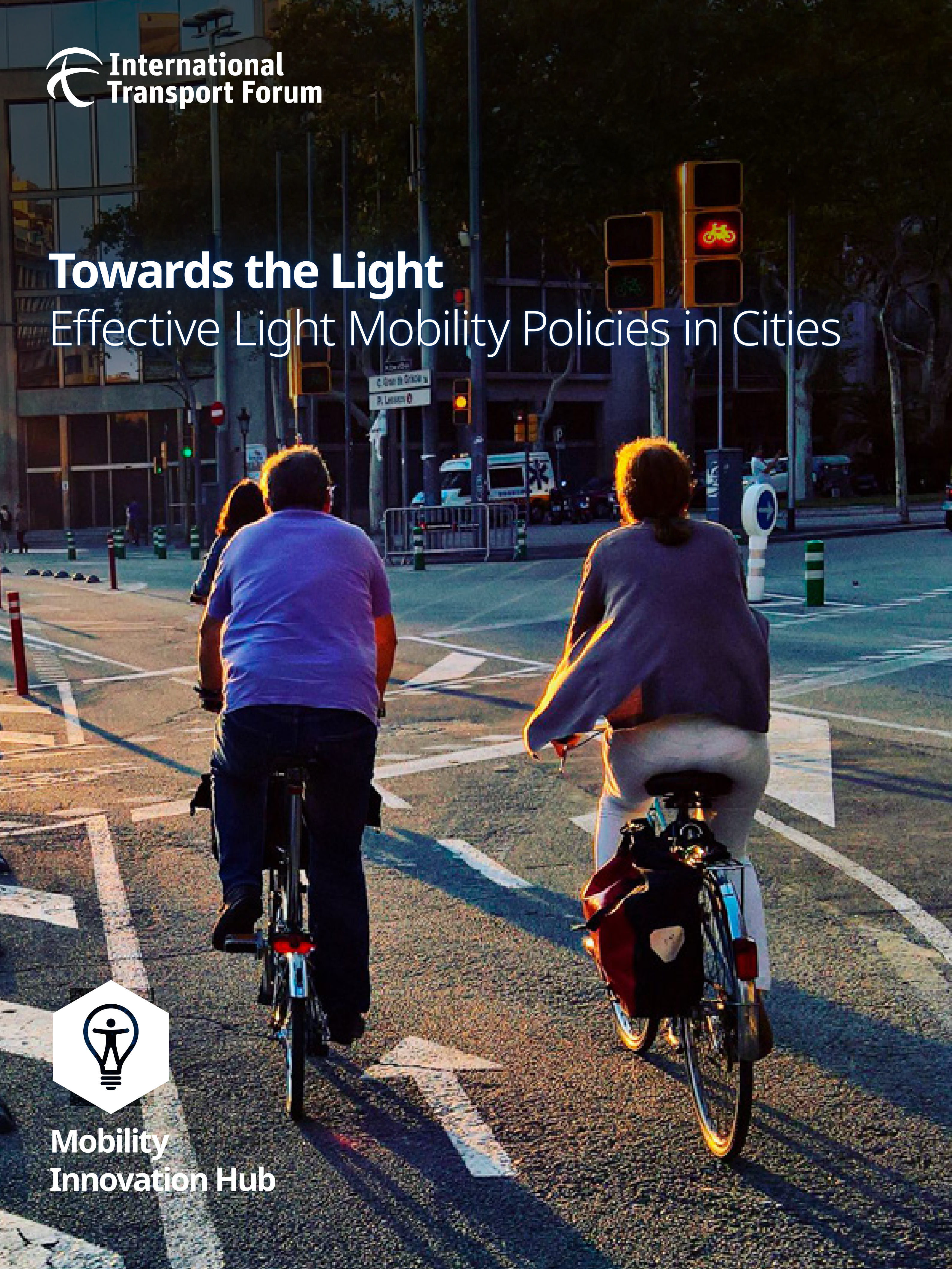
International Transport Forum

Towards the Light

Effective Light Mobility Policies in Cities



Mobility Innovation Hub

International Transport Forum

Towards the Light

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The International Transport Forum

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About the ITF Mobility Innovation Hub

ITF's Mobility Innovation Hub helps governments to develop innovative policies for better transport in the face of uncertainty and rapid change. It scans for transport-relevant developments at the horizon of public authority foresight, assesses their potential impacts and highlights best practices for deploying effective policies.

Case-Specific Policy Analysis Reports

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Abbreviations and acronyms

ABS	antilock braking system
CHIP	Cycle Highways Innovation for smarter People (planning project)
CO2eq	carbon dioxide equivalent
EU	European Union
GHG	greenhouse gas
HEAT	Health and Equity Assessment
HIA	health impact assessment (HIA)
ITF	International Transport Forum
kg	kilogram
kW	kilowatt
kWh	kilowatt-hour
km	kilometre
PATH	Partnership for Active Travel and Health (framework)
SUV	sports utility vehicle
UNECE	United Nations Economic Commission for Europe

Executive summary

What we did

This report explores how traffic systems and infrastructure can be redesigned and expanded for a broader range of vehicle types, especially "smaller-than-car" or light mobility options. It identifies the potential benefits of making vehicles lighter and diversifying the range of vehicles used for everyday mobility. It also highlights successful policies for encouraging a shift towards urban light mobility in cities. Finally, it presents strategies for implementing frameworks for such policies and highlights measures decision makers should consider as part of their light mobility strategy.

What we found

Over the past century, urban road systems have undergone simplification and convergence around a small group of large and fast vehicles: cars, vans, and trucks. Roads and streets were designed for these vehicles, and cities were adapted, built and expanded with them in mind. As a result, large, motorised vehicles have become omnipresent in urban spaces; and as society has integrated them into daily life, they, in turn, have changed society.

Much of the discourse around transitioning urban transport fleets assumes that the range of vehicles will remain essentially the same but that these will instead be powered and used in new, more sustainable ways. This discussion rarely extends into diversifying the range of vehicles used for everyday mobility. Effective policies to encourage light mobility can help reduce the well-recognised negative impacts of car-centric development on safety, public health, the environment and social equity without compromising access to opportunities and essential services.

Transformations are complex and deep leverage points that allow for a small shift in one thing to produce more significant changes everywhere else are needed to achieve sustainable transformations. Successfully greening transport requires aligning national, regional and local policy aims to ensure that they pull in the same direction and do not undermine one another. Effective, evidence-based communication strategies serve to inform the population and policy makers at all levels of the need for these changes.

Framing and implementing effective, coherent light mobility policies requires addressing the context of and attitudes related to mobility decision-making and behaviour. The PATH framework provides a comprehensive approach to create an environment that allows users of light mobility to travel around the city in a safe, useful and enjoyable manner based on five pillars: land use planning, infrastructure, integration with collective transport, capacity building and communication campaigns.

What we recommend

Seize the day! Take advantage of windows of opportunity to enact changes and set new goals.

When windows of opportunity arise, policy makers must be decisive in seizing them. They should take advantage of the momentum to change the mindset from which the current system arose and set new goals. To do so entails a high level of preparation and a clear vision of the direction the transport system should take.

Line up! Align policies for promoting light mobility at the national, regional and local levels.

Overcoming car-centric mobility requires aligned changes at all levels of government. National and regional decision makers should set the stage with adequate funding and robust governance structures that allow local policy makers to introduce targeted measures that meet local needs.

Measure up! Assess potential interventions in support of light mobility and monitor and evaluate implemented policies to demonstrate impact.

Policies should be target-oriented and specific, with clear definitions and goals to make them measurable. Monitoring and evaluating the impact of interventions to increase the share of light mobility will help to achieve targets, stay within timelines and optimise resource use under budgetary constraints. Performance metrics also ensure transparency and support effective stakeholder communication.

Get going! Improve walking conditions and local connectivity for improved access to opportunities.

The core of any light mobility policy is pedestrians' safety, comfort and convenience. A greater diversity of vehicle types should not come at the expense of those who choose to walk. Improving walking conditions and changing land-use so they prioritise local connectivity and access to workplaces, shops, leisure locations and other opportunities is critical to fomenting light mobility.

Go faster! Develop high-quality light mobility infrastructure for safe interactions with other traffic.

Light vehicles generally allow people to move faster than on foot. This expands their geographic reach and reduces travel times. That said, a greater variety of vehicles with different properties and speeds increases the likelihood of collisions and crashes. The infrastructure for light mobility should therefore prioritise the safety of the most vulnerable and exposed users in interactions with faster and bigger vehicles. It should be safe (ensuring the health and safety of its users), cohesive (connected and providing its users with a link between all potential origins and destinations in a city and beyond), direct (minimising any detours while travelling by allowing users to travel as directly as possible), comfortable (free of the bottlenecks, nuisances or shortcomings that might otherwise force its users to exert additional effort – such as slopes, uneven surfaces and excessive stopping) and attractive (making it enjoyable to use to increase the likelihood of it being used) for all users.

Go further! Integrate collective transport, pedestrian spaces and light mobility infrastructure.

In large cities, accessing important destinations often requires travelling long distances at relatively high speeds. To ensure that access is maintained while still encouraging more people to opt to move lightly, urban transport systems should promote the use of collective transport for longer trips while providing the space to travel lightly for shorter distances. Ensuring an effective integration of walking infrastructure, light mobility options, and the city's public transport system are vital to ensuring that accessibility is maintained while still encouraging more people to opt to move lightly through cities.

Bring everyone along! Use communication campaigns and education programmes to inspire a change in attitudes and mobility behaviour.

Changing an engrained transport system requires that its users understand the new approach and have an opportunity to explore it. Targeted communication, educational programmes and capacity-building initiatives can change attitudes towards mobility. Such behavioural strategy should encompass education for children, capacity building for transport experts and policy makers, and training for road users.

Light mobility: What is it and why does it matter?

Over the past century, urban road traffic systems have undergone simplification and convergence around a small group of large and fast vehicle types – cars, vans and trucks. Roads and streets were designed for these vehicles, and cities were adapted and built with them in mind. These large vehicles have become omnipresent in urban space, and as society has integrated them into daily life, they, in turn, have changed society. This simplification, convergence and embeddedness is the hallmark of past transport technology revolutions – indeed, of all technology revolutions. But is *"large and fast"* uniformly fit for purpose across diverse and dynamic cities and towns? And as with prior transport revolutions, will the one that marked a century of increasing motorisation run its course? If so, what socio-technical system will supplant the current one?

The answer is complex and will extend into several domains – including digitalisation, artificial intelligence, shifts in work and travel patterns, new mobility offers and electrification. But much of the discourse around the transport transition assumes that the range of vehicles upon which people depend to move will remain essentially unchanged. Rather than rethinking and reimagining how and why vehicles are used and what vehicles could be used to meet the needs and desires that drive mobility, the focus has been on transitioning how existing vehicle types will be powered to increase their sustainability. The discussion rarely extends into changing vehicle form-factors and diversifying the range of vehicles used for everyday mobility. This is the focus of this report: redesigning and expanding traffic systems and infrastructure to accommodate a much wider range of vehicle types – especially "smaller-than-car" or light mobility options.

