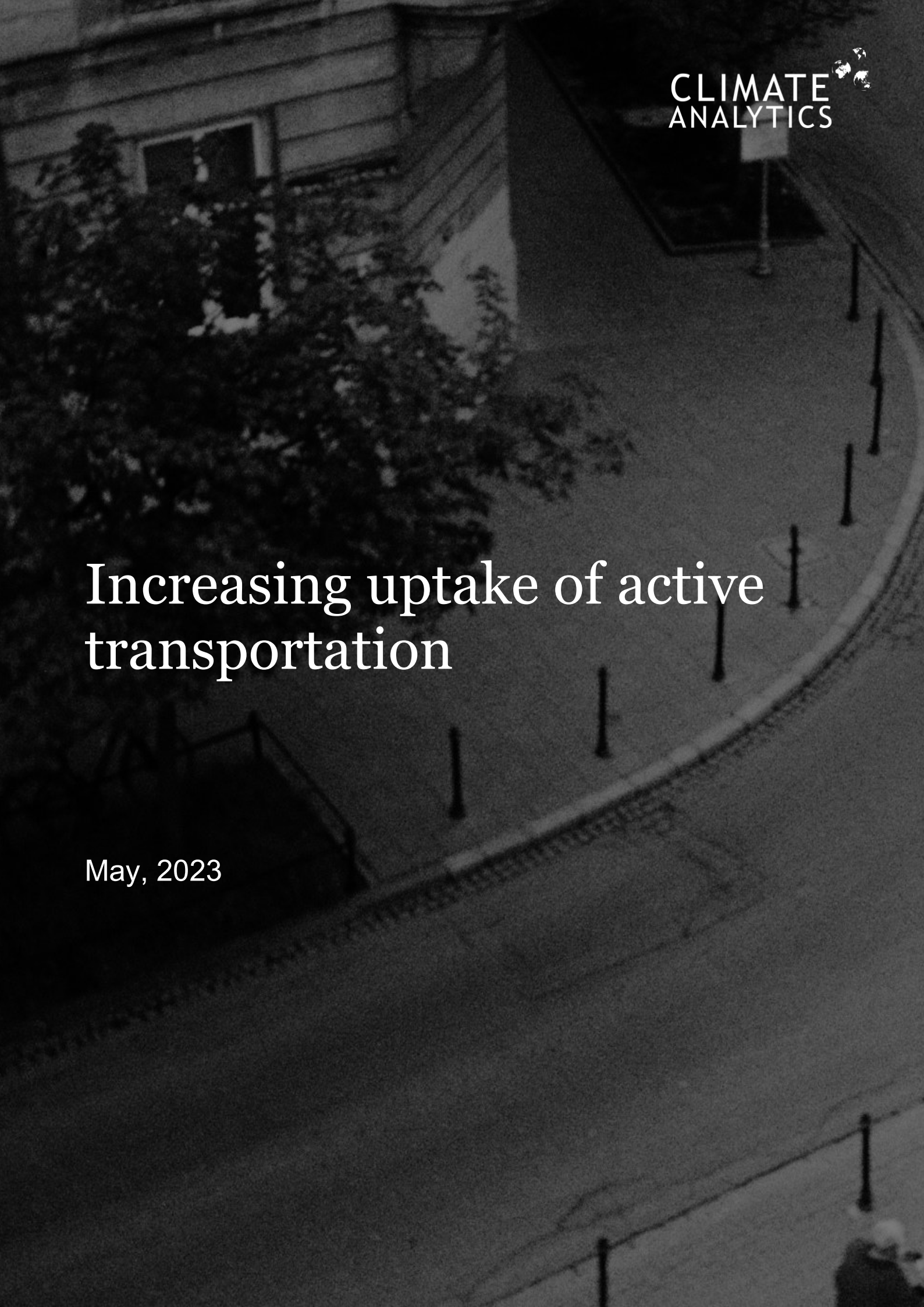

CLIMATE ANALYTICS

Increasing uptake of active transportation

May, 2023

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CLIMATE ANALYTICS

Supporting science based policy to prevent dangerous climate change enabling sustainable development

Contents

Cycling

Improving cycling infrastructure

Expanding cycling infrastructure is essential to shift from individual car transport to cycling. Extra cycling lanes make more destinations bike accessible. This improvement increases cycling exponentially. Improved cycling infrastructure also improves safety for all those using the road and help cyclists to feel more safe during their journeys (Wolek et al., 2021).

Policymakers must develop cycling infrastructure intentionally. The following criteria are essential to expanding cycling infrastructure strategically ('Cycling Infrastructure – Planning for the Future of Cyclists in Your City', 2019; *How to Achieve a Walking and Cycling Transformation in Your City*, n.d.):

- All cycling lanes help. However, if policymakers must prioritise certain lanes, cycling lanes connecting urban centres or neighbouring cities have the highest priority.
- Policymakers must use already existing space (e.g. parking spaces, unused railway tracks, flood banks, etc.)
- Policymakers must increase lighting to improve cycling lane safety and utilisation.
- Urban renovations should prioritise cycling lanes.
- Policymakers should clearly separate cycling lanes from other modes of transport, especially cars and pedestrians.

Cycling infrastructure is both much cheaper per kilometre than roads and provides extra social benefits. After Frankfurt am Main, Germany, converted one lane in each direction on part of a major highway into a cycling lane, many residents believed that the area around the cycling lanes became quieter, safer for children, had better air quality, and improved traffic volume (Lanzendorf et. al., 2022). Improved bicycle infrastructure also increases the value of properties in the vicinity of a cycling bike network (Li and Joh, 2017).

Cycling infrastructure examples

Between 2005 and 2011, Bogotá increased the share of travellers who cycle by 57%. This jump was one of the world's most dramatic cycling increases. Four years later, cycling's share of local transport spiked by an extra 30%. Plan Bici, which began in 2016, plans to double the network, called CicloRutas, over the next twenty years and spread 'bicycle consciousness' among Bogotá's youth (Chartier et al., 2020). Bogota plans to have bicycle routes within 500 metres of every household by 2038 (the 500th

anniversary of the city's founding). Bogotá would become the 'cycling capital of the world' under this plan.

In 2021 Germany published the "National Cycling Plan 3.0", which aims to create a cohesive vision for cycling infrastructure through 2030. The plan prioritises expanding sustainable infrastructure in rural and underdeveloped areas. The plan emphasises intentionally expanding cycling to build better communities, improve citizen health, and facilitate sustainable transport in the face of a worsening climate crisis (Federal Ministry of Transport and Digital Infrastructure, 2021).

