How to measure the environmental impact of micromobility
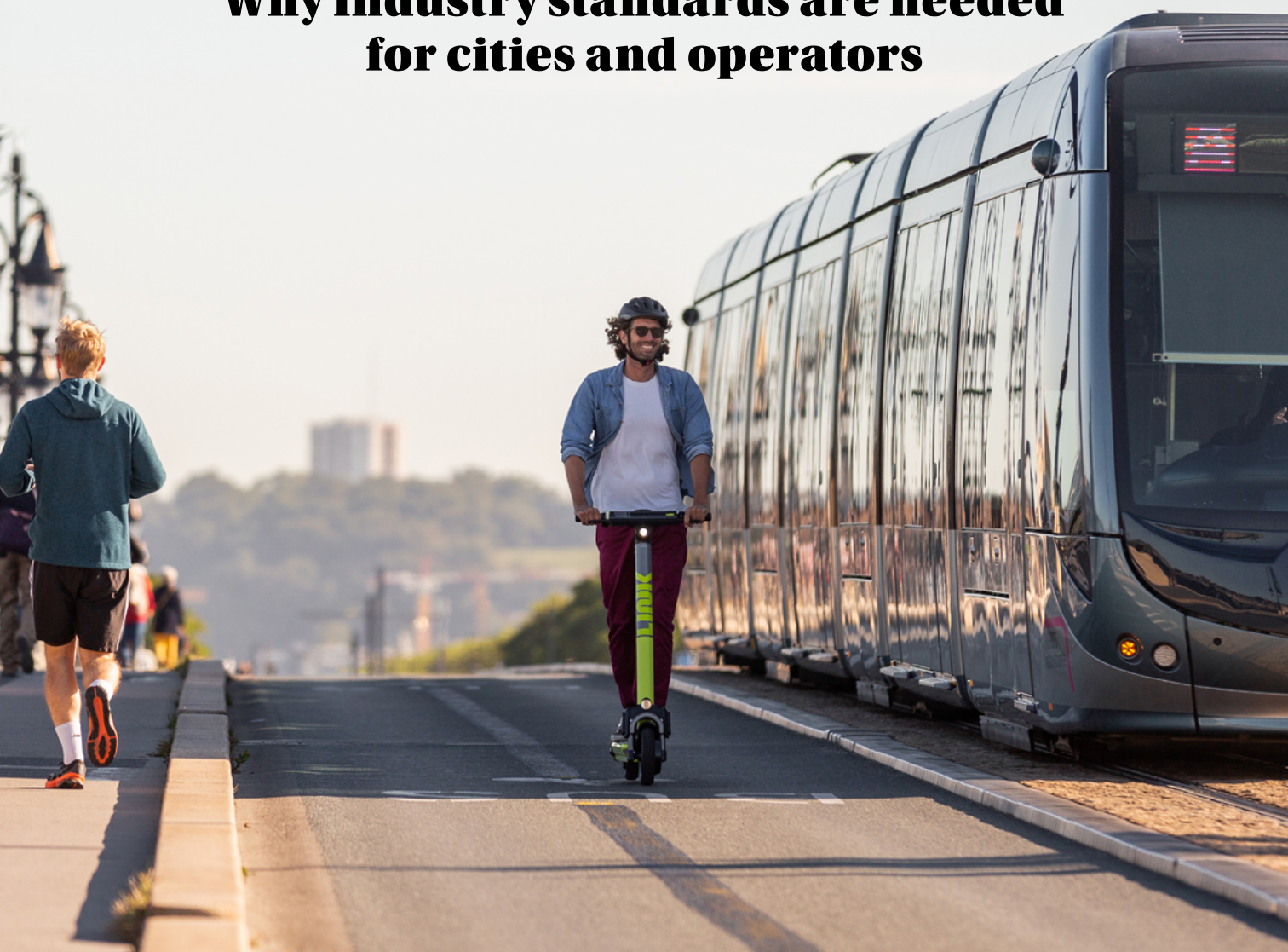
Why industry standards are needed for cities and operators

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How to measure sustainability through lifecycle assessments

I n 2020, Anne de Bortoli was conducting research into the environmental impact of shared scooters operating in Paris. She reached out to 13 operators but received only one response.

