



Urban Mobility Index

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A Centre for Economics & Business Research Exploration in Collaboration with
Qualcomm

Cebr

The Cebr Team

This report has been produced by Cebr, an independent economics and business research consultancy established in 1992, providing forecasts and advice to City institutions, Government departments, local authorities and numerous blue chip companies throughout Europe. The study was produced by Nina Skero, Managing Economist at Cebr, and Jack Coy, Cebr Economist.

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1 Introduction

The spaces in which we live, work and socialise are changing. In 1950, under a third of the world's population lived in urban areas. Today, that number stands at over half, and by 2050 it will be roughly two thirds.¹

As greater numbers of people gravitate towards city living, peoples' idea of the role of the city is expanding. So too is the city's size. Mega cities, those with 10 million inhabitants or more, are on the rise. Nearly one in eight urban dwellers live in one of the world's 28 mega cities and an additional 13 cities are expected to evolve into mega city status by 2030.

The mega city is one of opportunity. Though its street may not be paved with gold, it invariably offers more jobs and better pay. Socially and culturally, it offers the greatest number of experiences to the country. It also represents a global destination, somewhere millions of the world's citizens travel to.

But the mega city is also one of great issues. Issues that will only become more acute as such cities continue to grow in both size and number. Among the most prominent of these challenges is transportation and its effect on levels of carbon emissions.

The modern city is designed and built around its means of transporting people from A to B. From London's centre, originally planned around the horse and cart, to New York's grid system, developed with the automobile in mind, a city's layout is in many ways a reflection of its transportation network.

However, as cities continue to change, so too must their transportation systems. The way people navigate a modern city - what we term urban mobility - poses many questions. Can a mega city occupying a fixed space reduce congestion when faced with a growing population? Can it avoid increasing journey times as more people look to travel? Can quality of life be maintained, or increased, in a city with so much more travel infrastructure? How must public and private transport flex to carry millions more in the coming years? Perhaps most importantly, how can these and multiple other questions be addressed while simultaneously facing an imperative to reduce the environmental impact of all transport systems?

There is clearly no single solution or an ideal city model that answers these questions. There is, however, a common thread in the way cities are responding to the urban mobility challenge - technology. Just as urban areas built around river barges or the horse shifted to accommodate the emergence of the car, new technology is prompting a major rethink about the way we organise cities. The internet, smartphones and connected devices are having a profound impact on the shape of the cities in which we live. Maturing and emerging technologies such as electric vehicles (EV), connected public transport systems, 'smart' traffic sensors and even driverless cars offer a glimpse into what the mega city of the future might look like. A city through which people can travel in an efficient, easy and sustainable manner.

The purpose of this report is to examine and assess how cities across the world are approaching this ultimate goal of sustainable urban mobility and the progress of some key cities across the globe towards achieving zero emissions transportation solutions.

¹ United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights

To do so, the report considers a range of data sources and relevant literature and produces a set of indicators that are considered crucial measures of a city's journeys towards zero emissions transportation. While literature exists that considers individual cities' efforts to eliminate emissions, or the advancements in technology that are making it possible to pursue a zero emissions target, this report combines previously published information with original research to present a fresh, holistic global view. This approach allows for the introduction of a comparative angle that reveals why some cities are moving towards zero emissions faster than others and what lessons we can take away from those places that are performing especially well.

While there is no single model for what a zero emissions city of the future will look like, many are bound to share a few traits. Residents of zero emission cities will primarily rely on walking, cycling, and public transport to commute. Taxis, inner city rail and bus fleets will depend on clean, sustainable energy for power. Governments of zero emission cities will prioritise sustainable transportation networks both in terms of regulation and funding.

Likewise, those that choose private vehicles will likely be relying on electrically powered ones. Many car trips will also rely on car sharing and, instead of buying personal cars, households will subscribe to schemes that will allow them access to a car when they need one. The preference for public transport and car sharing will reduce the number of vehicles on the road as well as the space needed for driving and parking cars. Congestion will ease and freed space could be converted into green leisure areas or used more efficiently for housing or commercial developments.

Autonomous vehicles will also play a significant role in making zero emissions transportation a reality. Driverless cars, taxis, buses and trains will minimise human error and make journeys much more efficient, reducing congestion and increasing travel speed. Paired with EVs, these two technologies will have the greatest impact on urban mobility.

Finally, cities that have made the most progress towards creating a zero emissions city will pair technological advancements and sustainable infrastructure with substantial financial and non-financial incentives to encourage the use of sustainable transport. Such cities will have made the zero emissions agenda a priority via binding city-level plans and through international commitments at a country level.

Methodology

In order to establish which of the world's city transportation solutions are the closest to becoming emissions free, this report relies on an indexing approach in which a higher score indicates that the given city is closer to eliminating emissions, with 100% indicating the goal has been achieved. The overall index score for each is based on the city's performance against 20 indicators, all of which assess how the city is currently addressing challenges related to emissions or how it is preparing to approach these tasks going forward.

The 20 indicators are divided into three overarching sub-indices to assess a city's performance in one of three major areas deemed necessary for achieving emissions free status: its status quo, the conditions for change, and its preparedness for the future.

The **status quo** sub-index considers the cities' current performance in terms of various transportation and emission-related considerations. This includes measures of outdoor air pollution, congestion, the share of journeys made in a personal vehicle and CO₂ emissions. It also includes more general indicators that speak to the magnitude of challenges that the city faces on its journey towards zero emissions, such

as the rate of population growth and energy intensity. Much progress has been made in reducing personal energy use in many developed cities in recent years, although it is important to consider residents of developed cities consume more and that this may come at an environmental cost.

The **conditions for change** sub-index examines how a city is encouraging its residents to adopt low emission or EVs, or utilise sustainable travel alternatives. Indicators include availability of cycle schemes, the financial and non-financial incentives in place for those buying and operating EVs, the prevalence of low emission zones, and the relative price of fuel to electricity.

Finally, the **preparedness for the future** sub-index looks at what visionary measures cities are implementing to ensure they minimise or eliminate emissions from transportation in the coming years. Among these indicators are autonomous vehicle preparedness, availability of EV charging points, and commitment to the low emissions agenda in local and international agreements.

The index considers 35 cities from across the world. The included cities were selected based on their population, total GDP, GDP per capita, inclusion in a broader set of literature considering environmental sustainability, and pollution levels. A full overview of the methodology, the list of cities and these indicators is provided in Tables 1 and 2 in the Appendix.

2 Executive summary

In order to cope with increasing demands on transportation systems while reducing environmental impact and improving residents' quality of life, cities around the world have engaged in a race of sorts – the race to become the world's first city with a zero emissions transportation system.

While many cities hold zero emission ambitions, some are much farther along this journey and are likely contenders for the title of first zero emissions city.

This report ranks 35 global cities based on their level of progress towards achieving this goal, finding that:

- **Oslo is set to be the world's first city with a zero emissions transportation solution.** The Norwegian capital tops the overall ranking, with London and Amsterdam occupying second and third spots respectively
- **European cities lead the way for sustainable transport.** Eight of the top ten scoring cities are based in Europe thanks to a mixture of innovative transportation schemes, intelligent use of technology and an advanced approach to incentivising citizens to change habits. Tokyo and Seoul round out the top ten
- **Asian cities among the most ambitious and visionary in their approach to a zero emissions future, but are challenged by the scale of the current situation.** Cities across Asia show a particularly strong performance in their preparedness for the future, with a desire to create smart, connected cities filled with driverless EVs and public transport, but grave air pollution concerns mean they face a long road ahead
- **Progress of North American cities is weakened by a reluctance to fully embrace change.** A feature shared by many North American cities that damages their overall ranking is citizens' attachment to private, polluting vehicles. Low fuel costs and a tangled federal, state and city legislative framework combine to leave North America in a position where citizens have a mixed level of incentives to change their habits
- **South American cities are still in early stages of battling emissions, but face fewer challenges.** While there are some encouraging signs emerging from South America, cities are largely in the early stages of introducing low emission measures to transport systems and their pace of progress is slow. However, at present they face fewer challenges than in other parts of the world and could therefore achieve a sustainable transportation system more quickly, should they escalate efforts
- **With cheap oil and few zero emission incentives, Abu Dhabi sits towards the bottom of the index. However, its huge ambitions and willingness to invest significant sums means it could quickly leap up the index.** The Gulf city is in a somewhat unique position, as it scores poorly across both its current position and in its efforts to create change, but extremely highly when it comes to preparedness for the future. There is evidence the city is seeking to skip stages of the journey towards achieving zero emissions and should it stay on its current trajectory, the city could rush up the index in the coming years

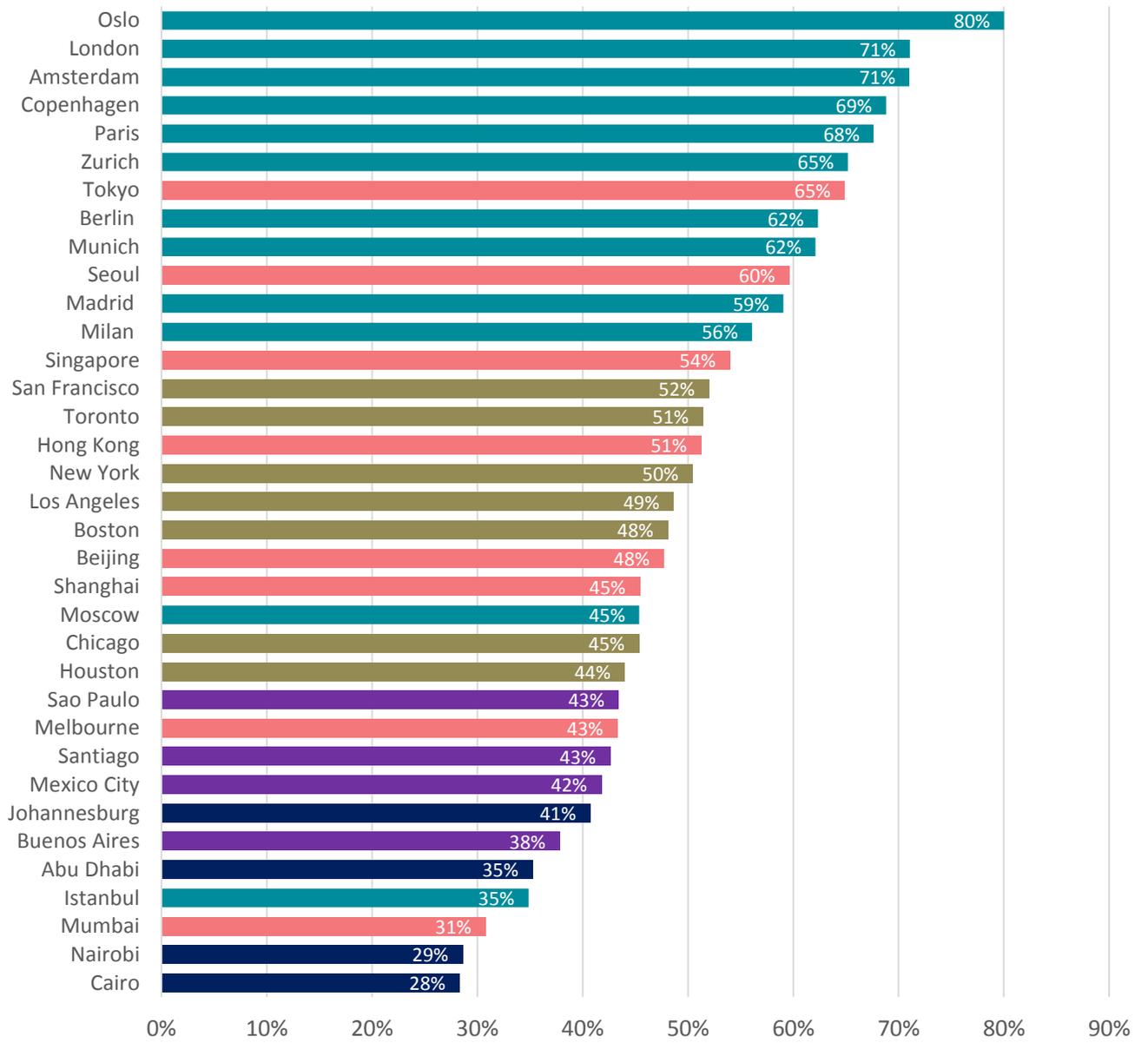
- **For African cities, achieving zero emissions is still not a top priority, with little evidence of efforts on the behalf of government or private parties.** Though cities such as Cairo, Johannesburg, and Nairobi have a relatively low reliance on private, polluting vehicles, there is little evidence of a desire for change either at a governmental or citizen level and zero emissions isn't deemed a key priority

3 Oslo, London, and Amsterdam top the overall index ranking

- **The overall index score captures how close a city is to fulfilling its zero emission aspirations. The city's ranking measures its performance against other global centres**
- **The top five spots in the overall index are held by European capitals. One trait these cities share is that they are in relatively wealthy parts of the world. This somewhat helps their overall scores as, for example, a higher share of residents can afford to regularly upgrade their cars**
- **Tokyo and Seoul stand out as the only two non-European cities to make the top 10 list**
- **The bottom of the list is largely populated by cities in Africa and South America. Due to varying stages of economic development, these cities face particular challenges in promoting the zero emissions agenda**

The index ranking captures how far along its zero emission journey a city is. A score of 100% would indicate that a city has realised its ambitions and is already operating an entirely sustainable urban mobility system. The below figure shows each city's overall score, with higher values signifying that it is closer to the goal, as well as its ranking compared to other cities in the index.