Milan's *Cambio Biciplan* will expand existing and new cycling routes by 750km. About 86% of Milan's residents will live within 1 kilometre of the new network, making cycling Milan's most convenient transport option. *Cambio Biciplan* also seeks to improve public health, cut traffic, and address some of Europe's worst urban air pollution by reducing vehicle emissions. Milan will also install "smart technology", such as motion-sensor lighting, digital information displays, and supporting optic cables, alongside the routes. Routes will open as soon as Summer 2022 and the project will be completed by 2035 (O'Sullivan, 2022).

Cycling motorways

In discussions on cycling infrastructure or green transport generally, most policymakers focus on short-distance trips. However, cycling may also replace other modes of transport for mid-distance trips within a city or between cities. Implementing "cycling highways" is an important incentive for such trips.
Bicycle highways routes must:

- be dedicated solely to bicycle traffic,
- be longer than five kilometres,
- consist of materials which facilitate higher speeds than normal inner-city bike paths or sidewalks, e.g. asphalt or concrete,
- pass under or over motorways, and
- have no traffic lights.

Researchers recommend that bicycle highways follow pre-existing commuter routes and serve hubs with the potential for 200-500 cyclists per day (Cabral Dias & Gomes Ribeiro, 2021; *Cycle Highway Manual*, n.d.). In contrast to "usual" cycling routes, the population density at end nodes is more important than the population density between the nodes.

Bicycle highways reduce conflict with cars or pedestrians and prioritise speed for longer distances (Cabral Dias & Gomes Ribeiro, 2021). These changes incentivize long-distance cycling (Cabral Dias & Gomes Ribeiro, 2021). Improved lighting, road surface conditions, and traffic safety in cycling infrastructure correlated with increased cycling and cyclist satisfaction (Skov-Petersen et al., 2017). Researchers estimate that bicycle highways increased local induced bicycle trips (i.e. those which otherwise would have not been

made by bicycle) by 6% (Skov-Petersen et al., 2017). Overall bicycle traffic increased by 33% in the daytime and by around 73% at night (Skov-Petersen et al., 2017).
Key organisations supporting implementing European bicycle highways include the European Cyclists' Federation, the European project for Cycle Highways Innovation for smarter People Transport and Spatial Planning (CHIPS), and the Super Cykelstier Office.

Bicycle highway examples

Denmark implemented a network of cycle superhighways between the Capitol Region and 30 surrounding municipalities. Orange-marked asphalt and road signs clearly mark routes

and connect residential, commercial and university districts. As of 2020, 40 routes have opened and Denmark has planned for over 20 more ('Cycle Superhighways', n.d.). Regional bicycle highways will span over 850km. ('Cycle Superhighways', n.d.). The number of cyclists on one route, called Farumruten, increased by 68% since the route became a bicycle highway in 2013.

Belgium is building 100 bicycle highway routes in the Flanders and Brussels regions, which on completion will span 2,700 kilometres. Routes currently have systematic signage and a dedicated "F" symbol, even though bicycle highways do not yet have a specific legal designation. Belgium developed an online dedicated route planner, where cyclists can plan and download trip routes, indicate and look up road conditions and highway quality, and submit work requests (*Veelgestelde vragen*, n.d.).

China has built the longest elevated cycle path (as opposed to the traditional ground-level, highway adjacent bicycle highway) in the south-eastern city of Xiamen. The route is 7.6 km long, connects the main residential and commercial districts, and provides connection to bus and subway lines (Edmond, 2017).

Increasing cycling safety

Safety is one of the most important factors to encourage greater cycling (Kallenbach, 2021). Both real and perceived safety are critical when designing bicycle infrastructure. The perceived risk of cycling on roadways and around traffic is one of the most significant cycling deterrents (Pucher & Buehler, 2017).

Key strategies for increasing safety when cycling include:

- Calming and reducing urban auto traffic through reduced speed limits, reduced parking, and certain car-free areas (Pucher & Buehler, 2007).
- Increasing time and space separation between bicycles and motor vehicles (DiGioia et al., 2017). This separation will decrease potential conflict between the two modes of transportation (DiGioia et al., 2017).

Both strategies decrease *interactions* between different modes of transport. Decreasing these interactions is decisive for cyclists' real and perceived safety. Different bicycle corridor treatments (buffered bike lanes, coloured bike lanes in conflict areas, bicycle

boulevards, strategic rumble strips, bollards, parking protection, etc.) can decrease interactions between bicycles and cars (DiGioia et al., 2017; *Urban Bikeway Design Guide*, 2017). Intersection treatments are especially critical for cyclists. The National Association of City Transport Officials recommends bike boxes, clear marking and two stage turning, refuge islands and/or bicycle through-ways (*Urban Bikeway Design Guide*, 2017).

Different strategies and drivers require distinct considerations. For example, parking protected cycle tracks require widened buffer space to prevent conflict between cyclists and car doors. Para-transit vehicles may require wider buffers for ramps and mobility aids.

Cycling safety reform examples

Amsterdam adapted cycling infrastructure to the local urban environment. Cycling in Amsterdam became safer and more comfortable. These adaptations helped promote cycling among children and the elderly.

People in Copenhagen began cycling more in the 1970s. Rising oil prices, relatively flat terrain, and the city's small footprint contributed to the shift. When Copenhagen invested in separate and elevate bike lanes, the subjective feeling of safety increased between 20% and 100% (Bach, 2014). A 2017 study found that the number of cyclists increased by 15-20%. This increase had a cascading effect. The more cyclists regularly using the roads, the safer they become for bicycles (Jacobsen, 2003).

Separate stop lines for motorists and bicyclists enhance bicyclist safety in Germany. If a bike lane runs parallel to a signed intersection's approach lane, the bicyclist stop line comes closer to the intersection than the car's stop line (Pucher & Buehler, 2007). Cars must stop behind cyclists (Pucher & Buehler, 2007). This design reduces conflict between right-turning vehicles and bicycles by enhancing bicyclist visibility.

Encouraging multimodality

Long daily commutes prevent people from switching to active transport methods. Combining different modes of transport (multimodality) helps cities with unfavourable biking geography (e.g. mountainous cities). With good policy conditions, multimodality could be more popular among cyclists than cycling alone. For example, 67% of German cyclists commuted with a multimodal system, while only 33% biked the whole route (*Radverkehr und Verkehrswende*, 2021).

