fuel.) These systems also reduce demand on urban power grids, which helps to lower electricity prices at peak times and to free more capacity for vehicle charging.

Regulation. As advanced mobility services and technologies have penetrated cities, public officials at the city, regional, and national levels have responded by establishing an array of new regulations. These regulations reflect local

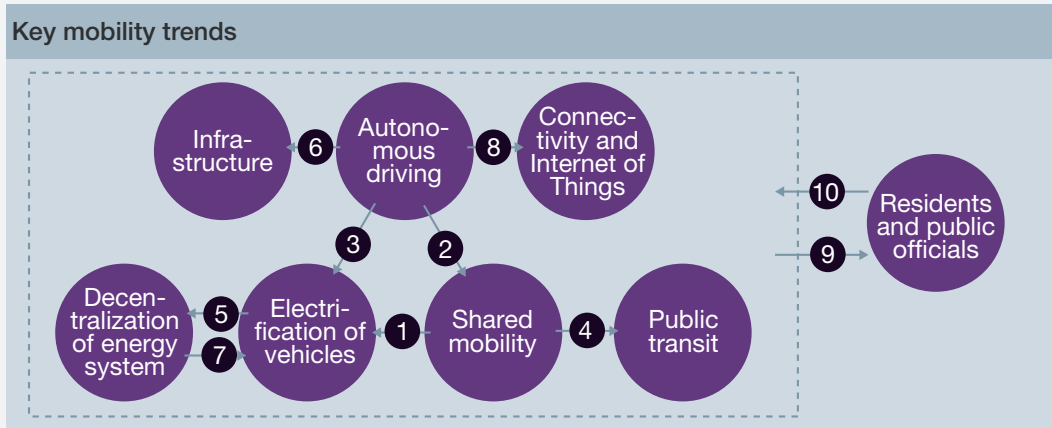
priorities and stakeholder influences, which have not always favored integrated mobility. National or state-level regulations, such as tax breaks and incentives for EVs, have given a boost to integrated mobility in many cities, but local regulations, such as traffic rules that reserve bus-only lanes on city streets, could be even more consequential. To capture the benefits of integrated mobility, governments may want to consider creating regulations that encourage consumer-friendly developments while also promoting larger public goals, such as clean air and reduced congestion.

Individually, these trends will have a profound influence. As they unfold in tandem, their effects could be reinforced and multiplied (Exhibit 1). For example, AVs would reduce the cost difference between private car ownership and ride hailing, leading to greater use of shared mobility services. This would affect public transit: research shows that the more people use shared transportation, the more likely they are to use public transit. The adoption of both private and shared AVs should also increase mobility consumption, which would favor the adoption of EVs, since they are more economical than conventional cars when vehicle utilization rates are high.

How cities can manage the transition to integrated mobility

Broadly speaking, integrated mobility systems could improve the lives of city dwellers in several respects. One is environmental quality. As more urban journeys shift—to EVs, shared mobility services, and public transit—tailpipe emissions of carbon dioxide, nitrogen oxides, and fine airborne particulates in cities should go down. This will help reduce health problems, such as respiratory diseases, heart attacks, and premature births, that are aggravated by local air pollution.

Exhibit 1 Some emerging mobility trends will have reinforcing effects on one other.



Reinforcing effects from mobility trends

- 1 An uptake in shared mobility will accelerate electrification, as higher utilization favors the economics of electric vehicles.
- 2 Self-driving functionality could lead to a competitive proposition for shared mobility.
- 3 Self-driving vehicles, both private and shared, are likely to increase mobility consumption, in which case electric vehicles offer a lower total cost of ownership.
- 4 An uptake in shared mobility will affect public transit.
- 5 Electricity demand will surge while demand for fuel goes down; electric-vehicle production at scale could accelerate the drop in battery prices.
- 6 Self-driving and electric vehicles will require different charging and parking infrastructure, likely freeing up real estate in city centers (eg, street and garage parking) and making suburbs more accessible.
- 7 Increasing penetration of renewable energy could accelerate the financial and environmental attractiveness of electric vehicles.
- 8 Self-driving vehicles might accelerate the uptake of IoT applications.
- 9 Mobility trends could impact residents in ways such as shifts in work formats (eg, taxi employees vs self-employed ride-hailing drivers), real-estate values, and cost and time spent in transit.
- 10 City authorities can shape their mobility agenda to capture fiscal, social, and environmental benefits through forward-thinking policy.