The status quo and how light mobility fits in

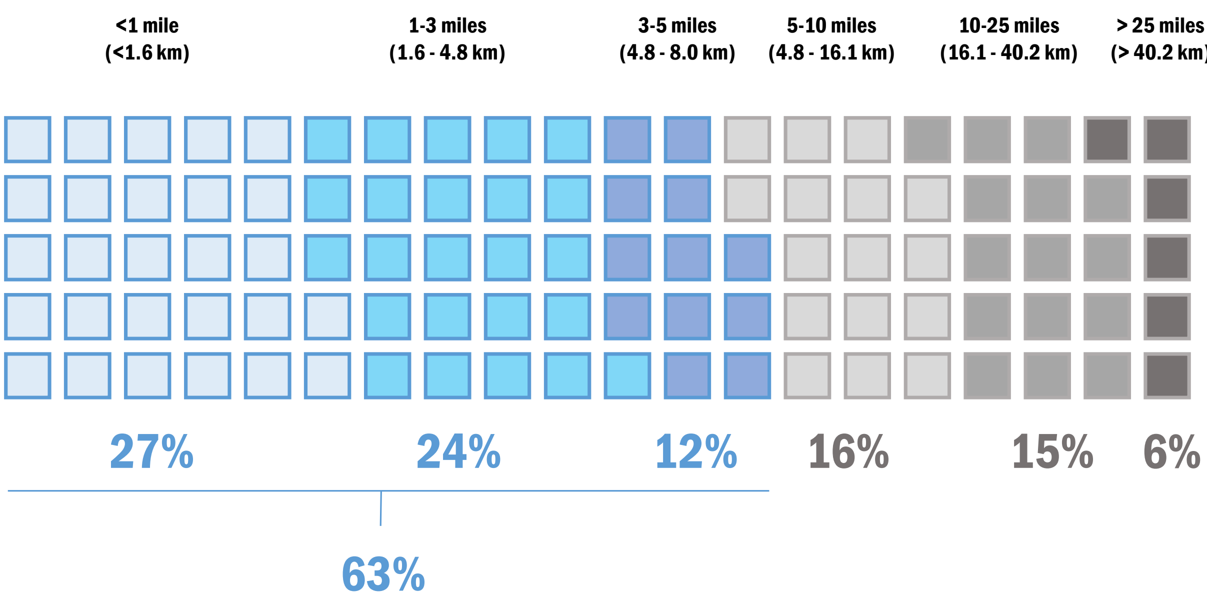
Roads and streets help people and goods access opportunities and destinations that are not adjacent. They are foundational infrastructure in that they are necessary in order for people to live fulfilled lives. They form essential public spaces and help structure urban forms and functions. But they are rarely explicitly designed for *people* or a wide *diversity* of uses (International Transport Forum, 2022a). Their design, specification and construction have concerned a small set of motorised vehicles – cars, vans, powered two-wheelers (e.g., motorcycles), buses and trucks – to the detriment of other vehicles and uses. This is partly understandable; the benefits conferred by these vehicles are significant for the people and companies using them, but because of the danger they pose to other road users due to their mass and speed, segregating and simplifying traffic spaces and prioritising these vehicles allowed societies to extract more value from this activity. However, the large-scale uptake of these vehicles has also generated significant and increasingly untenable burdens on societies and even on the drivers of these vehicles themselves. These include an ever-growing contribution to global greenhouse gas emissions and climate de-stabilisation, millions of deaths and injuries and significant economic costs stemming from traffic congestion (International Transport Forum, 2023a).

Vehicles represent a significant capital investment on the part of individuals and companies. Purchasing or leasing a vehicle is a consequential decision rarely guided only by rational utilitarian choices. While aspects such as cost, availability of finance, safety (for occupants), range (especially for electric vehicles) and capacity all feature in people's acquisition decisions, other affective and emotional factors are also largely present (Austmann, 2021; Cui et al., 2021; Degirmenci and Breitner, 2017; Higueras-Castillo et al., 2021; Jansson et al., 2017; Mandys, 2021; Reina Paz and Rodríguez Vargas, 2023).

Against this complex decision-making background, two critical and often unaddressed factors also weigh heavily on buying and using vehicles. First, all purchase and use decisions implicitly relate to an existing built context and traffic environment. Purchasing a large car would make little sense in a world where only bike paths exist. Likewise, many consumers would implicitly view purchasing a small and slower vehicle as inherently unsafe in a world where the traffic environment favours large and fast vehicles. Beyond the traffic environment itself, when the entire *system of provision* for mobility centres on facilitating one type of vehicle family and its use, it makes little sense for people to deviate from those vehicle choices (Mattioli et al., 2020).

The second typically unspoken factor is that people make vehicle purchase decisions based on relatively infrequent but still valued outlier trip profiles and not on average trips or typical usage. This factor most typically relates to decisions on vehicle capacity, speed and range. While global contexts vary, cars usually carry far fewer occupants than they are designed for and, in many cases, only carry the driver. Likewise, they are designed to carry or tow loads that are rarely, if ever, hauled. Furthermore, they are designed to operate at high speeds – though, in practice, traffic congestion and street design mean that where and when much urban car traffic takes place, car travel speeds are significantly lower and, in many contexts, are roughly the same or slower than public transport and electric bicycles (INRIX, 2023; International Transport Forum, 2023b).

Figure 1. 2022 Distribution of trips in the United States, by travel distance



Note: Only includes trips with a before or after dwell time of more than 10 minutes.
Source: US DoT (2023).

Cars are also designed for long-distance travel. The driving range between refuelling or recharging, while an acute concern in electric car purchase decisions, is less of a concern for fossil fuel vehicles because of the vast network of fuel stations. Nonetheless, most trips – especially in urban settings – are less than

8-10 kilometres, a distance easily travelled by bicycle or e-bike. For instance, 63% of all trips in the United States are less than eight kilometres long, and over a quarter are less than 1.6 kilometres long (1 mile). Still, the car remains the dominant mode of transport used for those trips (see Figure 1).

What is light mobility?

Mobility refers to the potential to freely move or be moved from one place to another (ELTIS, 2019; McKay J., 2019). This ability can refer to how this movement is enabled – e.g., *active mobility* refers to the potential to move oneself using one's own power. Similarly, *light mobility* refers to the ability to get around using smaller and lighter means than cars. Mobility is enabled by a wide range of vehicles and other means, but only some of these are addressed in national and international standard-setting and vehicle homologation bodies.

First among these bodies is Working Party 29 (WP.29) of the UNECE World Forum for Harmonization of Vehicle Regulations. This body establishes global technical regulations for wheeled vehicles to ensure safety, energy efficiency and environmental protection. The vehicle taxonomy WP.29 sets out in its 2023 "Consolidated Resolution on the Construction of Vehicles (R.E.3)" focuses on defining vehicle categories based on vehicle characteristics, including the number of wheels, weight, dimensions and power (UNECE WP 29, 2023).

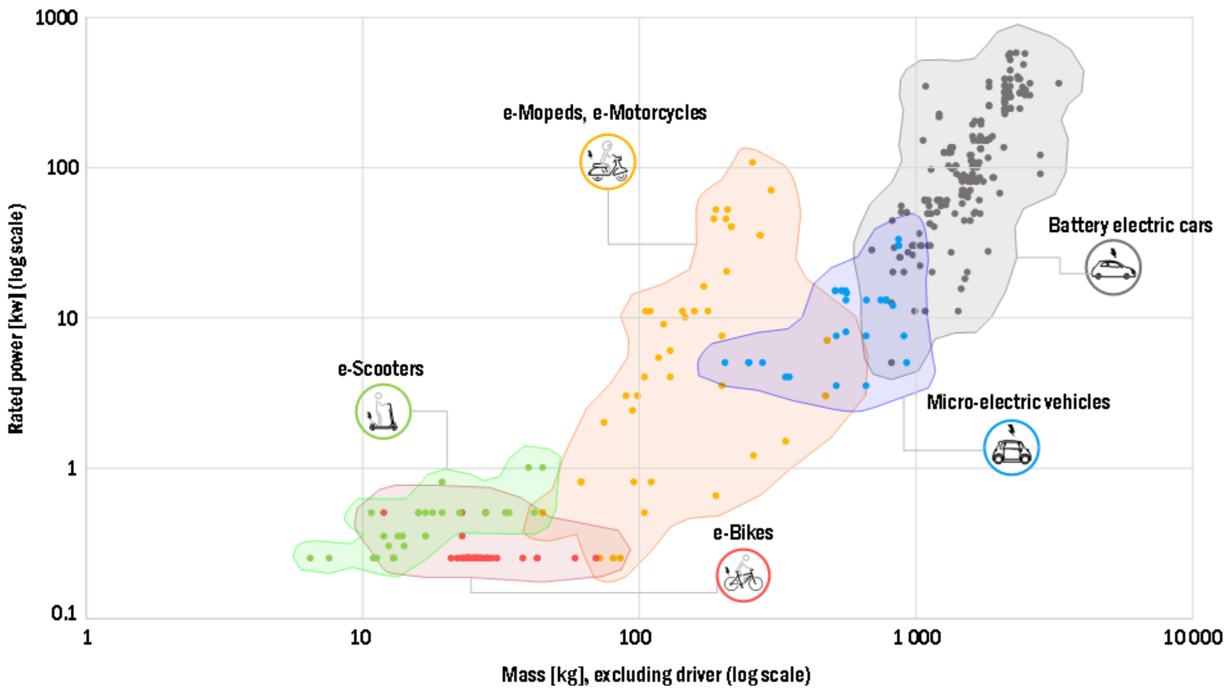
Category "L" vehicles in WP.29's taxonomy describes seven classes of vehicles with less than four wheels. These tend to be smaller vehicles and include motorcycles, powered tricycles and light quadricycles. The upper end of the Category L spectrum comprises larger powered quadricycles. L6 quadricycles have a maximum mass of 350 kg (not including the weight of batteries for electric vehicles), a top speed of 45 km/h and an engine cylinder capacity of no more than 50 cm^3 for internal combustion engines or a maximum net power output of no less than 4 kW. L7 quadricycles have an unladen mass (excluded the mass of batteries for electric vehicles) of no more than 400 kg (500 kg for goods-carrying vehicles) and a maximum continuous power rating of no more than 15 kW. Most countries have enacted regulations regarding Category L vehicles – especially for powered mopeds and motorcycles. Some have also established regulations for larger (L6 and L7) quadricycles with respect to their weight and top operating speeds, including the United States (where they are classed as *"Low-speed vehicles"* or *"Neighborhood Electric Vehicles"),* France (where they are classed as *"Voitures sans permis"– license-free vehicles*), Korea and China.

The UNECE taxonomy also includes Category "M" vehicles. These are larger, powered vehicles having at least four wheels and used for the carriage of passengers. Category M includes what are commonly considered cars or light vans.

Although these vehicle classes roughly cover many of the vehicles that comprise light mobility, they gloss over significant differences at the lower and higher ends of the spectrum. For instance, e-kick scooters, bicycles and pedelecs (e-bikes whose motor assistance cuts out at 25 km/h) are not included in the taxonomy or its transposition into EU vehicle categories (EU, 2013). At the other end of the spectrum, larger and heavier Category L6 and L7 vehicles, including micro-electric vehicles such as the Citroen Ami quadricycle (6kW of power output, 45 km/h top speed and weighing 485 kg), have more in common with microcars in the "car-like" M category such as the Wuling Mini electric vehicle (20kW of power output, 100 km/h top speed and weighing 665 kg) than the latter has with other small M-class electric cars such as the Smart EQ fortwo – 17.6 kWh battery (60kW of power output, 130 km/h top speed and 1 095 kg) or the Fiat 500e – 24 kWh battery (70kw of power output, 135 km/h top speed and 1 255 kg).

In fact, looking across a wide range of electric vehicles, significant overlap emerges between different types of vehicle families (Figure 2). From a broad policy and street design perspective, *"smaller than car"* light mobility covers vehicles that are not included in the UNECE classification Category L class and should extend to some of the smallest microcars currently included in the car-like Category M class).

Figure 2. Small to car-sized electric vehicles, by rated power and weight (n=428)



Source: ITF based on data from Weiss et al. (2020).