Making it easier to bring bikes on trains, subways, trams or buses would make it possible for long-distance commuters to move from cars to intermodal commutes with cycling. Promoting multimodality with cycling requires:

- Adapting the existing fleet for increased bike transport, e.g. including more foldable seating and special compartments in trains and subways.

- Decreasing or abolishing fees for the transporting bikes on public transport, especially for regular commuters.
- Building more parking spots for bicycles and cars near train stations, long-distance or rural bus stations. Policymakers should prioritise highly frequented and peripheral stations.
- Increasing the accessibility of train stations with ramps or lifts. These improvements also increase accessibility for mobility aids used by people with disabilities.

The EU financed Interreg Smart Commuting Programme provides interesting resources to support multi-modal and environmentally friendly transit systems (*Smart Commuting*, 2020). The programme emphasises transnational projects in CEE states (*Smart Commuting*, 2020).

Multimodal network examples

Augsburg, Germany introduced the country's first mobility flat rate (*Mobil Flat*, 2022). Local consumers can enjoy bus, car sharing, bicycles, etc. for a set monthly rate of 79 EUR (*Mobil Flat*, 2022).

Groningen, Netherlands implemented a series of Park and Ride locations (P&R), connecting cyclists and drivers to major city services inside and outside of the city centre. Electric buses depart from P&R locations every five to ten minutes, achieving a relatively high 70% occupancy rate during the busiest hours. Groningen's P&R system succeeded because of a public-private and metro-regional partnership. The partnerships improved interchange locations by adding or improving amenities, such as covered bike racks, charging for e-bikes, and reduced fare transit between homes and hubs (Schaafsma, 2020). This program has relatively successfully promoted intermodal commuting and nudged commuters towards less emissions intensive transport.

London, United Kingdom has a frequently cited model for a multi-modal network. The system has extensive rail, bus, and ferry options. Stations integrate all networks to facilitate easy transfers between transport modes. London's system uses extensive on-site staffing to answer questions and solve problems that could throw off a multimodal commute (construction, scheduling, etc.). London's Oyster Card holds multiple forms of tickets for all types of local and regional transit. The system includes period tickets, travel permits, and "pay as you go" funds operated through a tap-in, tap-out system. In 2014, Oyster Card successfully coordinated with bank-card based contactless payment one out of ten contactless payments in the UK are on London's transport network (Litman, 2021a). One out of ten contactless payments in the UK today are on London's transport network (Litman, 2021a).

Oslo, Norway: Oslo's "Oslo Pass" includes both travel on all municipal public transport and, depending on a fee for one-, two- or three-day use for:

- entry to more than 30 museums and attractions;
- parking in municipal car parks;

- entry to outdoor swimming pools;
- participation in walking tours;
- discounts on sightseeing, a ski simulator, Tusenfryd Amusement Park, concert tickets, climbing, ski and bike rental, and
- special offers in restaurants, shops, entertainment and leisure venues (*Oslo Pass - Official City Card*, 2022).

Hungary linked its four million (as of 2020) national identity card holders to a new national rail ticketing system. This “smart-card” system stores transportation tickets with already existing card information.

Bike rentals

Bike rentals are a good alternative for people who cannot afford or do not want their own bike. Researchers have cited bicycle rental and sharing systems as a potential solution to the "last mile problem” (Liu et al., 2012). Travellers would have journeyed mostly with other modes of transport, e.g. public transit (Liu et al., 2012).
Policymakers can divide bike rentals into short- and long-term rentals. Short term rentals tend to be close to points of interest and within mixed-use or commercial districts. Short-term rentals facilitate last mile connections for trips which may have otherwise used more emissions intensive modes of transportation. Short-term rentals often depend on a reasonable distribution of rental stations, fee schedules and the existence of substantial bike infrastructure (Zhang et al., 2018). Easy ticketing, e.g. the usage of public transport tickets for short-term rentals, could facilitate its utilisation rate.

Long term rentals apply when individuals rent a bicycle for weeks or months at a time, only returning the bicycle at the end of their lease. These programs reduce bicycle usage’s high start-up costs, which may be prohibitive for some users. Visitors for a few months (e.g. foreign students) can also benefit, since they would not need to purchase and resell a bike. This free-floating model prioritises flexibility and longer trips over short-term rentals.

Bike sharing reduces barriers to bicycle use and addresses last mile problems. These systems provide an alternative to private car use, lower emissions, and increase mobility for citizens and visitors.

Bicycle rental examples

Private firms offer the majority of bike sharing options. Some examples include NoBelity, Holland Bikes, and Aveola. The Dutch firm Swapfiets has more than 200,000 members in 50 cities in France, the Netherlands, Germany, Belgium and Denmark. Decathlon also offers such services in France (Reid, 2020).

Citi Bike includes over 1,300 stations with bikes across the New York City boroughs Manhattan, Brooklyn, Queens, the Bronx and the neighbouring Jersey City (*Citi Bike*,

n.d.). Individuals check out a bike from one location and may return it to another in a system of short-term, urban rentals (*Citi Bike*, n.d.).

GetHenry in Germany provides long-term e-bike rentals between six and 36 months, depending on the model. GetHenry provides two main forms of leasing: long-term rental (LLD) or rental with purchase option (LOA). GetHenry covers maintenance and insurance during the rental period (*GetHenry DE*, n.d.).

Popularising cargo bikes

Transporting bulky products deters car owners from giving up their cars, even if car owners rarely transport such products or alternatives (e.g. car rentals) exist. Increasing the availability of cargo-bikes could facilitate the transition from private car ownership.
Cargo bike sharing reduces private car trips. The Institute of Advanced Sustainability Studies found that of the 931 cargo bike users surveyed, 46% would have made their trip with a car without a cargo bike sharing scheme. Over 90% of surveyed cargo bike users want to use a cargo bike again. This response shows that cargo bikes change people's habits. However, pricing and access remain some of the biggest barriers to cargo bike usage. Only one third of surveyed users intend to buy their own cargo bike. Evidently, schemes supporting occasional cargo-bike usage are desirable (Becker, 2017).

Private cargo bikes constitute an option for those transporting bulky products more often. Policy makers should consider subsidising cargo bicycles to reduce the high upfront cost, just like with electric vehicles.

Cargo bike examples

Vicenza, Italy in the late 1990s and 2000s restricted cargo vehicle use in the city centre to protect the historical city centre and reduce emissions. Despite protest by delivery companies, most deliveries in the city centre are via cargo bike. Deliverers collect packages at smaller consolidation centres around the city and ferry the packages via bicycle to their recipients (Ville et al., 2013).