The well-being of citizens should also improve as smarter forms of urban transport prevent traffic accidents. The World Health Organization estimates that 1.25 million people died in road crashes in 2015. But a shift toward AVs would prevent many crashes, and the ensuing traffic slowdowns, by eliminating the human errors that cause the majority of accidents.

Then there is the problem of traffic congestion, which costs more than 1 percent of GDP globally. Congestion could be eased by connected AVs (which can boost the throughput of roads by driving closer together) and sophisticated traffic-management systems, such as dynamic tolling. Other benefits of advanced mobility include expanded access to mobility for citizens who either cannot drive or live far from transport hubs, and the extra free time people will gain from using AVs, shared vehicles, and mass transit more than they do now.

This is not to say that the transition to integrated mobility will have no drawbacks. Shifts in employment, for example, could occur as more AVs and EVs roll out, reducing the need for drivers and mechanics. City officials will also need to make sure that the cost of mobility is equitable, that increases in passenger and vehicle miles resulting from the use of AVs do not worsen pollution, traffic, or safety, and that public transit improves the mobility system as a whole. To maximize the benefits of the mobility transition and prevent changes from imposing significant costs on society, city officials will need to pay attention to several critical topics.

- **Mass transit.** Mass public transit will be essential to preventing congestion as more vehicles take to the road. But if mass transit is infrequent or slow or otherwise unsatisfactory, city residents might switch to low-cost, on-demand shared mobility services, thereby

making traffic worse. Governments will need to make sure that mass transit remains a widely appealing alternative to private mobility. Cities might also consider encouraging people to use mass transit by subsidizing trips to and from transit hubs via shared services.

- **Land use.** Changes in the number and mix of city vehicles will have important implications for how land is managed. Consider one relatively mundane land-use issue: parking. Parking space occupies up to 15 percent of public land in sprawling metropolitan areas. Shrinking vehicle fleets should make it possible to repurpose some of that space. But some of it will still need to serve the mobility system. Turning some on-street parking spots into zones where passengers can climb into and out of vehicles might improve the flow of traffic. Cities can also consider managing their future development so that it does not result in inefficient land-use patterns.
- **Revenue.** Disruptive change to mobility systems could alter the tax bases of many cities. In the Seamless Mobility or Clean and Shared scenarios, extensive adoption of EVs could reduce revenues from fuel taxes by 20 to 65 percent unless taxation systems are reconfigured. On the other hand, connectivity and the Internet of Things could be used to levy and collect new taxes for the use of infrastructure on a per-mile basis or for time spent driving in heavily traveled districts.
- **Infrastructure.** On average, new roads become congested within seven years. Building more roads may not be enough to accommodate the increases in passenger and vehicle miles that we have projected. Cities will need some mechanisms to lessen demand on roads, such as dynamic pricing. They can also apply new

measures to increase capacity. Just as some areas now reserve lanes for low-emissions or high-occupancy vehicles, cities could set aside AV-only lanes so AVs can travel at higher speeds than they might in lanes where they would be surrounded by human-driven vehicles.

Envisioning the future(s) of urban mobility: Three scenarios

To help officials and planners anticipate the future of mobility, we have developed three scenarios. Each one is linked to a particular type of city, defined by levels of economic development, household income, and population density. By looking at today's conditions and modeling how mobility trends could play out in each scenario, we can offer city planners some ideas about which trends might advance more quickly than others, and what the effects those trends could have on safety, traffic, and the environment. Our analysis suggests that the Seamless Mobility scenario for dense, developed cities would produce the most societal benefits, and that the Clean and Shared scenario for dense, developing cities and the Private Autonomy scenario for high-income, low-density cities would also have significant benefits (Exhibit 2).