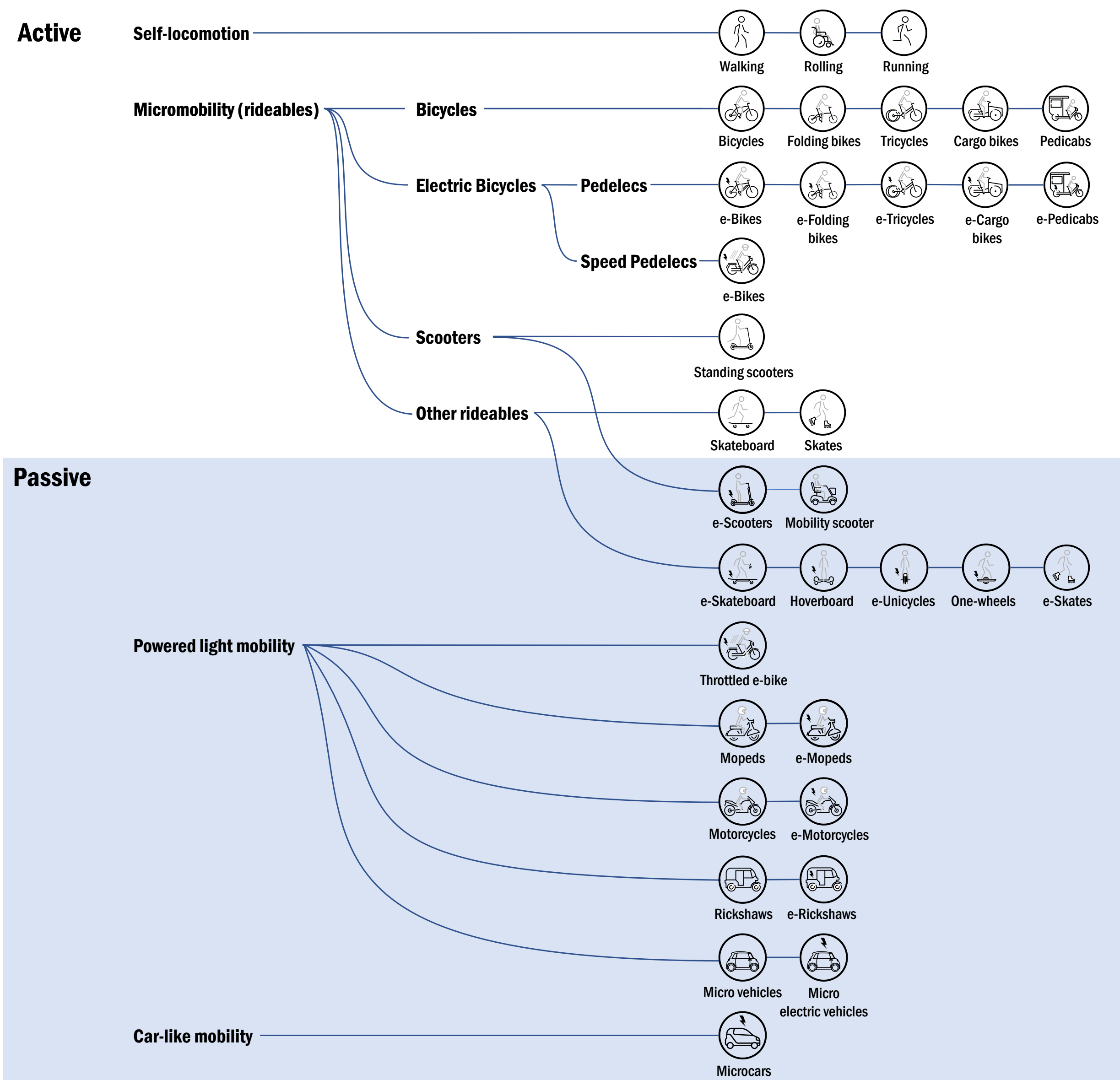
Specifically, the space between Category L6 and L7 micro-vehicles/quadricycles and the smaller end of the size and weight range of Category M1 vehicles is an unmapped part of the light mobility spectrum. Some national classification systems address this missing gap. For instance, Japanese vehicle classification regulations include the *Keijidosha* or *Kei* class for vehicles measuring no more than 3.4 metres long, 1.48 metres wide and 2 metres high with a maximum power of 47 kW. In this report, the term *microcar* describes the smallest Category M1 vehicles weighing less than approximately 1 000 kg.

The ITF has established a taxonomy of new mobility services and vehicles (International Transport Forum, 2023c) that serves as the basis for a broader mapping of what comprises light mobility. The current report proposes a comprehensive overview of the entire light mobility landscape building on this existing framework (Figure 3). This landscape and its categorisation are not meant to replace formal technical specifications and regulations concerning different vehicle types but, rather, aim to help sketch a policy- and street-design-relevant taxonomy of light mobility.

This overview is broader than other vehicle classification systems in that it covers the full spectrum of "smaller-than-car" means of mobility, including those requiring no vehicle or no powered vehicles. The overview also differentiates between active and passive forms of light mobility. *Active travel* is "travel in which the sustained physical exertion of the traveller directly contributes to their motion" (Cook et al., 2022). Physical exertion is a critical policy-relevant differentiator between travel modes since active travel confers important individual and societal benefits linked to maintained and improved health that are not shared by other, more sedentary travel modes (International Transport Forum, 2023b).

Walking, wheelchairing, and other forms of self-locomotion are at the top of the classification. They represent the lightest form of light mobility and comprise the basis for most people's daily mobility patterns.

Figure 3.The Light Mobility Landscape



Note: A *pedelec* e-bike offers pedal assistance up to approximately 25 km/h, a *speed pedelec* up to 45 km/h, and a *throttled e-bike* provides direct power to the motor without needing to pedal. In this report, a *micro (electric) vehicle* is a large Category L quadricycle (L6 and L7), whereas a *microcar* is a small Category M1 vehicle weighing less than approximately 1 000 kg.
Source: Based on International Transport Forum (2023b).

Micromobility forms the second broad component of active travel options in the light mobility landscape. Previous ITF work has established a safety-oriented micromobility taxonomy based on *speed and mass* (International Transport Forum, 2020). This classification is based on various micromobility vehicle types (or “rideables”), as outlined in International Transport Forum (2022a, 2023b).

Bicycle-like vehicles display a wide range of specific form factors, such as city, mountain, racing, folding, tricycle and cargo bikes. These can all be equipped with electric-assist motors and batteries, thus transforming them into electric-assisted bicycles (or pedelecs) where the motor assists up to a specific speed (25km/h in Europe) while the rider actively pedals. The cut-off speed is higher (45km/h in Europe) for speed pedelecs.

Scooters (push-scooters or kick-scooters) form another critical part of the broad micromobility family. However, when powered by an electric motor, these vehicles switch into the “passive” mobility category – requiring no continued physical input to move. Likewise, the “other” light rideables sub-category of vehicles is split between vehicles requiring sustained physical input to move and those not.

Powered light mobility includes throttled e-bikes (electric “bicycles” which can go up to 45 km/h without any pedal input) as well as the entire range of UNECE Category L class vehicles, including micro-vehicles and micro-electric vehicles (L6 and L7 quadricycles).

The final light mobility category – “car-like” mobility – includes the smallest and lightest UNECE Category M1 vehicles, such as *Kei* cars and other very small urban M1 vehicles.

Benefits of light mobility

Light mobility confers significant benefits in three principal domains. These are the health benefits delivered by active light mobility; a range of environmental and energy efficiency benefits stemming from electrification, down-sizing and light-weighting of vehicles; and reduced space consumption due to smaller vehicle footprints. Light mobility may also contribute to quieter traffic environments (due to electrification, reduced speed and reduced vehicle mass), more social interactions (because there is less isolation of vehicle users from other street occupants), and more convivial and liveable public spaces. The following section explores the first three types of benefits (health, energy efficiency, and space consumption).

Health benefits from active light mobility

Although active travel positively correlates to multiple health endpoints, it also exposes people to risks that may erode some of the benefits of physical activity. These are principally related to crashes and physical trauma, and exposure to air pollution. On balance and on average, however, active travel’s positive contribution to good health is orders of magnitude greater than the negative health impacts of crashes and air pollution. This benefit is not uniformly distributed across populations, which has an incidence on equity consideration. Generally speaking, the balance of evidence on the distribution of the benefits of active travel indicates that active travel is healthy for all but may be less beneficial for many in certain contexts (Braun et al., 2023).

Insufficient physical activity and sedentarism – prolonged sitting in particular – are some of the most critical addressable risk factors for non-communicable diseases and poor mental health outcomes. Physical inactivity and excessive sitting increase the risk of obesity, coronary heart disease, stroke, hypertension, diabetes, cancer, osteoporosis, osteoarthritis, depression and dementia (International Transport Forum, 2013; Nikitara et al., 2021; World Health Organization, 2022a, 2022b). In 2016, approximately a quarter of all adults were insufficiently physically active; 27.5% engaged in less than 150 minutes of moderate physical activity per week (Guthold et al., 2018; World Health Organization, 2022b).

Active travel actively contributes to reducing health risks. Increased physical activity reduces poor health outcomes and premature death associated with low activity levels and attenuates the negative health impact of excessive sedentary activities and sitting time (Ekelund et al., 2016). Daily active travel is a cornerstone of physically active and healthy lives. The contribution of active travel to multiple health endpoints is extraordinarily robust and well-documented (De Hartog et al., 2010; Götschi et al., 2016; International Transport Forum, 2013; Lorenzo et al., 2020; Matthews et al., 2007; Mueller et al., 2015; Nieuwenhuijsen et al., 2016; Rabl and De Nazelle, 2012; Reiner et al., 2013; Rojas-Rueda, De Nazelle et al., 2011; Saunders et al., 2013; Vancampfort et al., 2018; Vogel et al., 2009; Wanjau et al., 2023; Wanner et al., 2012; Woodcock et al., 2011).

Recent evidence underscores that active travel improves mental health and cognitive function. Here too, the developing evidence supporting a correlation between active travel-induced physical activity and improved health outcomes is robust (Avila-Palencia et al., 2018; Fyhri et al., 2023; Humphreys et al., 2013; Knott et al., 2018; Martin et al., 2014; Singleton, 2019; Wild and Woodward, 2019).

The health improvement effect of active travel is conditioned by whether the physical activity incurred by travel substitutes is additional to other forms of physical activity (Möller et al., 2020). It is also not linear across most health endpoints, with the most significant health improvement experienced as people with sedentary or low-physical-activity lifestyles start increasing their levels of physical activity (De Nazelle et al., 2011; Hollingworth et al., 2015; International Transport Forum, 2013; Mueller et al., 2015; Rabl and De Nazelle, 2012; Rojas-Rueda et al., 2011; Saunders et al., 2013). Nonetheless, active travel also confers benefits to those already physically active. The overall contribution of active travel to health shifts from health improvement to maintenance of good health as levels of physical activity increase (Hollingworth et al., 2015).

The overall impact of active travel on health must account for some of the health risks associated with walking, cycling and other forms of active travel. These risks include exposure of travellers to air pollution – particularly fine particulate matter from fuel combustion and car brake-pad and tyre wear – and the risk of injuries or death due to crashes (International Transport Forum, 2013). Health impact assessments (HIAs) consistently show significantly positive health benefit-risk or benefit-cost ratios in favour of active travel (De Nazelle et al., 2011; Holm et al., 2012; Lindsay et al., 2011; Mela and Girardi, 2022; Mueller et al., 2015, 2018; Pérez et al., 2017; Rojas-Rueda et al., 2011; Rojas-Rueda et al., 2012, 2013; Woodcock et al., 2013; Woodcock et al. 2014).

The benefits of active travel go beyond the health benefits alone. An expansive cost-benefit exercise accounting for climate change, air pollution, noise, soil and water quality, land use and infrastructure, traffic infrastructure maintenance, material resource requirements, vehicle operation costs, travel time, congestion, health benefits, crashes, perceived safety and discomfort, and quality of life and tourism finds that walking and cycling generates a benefit of EUR 0.37 and EUR 0.18 per kilometre in the EU. Conversely, each kilometre driven by car in the EU imposes an external cost of EUR 0.11 (Gössling et al., 2019).