"Only one replied to tell me they would not be sharing any data," she says. "To make a good sustainability assessment you need data. I had to bypass the operators but, in the end, because I published a balanced paper, they came back to me and gradually offered up some data."

More than two years later, de Bortoli's work has played a part to help build trust among cities, academics and operators. As well as being in charge of one of the largest research centres in lifecycle assessments and sustainable metrics modelling at Polytechnique Montreal (CIRAIG), she now sits in a newly formed working group aimed at establishing guidelines and standards on micromobility lifecycle emissions assessments. The creation of the working group represents just how far scooter sustainability has risen up the agenda.

Anne de Bortoli

Carbon Neutrality Research Lead, CIRAIG - Polytechnique Montreal

Initiated by Superpedestrian in November 2021, the working group is headed by the New Urban Mobility Alliance (NUMO) and includes representation from major operators including Lime, Bolt, Tier, Bird, Lyft and Spin. Seven cities also participate, like Paris, Seattle, Los Angeles and Oslo, as well as experts like de Bortoli.

While operators and cities had been considering these and other questions for several years, cities were primarily focused on how to manage e-scooters. This then evolved to working with operators through partnerships to incorporate scooters as a viable transport alternative. As parking, pedestrian safety and sidewalk clutter improved, attention shifted to scooters' sustainability.

"My specialty was to calculate the environmental impacts of systems and so all my friends were asking me, 'Do you know what it is for scooters?'" de Bortoli recalls. "That's what triggered me to study their long-term sustainability."

While there had been a small study based on open data in Louisville in the US, there was very little transparent data available and not enough information on the lifecycle usage of scooters. De Bortoli, then a post-doctorate researcher at the École des Ponts ParisTech, was one of the first to publish a pioneering lifecycle assessment (LCA) of scooters in a large city.

A push for LCAs among micromobility operators began soon after when Paris, Portland, and San Francisco asked for LCAs as part of their RFP process.

Lifecycle Assessment: a tool to appraise environmental performances
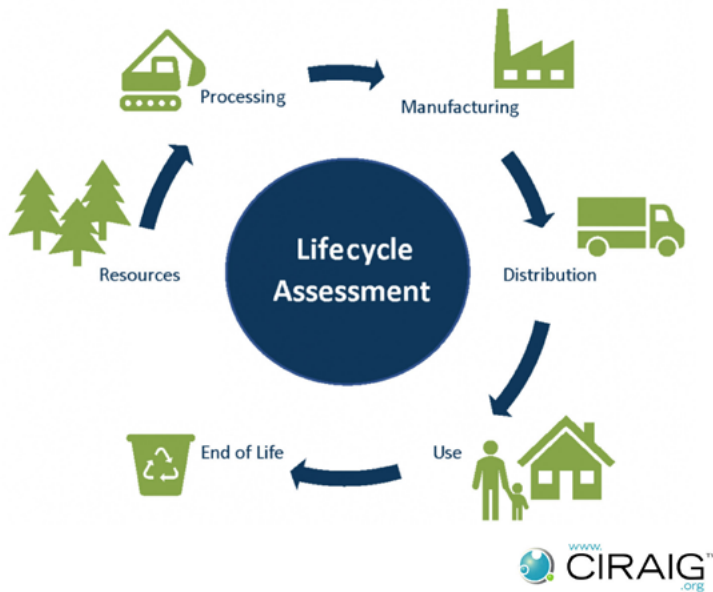
What is a lifecycle assessment?

A lifecycle assessment is a way of measuring the emissions from a product or service that takes into account emissions from the vehicle's entire lifecycle.

"It's not just emissions created while the vehicle is operating, but also emissions that come from extracting the raw materials, manufacturing it, shipping it, and servicing it, as well as the electricity that is used to power it," explains Leah Lazer, Research Associate at the World Resources Institute and NUMO.

Leah Lazer
Research Associate at the World Resources Institute and NUMO

"It also considers what happens at the end of its lifecycle and how it is then treated. It's a much more holistic way of comparing the climate impacts of different modes."

An LCA for scooters typically calculates the environmental impact in grams of carbon dioxide per kilometre travelled. Initial findings from the US study in 2020 found on average a scooter produced 130 grams of CO_2 equivalent per kilometre travelled.