Since 2013, Germany and Austria have quietly hosted a network of private and voluntarily organised cargo bike rental stations. Some stations have electric drives. Bicycles are available on a donation basis (Becker & Rudolf, 2018). In one study of these programs, 46% of urban participants stated that if they did not have access to a cargo bike, they would have taken the trip by car (Becker & Rudolf, 2018). This degree of substitutions indicates that cargo bikes can have a significant impact on reducing emissions (Becker & Rudolf, 2018). Policymakers and analysts can evaluate the effectiveness of such systems by studying this initiative.

Increasing the use of e-Bikes

E-bikes are becoming significantly more popular as people seek environmentally friendlier forms of transportation, exercise, and entertainment. In 2019, over 3.4 million e-bikes were sold in the EU. If favourable legislation remains, sales are projected to reach 13.5 units annually by 2030. Car manufacturers offer electric bikes increasingly often (*European Mobility Atlas 2021*, 2021). According to EU regulations, batteries can provide work until the cyclist reaches a speed of 25 kph. Beyond this speed, the motor must switch off and the rider can accelerate further using only their muscles (Rösler, 2021).

E-bikes can travel much further within or between municipalities compared to regular bikes and can even compete with passenger cars. Recent inquiry suggests that each additional e-bike could reduce annual passenger car transport by 2,000 vehicle-kilometres and reduce net carbon emissions by just under 500 kg per year (Berjisian & Bigazzi, 2019). E-bikes also increase physical activity, producing additional health benefits (Berjisian & Bigazzi, 2019).

The main ways to increase e-bike adoption include:

- Increasing public e-bike charging stations in and around high traffic areas.
- Including subsidies and/or tax breaks for the purchase of e-bikes, as suggested by the EU Council in December 2021 for the amendment of the EU VAT Directive (Council Directive 14754/21, 2021).
- Further develop bicycle infrastructure to facilitate increased bicycle traffic and improve safety outcomes. Cycling motorways are especially critical in this development.

E-bike integration examples

Germany established the JobRad program, which subsidised bike or e-bike purchases for the employees of participating firms (*JobRad Vorteile*, 2022). Currently, over 30,000 employers participate in the program.

Sweden offered a 25% subsidy to purchase an electric bicycle between September 2017 and August 2018. Despite the program's short lifespan, the program became very popular. The government subsidised bike purchases up to 1000 EUR (Morley, 2020). Sales increased by 50% during this time period (Morley, 2020). Industry group Cykelbranschen estimates that e-bike market shares continue to increase despite the discontinuation of the subsidy ('Om Cykelbranschen', 2021).

The European Union announced a VAT reduction purchasing and repairing e-bikes as part of the recent discussion around VAT reform. Member states, partnering with the European Cyclists' Federation and industry group CONEBI, agreed to cut VAT rates on rents, purchases, and repairs in areas where VAT rates can be legally cut. Before this reform, e-bikes were included in transportation forms powered by fuel, oil, or gas and

were therefore subject to higher VAT (Sutton, 2021). This reform is expected to reduce uptake and maintenance costs and provide a boost to the e-bike industry.

Docking stations for e-Bikes

In most cases, riders can detach the battery from an e-bike and charge the battery at home. Many riders take a charging cable and ask to use outlets at locations (shops, cafes, libraries, etc.) along their journey (Evans, n.d.). This solution is fairly ad-hoc and relies on the goodwill of shop owners and operators. There are also concerns about ensuring compatibility for the e-bike charger's amp rating, battery type, outlet type, and the journey's distance. For long distances and regular commutes, easily accessible charging stations may encourage e-bike use. These stations may encourage multi-day, domestic e-bike excursions as an attractive alternative to emissions intensive foreign trips.

The main three options for charging stations for e-bikes could be:

- Providing charging opportunities along attractive cycling lanes and marking them clearly on maps.
- Subsidise or provide tax breaks for service providers to install charging stations.
- Encouraging employers to purchase or install charging stations for their employees.

E-bike charging examples

Beginning in the summer of 2018, Bosch offered "PowerStations" around major tourist areas in Europe where Bosch e-bike owners can leave their bike batteries in lockers to charge. Bike Energy, which offers charging stations across Europe, also used this model. However, riders need a specific adapter to connect their battery to Bike Energy charging ports ('Where Can I Charge My E-Bike?', 2018). Online e-bike charging point maps can help individuals find charging ports at any point along their journey ('Mapa stacji ładowania rowerów elektrycznych', 2020).

After the Netherlands banned smoking at train stations, smart lighting company Lightwell turned ashtray poles into e-bike charging points as part of a pilot test with ProRail (Wilson, 2020). The charging points are free to use, relatively simple, and have the potential to support multimodal trips by e-bike and train.

Promoting cycling

People in some parts of society, especially in rural areas, perceive cycling as secondary to individual car transport. Policymakers can change this perception by presenting cycling as attractive and fashionable with numerous co-benefits. Urban planners, cycling and neighbourhood organisations, civic groups, local and central governments and

healthcare professionals can coordinate on a campaign to cohesively and effectively convince the general public of the benefits of cycling.

The campaign should reinforce cycling's individual and social benefits. The individual level could focus on health effects. For example, health professionals should focus on the fact that cycling may help individuals live longer and healthier. The societal focus could emphasise benefits such as reducing traffic congestion, noise pollution and air pollution from combustion engines. The message that each bike reduces traffic jams could improve the sometimes-difficult relations between car drivers and cyclists. Cities can also focus on the economic benefits of increased cycling and improved multimodal transportation, such as higher property values, increased retail sales and private investments (*Why Green and Healthy Transport Modes Deliver Vast Rewards for Cities*, 2021).

Coordinated messaging, perceived risk management, and reminders about cycling's individual and social benefits can motivate cycling and multimodal transport (Pucher & Dijkstra, 2003). This motivation can respond to increased demand for healthier, safer, and less emissions intensive transportation (Pucher & Dijkstra, 2003).