Light mobility: Environment, energy and CO_2 emission implications

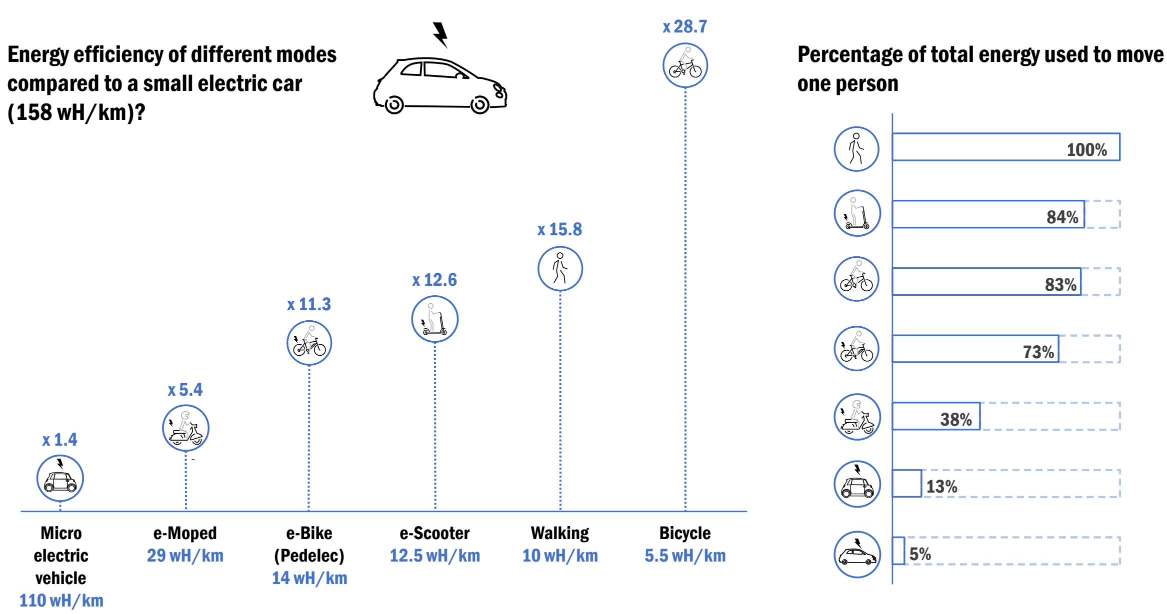
Light mobility is more efficient and uses fewer materials – and critical materials in particular – than cars (Brost et al., 2022). Cars are getting larger and heavier, especially as sports utility vehicles (SUVs) become more popular (ITF, 2017). In contrast, light mobility vehicles are, by definition, smaller and lighter than cars. Many of these are already electric, and the trend is for almost all of these vehicles to be electrified by 2050 (ITF, 2023a). These two factors result in considerably improved energy efficiency and environmental performance compared to cars – including electric cars.

Electrification relaxes many of the design constraints of internal combustion energy vehicles. Removing the need for a centralised and relatively large cylinder block, crankshaft, and multi-speed transmission already removes significant weight. These weight savings are counter-balanced by the need to house a battery with enough capacity to move the vehicle and its payload over useful distances. However, the potential for multiple high-power and -torque electric motors placed in versatile arrangements, including directly in wheel hubs, enables numerous vehicle form factors, including many light mobility alternatives (Weiss et al., 2020). These form factors offer different sets of amenities than cars, but, as discussed previously, they provide plausible options for many shorter daily trips, including those currently taken by car. More fundamentally, light-weighting and downsizing allow light mobility to better "right-size" vehicles to specific trip requirements. The growing popularity of micromobility and other forms of light mobility suggests that many people are responsive to this benefit and may change their vehicle purchase and use behaviours to capitalise on it – even if only for second vehicle purchases.

Smaller size and lighter weight mean that light mobility is orders of magnitude more energy-efficient than even small electric cars (Figure 4). Walking and cycling are the most energy-efficient means of travel but have lower speeds than other modes. Nonetheless, actual travel speeds in core urban areas at peak times are generally low in many cities and fall within the range of light mobility vehicle speeds, except for walking and some other forms of powered rideables (INRIX, 2023; International Transport Forum, 2023b).

Energy efficiency ideally relates to useful work undertaken – in this case, moving the vehicle payload, which includes the people and other items carried on or in the vehicle. These factors can vary considerably, and larger vehicles' potential payload capacity is greater than that of smaller vehicles. Nonetheless, most trips in large vehicles are considerably below their maximum capacity (Héran and Sivert, 2022). In these cases, it makes sense to understand the ratio of energy used to move the vehicle payload versus just moving the vehicle itself. Figure 4 shows that, when considering one person as a benchmark payload, only 5% of the energy use of a small electric car goes to moving the occupant versus 95% of the energy used to carry the vehicle deadweight. Lighter vehicles such as e-scooters and bicycles display much more favourable ratios, with about 80% of the energy used to move the rider and only 20% used to move the vehicle.

Figure 4. Comparison of light mobility alternatives' energy efficiency



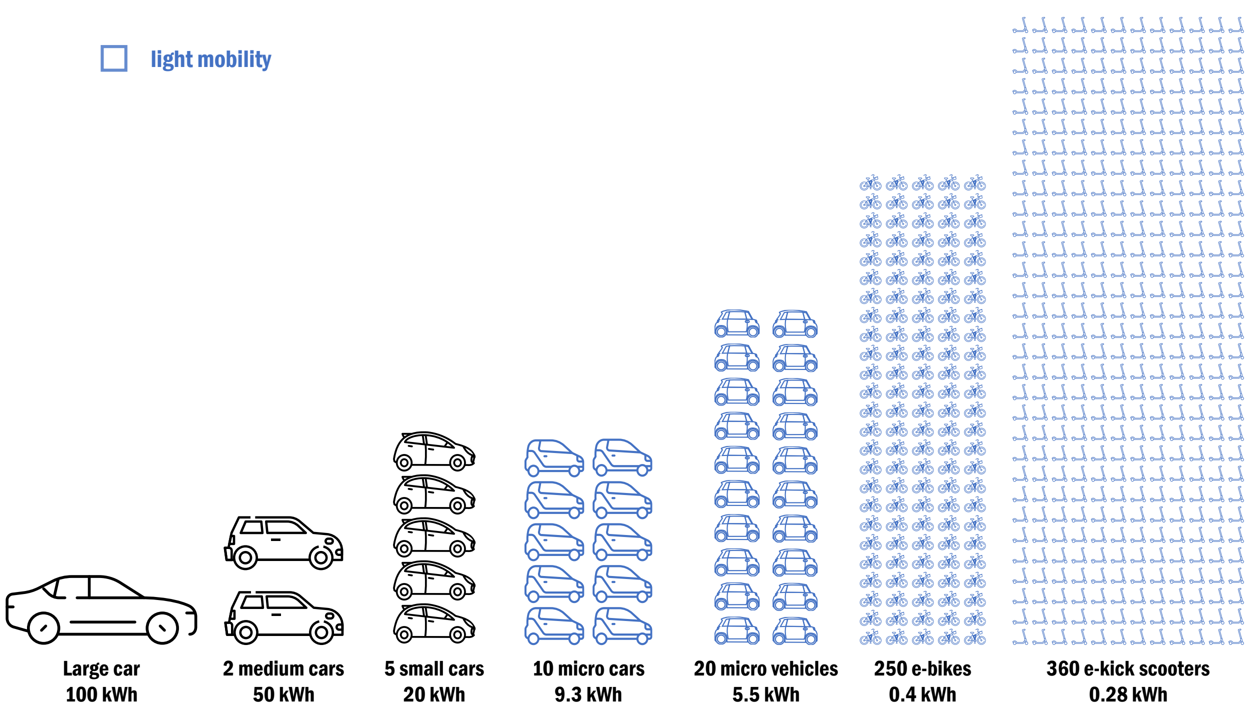
Source: ITF calculations and Héran and Sivert (2022).

Light mobility's energy, environmental and climate impacts extend beyond those stemming from using those vehicles and means of locomotion ("plug to wheel"). Full lifecycle impacts must account for the volume of energy demand (likely to grow with a move away from fossil sources of energy); the impacts of vehicle and battery production; and the upstream impacts of the generation, transmission and storage of electricity (Brost et al., 2022; International Transport Forum, 2017, International Transport Forum, 2020).

The production of batteries uses rare resources, requires energy and generates pollution. Electric-powered light mobility vehicles require smaller and lighter batteries; thus, their battery-related resource use and pollution impacts are lower than for larger electric vehicles. A 100 kWh battery used in a large electric vehicle corresponds to the battery needs for ten microcars, 20 micro-electric vehicles, and 250 to 360 e-bikes or e-scooters (Figure 5). Beyond the significantly reduced need for critical raw materials inherent in smaller batteries, their production entails far fewer CO_2 emissions since these increase proportionally with battery size and capacity. In Germany, for example, the production of a 0.4 kWh e-bike battery, a 10 kWh microcar battery and a 50 kWh electric car battery generates 40 kg, 900 kg and 4 500 kg of CO_2 equivalent emissions, respectively (Brost et al., 2022).

Lightweighting and downsizing vehicles can deliver significant climate benefits. Against a backdrop of ever-increasing light-duty vehicle weights (e.g. +40% over the past four decades in Europe), an approximate 30% reduction of light-duty vehicle mass would result in a near-doubling of expected CO_2 reductions from light-duty vehicles (-39% from 1990 levels by 2050 compared to -21% without mass-reduction) (ITF, 2017). These CO_2 emission reductions stem from mass reductions within one vehicle class – light-duty vehicles. As such, they only represent a partial estimate of the type of CO_2 emission reductions that could result from a broader uptake and shift to light mobility.

Figure 5. Number of car and light mobility vehicle batteries that can be produced instead of a 100 kWh large-car battery pack



Source: ITF calculations and Bigo (2022).

How much this broader shift to light mobility contributes to overall CO_2 emission reductions will depend on several factors. The first, as discussed above, is the energy efficiency of light mobility – including electric vehicles. The second factor, also discussed earlier, relates to the entire lifecycle of CO_2 emissions from electricity generation and transmission, as well as the lifecycle impacts of battery and vehicle production and disposal. Finally, overall travel distances covered by trips which can be switched to light mobility will determine overall light mobility CO_2 emissions.

A comprehensive assessment looking at these factors in Germany by Brost et al. (2022) found that a significant but plausible shift to light mobility (excluding walking and non-electric-assisted cycling and other forms of micromobility) would result in a 44% reduction in CO_{2eq} emissions from current car-related CO_{2eq} emissions (which represent 61% of current German transport emission). Approximately half of this emission reduction is due to a shift from cars to e-scooters and e-bikes, including pedelecs and speed pedelecs (19%). The remainder of the reductions derive from a switch from cars to microcars (14%) and e-mopeds and e-motorcycles (11%). Light mobility's distance-weighted average lifecycle CO_{2eq} emissions per kilometre were 24 g CO_{2eq}/km versus 203 g CO_{2eq}/km for the car travel it replaced – an 88% overall reduction. Overall, the shift to (electric) light mobility in Germany was projected to result in a yearly decrease of 57 million tonnes of CO_{2eq}.

Brost et al. (2022) estimate the light-mobility-for-car substitution potential to be high in Germany, though it is not evenly distributed among light mobility modes. On the low end, e-scooters could replace only 6% of all car trips and only 1% of overall car travel distances. Pedelecs and cargo pedelecs could replace 27% and 29% of all car trips and 9% and 10% of all car travel distances. On the high end of the substitution spectrum, micro-electric vehicles could replace between 65% and 75% of all car trips and 47% to 50% of all car kilometres travelled. According to the study, light electric mobility could replace 76% of all German car trips and 50% of all car kilometres. Of that distance travelled, 47% of substitutable car kilometres are projected to be in medium-sized towns, 23% in large and very large urban conurbations and 30% in small towns and villages.