Figure 1 – Overall urban mobility index score



The top of the index is dominated by European cities. Oslo comes out as the city closest to achieving the status of a city operating a zero emissions transportation system, followed by London and Amsterdam. One trait these top three cities share is that they are in relatively wealthy parts of the world that are also in advanced stages of economic development. This somewhat helps their overall scores as, for example, a higher share of residents can afford to regularly upgrade their cars, which may make them more likely to drive a low emission car or EV.

However, while Oslo, London and Amsterdam do have some general advantages that make them more likely contenders in the zero emissions race, they also all show a firm commitment to the zero emissions agenda. Furthermore, they have created a set of incentives and regulations to see those commitments through. They offer easy access to EV charging points, operate low emission zones, provide citizens with a reliable transport infrastructure, and financially incentivise the purchase of environmentally friendly vehicles. Oslo plans to ban all cars from the city centre by 2019 and cut emissions from taxis entirely by 2023. London is accelerating plans for an ultra-low emissions zone and the city plans on purchasing only hybrid or zero emission buses after 2018. Amsterdam is working to expand its low emission zone and plans on operating only zero emission buses by 2026. These ambitious plans, and historic efforts that have made their implementation possible, have propelled the three cities to the top of the index and made them the most likely candidates for the world's first zero emissions city.

A focus on: Oslo

Overall score: 80% (ranking 1st)

Status quo: 75% (3rd)

Conditions for change: 95% (1st)

Preparedness for future: 66% (4th)

Oslo plans to be fossil fuel free by 2050

Renowned as one of the most progressive cities in the world, Norway's political and economic centre is the closest it is possible to find for a sustainable urban transportation system. With noticeably clean air, EVs and chargers on almost every street corner, and a quietly efficient public transportation system, wandering Oslo's streets is, for many visitors from other continents, like glimpsing a city from the near future.

Oslo has more EVs on the road than any other city in the world and epitomises the wider country's comprehensive incentives and forward-thinking investment in environmentally-friendly transport. This has led to over a quarter of all new cars bought today in Norway being an EV.

In 2008, in a bid to lower emissions, the Norwegian capital paved the way for EVs by adding hundreds of charge points to the city and heavily subsidising private chargers by covering up to 60% of installation costs. Today, there are over 1,000 private and public charge points in Oslo, amounting to more per resident than any other city on the index. To further incentivise buyers, EVs are exempt from purchase tax and VAT and are charged a lower rate of vehicle tax. In addition to cash incentives, EV drivers in Oslo enjoy free parking in city carparks, free charging at public stations, use of bus lanes, and toll exemptions on Oslo's ring road. With high taxes on other fuels, plus levies on larger engine sizes, consumers have been quick to take advantage and go electric.

The Norwegian capital's high uptake of EVs is reflected in the city's clear lead in the conditions for change sub-index, but Oslo performs well in other measures too. Its outdoor air pollution levels are low, and it has the lowest CO₂ emissions per capita of any European city. Significant numbers of low emissions vehicles on the road plays a large part in achieving this, as well as Oslo's efforts to modernise its public transport fleet. In 2011, buses running on fossil fuels were replaced with biofuel and bio-gas vehicles, reusing methane and organic waste from the city. Going forward, the low-emissions agenda could be further reinforced by improving the city's non-car networks. For now, with strong investment into travel infrastructure congestion levels in the city are low, but even with Oslo currently the fastest-growing major city in Europe this should not be taken for granted for the future.

Not content with its current successes, Oslo has its eyes on further ambitious targets. The city council has pledged to ban all private cars from the city centre by 2019. Meeting this target would see Oslo become the first city to impose a permanent car ban across the entire central city and confirm that it is on course to become the first city with a zero emissions transportation system. The new measures will be coupled with over 60km of new bicycle-lanes. It also plans to be free from all fossil fuel usage by 2050. As a signal of intent, Oslo is the first city to ban investment into fossil fuels, and divest portions of its \$9 billion city pension fund from coal, oil and gas companies.

With the Norwegian government looking set to achieve its target to have 50,000 zero emissions vehicles on the country's roads by 2018 in just a few short years and given Oslo's outstanding progress, it would be unwise to bet against the city achieving these visionary goals.

Eager to transform its footprint and willing to put its full financial and political commitment behind projects, Oslo has shown how quickly cities can see significant results if they create the right set of incentives and, if it continues on its current path, will be the world's first zero emissions city.

A focus on: London

Overall score: 71% (ranking 2nd)

Status quo: 73% (5th)

Conditions for change: 71% (3rd)

Preparedness for future: 66% (3rd)

By 2025, London aims to cut 1990 carbon emission levels by 60%

Famously characterised throughout its history by some of its celebrated citizens as a dirty, crowded and smog-ridden city, London has perhaps undertaken the greatest effort among those on the index to change. Now a global financial rather than industrial powerhouse, London has swapped smoke stacks for skyscrapers. But this has brought with it a new, more complex set of issues and London may not seem an example of a green city to all residents. Congestion levels are high, and public transport is put under daily pressure.

Yet green space covers a third of the city, and air pollution levels are comparatively low. Along with this, policies aimed at cutting emissions have worked – residents generally rely on public transport, rather than private, and Londoners are some of the most energy efficient urban dwellers in the world (only Zurich and Copenhagen rate higher).

Placing second in the overall index, the UK's capital scores well across all sub-indices, reflecting the city's balanced policies. London has been active in responding to environmental and urban pressure and the city's consistent high scores across the sub-indices reflect this.

London has continued to forward policies that establish the city at the forefront of green transport. By 2025, the city aims to reduce greenhouse gas emissions by 60% compared to 1990 levels. In 2008, the introduction of a year-round 24-hour low emission zone showed commitment to a city-wide green transport agenda. Recently, in an effort to ease congestion and extend access for pedestrians and cyclists, plans were confirmed for three new river crossings across the Thames, and the Mayor opened a consultation to the public to further lower emissions

The UK capital achieves its highest score in the conditions for change sub-index, thanks to a broad mix of policies that have primed the city's transport system to encourage low emissions vehicles (LEV). LEV owners are incentivised with Government grants worth up to £4,500, full exemption from the city's congestion charge, and access to extra parking charge points in the city centre. The city also boasts one of the most comprehensive city-wide bike sharing schemes in the index.

While working hard to lower emissions today, London is also well positioned to take on new technology. The GATEway project² began trialling driverless cars on London's roads in 2016. Going forward, further investment is likely to be seen in London. Alongside three other UK cities, the Go-Ultra-Low plan³ promises to invest £600 million by 2020 towards ultra-low emission vehicle uptake. With a particular eye to the future, £13 million will be invested into London's 'Neighbourhoods of the Future', prioritising ultra-low emission vehicles in several London boroughs. Investing heavily in cutting-edge technology, London is poised to become an environmental example for other cities in years to come. However, it must ensure forward-facing policies are coupled with addressing current congestion, particularly strain on public transportation infrastructure, to keep the city moving.

² <https://gateway-project.org.uk/>

³ <https://www.goultralow.com/>



A focus on: Amsterdam

Overall score: 71% (ranking 3rd)

Status quo: 71% (9th)

Conditions for change: 76% (2nd)

Preparedness for future: 62% (8th)

By 2040, up to 90% of Amsterdam's car journeys will be powered by green electricity from windmills, solar panels, and biomass power stations

An image synonymous with Amsterdam is the bicycle, and as the de facto means of transportation at times it seems like there are more bikes than people on the city's streets. It is tempting to view Amsterdam as cycling its way towards zero emissions and with a small population and low dependence on cars, it does indeed have some of the lowest congestion and outdoor pollution levels in Europe.

However, Amsterdam's green credentials extend far beyond its position as the most cyclist-friendly city in the world. It has quietly become a global leader in EVs and has coupled this with successful policies aimed across the spectrum of sustainable transport solutions.

The government offers generous subsidies for EVs, coupled with city-wide charge points. Citizens are further incentivised by extra parking rights for private EVs. With the extensive range of benefits, residents have bought into the zero emissions journey. EVs make up around 10% of all new vehicle purchases, placing Amsterdam second only to Oslo in this measure.

The number of trips taken on green public and shared transportation is also growing. 'On demand' electric car sharing services such as Car2Go have grown in popularity and the Amsterdam-based firm Taxi Electric, the first fully electric taxi service in Europe, are helping ease dependence on private, polluting vehicles.

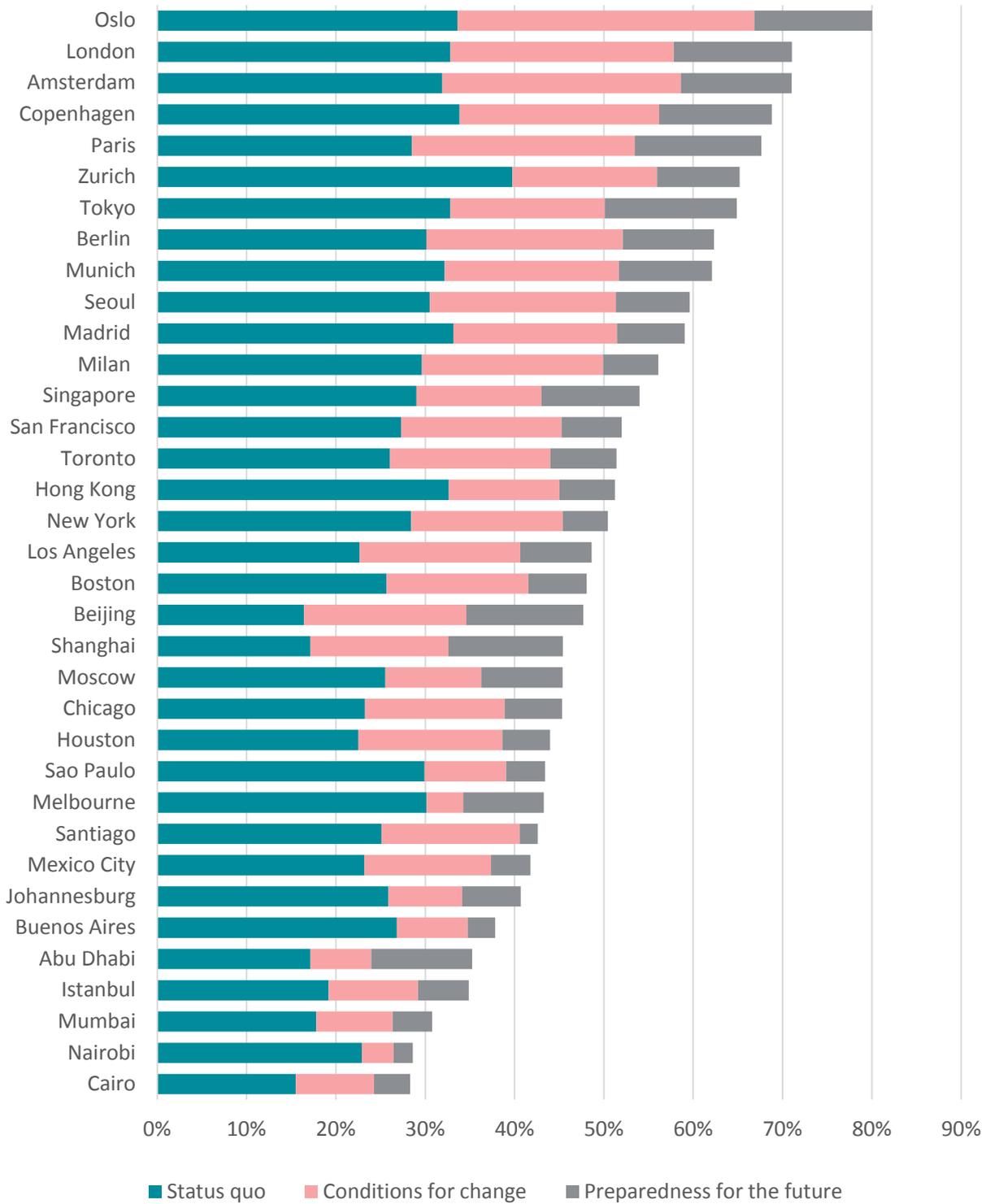
The result of these efforts is noteworthy. Overall, less than 40% of journeys taken in Amsterdam are by private vehicle. This is below the index average of 43%, but higher than the share of trips by private vehicle in some other cities – in Hong Kong for example, the share is 11%.