In an update of her first study in Paris, de Bortoli saw a dramatic improvement from first-generation scooters to second generation.

"For some operators, who worked really well on the servicing of the scooters, their footprint dropped from 109 grams CO_2 equivalent per kilometre travelled to 60 grams," she says. "A drop of nearly 50 percent."

The biggest improvements came from more robust designs leading to a longer lifespan of scooters, as well as the use of swappable batteries, better infrastructure and cooperation with cities, and improved servicing utilising renewable energy.

"In the beginning, fleet operators were entering the market as fast as possible with as many vehicles to attract as many customers as possible," says Semih Severengiz, who works in Bochum University's Sustainable Technologies Lab. "Then they entered a consolidation phase where they focused on providing more robust products with a longer lifespan."

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Washington DC: taking an iterative approach

The US capital embarked on a year-long permit programme that began in 2019 and now consists of five operators.

While sustainability actions are not specifically mentioned in the city's terms and conditions for permits, it is part of the overarching goals for the programme. Micromobility supports the goals of the city's MoveDC and SustainableDC long-term plans.

Sharada Strasmore, Shared Micromobility Planner, District Department of Transportation, Washington DC, says she and her colleagues have lacked a best-practice framework for scoring the sustainability claims of each operator and have taken an iterative approach to update the permit requirements with best practices for each application phase.

"The information from each company is very different– the format the information is in and what and how they talk about the work each company has done in regards to the sustainability aspects of their scooters and operations," she explains. "A new working group offered us the opportunity to develop best practices around how the companies create lifecycle assessments."

She adds that as companies have continued to mature, and the hardware and software of the scooters have become more innovative, she feels the sector as a whole is in a more stable position to allow cities to properly assess their sustainability.

"While sustainability is one of our programme goals, such as MoveDC and SustainableDC, the data and how a company chooses to address sustainability has always been difficult without a standardisation or LCA best practice," she adds. "NUMO offers the opportunity to have industry, regulators, and experts to have this conversation in a low-stakes environment to reach best practices."

Improving the lifespan of scooters

Some early models of e-scooters had an average lifespan of just 28 days. Many can now operate on city streets for years as design and build have improved to withstand the cut and thrust of everyday use and risks of tampering. Some cities require them to be docked and locked, further reducing the risk of vandalism which often leads to a reduced lifespan.

"We're no longer seeing scooters with a few months of life but rather a few years of life," explains Pierpaolo Cazzola, former advisor to the Secretary General of the International Transport Forum (ITF). "This is encouraging because the longer the lifespan, then the lower the CO_2 equivalent per kilometre travelled is going to be."

The caveat here is that as the scooters become heavier more materials are required to produce them.

"The Xiaomi scooter was the first version rolled out that was much smaller and leaner. In a way you now see scooters are bigger and heavier," adds Cazzola. "More materials mean more lifecycle emissions."

But improvements in manufacturing and supply chains have led to marked increases in efficiencies. Most emissions from scooters are not from their operation but from the manufacturing phase. There is a growing understanding of that with many companies now integrating their supply chains to have more visibility and more control over the manufacturing process to make sustainability gains.

Many operators now design their own scooters, which gives them direct control over the lifespan of their scooters.

Pierpaolo Cazzola

Independent advisor on energy, transport, technology and environmental sustainability

"From the beginning we thought about designing a vehicle that is really robust, that lasts longer, can be on the road for longer, and is not as breakable," says Haya Verwoord Douidri, Executive Vice President, Global Market Development, Policy and Strategy at Superpedestrian. "Out of all the vehicles we have deployed, since 2020, most of them are still on the road. We have a very small percentage of vehicles that have been decommissioned."

The actual components that go into producing a scooter, such as alloy, can greatly affect a scooter's lifecycle and sustainability claims. If the alloy is sourced from China, the carbon dioxide emissions are quite high because it is an energy intensive process, typically involving the burning of coal. But if the alloy is sourced elsewhere or from a factory in China that uses renewable energy to produce alloy, or green alloy, the footprint improves.