Dense, developing cities

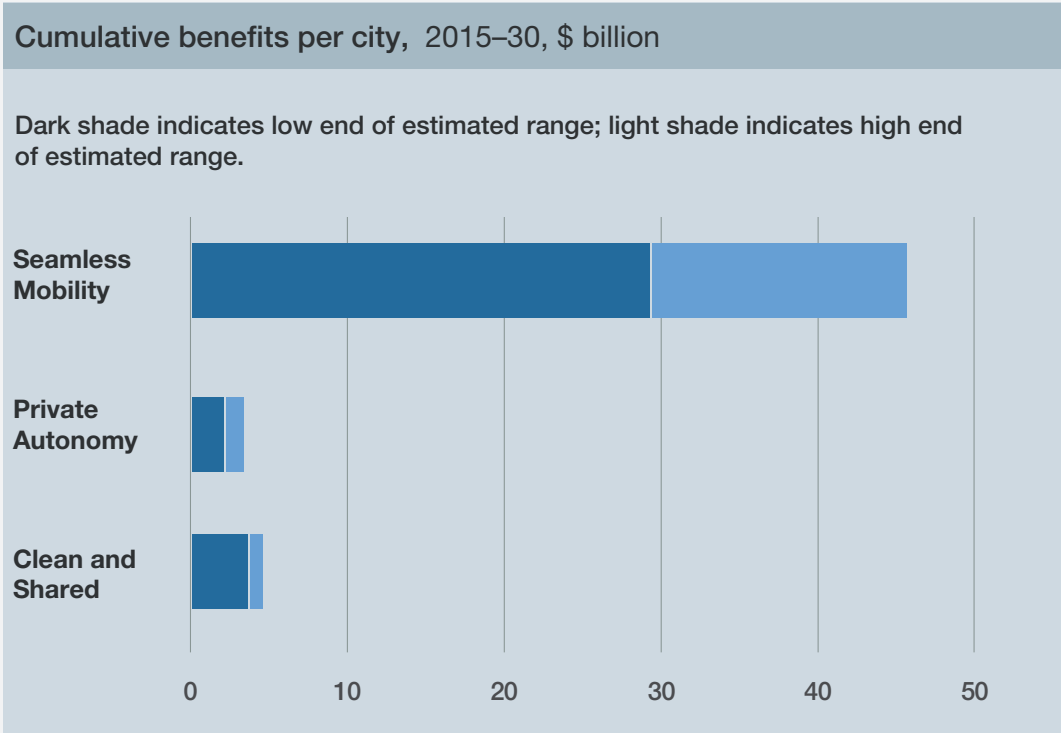
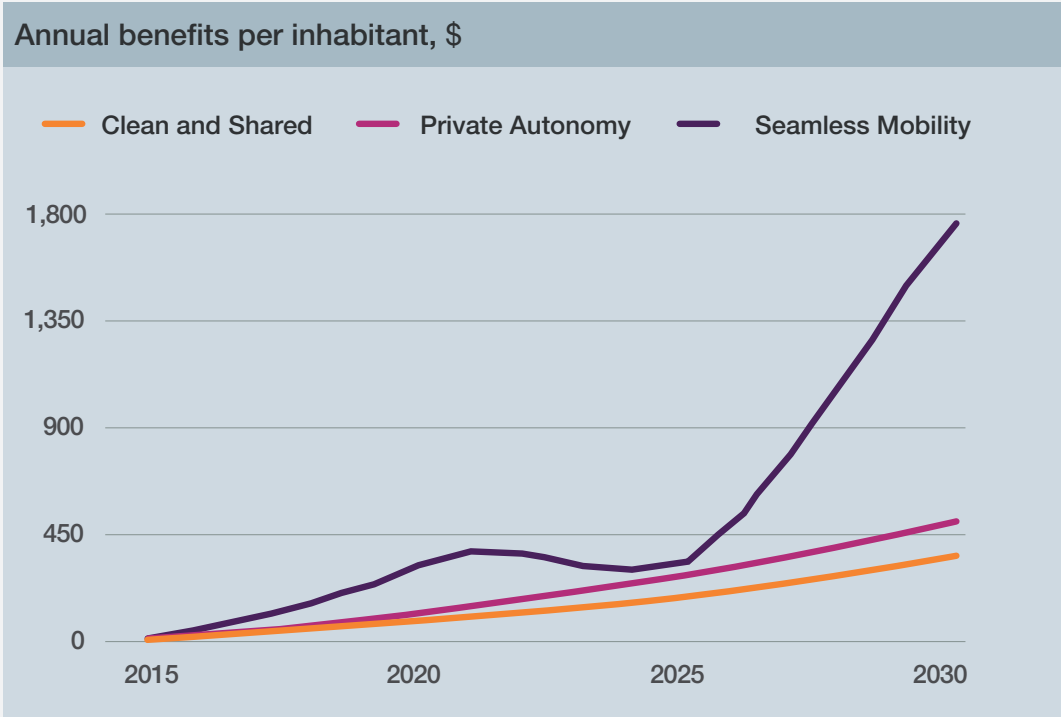
Densely settled cities in developing countries face a serious mobility squeeze. Congestion is severe, partly because roads and other forms of transport infrastructure are inadequate and in disrepair, and partly because traffic patterns are complex. Heavy air pollution takes a toll on the health of urban residents. And rapid population growth creates more demand for mobility by the day.