The city has been aggressive in its emissions targets, aiming for a 40% reduction by 2025 compared with 1990 levels, far beyond the EU target of a 20% cut by 2020. Amsterdam hopes to achieve this with significant, targeted investment. On top of a €40 million Climate and Energy Fund, the city has committed a Sustainability Fund of nearly €50 million that supports the city's long-term energy strategy, including projects for transport and air quality. Plans include having 4,000 electric charging stations on roads by 2018 and all electric buses and taxis throughout the city by 2025/26. There are additional plans to install freight transfer hubs on the outskirts of Amsterdam that will transfer cargo on to low or zero emission vehicles.

Amsterdam's vision for the future is not limited to expanding its use of current technologies. The city is joining many others in exploring autonomous vehicles, but in its own unique way. In a project with the Massachusetts Institute for Technology, the city is launching prototypes for autonomous boats, known as 'Roboats', on its numerous canals. The driverless boats, which can transport goods and people, can also be stacked to form bridges across canals to ease crowding at busy events. With over 50 kilometres of canals covering nearly a quarter of the city, Roboats could become an important part of the city's transportation network.

While the city already holds an impressive third spot in the overall index, it could boost its standing even further by addressing the few indicators in which it scored less well, for instance non-financial incentives for zero emission vehicles.

Figure 2 –Urban mobility index score divided by sub-index contribution



4 European cities form the top 5 list in the status quo sub-index

- The *status quo* sub-index assesses the current performance of cities in terms of transport and emissions
- Thanks to their advanced stages of economic development, but also due to a clear set of well enforced environmentally friendly policies, European cities come out at the top of the sub-index
- Zurich is the highest scorer in the status quo sub-index. Minimal levels of air pollution, a lack of traffic congestion, ample access to green spaces, and a strong transport infrastructure all play their part in propelling the Swiss city to the top of this category
- Many major European cities are less energy intensive than their Asian or Middle Eastern counterparts, the major exception being Moscow. A comparatively higher cost of energy in Europe has led to developments in transport and industry to maximise energy efficiency.

While ambitious plans, financial investment in transportation infrastructure and encouraging a change in citizen habits are going to be critical in achieving zero emissions goals, it is important to consider the cities' starting points when evaluating where each stands on its journey. The 'status quo' sub-index therefore assesses the current performance of cities in terms of transport and emissions.

It asks how the average citizen can currently get from A to B, and what pressure this travel puts on both the city and the environment. This includes level of congestion and, importantly, the share of journeys using private transport. Other important factors such as levels of air pollution, energy efficiency and energy sources are considered also.

The leader in this sub-index, Zurich, has successfully managed to implement policies to meet environmental targets. Its European neighbours have also excelled in this category, partially thanks to modern transport infrastructure, an efficient use of energy and a comparatively high reliance on commuting via public transport, walking or cycling.

Two Asian cities, Tokyo and Seoul, are placed in the top ten in this sub-index, benefitting from modern and effective public transport infrastructure. The varied choice and efficiency of public transport in these cities create wide-ranging connectivity without the need for private, polluting vehicles. Therefore, few residents rely upon their cars and the modal share of public transport is high. This variety of public transport allows citizens to choose the most effective route, also minimising the environmental footprint of travel.



A focus on: Zurich

Overall score: 65% (ranking 6th)

Status quo: 88% (1th)

Conditions for change: 46% (17th)

Preparedness for future: 46% (13st)

Zurich aims to slash personal energy usage and become the world's first '2000-watt society'

Ranking sixth overall, Zurich is a leader in energy efficiency and environmental performance. Despite falling under three levels of federal, cantonal, and city regulations, the city has focused on effective policies towards green mobility. With a high proportion of jobs in finance and business services, typically low in environmental impact, Zurich has a natural advantage to meet emission targets.

Zurich's public transport is highly coordinated, utilising trams, trains and buses, meaning residents are less dependent on their cars. Thanks to a vast tram network, and citizens' walking and cycling habits, almost two-thirds of journeys in the city are made by public transport.

This has helped Zurich progress toward its goal to become the world's first '2,000-watt society', seeking to cut personal energy use to 2,000 watts a year, a goal that requires slashing usage by around two thirds compared to 2009 levels. Intermediate sub-projects, such as EnergieVision 2020, act as stepping stone to the 2,000-watt result. In order to meet this goal the city has invested in renewable energies like hydroelectric, renovated buildings for greater efficiency and introduced 'energy coaching facilities'. The results speak for themselves, with the city boasting the lowest energy consumption per dollar of GDP in the index.

Still, Zurich has done less than some European cities to encourage low emissions transport. Whilst there are tax breaks for buying low emissions vehicles, the city has no non-financial incentives. Furthermore, access to charging equipment could be improved and with further availability EV uptake would no doubt improve. For LEVs to truly take off to levels seen in other European cities, Zurich needs targeted investment and commitment to charging infrastructure.

There is also a lack of regulatory incentives for green transport. The city has no low emissions zone, though not for lack of trying. A familiar story for the city, tangled bureaucracy has made achieving certain goals difficult. Zurich lacks the autonomy to create a local air quality plan, and there is no national law dictating low emissions zone policies. When the city attempted to create one, it failed to get approval at Canton level, and plans were scrapped.

Despite political roadblocks, which frustrate in meeting targets, Zurich has nonetheless succeeded in lowering emissions. Zurich shows that, even if national laws limit what is possible, environmental goals can be met through innovation. The Swiss city provides an important lesson for others, to tailor environmental policy within the scope of what is possible.

With so many residents still depending on private, polluting cars for commuting, North American cities were heavily weighted down in this status quo indicator. Many Asian cities faced a very different challenge that nonetheless also impacted their score. While usage of public transport is generally high in the region, helping lower emissions, congestion remains a significant problem.

That is not to say polluting vehicle use and congestion are issues that European cities are exempt from. In a bid to curb pollution and congestion, Paris has occasionally introduced road space rationing – a measure in which only certain cars, for example those with even numbered license plates, have the right to be on the road. Milan has also previously implemented similar short term measures in response to high pollution readings. In the Americas, cities such as Mexico City and Sao Paulo have similar schemes in place, but on a permanent basis.

The status quo sub-index also considers how energy efficient cities are and where they stand currently in terms of emissions and pollution. Both North American and European cities are generally the most energy efficient per head, with a more mixed spread for Asian and South American cities. Owing to the high number of journeys made in petrol-based cars, US cities scored poorly in CO₂ emissions. It is worth noting that many developing cities, perhaps counter-intuitively, achieved high scores on this indicator thanks to low levels of private vehicle ownership and usage. Developed cities that performed well, particularly European ones such as Oslo, benefitted from promoting low-emissions public and private vehicles.

The sub-index captures various indicators that highlight what life is like for people living in these cities. A key factor is amount of outdoor air pollution and extreme levels in this indicator compromised the overall scores for a handful of cities, including both Chinese cities of Shanghai and Beijing. This reveals an area that requires significant progress for the cities scoring poorly and cannot be overlooked as they advance a green agenda.

Conversely, European cities generally score well in terms of air pollution. They are somewhat aided by their stage of development, having progressed through more energy-hungry industrial phases unlike their developing counterparts. Though each city's stage of development is certainly a factor, it is far from the only determinant of success in this category. Many European cities have made it a priority to cut emissions and have seen their urban transport systems, both public and private, evolve accordingly. One example of this is Madrid's purchase of over 50 hybrid busses in 2016, which will help the Spanish capital curb CO₂ emissions. The city has had a ban in place since 2010 that prohibits the purchase of new diesel powered buses, so with time the overall bus fleet will become increasingly eco-friendly. Many European cities are encouraging a similar shift in their bus fleets and also among their taxi companies. For example, in Paris the G7 taxi company offers its customers the ability to specify their preference for a plug-in hybrid EV or EV when ordering a car.

This sub-index demonstrates that those cities with recent decades of investment and initiatives, by both government bodies and private sector parties, have been able to encourage a shift away from polluting vehicles, an essential step for any city that wants to reach emission neutrality.



A focus on: Paris

Overall score: 68% (ranking 5th)

Status quo: 63% (16th)

Conditions for change: 71% (4th)

Preparedness for future: 71% (2nd)

Paris set to ban diesel powered vehicles from the city centre by 2020

Innovation runs through the heart of Parisian success, from its leading role in fashion and art through to its gastronomy. An unlikely addition to this list would be its innovative approach to urban transportation, yet ranking fifth overall, Paris offers some of the most unique, thoughtful policies of any city in the index.

Its creativity will be essential if it is to reduce emissions, with Paris standing in sharp contrast to many other European cities and ranking low in the status quo sub-index, owing to the high reliance on private vehicles. In many measures, Paris holds its own with the leading European cities in the status quo sub-index. With sustainable population growth, citizens are energy efficient, and pollution levels are low. However, private cars are the primary mode of transport, with two thirds of journeys made in private vehicles, in turn increasing urban congestion.

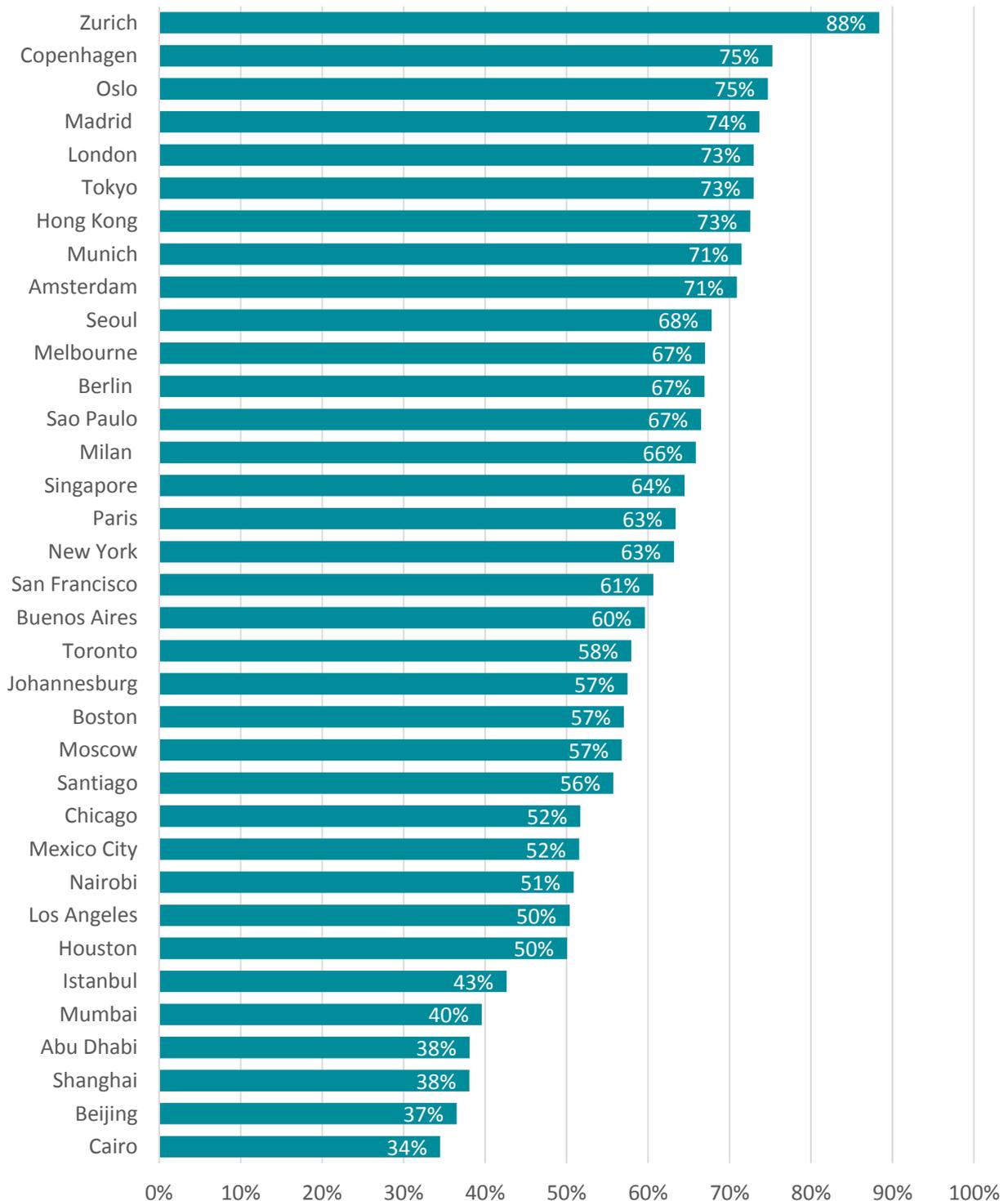
With high levels of tourism year-round, Paris has an extensive and varied public transport network. In particular, the city has invested deeply in self-service public transport. The city's Vélib' scheme, launched in 2007, is the largest bike sharing initiative outside of China, and is widely used as a model for other cities. In 2011, the launch of Autolib', the city's all EV sharing service, reinforced Paris as a green transport trendsetter. The scheme includes a fleet of around 4,000 EVs, used by over 126,000 subscribers, offering a future solution to Parisians' dependence on private, polluting cars. In 2016, the Cityscoot project extended Parisians' options further with a moped sharing scheme, introducing a fleet of electric scooters which emit no noise or fumes. However, despite the scale and ambition of these schemes, Parisians remain highly reliant upon their cars. Overall, less than 1% of Parisians walk or cycle to work.