"As companies look at the manufacturing of scooters as more of a long-term investment, to effectively prolong their life span, the cost per kilometre, or the cost per year of the vehicle drops, and if it does then the operators' economic sustainability also improves," says Cazzola.

Batteries

While battery technology has improved, swappable batteries and extended embedded long-range batteries have brought about dramatic reductions in emissions and improved efficiencies for operators servicing the scooters.

Previously a van might drive around a city to collect e-scooters to transfer them to a central charging location, often on the city outskirts, to be recharged. Once the scooter batteries were full, they would then be distributed around the city. This not only added to a city's emissions but also its congestion.

"During the first year of scooters in Paris, the servicing of them was really wild," recalls de Bortoli. "Anyone could register as a freelancer to collect the scooters to be recharged. People were fighting on the streets to get the scooters to be charged and most often driving around in diesel vans to warehouses in the suburbs to recharge them. It was not efficient at all."

Swappable batteries mean only the batteries are transported to be charged, often on e-cargo bikes or electric vans, to smaller more central locations dotted across a city.

De Bortoli notes that in a country where the electricity mix is not too carbon intensive swappable batteries have helped reduce the impact of the servicing element of scooters to five grams of CO_2 equivalent over 1 kilometre.

One operator noted when conducting a lifecycle assessment for a city with a very clean electricity grid that this improved their LCA. The environmental impact from charging vehicles can vary widely across markets depending on the source of local electricity.

However, swappable batteries have hinges and locking mechanisms which supplant battery space, reducing the capacity of swappables by up to one third and increasing charging frequency.

Operators like Superpedestrian and Bird prefer embedded batteries. Superpedestrian's embedded battery includes a 61-mile+ range, and only requires charging every four to seven days, depending on usage patterns. This extended range means that riders can travel further, and miles driven (and associated carbon emissions) for charging pickup and redeployment are minimised.

Routing and servicing

Fleet management monitoring software is also helping to minimise service vehicle miles travelled (VMT) and reduce 'deadheading'–moving empty scooters around to meet demand in certain areas.

Combined with improved onboard vehicle intelligence, all of this helps operators achieve three goals: mitigate emissions, avoid further congestion in the city, and make the economics more sustainable and profitable.

"It not only enables long-lasting scooters, but also your maintenance schedule to be much better because we can prevent potential issues with brakes, lights, motors, batteries and all the different electrical components on board," explains Verwoord Douidri.

The technology helps operators avoid trips to collect scooters in need of repair and instead most issues can be diagnosed remotely– and sometimes addressed remotely–thereby cutting the need to transport them back to the warehouse.

"If you look after sustainability, you are looking after practices that improve the way you service your scooters which probably reduces your costs," adds Cazzola. "It's an environmentally and economically sustainable model."

Haya Verwoord Douidri

Executive Vice President, global market development, policy and strategy at Superpedestrian

Bordeaux: why micromobility needs a different tender process

The French city prides itself on having "sustainability in its DNA" and in particular transport–more so in the last two years since the Green party (Europe Écologie Les Verts) took control of greater Bordeaux Metropolitan Council.

As with most other cities, Bordeaux's main priority when scooters first arrived in 2017 was public space management.

"At first we didn't really know how they would work," says Pierre Brebinaud, Freefloating Services Project Manager at Bordeaux Metropole. "It was a bit chaotic."

His main priority was to ensure operators signed an agreement. Later, the size of each operators' fleet was capped and eventually the number of operators.

"It was too hard to monitor all their activities," he adds.

Last year the city launched a new tender that would only allow two operators to run shared scooter services in the greater region. That process is now in the selection phase.

"Public space management was still the main focus in this new tender but we did include sustainability aspects as well," he says.

In the bids Bordeaux Metropole received, operators provided detailed accounts of their environmental footprints–from the manufacturing stage to how they are transported and how many parts of their scooters can be recycled.

"We noticed a change of emphasis from operators in that they were flagging their sustainability credentials more," he explains. "They were able to link sustainable actions to the financial stability of their operations. The difficulty is comparing this between two operators, even two cities, and different methods between countries."

Similarly to Washington DC, Bordeaux has found it challenging to get certain information from operators.

"We are not paying for their services, so it's not a typical tender process," he explains. "They are private companies and we are a public service. We can rank the operators but cannot ask specific things from them. We can emphasise what areas we will be looking at and focus our attention on them in the selection process but we cannot impose requirements on them."