This set of conditions favors the emergence of what we call a Clean and Shared model for urban mobility, characterized by the following shifts:

- *More infrastructure improvements.* The most valuable upgrades will be those that make it easier for people to get around using modes of transportation, such as shared mobility services and mass transit, that do not worsen traffic congestion, air pollution, or other pressing problems. Without better infrastructure, though, the benefits of integrated mobility could be curtailed.
- *The expansion of cost-effective forms of transport.* High-capacity public transport and shared mobility services will probably do the most to satisfy rising demand for mobility. We estimate that by 2030, shared light vehicles could account for a third of vehicle-miles traveled in an average-size city.
- *Little uptake of AVs.* Public and shared mobility services will likely favor vehicles driven by people, because labor costs are low, sustaining employment remains a priority for policy makers, and AVs might be stymied by bad roads and heavy traffic.
- *A shift toward EVs.* This would be enabled by advances in decentralized renewable-power generation (for example, rooftop solar) and motivated by concerns about air pollution. We project that approximately 40 percent of vehicles in developing, dense cities will be electric by 2030. These developments could create challenges for utilities, however, given the aging power grids in many dense, developing cities.

Some 15 developing, dense cities, including Delhi, Istanbul, and Mumbai, appear well-positioned to make early transitions to integrated mobility, based on their population sizes, above-average GDP per capita, record of implementing public projects effectively, and urgent pollution and congestion problems.

Exhibit 2 Societal benefits are greatest under the Seamless Mobility scenario and substantial under the other two scenarios.



McKinsey&Company | Source: Bloomberg New Energy Finance; McKinsey analysis

According to our forecasts, these cities stand to gain a lot from mobility advances. We estimate that a developing, dense city of average size could realize \$600 million in annual societal benefits by 2030. From 2015 to 2030, these benefits would add up to between \$3 billion and \$4 billion, or \$2,200 to \$2,800 per resident. Nearly four-fifths of these benefits will result from improvements in safety (Exhibit 3).