Yet, Paris' commitment to large scale, innovative green transport projects has led to infrastructure put in place that positions it perfectly to make further progress along its low emissions agenda in the coming years. Paris now has the second highest density of EV charge points in the city index after Oslo, leaving the city well prepared for the future and complementing its clear commitment to the global low-emissions agenda.

The availability of EV infrastructure is being paired with encouragement to use it and other low emission transport. Addressing high use of diesel cars, Mayor Anne Hidalgo has vowed to ban diesel powered vehicles from the centre by 2020. Alongside this, €8m is being directed into pedestrianizing the right bank of the Seine, and the city continues to promote cycling as the cycle lane coverage is currently being doubled to 870 miles. In an attempt to lower pollution in the city, measures introduced in 2017 require all vehicles driving through the French capital to display an emissions sticker. The stickers, which assign each vehicle a pollution rating from one to six, must be displayed or drivers face a fine. Furthermore, the more polluting vehicles with a higher sticker score may be banned from driving through the city at times of high pollution.

Positioned fourth and second respectively in conditions for change and preparedness for the future, Paris may become a world leader in low emissions transport in years to come. The future certainly seems bright for the city of lights, but the final piece of the puzzle will be weaning residents off their polluting cars and on to the green alternatives in place.

Figure 3 –Status quo sub-index scores



5 Despite recent improvements, US cities need to create better conditions for change

- The *conditions for change* sub-index measures how cities are preparing for low emission vehicles, encouraging their uptake and how effective these policies have been
- Although the top 10 spots in the sub-index are held by various European cities and Seoul, North American cities score higher in this category than in others
- Two indicators boosting the North American cities' performance are financial incentives for zero emission vehicles (the US in particular has implemented very generous Government grants) and the utilisation of green travel initiatives for public transport and taxis
- Still, North American cities can do more to prioritise the zero emissions agenda. The utilisation of low emission zones, a common practice in Europe and some parts of Asia, is virtually non-existent in the US

Building upon the status quo ranking, indicators in the 'conditions for change' sub-index measure cities' advancements towards city-wide integration of low emissions transport.

Unsurprisingly, with world-leading commitment towards green vehicles and EVs already a ubiquitous feature across the city, Oslo tops the table in this sub-index. The city sets itself apart with a wide range of measures to promote green transport and has the infrastructure to sustain further growth in adoption.

Similarly, the top five cities in the conditions for change sub-index, all European, have shown clear commitment to making green transport a visible feature of their roads. The success of these cities reflects their residents' usage of low emission vehicles, a consequence of the incentives available to buyers seen in cities like London, Paris and Copenhagen. In particular, cities that offer incentives not only to buy, but crucially also to use, efficient vehicles - from free parking to special access - have seen residents embrace the technology.

Although the highest scoring North American cities - Los Angeles and San Francisco - are only 12th and 13th in the sub-index, conditions for change is the category in which this region shows the strongest performance. It is important to recognise such cities' recent efforts to advance their zero emissions agenda. A number of grants have been allocated to US-based manufacturers of EVs in order to boost production and development. At a household level, the US also has tax exemptions and local rebate programs in place to encourage the uptake of EVs.

Despite these efforts, however, American cities suffer in their drive to reduce emissions due to citizens' attachment to their private vehicles and low fuel costs, in addition to a tangled federal, state and city legislative framework. High levels of private petrol car ownership and use are a central cause of transportation emissions, leading to the US goal of having one million EVs on the road by 2015 being missed by a wide margin. Indeed, it is a target that now may not be achieved until 2020 or later.

No US cities in the index have penalties-based incentives, such as a low emissions zone, to encourage adoption of more efficient vehicles, a tactic effectively used by many European cities. Working to boost the popularity of EVs through such incentives is a proven approach worth considering when looking to shift citizens' habits.

Formalising plans for eliminating emissions is another important step. San Francisco has laid down its aims in the city's Transportation Plan 2040, which clearly outlines the distribution of \$75 billion worth of funding by 2040. The investment will be targeted at everything from major infrastructural projects like a new Bay Area tube, to widespread provision of EV charging, 40 miles of pedestrianized streets and a city-wide Bicycle Strategy funded in full. All of this will be necessary in meeting the city's Climate Action Plan goals, to reduce greenhouse gas emissions to 80% below 1990 levels by 2050.

Across the United States, a number of cities and states have similarly pledged to cut emissions by 80% by 2050. Although individual cities can choose their base year, this represents a significant movement towards achieving energy efficiency.



A focus on: San Francisco

Overall score: 52% (ranking 14th)

Status quo: 61% (18th)

Conditions for change: 51% (13th)

Preparedness for future: 34% (20th)

A global hub for technology-led innovations and birthplace of Uber, San Francisco applies approach to green transport but finds citizens remain attached to their private vehicles

Home to many of the world's most famous technology giants and start-ups, the iconic North Californian city of San Francisco also has a growing reputation as a green transport trailblazer in the US. Appropriately, a technology-led and highly innovative approach to policies encouraging green transport and cutting emissions help San Francisco lead the way for American cities in the index, coming 14th in the overall rankings.

San Francisco has many factors playing in its favour, including sustainable levels of population growth and density. Residents also enjoy a wealth of green space in the city, second only to New York for this measure in the US. And, with some of the lowest outdoor pollution levels of any city on the index, the city's green policies have seen success. The Californian city exemplifies the wider State's attitude towards green transport with a high number of EVs and hybrids already out on the roads, and its provision of charge points growing.

However, although San Francisco has established itself as a leader of electric transport in the US it has some way to go. Levels of CO₂ emissions remain far higher than those of most European cities. This is largely a product of high reliance on private, polluting vehicles – a pitfall felt by all other US cities in the index. The city's innovative public transport and vehicle sharing policies are attempting to address this. For example, 2009 legislation requires all businesses with more than 20 employees to incentivise public transport or carpooling to staff. This is just one of an extensive list of incentives, offered at city and State level, to cut emissions. The Clean Vehicle Rebate Project offers generous rebates on top of US federal subsidies to individuals and businesses alike. Other policies, such as a law requiring all new construction projects to install one EV charging station per four parking spaces, will likely pay off in years to come.

Overall, San Francisco has made great progress in getting green vehicles onto roads. In addition to federal and Californian buying incentives, zero emissions vehicles are afforded High Occupancy Vehicle (HOV) lane use. Furthermore, San Francisco has brought innovation as well as ambition to electric car uptake. Many cities have added electric buses to their city's fleet, but San Francisco's public vehicles additionally include hundreds of low emissions taxis, ambulances, fire trucks and heavy duty vehicles. Overall, the market share of EVs is around 5%, amongst the highest in the country. This is a testament to the city's creative and committed approach to green transport, holding many lessons for other American cities.

While North American cities sit in the middle of the ranking, the poorest scorers are in Africa, South America, and Oceania. Cities such as Johannesburg and Melbourne have done little to pave the way for electric car owners, leaving too much onus on private companies to provide options. With infrastructural gaps and few incentives, citizens have been slow to respond. Cities such as Santiago and Mexico City show some important progress towards zero emission targets, but are still in early phases of their respective journeys.

Out of the three sub-indices, Asian cities performed their worst in conditions for change, particularly weighed down by a lack of low emissions zones (LEZs), with the exception of Tokyo. This is less a reflection of investment capacity and more an insight into how cities envisage their transport systems. While creating a low emissions zone is feasible in many cities, the move is restrictive for many road users. Therefore, the implementation of a low emission zone is a statement of intent that a city is willing to limit its drivers' freedoms in order to address pollution. Tokyo was the first city to create a low emission zone in 2013, reinforcing its emissions targets with meaningful restrictions. Many European cities have followed suit, prompted by the European Union's protocols for emissions standards, which incrementally strengthen emissions restrictions. Europe leads the way in low emissions zones - there are now over 70 LEZs in Germany alone. American cities, however, have not yet committed to this step, and a lack of LEVs hurt their performance in this sub-index.

Another key indicator was cities' commitment to green public transport. Many cities throughout Europe have seized opportunities to both set an example for the adoption of green vehicles and use them to lower emissions.



A focus on: New York

Overall score: 50% (ranking 17th)

Status quo: 63% (17th)

Conditions for change: 48% (16th)

Preparedness for future: 25% (28th)

New York City is one of most densely packed cities ranked and population growth shows no sign of slowing, leaving it with the greatest challenges

America's most populous city captures the imagination of millions at home and abroad. The eight million people who call the New York City home and over 60 million tourists each year jostle to navigate a city space of just 305 square miles. It is little wonder New York is the city that never sleeps.

The city's global draw has put pressure on its environmental and transport aims. Whilst outscoring many other American cities in indicators of their current level of success, New York has further progress to make in its low emissions agenda and is yet to see wide uptake of EVs, which is explained in part by the fact that there are fewer electric charging stations per person in New York than in any other US city in the index. In an attempt to raise the profile of EVs in the city and encourage wider use the Official FIA Formula-E Championship, an all-electric global motorsport series, is set to hold a race on the streets of Brooklyn in July 2017.

Though it has struggled to encourage adoption of lower emissions private vehicles, the city has created numerous policies to tackle congestion and lower carbon emissions while keeping its millions of residents and visitors travelling. New York's green transportation goals revolve mainly around public transit, walking, and cycling. After launching plans to reduce emissions and energy consumption in 2007 and doubling the amount of bike lanes, the city has seen commuting by bicycle grow. This has been further improved by the well-integrated 'Citibike' network, the largest bike sharing scheme in the United States. Furthermore, the city has invested wholeheartedly into low emissions public transport. Thanks to investment in greener public vehicles, New York has the largest hybrid bus fleet (running on electricity and diesel) in the United States.

However, green public transportation and growth in bicycle use alone will not be enough to offset the huge number of cars and taxis that are such a feature of the city's streets. More efficient private vehicles must play a more prominent role in further cutting emissions. Whilst financial incentives are in place, on top of significant federal subsidies, non-financial benefits may further boost uptake. Granting LEVs extra lane access has been a good start. However, the high price of electricity relative to petrol somewhat softens some of the appeal of EVs to citizens and New York still lacks a low emissions zone, two areas of focus that have had a significant impact in Europe.

Looking forward, New York has been making encouraging moves to further advance its green agenda, ambitiously pledging to cut 2005 emissions levels by 80% as of 2050. Also promisingly, many of the city's 2007 PlaNYC goals – covering 10 areas of interest ranging from transport to air quality – were largely met. After starting 97% of the initiatives and fulfilling almost two thirds, further milestones were added.

This comes with a caveat, though. An \$8 congestion charge on all cars entering the city centre was proposed in the plans and would have been the first fee scheme in the United States, but was never put to vote. This perhaps reveals that the city's greatest obstacle is not the number of people travelling, but its mind-set and attitude towards change, something reflected at a national level. The US not signing the Kyoto Treaty shows a lack of formal commitment to the low emissions agenda, an attitude that may have to change before individual cities can make real progress in encouraging a larger share of residents to buy in to green transport.