The limitations of lifecycle assessments

LCAs are useful in providing some understanding of where action or policies can have an impact and can inform policy decisions. But as the ITF's *Good to go?* report notes, "they should only be seen as instruments allowing a better understanding of the system considered, under given assumptions, and not as the absolute truth (which is very case specific)".

Such variables can even include the local culture and how the general public behaves and treats public or shared products and services. Cities where people are less careful can even have an impact on the lifespan of a scooter.

The kind of trip a person replaces with a scooter can also have vastly different consequences

"Companies that are more rigorous or transparent might end up reporting higher emissions and be penalised instead of rewarded for their transparency"

Leah Lazer, Research Associate at the World Resources Institute and NUMO

in terms of greenhouse gas emissions.

De Bortoli introduced a new model based on her studies in Paris that can quantify the ecological impact of scooters which won her the ITF's Young Researcher of the Year in 2020. It calculates the environmental footprint generated by the scooter over its lifecycle to travel one kilometre and can also look at why scooters are used, what mode they are replacing, or if their use created a new trip.

"In Paris, it is better if you use a scooter instead of taking a bus which is run on diesel," says de Bortoli. "But if you take a scooter instead of the metro, it's not more sustainable. Other factors include the electricity mix available in a city, public transport options available, and if it is low carbon intensive."

Lazer from WRI believes it's important to take a step back and think about the impact that scooters have on the accessibility to the transport system as a whole. She says that if someone is using a scooter

to travel to a transit station that they would have normally walked to, that could seem like a bad thing in terms of emissions. But if it makes people more inclined to use public transit overall as opposed to a car, that is a much bigger win.

"If it is easier to get to transit station by scooter than by walking, then scooters can increase the appeal of public transit as a whole in a way that is difficult to quantify in the context of an emissions assessment, because it has to do with people's perception of accessibility of different modes. It's quite complex and has more to do with people and space rather than the vehicles themselves."

Semih Severengiz says that more empirical data is needed from operators which can show this substitution of certain modes of micromobility.

"It would show how many car trips we could avoid by micromobility offerings but it would also make a better assessment of the contribution of these kind of transport options."

Limits of LCAs and variables

While cities are increasingly asking for LCAs in their selection process, it is still very difficult to compare one to another as a range of different approaches and assumptions are used. LCAs are also resource and time intensive. They require extensive collaboration across departments, companies and suppliers. The work is further complicated due to the lack of a standard framework, which requires each company to start

Semih Severengiz

Professor, Sustainable Technologies Laboratory, Bochum University of Applied Sciences

from scratch when they create their LCAs.

"Companies that are more rigorous or transparent might end up reporting higher emissions and be penalised instead of rewarded for their transparency, which is the opposite of the incentives we want to create," explains Lazer.

They are also never truly finished. As business practices change, LCAs are constantly evolving, making them a "forever project" that helps companies track their impact and progress over time. Yet, at the same time companies that conduct LCAs on their supply chains and operations would also be more likely to uncover opportunities for improvement in material sourcing or disposal practices that potentially were not previously considered from an environmental impact lens.

Similarly, LCA results depend to a large extent on the input data, its quality, and the extent to which it reflects reality. Although certain guidelines or base standards can be used, an LCA needs to be tailor made for each city. It is also important to include a way to monitor and bring in objective input parameters like peer reviews and auditing.

"All operators are looking at LCAs in very varied ways," says Verwoord Douidri. "We all want to have a level playing field and a fair way of looking at LCAs and comparing. A standardised guideline or methodology would help not only operators but also cities to actually target and measure progress."

Chicago: cities need an industry standard on sustainability

In June, Chicago took the final step in selecting three operators that were granted a fully established permit. Prior to this, scooters had been operating under an "emerging business permit" which allowed them to function on a trial basis through the Business Affairs and Consumer Protection department. To continue legally after the pilots, the city council had to amend laws and add scooters to become a legitimate business category.

In February this year, the first request was put out under the new arrangement.