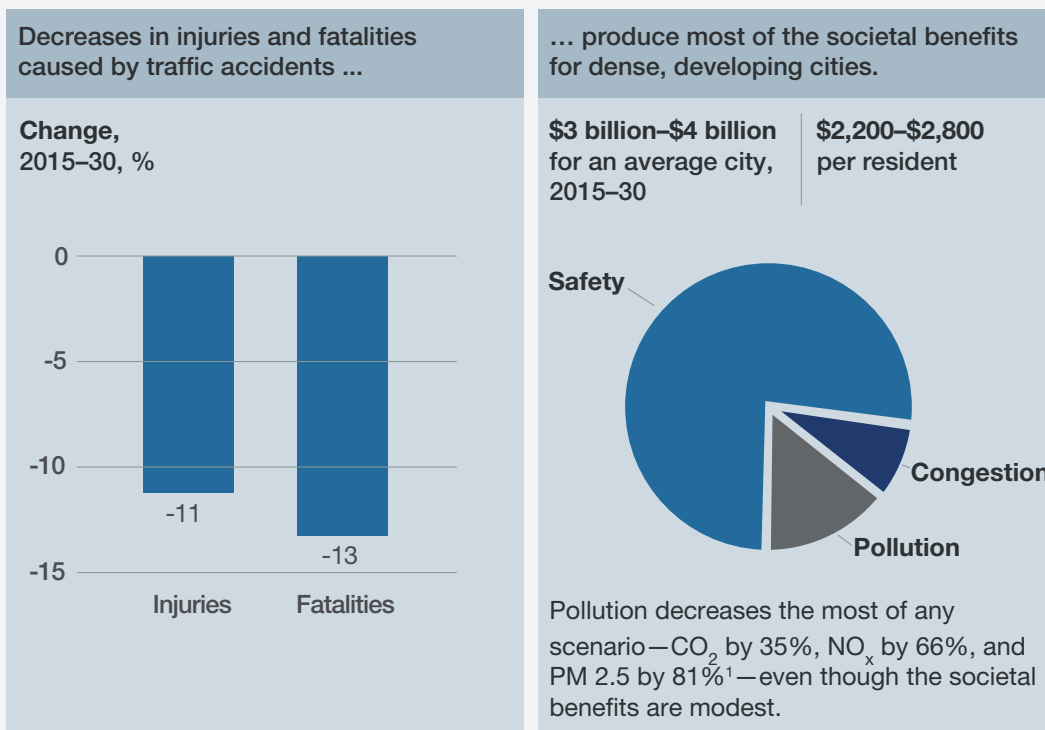
High-income, low-density cities

In the sprawling, suburban-style municipalities of Europe and North America, residents rely mainly

on private cars to get around. They also spend considerable amounts of time on the road. Places like these are conducive to a Private Autonomy model, in which private cars still dominate the mobility mix but new technologies enable different uses. The main features of the Private Autonomy model are as follows:

- **Extensive uptake of AVs.** Most of these will be EVs. This shift would eliminate much of the work of driving, giving drivers more free time. It could also reduce traffic congestion, particularly if cities use infrastructure, such as dedicated

Exhibit 3 Improvements in safety account for most of the benefits of integrated mobility under the Clean and Shared scenario.



¹ CO₂ = carbon dioxide, NO_x = nitrogen oxides, and PM 2.5 = fine airborne particulates.

AV lanes, to boost AVs' efficiency. On the other hand, as AVs make it more pleasant to travel by car, they could increase the demand for mobility and even encourage more low-density development.

- *More shared mobility.* These services (along with private AVs) could mobilize the elderly, the young, and other groups that cannot drive. They could also spare low-income groups the expense of owning cars. Greater access to mobility, along with the spread of AVs as described above, could cause a 25 percent increase in passenger miles by 2030, according to our forecasts.
- *Higher-impact public transit.* Efficient, flexible, and affordable mass transit, especially along major commuting arteries, will be needed to reduce traffic congestion—but will also face competition from private mobility services. Cities can explore ways of enhancing public transit so that it remains an appealing alternative to private transportation and meets the mobility needs of people who depend on it.

As we see it, the Private Autonomy model is likely to catch on first in developed suburban cities with high per capita GDP, openness to new technologies, and a successful record of implementing public projects. Such places include Houston, the Ruhr area of Germany, and Sydney.

We estimate that a high-income, low-density metropolitan area of average size could realize \$500 million in annual societal benefits by 2030—enough to boost its GDP by 0.9 percent. From 2015 to 2030, the benefits would amount to \$2 billion to \$3 billion for the city and \$1,800 to \$3,300 per resident (Exhibit 4).

About half of those benefits would come from improvements in passenger and pedestrian safety. Most of the remaining benefits would come from the avoided cost of congestion, assuming that connected AVs are widely used and cities attempt to maximize the efficiency of AVs. But environmental benefits would be small because of an overall rise in vehicle miles.