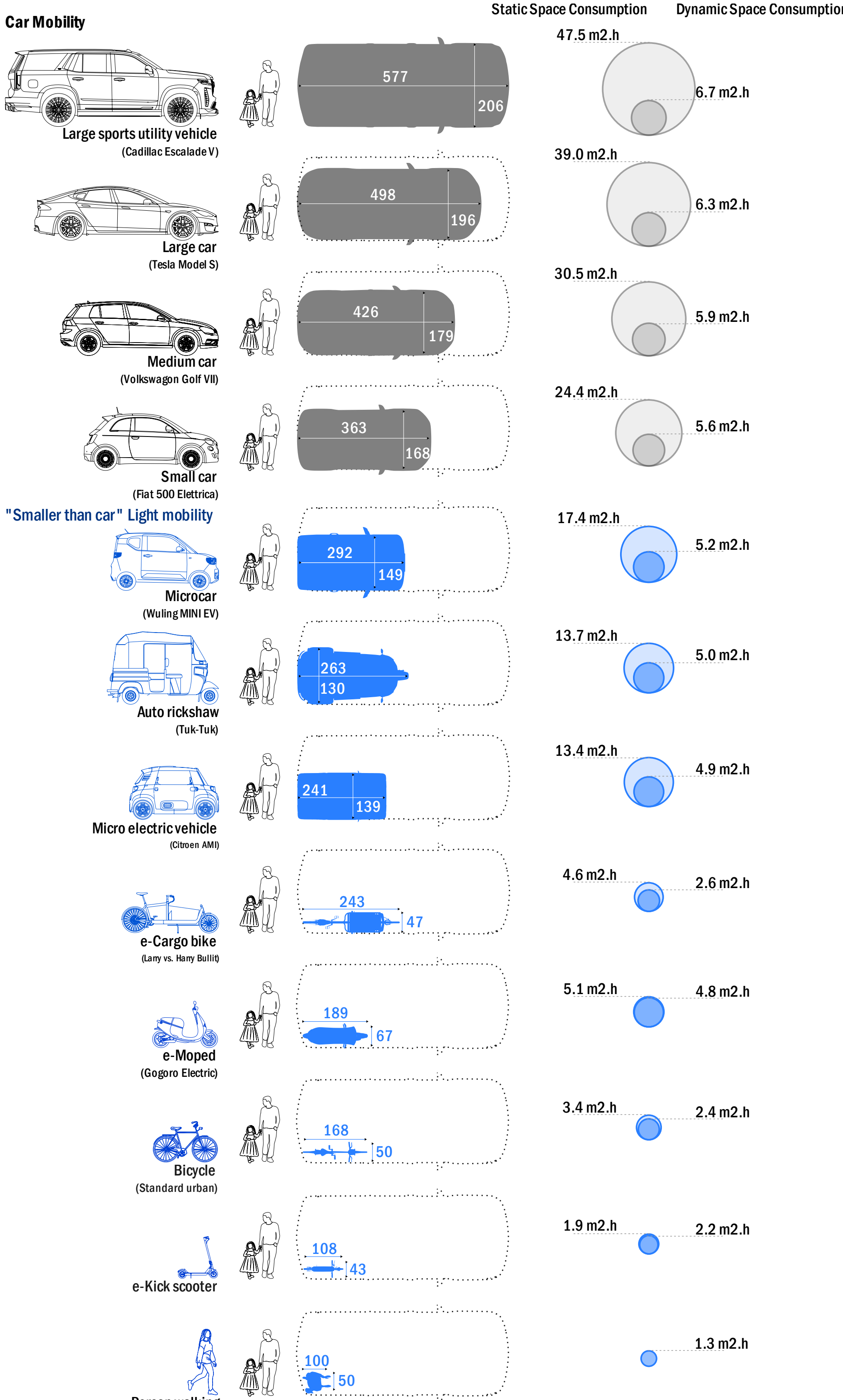
Recent modelling results from the International Transport Forum (2023c) show that light mobility would be better suited than larger motorised vehicles in a scenario where the entire vehicle fleet is electrified.

Light-mobility form factors require smaller battery capacities, reducing the need for raw materials to produce these batteries. Under a complete *vehicle electrification* scenario, where the electric transition fosters the uptake of smaller and shared modes, the fleet battery capacity would be reduced by 36% (40% for passenger transport and 10% for urban freight transport).

Furthermore, light mobility alternatives are more efficient than larger vehicles (consuming fewer kWh per passenger-kilometre and tonne-kilometre). Vehicles that maximize the ratio of load factor to vehicle capacity show better consumption performance. Therefore, transitioning to these vehicle forms would reduce the electricity consumption and demand needed to maintain the population's mobility needs and wants. A scenario where the electric transition reinforces the opportunity to promote the use of smaller and shared electric vehicles would require 14% less electricity demand than a *like-for-like complete vehicle electrification* scenario, where the electric transition is only based on the technology of the vehicle powertrain (International Transport Forum, 2023b).

Finally, light mobility alternatives are better suited for domestic charging, which would reduce the required public charging infrastructure. The findings show that a transition to electric light-mobility fleets could lessen the need for public electric charging by 33% when compared to a like-for-like complete vehicle electrification transition.

Figure 6. Dimensions, footprint and space consumption per person/trip of means of mobility



Notes: Vehicle dimensions from blueprints.com and ITF research. Estimates of dynamic space and static space consumption (m2.h) based on methodology detailed in ITF (2022). Dynamic space consumption calculated for travel at 22 km/h (average peak hour travel speed for urban cores in EU cities included in the 2023 Inrix traffic index) for all vehicles except e-mopeds (30 km/h), standard bicycles (18 km/h), e-kick scooters (15 km/h) and walking (4 km/h). The reference trip is a 2.5 km round trip with an 8-hour dwell time. Static space consumption accounts for vehicle footprint and not actual parking requirements. All calculations assume one person per vehicle.

Light Mobility: Space consumption

Urban space is a rare resource, and a significant share of it is dedicated to highly space-inefficient transport (ITF, 2018, 2021, 2022a, 2022b). Just as light-weighting and electrification can bring significant environmental and energy efficiency benefits, a shift to vehicles with smaller footprints can, all else held equal, free up urban and street space for other uses. This is important since the trend for heavier vehicles has also been accompanied by a tendency for larger vehicles. In Europe, for instance, car footprints have increased by approximately 18% from the 1960s to the 2010s. This trend has accelerated with the rapid uptake of larger SUVs, which now represent about 50% of all light-duty passenger vehicles sold in Europe (ACEA, 2023; International Transport Forum, 2022a).

Light mobility vehicles display much smaller vehicle footprints (Figure 6), both in their dynamic use of space (which is related to travel speeds, travel distance and vehicle size) and in the static use of space (a function of vehicle footprint, other space needed for parking and dwell time). The footprints of a microcar, a micro-electric vehicle, a bicycle and an e-kick-scooter are 36%, 28%, 7% and 4%, respectively, that of a large SUV and 75%, 54%, 24% and 8%, respectively, of a small electric car.

For a 2.5 km round trip and an eight-hour dwell time, an SUV consumes 101.9 m^2.h, a small electric car, 54.4 m^2.h, a microcar, 39.6 m^2.h, a micro-electric vehicle 31.3 m^2.h, a bicycle, 8.8 m^2.h and an e-scooter, 6.2 m^2.h per person (with all vehicles carrying one person). The space savings offered by light mobility rapidly aggregate into meaningful overall space savings, thus enabling new forms of space allocation. Previous work by the ITF looking to estimate space consumption impacts at the urban scale (but looking only at the uptake of a few classes of light mobility vehicles) estimated space savings of approximately 20% for a mid-sized city (International Transport Forum, 2022a). These are on the low side of what could be experienced with a broad-scale uptake of light mobility.

Findings from the International Transport Forum (2023c) indicate that a broad-scale uptake of electric vehicles, including emerging forms of smaller vehicles and shared services, supports more sustainable mobility outcomes. A complete electrification pathway where smaller vehicles and shared fleet services are at the heart of electric vehicle uptake takes up 34% less street space than one following like-for-like replacement of fossil-powered cars with battery-electric cars. However, the modelling also indicated a potential erosion of road safety if public authorities do not reallocate road space, deploy suitable light mobility infrastructure and implement proactive safety measures.

Adapting traffic environments for light mobility

A significant shift towards and uptake of light mobility will entail risks that must be managed. The most important of these risks relates to safety and the risk of crashes. Mixing lighter and slower travel modes in a traffic environment designed for and dominated by larger and faster vehicles increases both the risk of collisions and their severity. Some of these risks can be mitigated by ensuring high levels of passive and active safety measures – especially for vehicles on the larger and faster end of the light mobility spectrum, such as micro-electric vehicles and microcars (e.g., airbags and antilock braking system [ABS]). Smaller power-assisted wheeled vehicles, all the way down to e-push scooters, can also incorporate safety-improving technologies such as ABS braking. Overall, however, ensuring a safe transition towards greater use of light mobility will entail a more systematic re-think of how urban road environments are organised and which forms of traffic are prioritised in which contexts.

The Safe System approach

This re-organisation should follow sound safety principles like those which form the basis of the Safe System approach. The Safe System builds on the fundamental proposition that there is no acceptable level of fatalities or serious injuries due to road crashes. It assumes that, although human error is not only possible but likely, any person respecting the rules of the road should nonetheless have the expectation they should be safe from injury and death. This approach means that rather than making road users responsible for their safety in a sometimes inherently unsafe traffic system, all actors – especially those designing and maintaining the road environment and establishing rules for its use – bear a fundamental responsibility in delivering safety (International Transport Forum, 2022b). This has important implications for authorities' role in designing and managing traffic spaces for light mobility.

The Safe System builds on four fundamental principles (International Transport Forum, 2016, 2022b):

1. People make mistakes that can lead to crashes. The transport system needs to accommodate human error and unpredictability.
2. The human body has a known, limited physical ability to tolerate crash forces before harm occurs. The impact forces resulting from a collision must therefore be limited to prevent fatal or serious injury.
3. Individuals have a responsibility to act with care and within traffic laws. A shared responsibility exists with those who design, build, manage and use roads and vehicles to prevent crashes resulting in severe injury or death and to provide effective post-crash care.
4. All parts of the system must be strengthened in combination to multiply their effects and to ensure that road users are still protected if one part of the system fails.

Following the Safe System approach to road safety in the context of a significant increase in the use of light mobility will require substantial changes in the ways in which streets and traffic spaces are designed and managed – especially where the uptake of light mobility is expected to be most significant. It will require re-assessing which vehicles and road space users can safely mix, and in which contexts and at which speeds they can do so. It will similarly call into question how streets are designed and how street space is allocated to ensure safe outcomes. A fundamental move away from designing the entire traffic system for the sole use of large and fast vehicles, as has been the norm over the past century, will be required where a consensus exists to shift many trips to light mobility. More than just adding infrastructure and the piecemeal re-allocation of road space in a car-dominant traffic system, the safe large-scale uptake of light mobility will require adopting a new road-traffic design paradigm.

The "Good Street" framework

Previous ITF work on road space reallocation identified the "Good Street" framework as one that can guide policy and action in the transition to more light mobility (Immers et al., 2020; International Transport Forum, 2022). This framework was developed in the Netherlands based on decades of experience designing for mixed use of street space, especially the mixing of large and fast vehicles with bicycles and pedestrians. It expressly accounts for the increasing diversity of vehicle types and form factors, such as those characterising the whole light mobility spectrum. It incorporates the fundamental principles of the Safe System approach and outlines a vehicle-agnostic framework for establishing traffic space prioritisation and access rules based on design characteristics rather than on vehicle types. It does so by recognising that the use of street space for movement must be reconciled with other non-transport, but nonetheless valuable and meaningful, uses of that space. For all these reasons, the Good Street framework is well suited to provide the right framework conditions for a large-scale shift to light mobility.