"We had well-defined criteria for evaluating those applications," says Sean Wiedel, Assistant Commissioner, Chicago Department of Transportation. "Sustainability was one of those but we still have to rely on what the companies tell us. Some are more forthcoming than others."

One way Chicago has worked around this is by requesting all operators to provide references from the 10 largest cities they operate in. Wiedel says this allows him to gauge experience from past operations, sustainability, approaches to equity and a lot of other criteria which peers at other cities were happy to discuss openly and privately with him.

In the city's request for proposals there wasn't a full set of criteria on sustainability but companies were required to include information on their sustainability programme.

"Currently there is no good standard that we could hold up to and evaluate all the companies on the same criteria to see if they met a standard," he explains. "It was our own research and gut instinct to some extent. Different companies focused on different elements such as swappable or even water proof batteries. We had to weigh up those things and think, 'Which one is more important to us?'"

Wiedel says that a standard for sustainability would not only help him and other cities to evaluate but would also help vendors understand better what cities are looking for.

"A standard that we can hold the companies to, that has been defined by both cities across the country and world, and produced in partnership with the companies themselves would be immensely helpful going forward," he adds.

Are scooters facing unfair scrutiny?

S cooters are a fairly new mode of transport and, like anything new on the market, they get intensely analysed. Yet some say this level of analysis needs to be applied to more established modes of transport.

"No one is talking about the shared space of cities which is dedicated to cars," says Severengiz. "No one is talking about that as intensively as we have for micromobility. We do not have too many micromobility vehicles in a city, we have too many cars. Infrastructure in cities is far too concentrated on vehicle transport."

Verwoord Douidri wishes the same amount of scepticism would be placed on cars as scooters. As an example, she says that a lot more attention or focus is given to scooters parked incorrectly, than cars, which take up considerably more space.

"My main wish is to have honest conversations with cities and other operators so we can achieve bigger sustainable goals," she says. "All of this requires collaboration and LCAs are a part of the sustainability initiatives that will help reduce emissions. It's concrete, it's happening, it's not just a theory or a plan. It's a very practical way to transition."

Why Milton Keynes wants an end to scooter trials

In the UK city of Milton Keynes, sustainable transport has risen up the agenda along with people's desire to address climate challenges. One angle the city wanted to explore was in providing better mobility, and so it became one of the first cities in the country to trial shared scooters in 2020.

While LCAs and a deeper look at e-scooter operators' sustainability claims weren't at the "top of the agenda" when selecting companies, the city was searching for operators that were responsible, that cared about what they were doing and were addressing some of the negative aspects seen in other cities, such as illegal underage riding, or riding on the pavement.

"We were particularly looking at the attitude of companies to launch trials that were in line with our expectation: having a safe and effective solution for our locality," says Brian Matthews, Head of Transport Innovation, Milton Keynes Council.

One aspect that is different about the trial in Milton Keynes is it is one of the few cities in the UK that has multiple operators. Matthews says this allows for an upward spiral of driving efficiencies and better services and therefore more sustainability.

He saw this first hand in relation to how the operators serviced the scooters including battery swapping, and using electric vehicles.

"They realised it's actually more cost effective to run an electric pickup rather than a diesel," he

Brian Matthews

Head of Transport Innovation, Milton Keynes Council

observes. "Unless those companies got that right, it was going to cost them more."

The trials in the UK have been extended until March 2023, and while this might be a positive, Matthews and other cities were hoping for a more permanent system to be implemented. He says he was looking ahead to develop a strategy and procurement route for permanent operators in which Milton Keynes would focus more on the sustainability of operators.

"Two years ago, the position we were in was around operating scooters for a particular purpose to support transport in a very difficult situation [the Covid-19 pandemic and lockdowns]," he says. "Now the focus will be on long-term sustainability and partnering with operators on that basis."

The frustration for cities in the UK is they cannot invest long-term because operations are still on a trial basis and without a UK government guarantee that legislation will come forward to make them permanent, cities and operators are reluctant to invest further in sustainability.

"Clearly cities wanted to invest more on the infrastructure side to support the network and extract value," he adds. "Whether that be more docking stations, signage, line marking, and so on. We can design and introduce support infrastructure to make the scheme even better than it is at the moment and address some remaining challenges, but to achieve this we need a more permanent basis rather than ongoing trials."