Cycling promotion campaign examples

Seville, Spain focused on citizen participation and involvement when developing cycling infrastructure. Seville first gauged public support for cycling and infrastructure projects using public polling. Seville then deliberately placed decisions in the hands of citizens. Seville based its first round of bicycle network designs based partially on the demands of the cycling activist organisation *A Contramano* (Calvo & Marques, 2020). Seville ensured that citizens were invested in the project and felt that they had a say in Seville's development. The Mayor capitalised on the program's popularity and political will, and built critical bicycle infrastructure within one term (Calvo & Marques, 2020). Cycling trips increased eleven-fold within only a few years (Calvo & Marques, 2020). If policymakers clearly explain how participating in a forum can produce meaningful results, citizens and other interested parties will participate (Ansell and Gash, 2008). Citizen participation can produce a virtuous circle. Participation can produce effective results, and the effective results encourage greater participation.

In 2016, Atlanta, USA announced that it would invest one billion USD (963,914,000 EUR) towards bicycling and walking projects over the course of 25 years. The program would combine massive cycling infrastructure investments with increased awareness about cycling's health and environmental benefits. The slogan "Walk, Bike, Thrive!" has become ubiquitous, as messaging focused on neighbourhood revitalisation, benefits for Atlanta's schoolchildren, and the health benefits of cycling and walking (*Bike-Pedestrian Plan - Walk, Bike, Thrive!*, 2020).

Walking

Developing and improving pedestrian infrastructure

Due to direct exposure to the surrounding environment, pedestrians are more sensitive to the quality of space, environmental pollution and traffic safety than any other mode of traffic. Increasing urban walkability is essential to encourage walking.

There are several factors influencing walkability:

- physical infrastructure (space multifunctionality, street layout, safety, green infrastructure, etc.), and
- lack of conflict with other modes of transport, especially cycling and more recently electric scooters.

Vilnius' Street Design Manual identified 12 principles for walkway design:

- Provide green spaces between busy streets and walkways to protect pedestrians and provide shade.
- Organise parking spaces parallel to the street in two or three space groups. Greenery islands should separate the groups.
- Locate street crossings closer to each other. This design discourages pedestrians from crossing the street in unprotected areas.
- Provide lighting for pedestrians independent of the road itself.
- Motorised transport should only have an amount of space that reflects existing traffic. The remaining space should be allocated for pedestrians and other elements to raise the street's quality (trees, etc.)

A survey conducted in Vilnius indicates that the quality of pedestrian space influences modal split. The highest share of trips made on foot, almost 42%, occur in the city centre. In the city centre, infrastructure is well developed and maintained. Short distances from living places also play a role. One-third of all Vilnius workplaces are close to residences, recreational/leisure zones, commercial spots and social infrastructure. In the districts with good accessibility to the city centre, pedestrian trips also remain high at more than 35%. This accessibility comes from well-developed pedestrian infrastructure and walkable distances to crucial targets in and near the city centre. The smallest share of trips (11% and 12%) made by foot occurs in districts with poorly developed pedestrian infrastructure and a lack of everyday targets. These districts are located on the city's outskirts and in specialised neighbourhoods. Despite good infrastructure, these technical districts lack diversity, which forces residents to travel to other communities for education, work, and different social demands. At these distances, walking is often not suitable.

Pedestrian infrastructure examples

London's "Healthy Streets" initiative aims to encourage Londoners to walk at least 20 minutes per day. The Healthy Streets Approach provides a framework of policies and strategies that place walking equal to public transport and cycling. Under this Approach, London needs to re-examine its streets to make them pleasant, safe, and attractive for pedestrians. The Healthy Streets Approach will operate at three primary levels of policymaking and implementation: street level, network level, and strategic level (policy and planning). Ten indicators that horizontally address most topics essential for pedestrian comfort and safety support the Healthy Streets Approach. If all Londoners walked or cycled 20 minutes per day, National Health Service spending would decrease by an estimated ca. 1.7 billion GBP (1,969,009,700 EUR) in next 25 years (*Healthy Streets for London*, 2017).

In 2019, Gdynia, Poland, launched "Klimatyczne Centrum" (Climatic Centre) to counter individual car use, preserve a unique part of the city, and make Gdynia more attractive for pedestrians. "Klimatyczne Centrum" includes different measures focused on traffic calming, greening and improving traffic safety and parking conditions in central Gdynia. Specific policies include prioritising public transport and cyclists in traffic, putting greenery along urban streets, and improving street crossings to protect pedestrians. Gdynia coordinates these measures under the campaign logo "Climatic Centre" to improve public awareness about the program (*KLIMATyczne Centrum Gdyni*, 2020).

Making street crossings easier

Conflict between pedestrians and street-level traffic provide one of the greatest concerns when promoting walkability and walking safety. High density, high population and poor infrastructure exacerbate this risk. Policymakers can introduce steps to ensure pedestrian safety and reduce conflict.

Unless a walk is recreational, pedestrians strongly tend towards choosing the shortest route to their destination. Some pedestrians may decide to cross the street on a red light or pass the street between crossings. Crossings that prioritise cars over pedestrians, a choice common in many cities, strengthen these practices. Any consideration of pedestrian design should focus on nudging pedestrians towards the safest, highest quality route given road conditions. Common solutions include:

- Creating crossings where pedestrians exhibited the desire to cross. These crossings may be at intersections, mid-block, or between significant attractions. Crossings should not be limited to only intersections. Pedestrians may be willing to cross in uncontrolled and unsafe spaces if they feel the controlled crosswalk is too far away. Crossing design ought to consider future crossing behaviour.

- Crossings should be surface-level with the pedestrian walkway and clearly marked with zebra or ladder markings, which have been shown to be the most effective markings for slowing vehicle traffic.
- Signal timing should reflect the needs and abilities of the whole community and adapt to the crossing timings of the elderly, disabled, those with young children, and any individual who may require more time to cross than the average.
- Crossing distances should be as small as possible, with refuge islands, and at least as wide as the walkways they connect (*Crosswalk Marking Field Visibility Study* -, 2010; *Pedestrian Crossings*, 2022; Jain et al., 2014).

Some promote pedestrian bridges as a special solution. Although attractive in theory, they are often counterproductive and unsafe in practice. Proponents argue that pedestrian bridges remove the threat of conflict and move pedestrians out of harms' way. This diversion reinforces the primacy of vehicle transport and discourages all other forms of transportation. In their efforts to remove pedestrians from the street, designers create crossing routes which may be up to 10 times longer than crossing the street on the same level as cars and include highly inaccessible ramps and stairs. These areas are often poorly lit ('Pedestrian Bridges', 2019). The combination of speeding cars, dark corners, and steep, high stairs make pedestrian bridges feel quite unsafe for the most vulnerable members of society including women, children, and the elderly ('Pedestrian Bridges', 2019). The inhospitable design of most pedestrian bridges means that pedestrians will often avoid them and deliberately cross in unsafe places. Policymakers should only use pedestrian bridges if no other option exists.