The first principle of the Good Street framework is that effective speed limits depend on the design of public space, not on vehicle-specific regulations. In most traffic environments, space-specific speed limits are the norm for cars and other fast motorised users but not for all (e.g., bicycles, e-kick scooters, etc.). Furthermore, the design of many street environments does not incentivise users to respect the speed limit, thus increasing reliance on enforcement actions to ensure safe speeds. In practice, this means that vehicles of different mass often operate in the same street space at different speeds, leading to crashes, severe injuries and fatalities. In contrast to the status quo, the *Good Street* framework seeks to limit all vehicles (regardless of their achievable travel speeds) allowed to use the same public space to safe speeds principally by the design of the street environment rather than solely by enforcement. This approach recognises that speed management is the most critical yet invisible safety-enhancing "infrastructure".

The second Good Street principle addresses the need to determine which vehicles have access to which parts of the road network based first on mass and secondly by attainable speed. While mass is a straightforward characteristic, attainable or achievable speed is less so. In the context of the Good Street, attainable speed refers to "the speed that a vehicle can normally reach, i.e., without excessive effort on the part of the rider or (illegal) acceleration of the vehicle" (Immers et al., 2020). Both the first and second Good Street principles serve to ensure that traffic mixing can take place with the lowest (and therefore safest) amount of differential kinetic energy. This means that when mistakes do happen, low speed and mass differentials ensure that crash-related injuries are neither severe nor fatal.

All vehicles in the Good Street framework are classified into one of six mass-based vehicle families (column 1 in Figure 7). These mass-based categories are meant to be indicative, and the cut-offs between families are not a fixed feature of the framework. The Good Street framework further divides vehicle families into different speed-based sub-categories because of a wide range of achievable speeds in certain vehicle families – particularly the B and C families (Figure 7).

Figure 7. The Good Street vehicle families

Vehicle family	Operating speed					
	0-10 km/h	10-20 km/h	20-30 km/h	30-40 km/h	40-50 km/h	>50 km/h
A Pedestrians Self-locomotion	A10 walking	A20 jogging				
B Bicycles Micromobility-rideables <~ 35 kg		B20 bicycle, scooter, hoverboard, e-skates	B30 e-bike, e-scooter, monowheel	B40 speed pedelec, race bike		
C Light Motor Vehicles Powered light mobility <~ 350 kg		C20 cargo bike, bicycle "bus", Segway	C30 e-cargo bike, mobility scooter, light micro-(electric) vehicle		C50 moped, micro-(electric) vehicle	C50+ motorcycle, motorscooter
D Cars <~ 3500 kg					D50 large micro-(electric) vehicle	D50+ car delivery van
E Trucks, Buses >~ 3500 kg						E50+ bus, truck
F Rail vehicles						F50+ tram, light rail

Source: Adapted from Immers et al. (2020).

The Good Street vehicle families only partially align with the broad categories of light mobility identified in this report. The differentiation by achievable speed helps reflect the wide range of vehicle types and means of mobility on the smaller end of the light mobility spectrum but less so on the larger end of the spectrum – especially as concerns micro-electric vehicles weighing more than 350 kg but limited to speeds lower than 45 km/h as well as the smallest microcars weighing less than 1 000 kg. This may indicate some need to adapt the framework for different global and regional contexts where microcars and micro-electric vehicles are both legal and popular.

The third and fourth principles are focused on the possible uses of road space. The third addresses the need to balance the use of street space for traffic with other equally valuable but often less valued uses of that space, while the fourth calls for a clear framework to prioritise the types of spatial functions and qualities embedded into different street spaces.

The fifth principle calls for going beyond the now "obsolete" car-bike-pedestrian layout of streets, instead focusing on ensuring that networks are adapted and designed such that all vehicle families have safe, coherent and high-quality access to the city.

The final two principles operationalise how street space can be re-organised to deliver on the previous principles and the aspirations they build on. The sixth principle discusses how to establish urban traffic environments based on network function and desired spatial qualities. These traffic environments are linked to spatial functions and are associated with a reference traffic speed.

The seventh and final Good Street principle addresses the need to establish traffic domains at the local level that are aligned with the over-arching traffic environment. Each traffic domain (e.g., a street, a set of streets, a public square, etc.) is associated with a maximum speed limit and a corresponding normative vehicle family. Each traffic domain also includes rules and guidance relating to mixing and separating traffic, defining which modes may access the domain and under which conditions specific modes are excluded. Vehicles other than those in the normative design family may typically enter the traffic domain but must operate at the speed established for the normative vehicle family.

These seven principles serve as the basis for reframing traffic systems away from a singular focus on car and truck use towards a more flexible, safe and diverse traffic environment adapted to the broad spectrum of light mobility vehicles and travel means.

How to frame and implement effective and coherent light mobility policies

Embedding pro–light-mobility policies in cities is complex. As highlighted by the International Transport Forum (2023b), in the case of active mobility, promoting improvements in the quality of walking and cycling in cities requires going beyond infrastructure. It is necessary to combat moto-normative norms in policy-making, removing existing policy barriers and establishing conditions where those travelling in slower modes are not disadvantaged regarding access, safety or inclusion. Moto-normativity takes hold in cities dominated by the presence of cars, making it difficult to objectively address the car's role. Any assessment of the car versus alternatives is clouded by largely unconscious assumptions about how car travel is the default and preferred way to get around and that this should and will remain so (Walker, Tapp and Davis, 2022). In some contexts, Wilson and Mitra (2020) argue that the majority opposition to cycling infrastructure relates to policy makers concerns regarding the loss of road space for the car, with politicians often hesitant to support policies perceived to deter motorised transport usage.

The same holds for the broader scope of light mobility that considers not only *active* mobility (e.g., walking, cycling, wheelchairing) but also *non-active* rideables (e.g., e-scooters, motorised wheelchairs and mopeds) and mobility with small vehicles that are more space-efficient than full-sized cars (e.g., microcars, and other micro-vehicles). To centre cities around light mobility, it is not enough to provide infrastructure; one must design a system that discourages car dependence.

To effectively design a system that promotes light mobility, policy makers and planners must:

- **Identify system leverage points to maximise impact.** Transformations are complex, and deep leverage points that allow for a small shift in one thing to produce more-significant changes everywhere else are needed to achieve sustainable transformations through effective policy. Understanding where to act and where particular levers are more likely to be effective is crucial.
- **Align policy at the national, regional, and local levels.** Transport policy decision-making can be fractured. In different contexts, different agencies and ministries at all levels of government may have purview over some aspects of the system but not others – such as local roads vs. main throughways or walkways, or sidewalks vs. space allocated for motorised travel. Furthermore, overlapping competencies and changing contexts can leave elements of the system in "no man's land", with no agency considering it their responsibility. Because of this, it is essential to ensure that policy directions are aligned and competencies are clearly defined.
- **Understand how travel decisions are made**. Every day, citizens decide if, when and how to travel. These decisions, however, are not made in a vacuum. They are context-dependent and are made within a *system of provision* (Mattioli et al., 2020). Today, car-centric development and the cultural norms that sustain moto-normativity encourage car use by delivering a compelling experience. It is necessary to understand how these personal decisions are made to design a new context favouring or facilitating the desired behavioural change, i.e., shifting towards more light mobility in cities.

- **Implement comprehensive policies and assessment frameworks.** Having clearly defined policy directions and identified where to act, policies should not be delivered piecemeal. The unsystematic implementation of partial or stand-alone measures is unlikely to be successful. Comprehensive plans that are cohesive, complementary and additive are critical. Additionally, it is vital to have a clear assessment framework. Policies should have clear policy aims, and understanding how to measure the impact is just as important as designing the policies themselves.
- **Ensure fairness in transitions.** Socio-technical transformations, particularly during transitionary periods, can be chaotic. During these periods, it is critical to ensure that the most disadvantaged groups do not bear the costs of these transitions and that the new system's benefits are more equitably distributed.

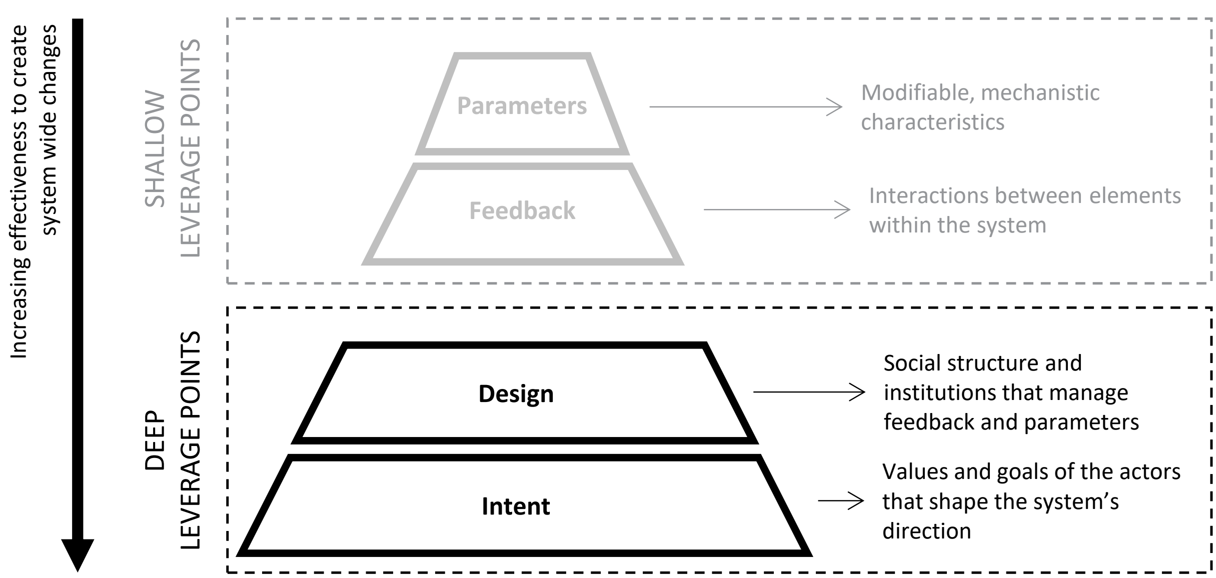
The remainder of this section discusses each area in turn.

Consider system characteristics and leverage points

Where can interventions be most effective? As highlighted above, urban transport system changes must consider human decision-making. Additionally, because the system is complex, it is necessary to understand where different measures can be most effective. In complex systems, including cities, leverage points allow for a small shift in one thing to produce more considerable changes across the system(Meadows, 1999). These deep leverage points are needed to achieve sustainable transformations through effective policy (Abson et al., 2017).

Any complex system can be said to have four characteristics: **parameters**, **feedback**, **design** and **intent**, each with a subset of potential leverage points – ranging from shallow to deep points (Abson et al., 2017). As Figure 8 shows, deep leverage points can be found in the **design** and **intent** of the system.

Figure 8. Identifying effective leverage points for systemic changes



Source: Figure adapted from Abson et al. (2017).

The **parameters** are the modifiable, mechanistic characteristics of the systems, including taxes, specific incentives and standards. Different system parameters interact with one another and there can be **feedback** between different parameters that affect how each function. Both of these components are, without a doubt, extremely important, and changes to them can improve outcomes. However, they are shallow because, without systemic broader changes that are part of a paradigm shift in the approach to policy, they are unlikely to change the general course of the system and are unlikely to be as effective or successful. This is in line with recent findings at the International Transport Forum (2023b) that highlighted that adding new policies to support active mobility without addressing the broader moto-normative legal and policy frameworks (which favour motorised transport) is unlikely to deliver all the potential benefits of more active mobility in cities.