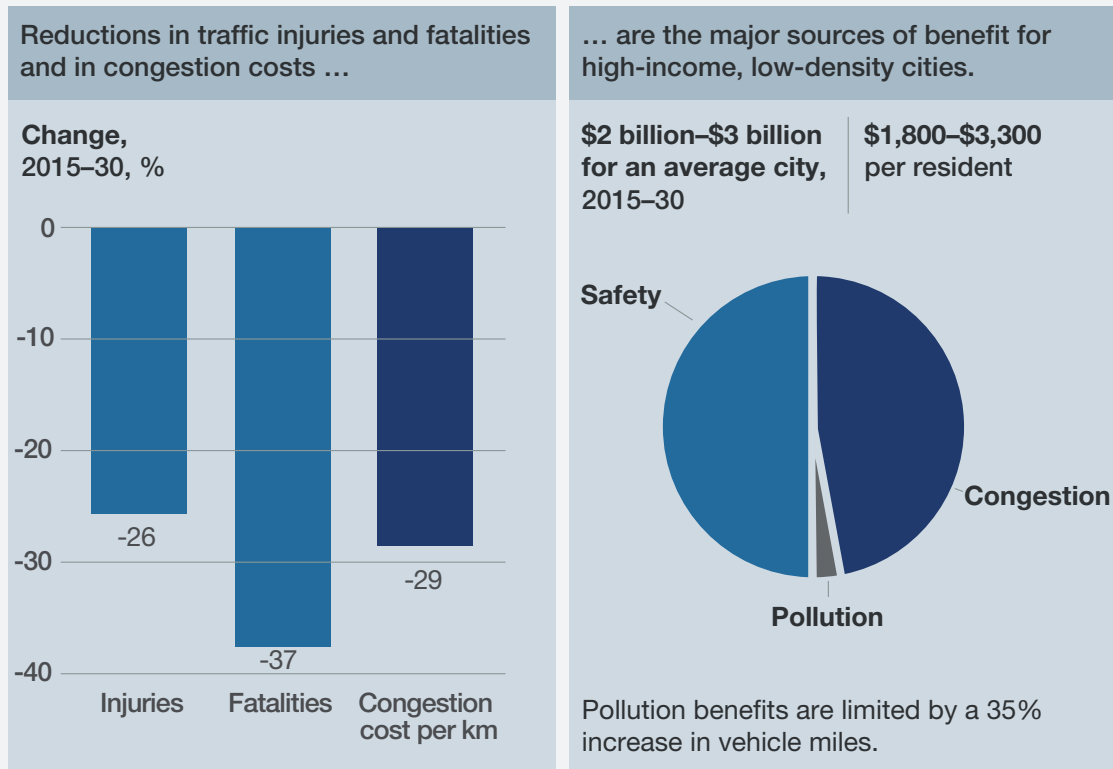
Dense, developed cities

Good-quality mass transit is the mainstay of urban mobility in high-income, densely settled cities. Some residents supplement their use of public transit with privately owned cars or shared vehicles. E-hailing services have also expanded quickly in these cities. The fact that advanced mobility services have won acceptance in dense, developed cities suggests that AVs and newer forms of shared mobility, such as peer-to-peer car sharing, will also blend in well. The result would be what we term the Seamless Mobility model: a flexible, highly responsive system that moves residents quickly from place to place, sometimes by switching among modes of transport. The signature elements of this model are as follows:

- *A shared fleet of public AVs.* This fleet could provide many residents with affordable mobility. Using EVs is likely to be most economical. We expect people to travel up to 30 percent more, leading to an overall increase in vehicle miles. This could cause more traffic congestion unless the right planning measures are taken. However, the high utilization of shared AVs should reduce fleet sizes.
- *Integrated mobility platforms.* These will allow cities to gather data from connected vehicles and infrastructure about prices, schedules, and real-time conditions. Cities could use the data

Exhibit 4

In the Private Autonomy scenario, safety and congestion improvements account for nearly all societal benefits of integrated mobility.



McKinsey&Company | Source: Bloomberg New Energy Finance; McKinsey analysis

to make smarter improvements and give riders the ability to plan and pay for trips, even using multiple providers.

- **Enhanced public transit.** Mass-transit rail systems, walking, and cycling will still offer unrivaled speed and capacity for many journeys. New technologies will enable improvements, such as live updates on the arrival times of buses and trains. And a public AV fleet could offer a more convenient, lower-cost means of transport than buses running along fixed routes. Such

changes may be needed to ensure that public transit remains viable.

- **Catalytic urban planning.** Planners can alter the urban landscape to enhance mobility. This might involve instituting congestion pricing to prevent traffic slowdowns or demarcating low-emissions zones to speed the uptake of EVs, among other possible changes. If the number of vehicles in Seamless Mobility cities goes down, as we expect it to, and AVs can be directed to park outside city centers, this would reduce the