Adequate pedestrian crossings increase walkability and promote pedestrian safety. These improvements promote walking. Crosswalks and pedestrian interactions with vehicles must generally prioritise the pedestrian as a matter of safety and comfort.

Street-crossing examples

Germany identified several geometric design practices intended to enhance pedestrian safety at signalised intersections. If a pedestrian crossing crosses more than two lanes, then a protective raised median functions as a "refuge". The median must be at least 2 metres wide. This practice applies to both signalised and unsignalized intersections.

In 2016, Berlin, Germany, introduced yellow lights at pedestrian crossings as a result of a successful experiment in Düsseldorf that has been ongoing since the 1950s (Glucroft, 2021). Additionally, many European cities (see: the Netherlands example below) have introduced audible countdown timers which serve a similar purpose as yellow traffic lights. These timers also increase the accessibility of crossings for the blind.

The United Kingdom has developed several innovative signalised pedestrian crossings that rely on modern detector technology to improve safety and traffic operations. The PUFFIN crossings use pedestrian detectors to vary the length of the pedestrian phase

automatically (Fong et al., 2003). This system gives pedestrians the time needed to cross (Fong et al., 2003). Some benefits of PUFFIN crossings include:

- Simplifying pedestrian signals (no flashing green man).
- Decreasing vehicle delays. For example, if the pedestrian crosses during the red phase after having pushed the pedestrian button, PUFFIN cancels the pedestrian call.
- Eliminating visibility problems by using nearside signals are used.

The Netherlands has experimented with delineated bicycle and pedestrian paths at roundabouts instead of traditional four-leg intersections. These intersections keep a larger separation between pedestrian paths, bicycles, and cars and reduce conflicts between different forms of transportation.

Sweden prohibits right turns on red, particularly at intersections with significant pedestrian and bicycle traffic. All signalised intersections with an approach speed limit greater than 70 kph should be provided with exclusive turn lanes and have protected-only phasing for left and right turns.

Improving pedestrian orientation and wayfinding

A critical aspect of improving walkability, especially for tourists and newcomers, is accessible wayfinding and signage for pedestrians. This signage facilitates walking and provides critical information about the pedestrian's environment. Proper wayfinding information helps individuals build a mental map of an area and more easily read and interact with their environments (*The Ultimate Guide to Pedestrian Wayfinding*, 2019). As a result, pedestrians may decide to walk instead of choosing a more carbon intensive form of transportation (e.g. taxi). Additional wayfinding may also have an additional benefit of increasing the attractiveness of a certain area and encouraging pedestrians to use services offered along their way.

Policymakers can improve wayfinding systems by:

- Adapting the signage to the scale of the human body. Unlike vehicle signage, pedestrian wayfinding aides must be at or around eye level and easy to spot.
- Increased accessibility: signage should be available in multiple languages, determined by demographics and area needs. Signage should include clear, systematic graphics. Signage should also feature braille and other accommodations for those with eyesight limitations.
- Designing around multimodality and pedestrian needs: wayfinding signs and resources should be placed around transport interchanges and stops in order to provide a more seamless transition between forms of transportation (*Seamless Seattle Pedestrian Wayfinding Program*, 2019).
- Harmonising signage and transportation information: to allow individuals to easily visually track their location and route, and to quickly orient themselves when switching from public transport to walking (*Wayfinding*, 2019).

Clear wayfinding systems increase pedestrian comfort and safety and encourage walking, both by residents and visitors (*Pedestrian Wayfinding Kiosk Project*, n.d.). Clear, inclusive signage allows pedestrians to efficiently navigate between two points, familiarise themselves with their city, and establish pedestrians as a design priority for the modern city.

Wayfinding examples

London, United Kingdom established a pedestrian wayfinding program called “Legible London,” managed by Transport for London. “Legible London” provides an integrated set of maps and signs with distinctive and intuitive design features. These features include freestanding signs, called ‘monoliths’, at tube stations and bus shelters. The monoliths are topped with a distinctive yellow beacon cap and walking person icon.

These features make the signs easy to spot within the urban environment and from a distance. Each monolith has two maps. A 'finder' map displays a 5-minute walking circle, and a 'planner' map displays a 15-minute walking circle. The maps illustrate significant landmarks in 3D. These landmarks help users identify the urban environment and serve as “mental navigational tools”. Both planner maps and finder maps are “heads–up” instead of “north–up” (Transport for London, n.d.-b). Many people find the “heads-up” system easier to use (Transport for London, n.d.-b).

Glasgow established a wayfinding initiative in 2008 to facilitate pedestrian journeys around the city centre. The city centre is known for its cultural initiatives, museums, concerts, and landmarks – all of which generate significant pedestrian traffic. The wayfinding system centred on a 15 square kilometre map of the city centre, housed in signs, posters, and fingerposts around the city. The master map highlights 250 local attractions and cultural sites and includes transit connections, information, and additional assistance points (*Glasgow Pedestrian Wayfinding System*, 2010).

Ottawa, Canada, concluded a wayfinding project in 2021, which focused on developing a cohesive, identity-building system that reflected the Ottawa community’s culture and needs (*Ottawa National Capital Wayfinding*, 2021). The project included input from multiple levels of government and partnered with the neighbouring town of Gatineau. The initiative provides an interesting study in cross-border cooperation, since the cities are separated by only a river but have populations which predominantly speak different languages. Graphics represented the heritage, urban, and natural environments of Ottawa and was initially trialled as part of a revitalisation project in order to generate stakeholder investment (Heller, 2018).

Creating pedestrian only zones

Pedestrian only zones could encourage more people to walk or combine public transport with walking, as opposed to other more carbon intensive forms of transportation. This combination is especially critical for addressing the "last mile problem", which continues to stymie efforts to nudge individuals towards more efficient

forms of transportation. The “last mile problem” is especially prominent in densely populated areas with numerous possible destinations for pedestrians.

Policy makers can increase the attractiveness of pedestrian-only zones by:

- significantly reducing, slowing down, or excluding car traffic. This would reduce air and noise pollution in the selected areas and encourage walking.
- Separating lanes for other modes of transport. Apart from cycling, this concerns especially electric scooters. Most cities have recently experienced a worsening pedestrian environment due to the scooters lying around and constituting a danger for pedestrians.
- Creating pedestrian corridors along public transport stations, instead of limiting pedestrian-only spaces to main squares. These corridors would facilitate combining walking with public transport use.
- Planning for pedestrian areas, with separate lanes for cycling and electric scooters during city or district planning.
- Allowing shortcuts (e.g. through densely populated areas) that could not be available for other modes of transport.
- Introducing complementary policies to avoid traffic jams in other areas, which would increase political costs significantly.