Despite their lower overall score in the conditions for change sub-index, a few South American cities have demonstrated their commitment to stay on the zero emissions track. Both Santiago and Mexico City have begun to make progress in encouraging green public transport, an important step towards wider uptake. For example, in Santiago the taxi fleet has gradually seen the introduction of EVs under the Nationally Appropriate Mitigation Action (NAMA) Green Zone project. Another South American city, Sao Paulo, has run pilot schemes to assess the feasibility of converting to an electric taxi fleet. Although full implementation will take time, these early signs of progress towards zero emissions transportation systems are encouraging.

Overall, this sub-index shows that, to be ready for the next stage in low emissions transport, cities must be proactive and willing to transform. With effective investment, cities can prime their transport infrastructure for low emissions vehicles and use a range of incentives to encourage citizens to go electric.

A focus on: São Paulo

Overall score: 43% (ranking 25th)

Status quo: 67% (13th)

Conditions for change: 26% (28th)

Preparedness for future: 22% (31st)

São Paulo is a regional leader in the car-free movement

Positioned 25th overall, São Paulo's low levels of pollution could see Brazil's most populous city become a focal point for green transport in Latin America, if investment is provided for advancing effective policies.

To reduce congestion, São Paulo has been bold in its methods. Officials prohibit cars from entering the city centre at specific times based on license plate numbers, enforced by heavy fines. Furthermore, the city leads the way in the car-free movement. At weekends, the 3.5km Minhocão highway is closed to cars, dedicated instead to pedestrians and cyclists. Similar bans are in place for other central streets on 'car-free Sundays', reflecting the city's willingness to radically restrict polluting private vehicles to achieve results.

The results of São Paulo's efforts have been positive. The city scores consistently well in the status quo sub-index, particularly in the share of public transport trips made, with only 30% of journeys made by private vehicle. Furthermore, congestion levels are low, as are outdoor air pollution levels. Finally, out of the South American cities in the index, only Buenos Aires scores better in CO₂ emissions per capita. Overall, São Paulo is a clear leader among South American cities in the status quo sub-index, ranking 13th and sitting between Berlin and Milan.

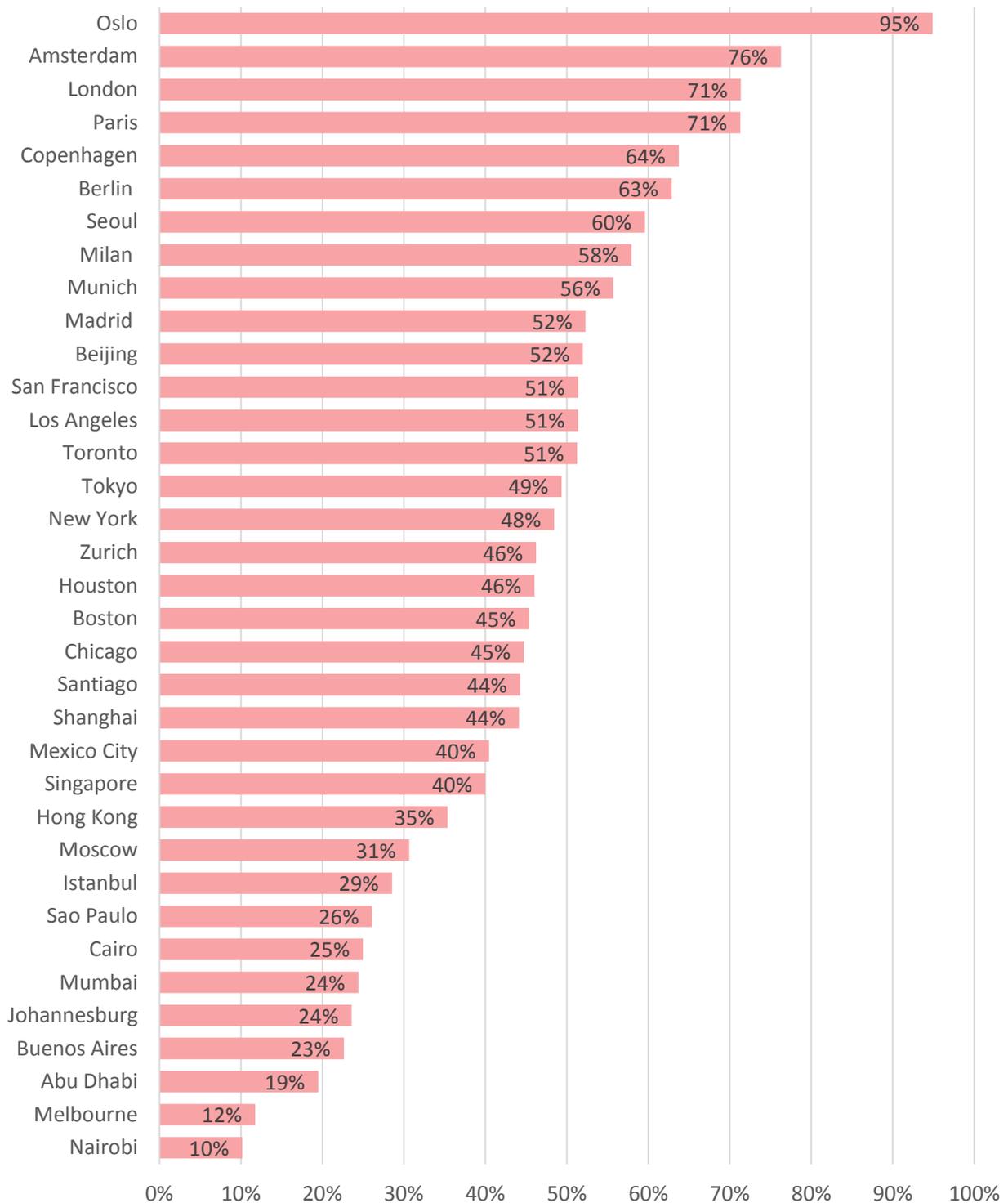
Brazil is also a world leader in the biofuels sector. The nation's car manufacturing industry has developed 'flexible-fuel vehicles' which can be powered by hydrous ethanol – or E100, a mix of ethanol and water. These flex vehicles have become a commercial success, and ethanol fuel is available at stations throughout São Paulo. Vehicles running on E100 are not emissions-free but are almost CO₂-neutral, offering another route to greener road transport in São Paulo.

Yet São Paulo has some distance to travel in low emissions transport, with EV uptake almost zero. This is unsurprising, with a lack of financial incentives for low emission vehicles and almost no public provision of chargers, key areas for improvement.

The city must also improve transport infrastructure. There are signs this area is one of increasing focus, with plans to invest \$18 billion into improved metro and bus networks by 2020. This may be effective in increasing public transport usage, and easing pressure on the city's overburdened roads.

São Paulo clearly has the intentions to forward the low-emissions agenda and it must now invest in the infrastructure to back this up. If funding is sufficient and well-targeted, the city could become a regional model in reducing emissions.

Figure 4 – Conditions for change sub-index scores



6 Abu Dhabi and Asia lead the way in preparing for transport of the future

- The *preparedness for the future* sub-index considers the forward-looking policies cities have adopted to pave the way for the next phase of low emissions technology
- Tokyo tops the sub-index thanks to a country-level commitment to low emissions and to city-specific factors, such as autonomous vehicle preparedness and widely available EV charging points
- Abu Dhabi scores 9th in this category, far higher than its overall ranking of 26th, thanks in large part to the Gulf city's investment into Masdar City – a research hub which has emerged as a global leader in the zero emissions space
- The presence of multiple Asian cities (Beijing, Shanghai and Singapore) in the top 10 demonstrates the region is pioneering the future of green transportation and may quickly overtake American and European cities

By assessing infrastructure investment, policy commitment to the low emission agenda, and autonomous vehicle preparedness, we can gain a dynamic insight into where cities are headed in terms of their zero emissions future. Future targets for low emissions underpin this sub-index, and the best performing cities all show clear and meaningful commitment to a low emissions agenda. European nations have made the most significant commitments to meeting emissions targets and cities' scores were boosted by having their own city-based plans and organisations. US cities were held back by the fact that the US has not signed the Kyoto Treaty, while South American cities showed little hard commitment to emissions targets.

Preparing for the future also means taking on new technology, including EV charge points and driverless vehicles. The uptake of autonomous vehicles demonstrated ambition and initiative from cities around the world – currently Singapore, London, and Abu Dhabi are leading the global race to get autonomous vehicles on their roads. It is important to note that autonomous vehicles may increase road usage by enabling longer commutes, but are anticipated to reduce energy use through low-emissions engines and the ability to interact with traffic control systems and each other. Although self-driving cars do not necessarily mean lower emissions, fuel efficiency can be maximised through such technology. In terms of providing chargers, Paris, Oslo, and Tokyo scored best, helping encourage their citizens to purchase EVs over more environmentally harmful alternatives.

The city that topped the sub-index, Tokyo, showed great progress towards meeting emissions targets and a particular ambition in bringing new transport technology into the city. Already a world leader in hydrogen fuel cell technology (with over 200,000 stationary cells currently used in Japanese homes) the government wants to move this technology onto the road. It aims to double the 80 hydrogen stations across the country, and to have 40,000 hydrogen fuel cell vehicles in usage by 2020. Japanese automobile giant Toyota is also helping, launching the company's first fuel cell powered car, the Mirai, in 2014. Furthermore, Tokyo has been innovative with its methods to lower emissions – in 2010 the Tokyo Metropolitan Assembly introduced mandatory emissions targets and introduced a cap-and-trade system for greenhouse gases, the first of its kind in Asia.



A focus on: Tokyo

Overall score: 65% (ranking 7th)

Status quo: 73% (6th)

Conditions for change: 49% (15th)

Preparedness for future: 74% (1st)

As of 2016, Japan has more electric charging points than petrol stations nationwide

Japan's bustling capital, known for its use of futuristic technology alongside ancient tradition, lives up to its reputation by bringing cutting-edge modernity to green transport. Thanks in particular to its efforts in preparing for a future of technology-led low emissions transportation, Tokyo ranks an impressive seventh spot in the overall index, the highest placed city outside of Europe.

The city's plans for the future are underpinned by high levels of investment in infrastructure, but also through an extensive commitment to the low emissions agenda at a national level. This has been backed up with extensive provision of EV technology. Tokyo lives up to its reputation as a technology trailblazer, aiming to have a robotic, driverless taxi service ready for the 2020 Olympics. The project, known as Robot Taxi, has seen heavy investment and is likely to use the Olympics as a launch pad to secure Japan's place at the forefront of environmentally-friendly technology.

While its sights are clearly fixed on the future, the fact Tokyo is so well-placed to succeed is due to its recent past. In 2007, Tokyo's metropolitan government outlined its 10-year project for a 'carbon-minus Tokyo', which has helped the city keep emissions, air pollution, and energy use down. Air pollution levels are sustainably low, and there is little congestion in the city, despite a large population. Tokyo's large, dense population has forced the city to develop an impressive public transport network, reflected in the city's top ten place in the status quo sub-index – fortunately, population growth is relatively stable, meaning Tokyo's transport networks are well-equipped for the future.

Importantly, whilst many cities find it difficult to discourage residents from using their cars, a mere 12% of trips made in Tokyo are by private vehicle – in the index, only Hong Kong and Nairobi can boast lower levels. At the heart of public transport is an extensive and efficient metro network, supplemented by buses and the tram line. Much of this success can be attributed to Tokyo's claim to be the first city to pioneer a low emissions zone, restricting diesel vehicles since 2003.

Simultaneously, the city has sought to boost EV uptake, with government subsidies for buying plug-in electric cars coupled with comprehensive networks of charging stations - only two cities in the index have more charge points per resident. Such measures will help to achieve the city's overarching goal to reduce greenhouse gas emissions related to traffic by 40% from 2000 levels by 2020. Further working towards emission reduction, Tokyo became the first Asian city to introduce a cap-and-trade scheme in 2010 for government, and industrial buildings – after its fifth year, the program had achieved a 25% reduction in emissions.



A focus on: Singapore

Overall score: 54% (ranking 13th)

Status quo: 64% (15th)

Conditions for change: 40% (24th)

Preparedness for future: 55% (10th)

Singapore is the first city to use driverless taxis on its roads

The world's only island city-state, Singapore has grand ambitions to establish itself as a global model for a connected city of the future through its 'Smart Nation' programme. By linking sensors, cameras and a multitude of other devices, Singapore monitors everything from traffic and crowd movement to the weather and even cleanliness. Promoting a green agenda and more efficient transport is a core goal of such a smart city.