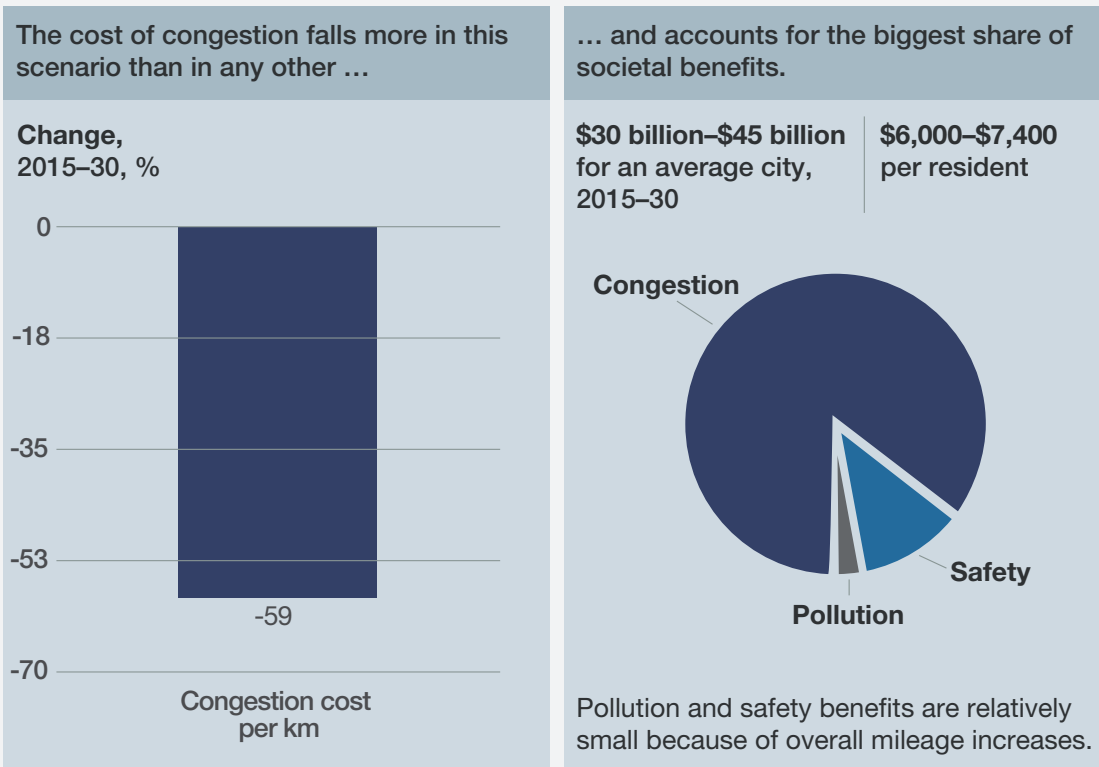
need for parking space and free valuable land area for other uses.

Fifteen dense, developed metropolitan areas have the high-quality public-transit systems, infrastructure-investment capacity, and expertise with public projects that should help them advance toward a Seamless Mobility system before other cities. These pioneer cities include London, Shanghai, and Singapore.

We estimate that Seamless Mobility would yield the greatest social benefits of any integrated model: up to \$2.5 billion per year by 2030 in an average city, enough to boost its GDP by as much as 3.9 percent. From 2015 to 2030, the cumulative benefit would be \$30 billion to \$45 billion, or \$6,000 to \$7,400 per resident (Exhibit 5). Most of the benefit will come from reduced congestion—provided that cities install infrastructure to let AVs and mass-transit vehicles operate efficiently. Safety and

Exhibit 5

Dense, developed cities would reap most of their benefits from reduced traffic congestion under the Seamless Mobility scenario.



McKinsey&Company | Source: Bloomberg New Energy Finance; McKinsey analysis

emissions will likely improve on a per-mile basis, but overall increases in mileage will mean that the absolute gains in safety and emissions will remain relatively modest, at just 15 percent of total benefits.



Advances in mobility are already affecting the transportation systems of major cities around the world, though not uniformly. Ride-hailing services, for example, have seen much faster growth than car sharing or EVs. Cities are mostly dealing with these trends in isolation. But cities can gain advantages by looking at the future of mobility in a comprehensive, integrated way that anticipates the dependencies and reinforcing effects among trends. This helps them understand the potential pace and impact of change, analyze trade-offs, and lay out helpful policy prescriptions. Cities that do this well stand a better chance of shaping the future of mobility in a way that balances benefits with potential adverse effects, and thereby improves the lives of their residents. ■

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¹ For more, see Eric Hannon, Colin McKerracher, Itamar Orlandi, and Surya Ramkumar, *An integrated perspective on the future of mobility*, a joint report from Bloomberg New Energy Finance and McKinsey & Company, on McKinsey.com.

² For more, see Paul Gao, Hans-Werner Kaas, Detlev Mohr, and Dominik Wee, "Disruptive trends that will transform the auto industry," January 2016, McKinsey.com.

³ *World urbanization prospects: The 2014 revision, highlights*, United Nations, Department of Economic and Social Affairs, Population Division, 2014, esa.un.org.

[Download the full report on which this article is based, *An integrated perspective on the future of mobility*, a joint report from Bloomberg New Energy Finance and McKinsey & Company, on McKinsey.com.](#)