Pedestrian only spaces face two main challenges. Firstly, some inhabitants of the pedestrian-only zones may have to rely on a car for different reasons. Secondly, some businesses whose customers may need to rely on car transport may be negatively affected. Very limited car travel, e.g. one lane and significantly reduced speed, can mitigate both challenges/ Businesses should allow parking only for limited time. Alternatively, certain shops offering products that can only be transported by car could offer a delivery service. Tax subsidies for affected businesses would make delivery especially attractive. In this case, the respective company cars could be allowed into the pedestrian space during business hours. Inhabitants of the zone owning a car should have an underground parking space at their disposal. This latter point particularly requires long-term planning. Policymakers should include such underground spaces during urban or district planning.

Pedestrian-only zone examples

London aims to become the world’s most walkable city and established the position of City Commissioner for Walking and Cycling to achieve this goal. The Commissioner aims to increase daily walking trips by one million and make walking the most obvious, enjoyable, and attractive option for short trips within the city. Any infrastructure plan prioritises walking. Pedestrian centred guidelines ensure the walkability of future designs. Planners focused on improving the walkability and safety of streets around schools through the use of stringent speed limits, crosswalks, and timed road closures (London Walkable City, 2018). Schoolchildren could walk to school more safely and efficiently (London Walkable City, 2018).

Barcelona's systematic multiuse design makes it consistently listed as one of the world's most walkable cities (Marquet & Miralles-Guasch, 2015). One out of every four trips are via foot, often less than ten minutes. The city's design emphasises the development of streetscapes and prioritises short walking trips within one's neighbourhood (Marquet & Miralles-Guasch, 2015).

Bonuses from healthcare providers

In addition to physical incentives to encourage more walking, individual incentives can motivate someone to walk more often. Numerous healthcare providers proposed a simple and innovative solution. People who achieve a certain number of steps per day or per week for a certain period receive various incentives. Mobile phones or special devices (e.g. FitBit, Apple Watch, or Garmin products) can register the amount of steps. Many programs rely on cash pay-outs for certain step-levels (Augurzky et al., 2012; Henkel et al., 2018; Stock et al., 2010).

Studies estimated that while these programs may result in a net loss in the first few years of use, after several years, savings on health interventions as a result of healthier lifestyles profit firms which introduce these programs (Augurzky et al., 2012; Henkel et al., 2018; Stock et al., 2010). This profit provides an additional financial incentive to introduce a step rewards program (Augurzky et al., 2012; Henkel et al., 2018; Stock et al., 2010).

While these programmes focus on the positive health benefits of increased activity levels, policymakers should recognize the environmental benefits of increased walking journeys. Increased walking necessarily replaces some trips, including by passenger cars or motorcycles. Greater walking also facilitates public transport use, since public transport always requires more walking than travelling by car. However, providers should conduct regular health check-ups for participants' insurance incentives, as there are an increasing number of ways to "spoof" insurance companies. Examples include attaching the FitBit or Smart device to a pendulum, drill, or metronome, as shown on Unfit-Bits (*Unfit-Bits*, n.d.).

Health bonus examples

CSS Insurance, a Swiss health insurance firm, offers a step rewards program with a cash pay-out system. Those insured by CSS can connect their Garmin, FitBit, or POLAR devices and agree to transmit only their step data to CSS. Every day that the individual achieves over 7,500 steps, the individual receives 20 centimes (MyStep – Your Steps Rewarded, n.d.). The individual receives 40 centimes on the days they achieve over 10,000 steps for a maximum pay-out of 146 CHF (141 EUR) per year (MyStep – Your Steps Rewarded, n.d.).

Yas Life, a health-tech startup based in Berlin, offers an app-based health tracker that partners with common activity trackers to monitor activity levels. Yas Life partners with insurance firms and helps implement "digital bonus programs". These programs

can incentivise positive health behaviours, particularly walking. In addition, Yas Life's app B2C offers a rewards program where individuals receive points and prizes based on daily step count and completed activities ('Bonusprogramm', n.d.).

Techniker Krankenkasse in Germany offers a bonus program TK-Fit. For walking at least 10,000 steps per week for 10 weeks within a 12 week period, participants receive bonus points ('Die TK-Fit Challenge', 2021). When combined with additional health measures, can be swapped into a yearly dividend ('Die TK-Fit Challenge', 2021).

Lighting in pedestrian spaces

Any initiative to increase walking must consider pedestrian scale lighting. Street-level lighting has been built for and around vehicles, often disregarding pedestrian needs and comfort.

Pedestrian scale lighting serves four general purposes:

- To aid in both actual and perceived safety.
- Assisting orientation and wayfinding in the dark.
- Ensuring pedestrian comfort at night.
- Increasing attractiveness of public spaces.

Pedestrians feel safer in spaces with adequate lighting and, critically, crime rates tend to be lower in spaces with improved street lighting (R. Clarke, 2008; Fotios & Castleton, 2016). Lighting is especially important at night, in places with limited winter daylight, and while navigating around obstacles and along journeys (Rahm & Johansson, 2018). Adequate pedestrian lighting in public spaces and high traffic areas is critical to motivating more walking journeys (Rahm & Johansson, 2018). When considering pedestrian scale lighting, policymakers should improve the lighting system's efficiency and environmental impact so that the cost of the lighting does not outweigh the benefit of increased foot traffic.

Some strategies to maximise efficiency include:

- careful planning to ensure adequate lighting without producing *too much* light. Considerations for appropriate spacing and coverage should be made for maximum efficiency
- Using the most efficient lighting solutions (LED or LPS lights, solar powered lights, etc.).
- Using dark sky friendly lights to minimise light pollution beyond what is strictly necessary (*3.6 Street and Pedestrian Lighting*, 2017; *Lighting Use & Design*, 2008; 'Outdoor Lighting Basics', n.d.).

By understanding pedestrian needs and utilising the most efficient lighting solution for each situation, cities can motivate walking, increase the attractiveness of their public spaces, and respect environmental concerns.