This ambition is somewhat tempered by reality, however, and Singapore has a mixed profile when it comes to green urban transport, ranking 13th overall. Known as the Garden City, it lives up to its name, as green space covers almost 50% of the city. One of the city's 2015 sustainability goals is for 90% of households to be within a 10 minute walk of a park. However, Singapore scores modestly on many other status quo indicators, ranking near the middle for CO₂ emissions and energy efficiency. Whilst use of public transport is high, five other Asian cities rank higher in the share of public transport journeys. Most challenging of all for the city's ambitions, relatively few residents have committed to environmentally-friendly technology.

To address this, Singapore has established a series of long term plans to combine economic development with sustainability. In 2009, \$1 billion was committed towards the Sustainable Singapore Blueprint, including targets for local air quality, transportation, and energy efficiency. The most recent transport goals include increasing the share of peak hour trips taken by public transport to 75% and expanding the cycle path network to 700 km.

Aiming for 70% of journeys at peak times to be on public transport, the city has invested in improved bus and rail services. Furthermore, the city has capped vehicle stock growth to 1.5% a year. While imposing quotas on high emitting vehicles, fuel efficient cars are exempt. In addition, the government offers a 40% rebate on green vehicle purchases. Consumers are beginning to respond, but the market share of EVs remains low. More could be done to boost the uptake of low-emissions vehicles. Introducing non-financial incentives, and priming the city's roads by investing into charging infrastructure, could help.

Technologically, Singapore is perhaps the most exciting city on the index. While other cities wait for autonomous cars to become available, Singapore-based firm nuTonomy has already put driverless taxis on the roads. Currently trialling a small fleet of electric, autonomous vehicles, the company aims to make Singapore the first country with a national driverless-taxi service by 2018. The government is also conducting trials with driverless electric buses.

Singapore is in many ways representative of Asian cities on the index. Relatively slow to get off the mark with EV uptake and without the advantage of decades of investment in infrastructure and policies enjoyed by its European counterparts, the city has invested significantly and at pace to catch up. As with other Asian cities, Singapore displays a reliance on forward-looking technology to bridge the gap and even leapfrog others on the path to a future of zero emissions transportation.

In terms of investment, it was Asian cities, rather than European or American ones, which showed the largest financial commitment to infrastructure. Beijing and Shanghai, which benefit from the size of the Chinese economy, performed better in the preparedness for the future sub-index than in the others. Boosted by high scores in the driverless technology indicator, other Asian cities also performed well, claiming four of the top ten spots.



A focus on: Beijing

Overall score: 48% (ranking 20th)

Status quo: 37% (34th)

Conditions for change: 52% (11th)

Preparedness for future: 65% (5th)

China is still increasing its greenhouse gas emissions, but has pledged to peak by 2030

Sitting at the heart of China's rapid economic growth over the past couple of decades, Beijing has seen changes at every level. But this has come with an environmental cost.

Ranking 20th overall, Beijing is one of the least consistent cities across the three sub-indices. Willing to pour funds into transport infrastructure and champion new technology, it remains weighed down by heavy pollution levels and high energy usage.

Beijing excels in investing in both public and private low emissions vehicles. The city is the spearhead for the Chinese Ministry of Transport's goals, and with over 1,000 electric buses, Beijing already has one of the largest electric fleets in the world. By 2019, 80% of Beijing's buses will be electric. Following from the successes of other cities, the government offers huge subsidies of up to \$12,000 to buy electric and, to a lesser extent, hybrid vehicles. This is likely to be a large factor in the uptake of EVs with citizens buying into such technology in ever growing numbers. Currently, 1% of new car purchases are EVs, the same market share as London.

Yet Beijing's citizens would not be quick to apply the term 'green' to their city. With enormous levels of air pollution and high energy emissions per capita, the city has deep problems to address. By 2020, China says it will cut CO₂ emissions from coal power by 180 million tonnes and will reduce major pollutants in the power sector by 60%. At a broader level, under the Paris Agreement the country has vowed to reach its carbon dioxide emissions peak by 2030. Beijing must find a way to sustainably develop, and low emissions transport can be at the core of this. In particular, the city's energy sources must shift towards renewables for meaningful environmental progress to be made. Currently, the low-emissions agenda on China's roads is offset by the high environmental cost of energy at its source. Wind and solar power must begin to displace coal for Beijing to limit its environmental footprint. Looking ahead, with the highest infrastructure investment across all cities in the index, Beijing is well equipped for the future. With driverless cars road tested in 2015 by Beijing-based firm Baidu, the city is progressing fast in its adoption of autonomous vehicles that could help reduce congestion. Yet, there is no ignoring the energy inefficiency and extreme air pollution levels. Beijing is keen to prove to the world its technological supremacy, but cannot overlook the polluting emissions that cloud the city. These must be addressed before Beijing can truly become a green city of the future.

In South America, where investment in transport infrastructure was low, cities still have progress to make. Yet, the roots of success can be seen in Santiago's nascent Transport Green Zone, a clear and important step towards meeting emissions targets. But infrastructural gaps must be addressed in South America, particularly a lack of charge points.

Overall, preparedness for future requires infrastructure investment, ambition, and a clear urban mobility vision - all reflected in the high scores of Asian cities. By paving the way for success and thinking ahead, these cities will likely be rewarded with fewer transportation challenges in the future. Yet it must be noted that future preparedness is just one pillar to success - cities with current pollution and emissions problems ought to make them a priority. One city that is certainly making an effort to transform its transportation future is Abu Dhabi. At present, the UAE capital faces challenges brought on by easy access to inexpensive oil, which has led to inefficient energy use and a preference for personal transport. However, with plans to provide EV charging points around the city and testing schemes for autonomous vehicles already in place, Abu Dhabi's transportation future looks positive.

A focus on: Abu Dhabi

Overall score: 35% (ranking 31st)

Status quo: 38% (32nd)

Conditions for change: 19% (33rd)

Preparedness for future: 56% (9th)

Abu Dhabi's Masdar City aims to be the first zero carbon city in the world, but has only achieved a portion of its goals

The gleaming capital of the United Arab Emirates, Abu Dhabi is one of the world's youngest major cities. It's perhaps unsurprising, given that the city's wealth can be largely attributed to oil exports, that Abu Dhabi ranks 31st overall in the Index. A rapidly growing population that far exceeds its original urban plan and with almost no platform for green transport (ranking in the bottom five for two sub-indexes), its citizens depend heavily on the car to travel.

Curiously, the city nonetheless has the lowest level of traffic congestion across all of the cities ranked, partially thanks to extensive infrastructure investment and the planned nature of urban expansion. But low congestion does not, for Abu Dhabi, lead to lower emissions. A combination of high car use and negligible uptake of low emissions vehicles leads Abu Dhabi to fare poorly in terms of CO₂ emissions and air pollution levels.

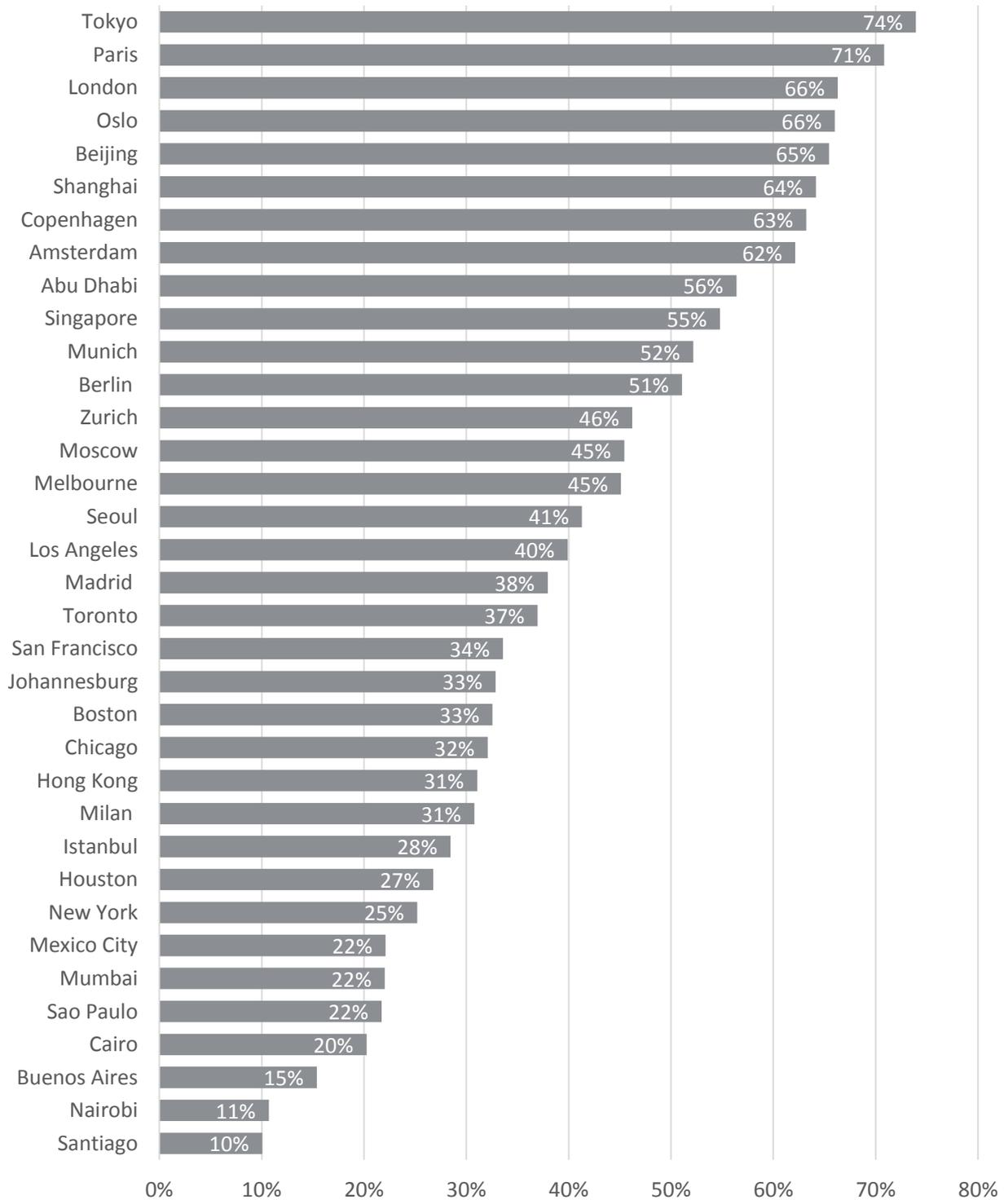
But the index reveals a significant change occurring as the city looks to reduce its dependence on oil. As it ploughs billions into high profile projects to transform itself, Abu Dhabi is demonstrating a clear vision for the future with a more sustainable urban transportation system at its heart. An example of this can be found in the ambitious endeavour, Masdar City. A city conceived a decade ago as the first 'zero carbon city' with \$15 billion of proposed investment, Masdar was to be a demonstration to the world of how our cities might look in the future, complete with highly efficient buildings and transport. Unfortunately, this vision has yet to become a reality and the project has been beset by delays, with less than 5% of the original 'greenprint' built. The completion goal has been pushed back to 2030, and it remains to be seen whether the 'ecotopia' can live up to its promises.

Focusing on transport, the Abu Dhabi Vision 2030 lays out guidelines to reduce reliance on private modes of transport. Aiming for less than 40% of trips to be made by private vehicles in 2030, large-scale investment in public transport led to the Dubai Metro. With over 50 stations, 75km of lines and around half a million passengers a day, the metro helps reduce CO₂ emissions by over 600 tonnes per day. Building upon this success, an electric tram was launched in 2014 and there are plans to extend the metro network to almost 200 stations.

Despite the challenges it faces, the city is clearly willing to put money behind low emissions policies and continues to push its vision for the future, including driverless cars, which are expected to be on the UAE's roads by 2020. In fact, Abu Dhabi may be trying to jump straight to the finish line, skipping key phases in the process and potentially leapfrogging other cities taking more traditional, evolutionary routes to change.