Focusing on the deeper leverage points in the design and intent components of the system, one can better understand how the different parameters work together to induce greater change. The system's design includes the social structure and institutions that manage feedback and parameters. As such, changes to the institution's design, as opposed to specific parameters managed by these institutions, can be more effective in achieving systemic changes. Similarly, changes to the values and goals of the actors that shape the system's direction can result in massive transformations in the system.

Deep **design** leverage points include:

1. the structure of information flows (i.e., access to information)
2. the rules of the system (e.g., incentives, constraints)
3. the power to add or change the system

Deep **intent** leverage points include:

1. the goals of the system
2. the mindset or paradigm out of which the system arises
3. the power to transcend paradigms.

In practice, achieving the necessary systemic changes requires aligning policy aims at all national, regional and local policy levels to ensure that applied policies pull in the same direction rather than undermining one another. There also needs to be effective, evidence-based communication strategies to inform the general population and policy makers at all levels of the need for these changes.

Additionally, policy makers must be decisive when windows of opportunity arise. Being positioned to act decisively in these moments requires high levels of preparation and a clear vision of the system's direction. As highlighted during the pandemic, cities and regions that already had established cycling and pedestrian plans and defined goals directly related to active mobility were much more successful in activating systemic levers that created sustained changes to the transport paradigms of their regions. They were able to implement and accelerate existing plans and, in doing so, further cement a new paradigm where, at the very least, the car is no longer the unquestioned default. Policy makers and politicians must leverage the momentum and seize policy moments to change the goals and mindset from which the system arises.

Align national, regional and local policy directions and goals

There is a role for local, regional and national policymaking in designing and implementing effective pro-light mobility policies that encourage walking, cycling, and the use of other rideables and smaller vehicles that take up less space and create a safer urban environment. De-centring the car within the urban mobility policies can a) ensure that more people can move around using their desired modes of transport without being negatively disadvantaged and b) contribute to more environmentally and socially responsible personal mobility.

There is ample evidence of the difficulty of implementing policy changes perceived as deprioritising the car and democratising urban mobility. Municipal planners in Canada, for instance, have highlighted that to build infrastructure for bicycles and other light mobility alternatives while navigating the politically sensitive nature of these spatial re-allocations, they tend to have to "piggyback" on other public works projects, use external grants and funding (from provincial or federal governments), pre-emptively re-route the infrastructure to minimise potential pushback, or find a political champion willing to take on the political risk of such changes (Wilson and Mitra, 2020).

This finding highlights the need for national strategies that provide direction and points to the importance of aligning national, regional and local policies. It also points to the different roles that policymaking at different levels of government can play in changing and implementing specific light mobility policies.

The national role

National policy makers play an essential role in identifying opportunities, introducing holistic frameworks (including fiscal conditions) and setting policy directions that regional and local policy makers can then use to embed policies that address their local needs and fit their local context.

Policy makers at the national level can set the stage by promoting the development of robust institutional governance structures centred around moving away from car-centric development. These governance structures include funding schemes, research structures, programs and, if necessary, new governing structures to ensure this becomes a priority. National policy makers can also play an important role in communicating to the rest of civil society, private enterprises and governing structures that a particular topic and direction is important and is being treated seriously.

They should establish national light mobility strategies encouraging non-car-centric city travel via smaller vehicles. These national strategies should include targets and a catalogue of concrete actions designed to achieve them. An example to follow is the establishment of national cycling strategies in recent years that define a global vision to co-ordinate cycling policies at all levels. Putting these strategies in place sends a political signal that cycling requires systematic consideration by different stakeholders (European Cyclists' Federation, 2022). This same approach can be extended beyond cycling to encompass light mobility more broadly.

Importantly, any light mobility strategy should be mindful of the potential new conflicts that could arise with increasing the number of small(er) vehicles on the roads. It must ensure that national light mobility policies consider pedestrians, cyclists, and other active travellers travelling at slower speeds. The fastest light mobility options (e.g., some e-bikes, mopeds, motorcycles, and mini cars) can achieve very high speeds and create new potential risks for pedestrians and those travelling slowly. Policy makers must ensure that all new light mobility policies align with safe systems principles and do not further marginalise pedestrians and other road users travelling at low speeds. This new strategy should also consider embedding light mobility within larger regional and national transport plans. In this regard, aligning light mobility and public transport (and other collective transport alternatives) is particularly relevant.

Finally, adequate funding is essential to implement light mobility policies successfully, and national policies are critical in this domain. To this end, conditionality is a vital national lever in terms of financing and guidance. Given different competencies and purviews, in many contexts, national governments cannot directly implement many policies at the local or regional levels. However, even in these cases, they often hold the purse strings and can impose predetermined policy conditions to reimburse funds. As such, national policies can still be instrumental in spearheading a structure that accommodates transport planning and designs geared towards a greater variety of light personal mobility alternatives and greater integration with collective modes of transport.

Conditionality is central to many private or commercial lending schemes and for sovereign borrowers (i.e., countries) from official donors like the World Bank or the International Monetary Fund. National governments have also used it to induce regional and local policy changes in various domains. A historical example of successfully using conditionality to generate transport policy changes is the 1984 National Minimum Drinking Age Act in the United States (23 U.S. Code § 158), which sought to increase road safety. This act required restricting alcohol sales and consumption to persons aged 21 or older as a condition of State Highway funding. There is evidence of the successful impact of this policy on public safety, particularly in reducing alcohol-related crashes among young drivers (McCartt, Hellinga and Kirley, 2010). More important to the topic at hand, however, it highlights just how effective conditionality can be. In four years, by 1988, this lever resulted in all 50 states and the District of Columbia raising their legal drinking ages to 21.

Although conditionality can be controversial and create public protests and distaste (Babb and Carruthers, 2008), it remains a strong policy lever in national and regional plans if the conditions are reasonable.

The regional role

The regional role of policy-making reinforces national policies and provides further refinement and specificity to the national guidelines within the region. Regional policy makers can strengthen, complement and expand relevant national policies by providing additional funding and schemes.

Regional policy makers can also lead the way by expanding the realm of possibilities and exploring new alternatives and directions, looking further while remaining aligned with national policies. In this way, they can impact the future direction of national policies. There is also an essential component of cross-regional learning that can act as a catalyst for further changes to the system. Leading regions can serve as case studies for new approaches and implementations, which can be essential for accelerating policy changes across different regions and at the national level more broadly.

Similarly to the national level, regional-level policy making should provide enough space for innovation and special use cases at the city level when these policies are implemented. However, it should be clear enough to ensure that these local policies align with the spirit of the policy directions designed at the national and regional levels.

The local role

The local role is crucial. Local needs, desires and aspirations should always inform high-level policy goals at the national and regional scales. From a policy perspective, well-designed national and regional policy frameworks enable local policy makers to find solutions that meet local needs and apply them within clear funding and assessment frameworks.

At this level, decisions are often much more specific, coming down to the details of where particular infrastructure is located and of the design of infrastructure components (like the width of wheeled lanes or sidewalks) and specific solutions that fit local needs. At the same time, local decisions also include broader policy-making goals designed to ensure the establishment of system-wide changes. Municipal and city policy makers can drastically change their context and have an immense impact by changing the activities encouraged on their streets.

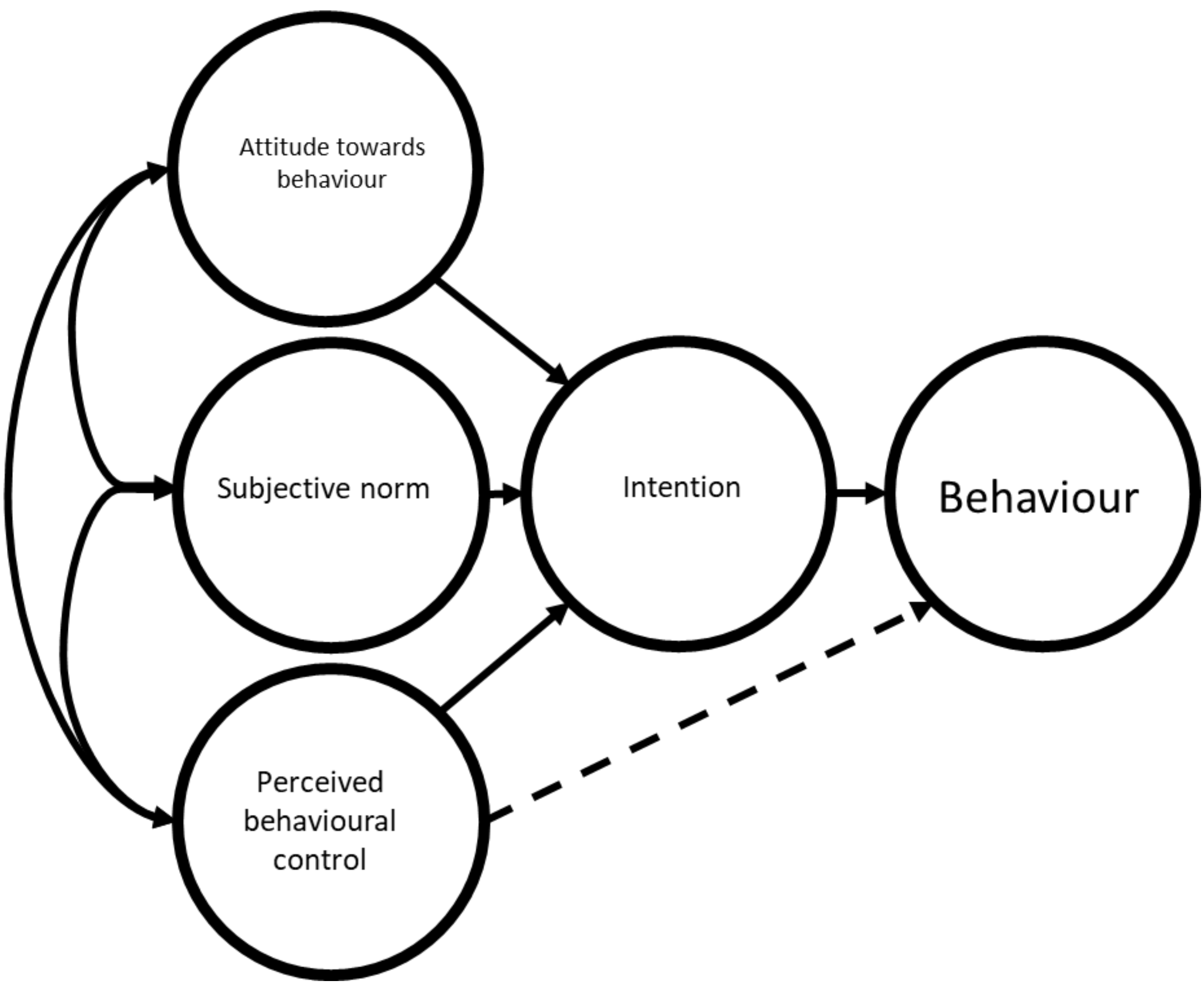
Understand travel behaviour decision-making

To promote light mobility, policy makers should carefully analyse travel decision-making and behaviour to support future planning.

Human decision-making is complex. Understanding why individuals make specific decisions at particular points is difficult to pinpoint. General attitudes and dispositions have long been found to be poor predictors of specific behaviours (Ajzen, 1991), even for strongly held beliefs. For instance, recent findings indicate there is likely little evidence that environmental attitudes are associated with high carbon emissions (Mattioli, Büchs and Scheiner, 2023). That is, caring about and being aware of the environmental impact of human activity is not a good predictor of whether individuals lead low-emission lifestyles.

The theory of planned behaviour (Ajzen, 1991) helps explain why this may be the case. Whether or not someone performs a particular behaviour depends on the intention (informed by their attitudes and dispositions), but only as long as the action is under their control and they have access to the necessary opportunities and resources needed to perform it (Figure 9).