Pedestrian lighting examples

Bradford, UK, as part of a goal to become carbon neutral by 2038, is replacing inefficient streetlights with more efficient, environmentally friendly lights. Bradford plans to replace 59,000 lanterns and 17,000 lampposts while modernising the system to maximise energy efficiency. By replacing outdated lights with LED lights, Bradford aims to save more than two million GBP (2,315,394 EUR) in annual energy costs and reduce annual carbon emissions by 6000 tonnes (*The Smart Street Lighting Project*, 2022). The lights will provide more specific energy consumption data, allowing for more targeted decision making and greater long run efficiency, in addition to the on-street benefits of improved lighting.

In 2011, Oslo, Norway implemented an innovative plan to retrofit and replace streetlights with more energy efficient options. The plan would reduce energy demand and carbon emissions. New, high efficiency lights featured data collection and communications systems that allow the city to control the light level as efficiently as possible ('Oslo, Norway's Street Lighting Retrofit', 2020). The city can specifically tailor each lamp's light level to the lamp's location and the weather conditions via the communication system. Operators can also see which lamps are malfunctioning or burnt out. This system is estimated to increase efficiency by 30%, in addition to the new lamp's energy savings. The change will yield a total energy demand reduction of 70% compared to the old system. Observers praise the ability to adjust lighting levels relative to demand and location as an innovative and environmentally friendly solution to safety concerns (Mjøs, 2007). Light levels can increase when needed to improve safety outcomes, and dimmed when not necessary to reduce energy demand and light pollution (Mjøs, 2007).

Strasbourg, France has won multiple awards for its work in creating pedestrian-friendly spaces over the last decade. The municipality focused on pedestrian-friendly lighting. For example, Strasbourg implemented smart pedestrian lights with a motion sensor that detects motion 35m away and controls the intensity of the light. Toulouse, Marseille, Paris, Lyon and Montpellier have implemented similar systems. These systems save up to 70% in energy requirements. A busy pedestrian underpass, where more than 400 cyclists and 50 pedestrians transit per hour on a weekday, provide a further example. In 2018, Strasbourg held a competition to redesign the underpass' lighting. The winning project embeds solar studs in the road leading to the tunnel, and uses a motion sensor to control the lighting in the underpass (*Strasbourg – lighting spaces of transition*, 2018). The studs display "intersecting colourful blades of light" with an EU-flag colour scheme, given Strasbourg's importance in the European Union (*Strasbourg – lighting spaces of transition*, 2018).

The city of short distances

Distances largely choose the mode of transport. In car-centred cities, distances between homes, essential services, green spaces or employment opportunities do not play a major role. Instead, policymakers focus on facilitating transport routes. This focus entrenches unsustainable practices, high commuting times, reduced air quality, and higher CO_2 emissions.

A ”city of short distances”, or “compact city”, provides an alternative to the car centred city, with its long distances and high transit times. “Compact cities” deliver a complex space of mixed functions, with the goal of reducing the demand for transport. Moreno proposed the 15 Minute City, which seeks to pivot city design towards a mode of urban planning that emphasises accessibility and multimodality. Major services are within a 15-minute walk, transit ride, or cycle. The key dimensions of a 15 Minute City are: density, proximity, diversity, and digitalisation. The 15 Minute City may be achieved through increased mixed-use housing models, which combine living spaces with office spaces, shops, health practices, and other essential services (Moreno et al., 2021). Available green spaces within 15 minutes walking distance are also essential for recreation.

Policymakers can apply the 15-Minute City can be applied at three different levels:

- a five-minute walk;
- a 15-minute walk, and
- a 15-minute bike ride.

Daily needs and small businesses should be within the first band (Duany & Steuteville, 2021). Full mixed-use buildings, parks, schools, and at least one regional transit stop should be within the second band (Duany & Steuteville, 2021). The third band should contain higher education, cultural, and medical facilities (Duany & Steuteville, 2021). Policymakers must consider population density when assuming the services that each band can feasibly support (Duany & Steuteville, 2021). These recommendations assume an average density of at least 8 living spaces per acre, with 2,600 people within the first band (± 20%).

Implementing a 15-Minute City must confront ingrained dependency. Existing cities are the result of car-based urban planning or a lack of any comprehensive planning. The 15-Minute City is more a flexible development process than the existing model. The more basic services that a city can provide within the 15 minutes walking distance, the more walking or cycling will increase. Some of this change will replace carbon intensive modes of transport.

Implementation of the 15-Minute City design can occur in two general phases:

- In the short term, instead of completely overhauling existing infrastructure, policymakers can incentivise necessary services within the 15-Minute walking circle. For example, policymakers could reduce rent for doctors' offices in areas which currently do not have a doctor in the neighbourhood. Other short-term approaches to implementing 15-Minute City ideals include turning schoolyards into public parks when schools are closed or offering preferential treatment to small shops or bakeries.
- In the long term, policymakers can implement the 15-Minute City through targeted urban planning and design. These designs can renew current spaces and build new ones.

Cities can become more resilient, build community hubs around close-knit neighbourhoods, increase health and quality of life, and decrease energy demand, emissions, and congestion (Palti & Bar, 2015).

City of short distances examples

In 2019 Paris, France set several targets aimed at establishing a 15-Minute City. Mayor Anne Hidalgo promoted this target by appointing a commissioner for the 15-minute city. The mayor banned high-polluting vehicles, created pedestrian and cyclist-only highways within the city, and created public green spaces in school yards. Other cities (notably Madrid, Milan, Ottawa, and Seattle) declared or adopted plans based on the Paris reforms (Yeung, 2021).

The Mayor Lopez of Bogota, Colombia announced the implementation of a 15 and 30-Minute City strategy in 30 neighbourhoods (Laverde, 2020). Specific actions taken include: developing "green corridors'' for cyclists and pedestrians, reclaiming public space for greening and community building, and encouraging mixed-use buildings (Puentes, 2020).

C40 Cities, a coalition of cities focused on fighting climate change proposed the 15-minute city as a pathway for sustainable development and recovery post-Covid-19 recovery (*Prioritising Cyclists and Pedestrians for a Safer, Stronger Recovery*, 2020). C40 Cities released a guidebook for implementing the 15-minute city plan with a specific focus on sustainability. The guide included the ten key approaches:

- the "complete neighbourhood" concept,
- people centred mobility,
- connected and digitalised spaces,
- ensuring space for everyone,
- green construction,
- green buildings,
- circular use of resources,
- green solutions,
- sustainable lifestyle promotion, and
- building a green local economy.

CLIMATE ANALYTICS