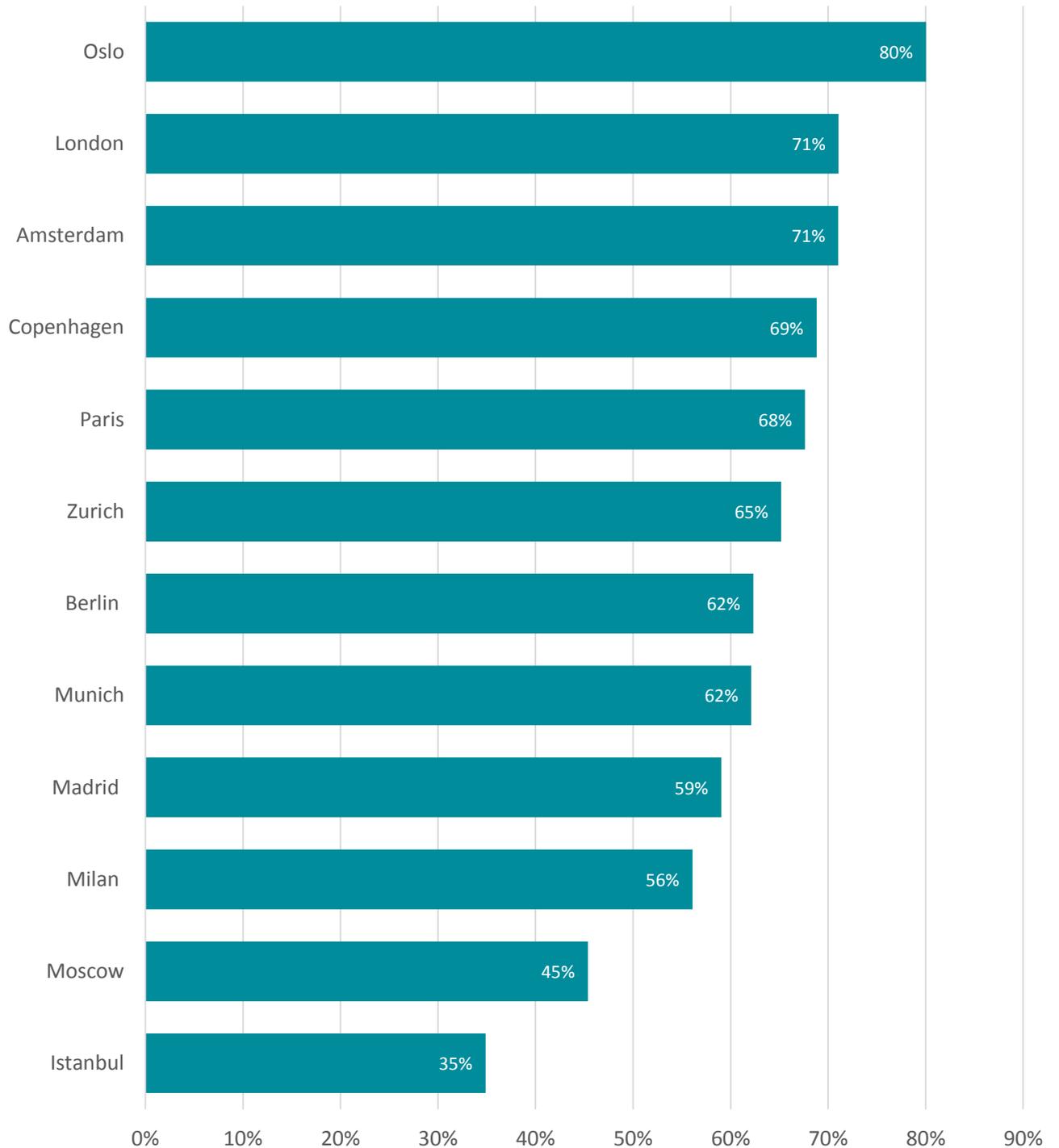
The city would do well to learn lessons from other cities in the index, particularly in how to encourage uptake of EVs by providing adequate infrastructure and legislation. It must also realise that transition towards more sustainable transport cannot be achieved through investment alone but demands nuanced policies, like vehicle sharing and low emission zones.

Figure 5 – Preparedness for the future sub-index scores

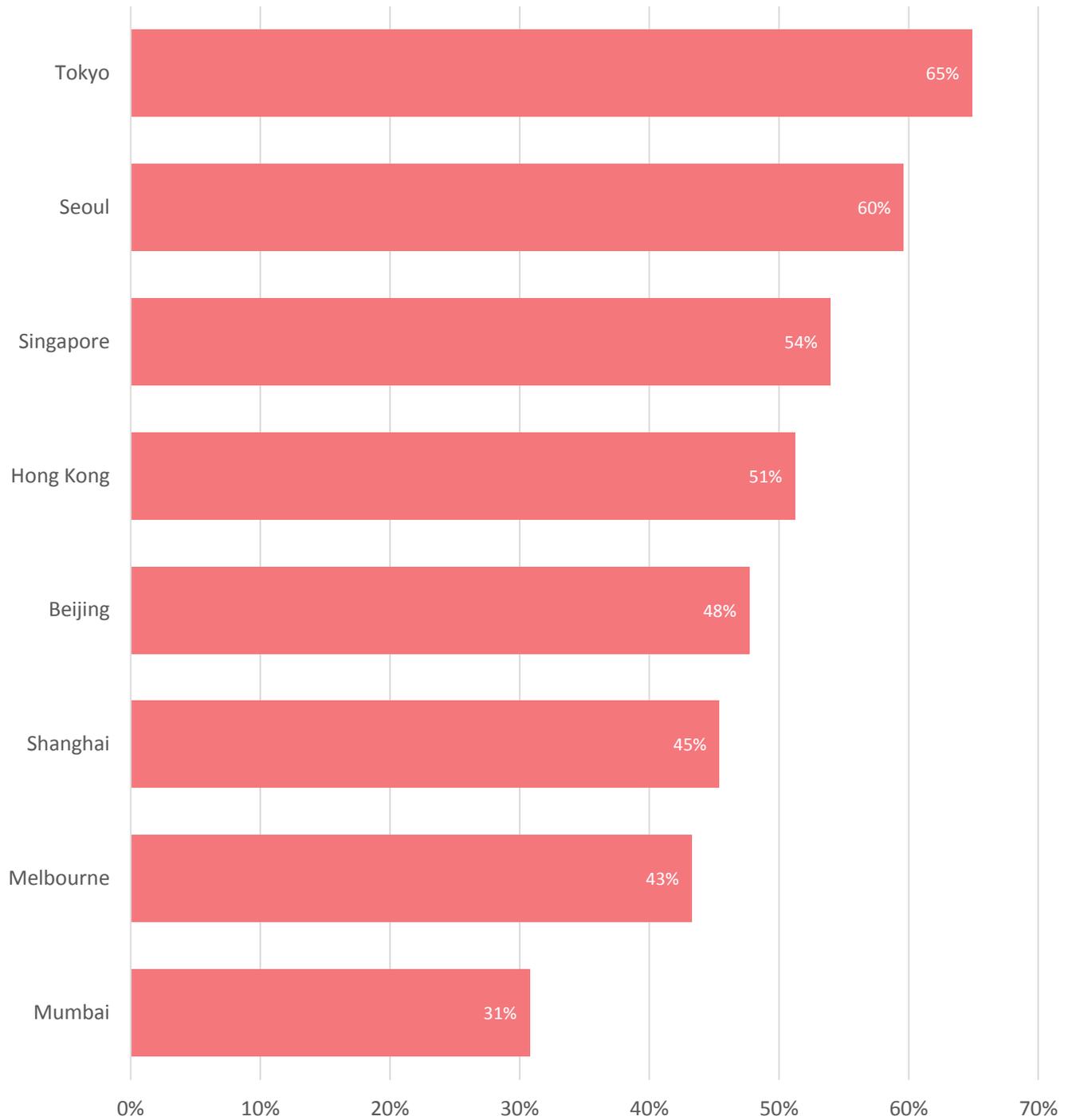


7 Regional performance tables

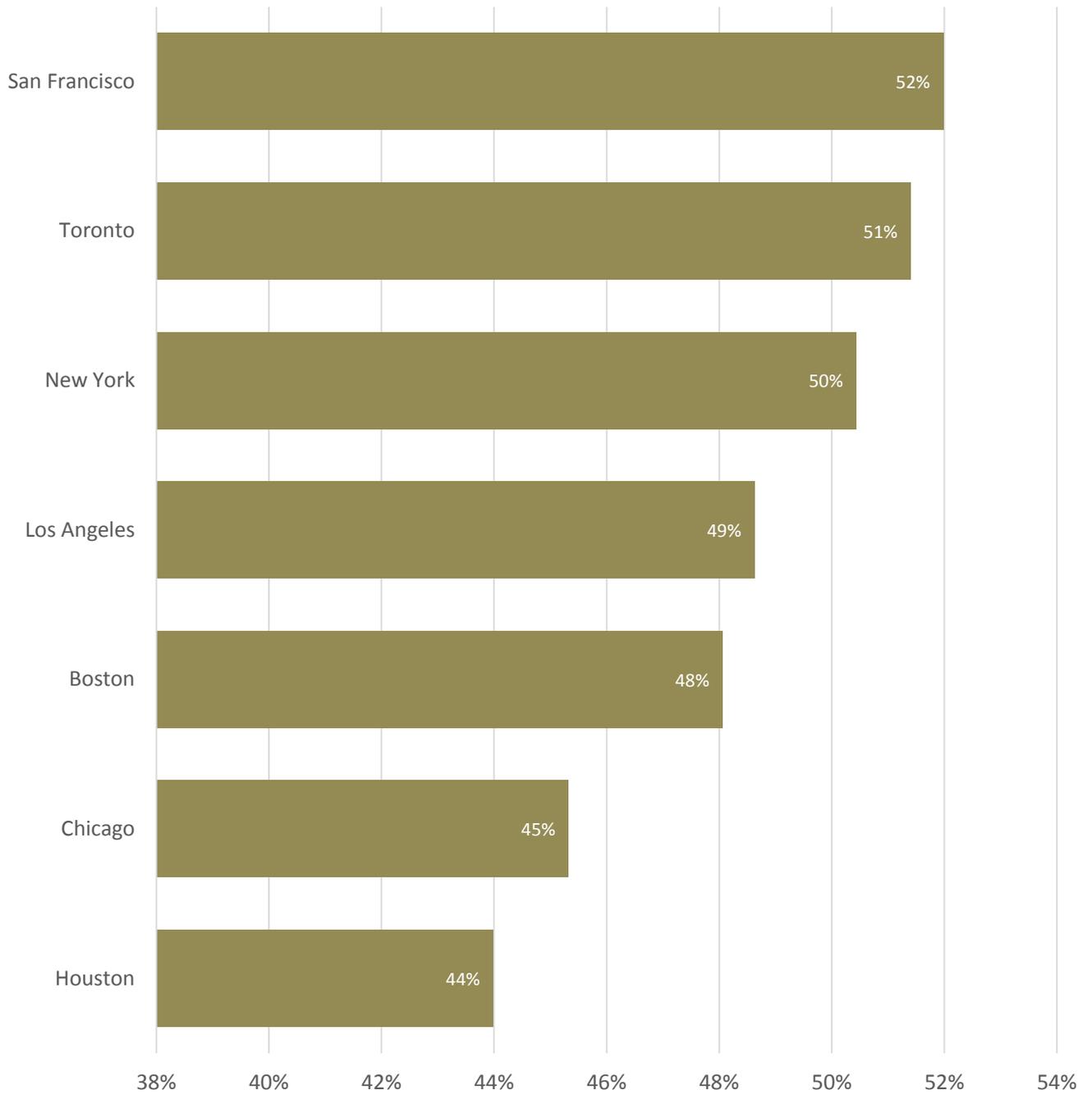
7.1 Overall urban mobility index scores, cities in Europe



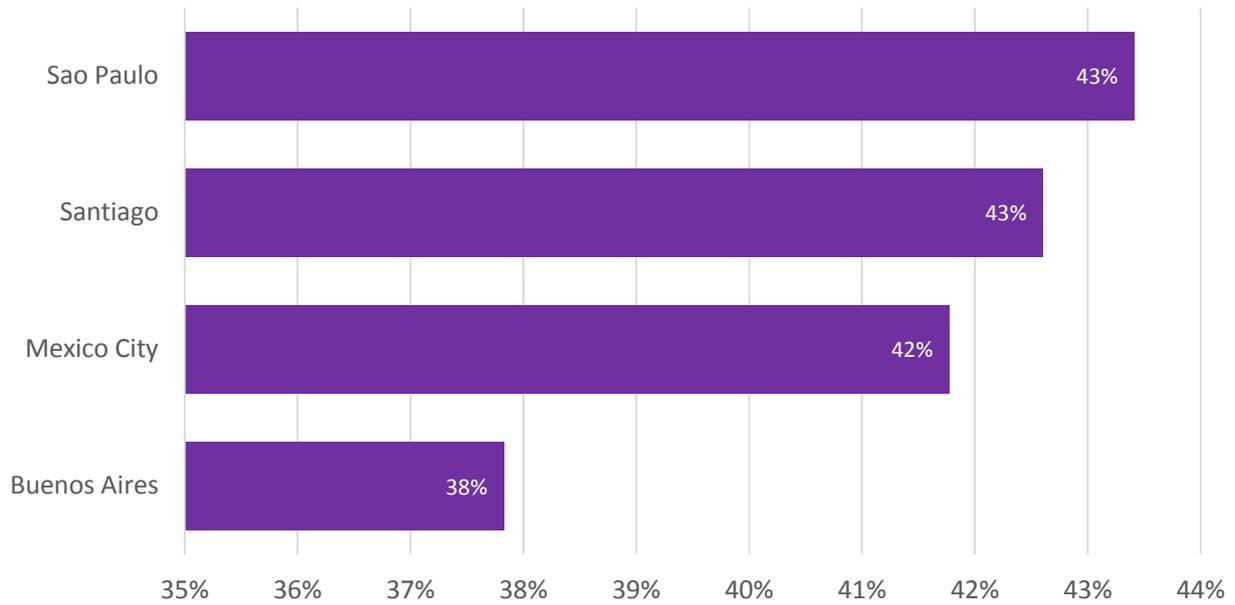
7.2 Overall urban mobility index scores, cities in Asia & Oceania



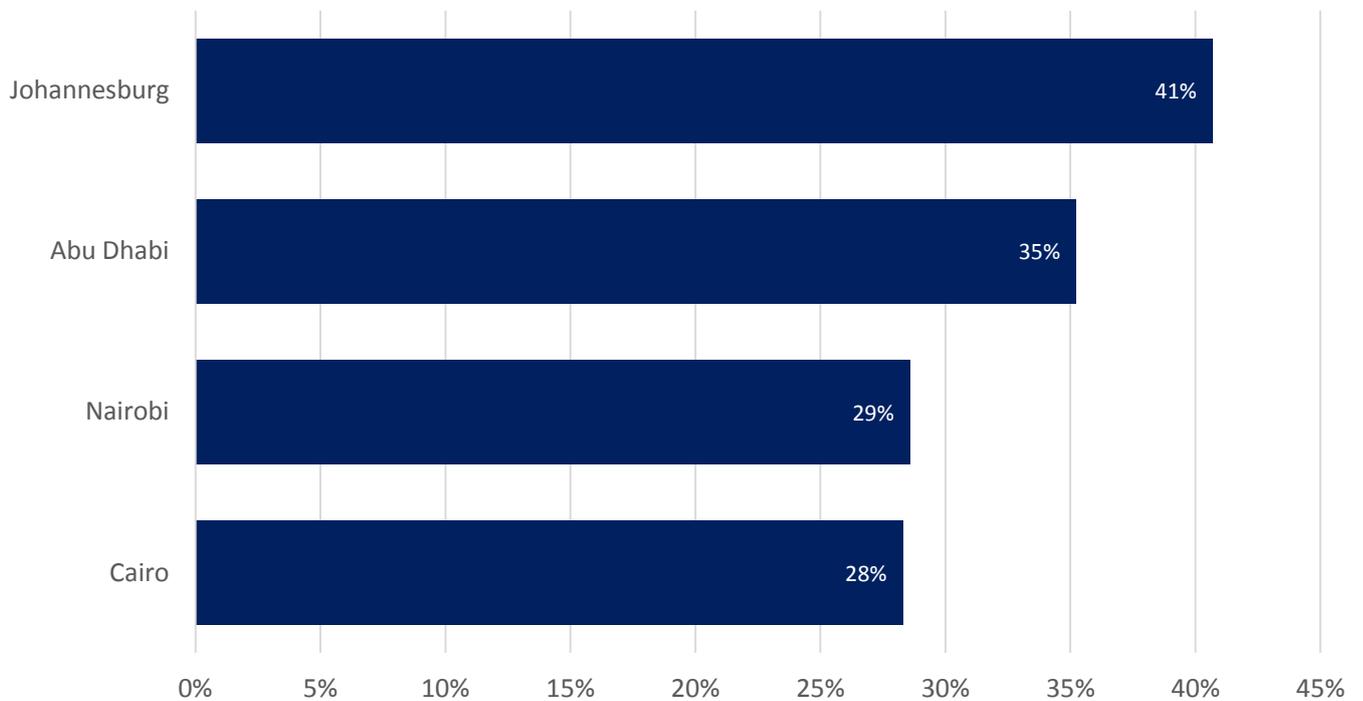
7.3 Overall urban mobility index scores, cities in North America



7.4 Overall urban mobility index scores, cities in South America



7.5 Overall urban mobility index scores, cities in the Middle East & Africa



8 Conclusions

With so many cities showing a firm commitment to eliminating emissions and some relatively advanced towards achieving this goal, the question is not whether a city with a zero emissions transportation solution will exist, but when.

Predicting which city's transportation system will reach the milestone of becoming emissions free and when is fraught with complexity. The speed of progress relies heavily on public and private commitment to implement existing goals and a continued or increased ability to achieve them. What is clear is that an entirely emissions free system for urban mobility is still a few decades away at the earliest, as even Oslo, the top scorer in these rankings and most mature city in its approach, has a target of 2050 to be free of fossil fuels. Given the city's track record of setting measured, achievable targets and its ability to meet them, this timeframe should be realistic.

However, rapid advances in technology and other cities' readiness to embrace them could accelerate this timeline, and displace Oslo as the forerunner in the race to become the world's first city with a zero emissions transportation system. Other European cities with a strong starting position and innovative mind-set are contenders and could leapfrog Oslo, while Asian and some Middle Eastern cities show signs of looking to jump straight to the finishing point by investing significant sums in technology and infrastructure.

The report demonstrates that it's not just technology that matters though. The attitude of governments and citizens is just as, if not more, important. Those cities that are willing to both pull the sustainable urban mobility agenda through incentives and push it via penalties have met with the greatest success, standing in contrast to others that remain firmly attached to traditional means of transportation.

It is important to acknowledge, however, just how much progress has been made worldwide. Emissions are now firmly on the international agenda and cities have made incredible strides in a short period of time to tackle the issue. The conditions for change are, broadly, in place and the future is looking positive, with technology breakthroughs in transportation now firmly aimed at reducing emissions. Each city faces its own unique challenges and solution, but with so many approaching a similar goal there are many commonalities and key learnings to be shared that will only accelerate advances towards cleaner, more connected and increasingly sustainable transportation systems.

9 Appendix I: Methodology and complete list of cities

The overall index score for each city is based on the city's performance against 20 indicators listed in Appendix II. For each indicator the same set of steps is followed which allows us to assign a value between 0% and 100% to each city:

- In order to account for outliers each data point is checked to determine if it falls outside of the mean +/- 2 standard deviations range. If it does, the city is assigned a value equal to either mean + 2 s.d. or mean - 2 s.d.
- The min max approach is used to assign an index value to each city. Specifically, the formula used is $(\text{data point} - \text{series min}) / (\text{series max} - \text{series min})$
- Given that a higher overall index score indicates a better performance for indicators where a lower figure signified a better performance (e.g. air pollutant count), the inverse of the data point or its negative equivalent were used.
- In the rare case that a data point for a particular city was not available the indicator average was used in its places. This only had to be done for two data points.

Once scores between 0% and 100% were assigned to each city within each indicator based on the above steps, the indicators were weighted equally to calculate the overall index score.

The sub-index scores represent a method to summarise the findings in a more informative format. Each indicator within a sub-index was weighted equally to produce the sub-index score.

The indicators in the status quo section were chosen to illustrate the organisation of transport and the environmental challenges in each city, as they stand today. The outdoor air pollution, energy intensity, and CO₂ emissions indicators all measure the state of the environment today which helps us understand the magnitude of challenges faced by cities and how they have fared thus far in terms of balancing expansion with environmental impacts. These indicators also tell us if the city's environmental footprint needs to be maintained or reduced, and if so by how much.

Population growth and population density further help illustrate the magnitude of the transportation challenges cities have and will face. The assumption behind these indicators is a city that is growing more rapidly has less time to adjust its transportation systems and will therefore face greater challenges in its ambition to eliminate all emissions.

The congestion level, modal split of trips taken, and transport infrastructure indicators measure if the city is adequately managing the transportation network. It also considers the habits and attitudes of citizens by looking at how they choose to get around and how satisfied they are with the transport infrastructure in place. Green spaces is another indicator that illustrates quality of life, as having enough space for green areas in partially a result of efficiently using road and parking space.

The conditions for change indicators consider what cities are doing to incentivise relevant stakeholders to pursue the zero emissions agenda. Indicators such as the availability of cycle and car sharing schemes, financial and non-financial incentives, low emission zones, and public transport initiatives all look at what the city has done to make it more desirable to commute in an environmentally friendly way, while also creating disincentives for polluting vehicles. The fuel price to electricity price ratio shows one of the monetary aspects behind drivers' considerations to buy an EV. This indicator is especially telling for cities in which electricity and/or fuel prices are heavily influenced by the government. The use of electric

vehicles indicator is a crucial one in the index as it directly speaks to the degree of progress the city has already made in terms of encouraging EV uptake.

Finally, the preparedness for the future sections considers each city's vision for urban mobility going forward as well as the frameworks in place to ensure that achieving a zero emissions transportation system is possible. The commitment to the low emissions agenda indicator considers if the city is participating in the Kyoto Protocol and the Paris Agreement, as well as if there is a formal city-level plan addressing emissions and an organisation within the city working on emission goals. The spending on infrastructure indicator highlights the priority given to addressing future mobility challenges while the availability of EV charging points illustrates how feasible it is for city residents to make the switch to electric. The autonomous vehicle preparedness measure recognises the rise of driverless vehicles and their role in the future of commuting. As such, it measures how much each city has done to prepare for autonomous vehicles, for example by conducting road testing.

Use of acronyms

The report occasionally makes use of acronyms. The list of utilised acronyms and the terms that they are abbreviations for is provided below:

Acronym	Full phrase
EV	Electric vehicle
HOV lane	High Occupancy Vehicle lane, lane reserved for vehicles with at least one passenger
LEV	Low emissions vehicle
NAMA	Nationally Appropriate Mitigation Action, a green zone project in Santiago
PHEV	Plug-in hybrid electric vehicle

List of cities included in the research

Asia/Oceania
Beijing
Hong Kong
Melbourne
Mumbai
Seoul
Shanghai
Singapore
Tokyo
Europe
Amsterdam
Berlin
Copenhagen
Istanbul
London
Madrid
Milan
Moscow
Munich
Oslo
Paris
Zurich
Middle East/Africa
Abu Dhabi
Cairo
Johannesburg
Nairobi
North America
Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Toronto
South America
Buenos Aires
Mexico City
Santiago
Sao Paulo

10 Appendix II: Detailed indicator information

Indicator / Variable	Unit	Source	
Outdoor air pollution	PM10 and PM2.5 (ug/m3)	WHO AAP Database	Status Quo
Congestion level	Increase in travel time	TomTom	
Modal split of trips taken	Share of trips made by private vehicle	Siemens Green City Index, Land Transport Authority	
Green spaces	% city space	Siemens Green City Index, EEA	
Transport infrastructure	Various	Skytrax, Metrobits	
Energy intensity	Consumption per \$ of GDP	EIA	
CO2 emissions	Emission per capita	EIU, CDP Cities	
Population growth	1990-2050 population growth	UN	
Population density	People per km2	Demographia World Atlas	
Availability of cycle schemes and car sharing schemes	Cebr score	Various	
Financial incentives for zero-emission vehicles	Cebr score	Mostly gov websites	
Non-financial incentives for zero-emission vehicles	Point system	Various	
Use of electric vehicles	Share of 2015 registrations	IEA, SMMT and other country-specific sources	
Price of fuel to price of electricity ratio	Pump price in US\$ per litre / kWh unit price	Eurostat, Bloomberg	
Green' travel initiatives for public transport and taxis	Cebr score	Various	
Low emission zones	Cebr score	Various	
Commitment to low emission agenda	Point system	Various	Preparedness for Future
Autonomous vehicle preparedness	Cebr score	Various	
Infrastructure public investment	Infrastructure investment as a share of GDP	OECD, World Bank	
Availability of charging points for electric vehicles	No. outlets per 1,000 residents	Charge Map, AFDC, IEA	