Figure 9. Theory of planned behaviour



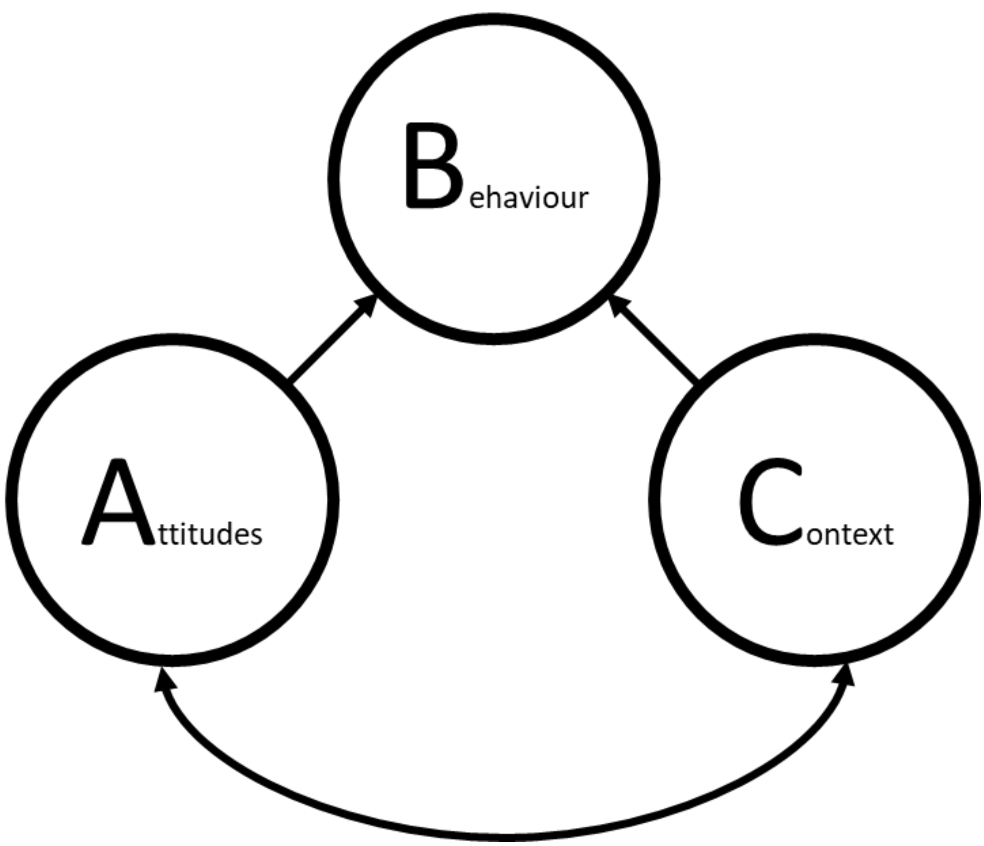
Source: Figure taken from Ajzen (1991).

Perceived subjective norms also play a role. Decisions are not made in a vacuum. As such, societal expectations and norms mediate behaviour. As highlighted by Guagnano, Stern and Dietz (1995) and Stern (2000) in their "ABC" theory (see Figure 10) attitudes and context are interrelated and inform behaviour. For instance, someone with a positive attitude towards public transport might not use it because it is inaccessible or does not provide access to where they need or want to go. However, changing the context by introducing new and improved public transport services will likely increase their likelihood of using public transport (Rahman and Sciara, 2022). Similarly, someone may feel very positively about walking but opt not to because of insecurity, fear of harassment, or societal perceptions of who walks.

This understanding of planned behaviour and decision-making makes it clear that effective and comprehensive policy plans intending to change travel behaviour should act on at least one of attitudes and context, but ideally both.

In transport terms, the *context* refers to new or improved services, land use changes, infrastructure, and structural changes to fiscal, legal and policy systems that can strongly favour, facilitate or reward certain behaviours, like mobility and modal choices. Policies acting on the mobility context change the resources available to citizens. They are more likely to result in short-term gains by inducing the desired behaviour among those who already were positively inclined to travel in a particular way but did not have the necessary resources to travel in this way, given the *ex ante* conditions and context they experienced.

Figure 10. ABC Theory (attitudes, behaviour, context)



Source: Figure adapted from Stern (2000).

However, changing the context effectively impacts the mobility system of provision (refer to Mattioli et al. (2020). And if these measures are broad enough and are sustained, they contribute to creating a vision-based system of provision for light mobility in an environment that is conducive to more individuals choosing to travel using light mobility alternatives. Among those without firmly held modal preferences, exogenous changes in the transport environment are likely to be followed by gradual adjustments in their perception and use of the system. In an environment that is not centred around the car, the "rational" choice of how to travel will evolve over time, making it more likely that more people will opt to travel lightly for more of their trips (even if they are not particularly enamoured with a particular light mode), simply because they find that for specific trips these modes are more convenient, faster or easier than travelling by car.

The habitual nature of daily mobility behaviour makes creating lasting changes in mobility behaviour difficult. Significant inertia and perceived lock-ins result from short-term and long-term travel decisions. In the long term, decisions such as residential location can severely constrain the attractiveness and availability of different modes. Similarly, medium- to long-term decisions like the investment of purchasing a private vehicle can condition the choice to drive for more trips due to the availability of the vehicle and because the associated costs of an additional trip by car are negligible compared to the total cost of ownership. To make matters worse, every new trip reduces the unit cost per kilometre driven. This structural commitment to specific modes is not unique to the car, although it is the most pervasive case. It can also happen with public transport (e.g., by buying a monthly, seasonal or yearly pass) or when purchasing other vehicles or mobility services. Finally, on a daily basis, the modal choice when leaving the home conditions the mode choice for all other trips in the trip chain until returning home.

Furthermore, these travel decisions are not always made consciously or for each trip. Individuals tend to default to their usual mode of choice. The system prompts habitual behaviour, with spatial, social and temporal cues prompting the recurring action. Evidence shows that adults show very stable behaviour over time regarding mode use and preference, with current usage and preference being good predictors of future mode choice and preferences (Olde Kalter et al., 2021). When actions are repeatedly performed, past behaviour is a much better predictor of future behaviour, and the intentions of the action become less relevant (Verplanken et al., 2008). As such, individuals are much more receptive to exploring alternatives at strategic points which include life changes (e.g., childbirth, moving homes, employment changes) or due to significant disruptions that make travelling their habitual way impossible (e.g., strikes, pandemics) when they need to consciously consider their intent and the available system characteristics of alternative modes.

These windows of opportunity where there is habit discontinuity (Verplanken et al., 2008) are critical for policymaking. Identifying individuals at those critical junctions when they are more receptive to changes, and engineering situations that allow for discovering different ways to move through the city, can be leveraged to induce the desired behavioural change. Communication strategies and educational and capacity-building initiatives that can change attitudes are needed to seize these opportunities. These strategies should be systematic and encompass education for children, capacity building for experts and policy makers, and training for users (e.g., license examinations and re-training). Changing an existing system requires ensuring that those that have long been using the system understand the new conditions and are given a chance to explore the new alternatives.

Implement comprehensive policies and assessment frameworks.

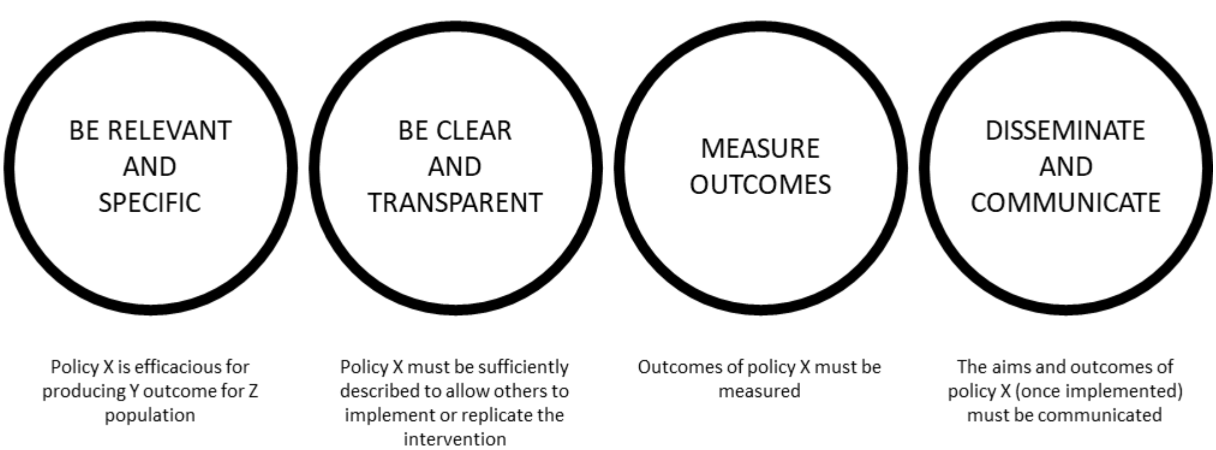
Successfully shifting to light mobility requires a consistent, clear and ambitious policymaking framework that guides the selection of locations and definition of interventions and allows for the *ex ante* and *ex post* evaluation of potential impacts. Interventions must be **attractive** to stakeholders while also being **effective** at attaining policy objectives and **achievable** given the temporal and budgetary constraints. Learning from global best practices and being aware of potential pitfalls and barriers are crucial to increasing the share of light mobility in different contexts.

A simplified framework for policy design

The first step is to define broad principles to guide all potential interventions. Understanding whether possible interventions show efficacy and efficiency in addressing underlying issues is not unique to transport policy. Taken from the field of prevention research, where there has been considerable interest in designing standards to determine whether interventions are efficacious, effective, and ready for dissemination (Flay et al., 2005), a simplified, high-level framework for effective policy design should serve as the line of departure for any policy, policy package or plan considered. Policies should be relevant and specific, they should be clear in the definition and goals, the desired outcomes should be measured, and there should be effective and open communication (Figure 11).

The overall policy plan, and any individual policy within it, should be specific regarding its policy aims and how it can help produce a particular outcome among specific population segments or the population more broadly. The policies should also be clear, transparent and sufficiently described so other policy makers can replicate the intervention and understand how a particular policy fits into the larger legal and policy frameworks. Once the policies have been implemented, the outcomes should be measured to ensure the approach's efficacy in achieving the desired effect; the assessment framework should be embedded into the policy promulgation itself. Finally, at all stages of the process, from the design to the implementation, there should be constant engagement with local stakeholders and those who any proposed policy change may impact.

Figure 11. Simplified framework for effective policy design



Source: Figure inspired by Flay et al. (2005).

Additionally, dissemination and communication are essential for public acceptance and engagement. The decision to support policy changes requires the balancing of self-interest and perceived societal benefits (Palm and Handy, 2018). Complex transport changes, schemes and plans can be challenging to communicate to the public, who may not receive balanced information in a contested political arena (Sherriff, 2015). Analysis of the implementation of pro-light mobility policies shows that successful implementations have had three complementary political actions that buoyed their success: seizing a political window of opportunity, aggressive communication strategies to shape the messaging of the project, and political leadership (Siemiatycki, Smith and Walks, 2016).

In the United States, where transportation agencies often turn to local, voter-approved taxes to fund transportation plans, there is some evidence that voters do not necessarily vote in self-interested patterns. Instead, the perceived impacts of the proposed policies on their community overall are a stronger determinant than their self-interest, which can lead to voters choosing not to support measures they believe would harm their communities even if they would benefit personally (Palm and Handy, 2018). However, this does not mean that self-interest is not an important determinant. There is some evidence from the United States (Palm and Handy, 2018) and Switzerland (Rérat and Ravalet, 2023) of cyclists often strongly supporting pro-cycling ballot measures. In Switzerland, this was particularly true for everyday and utilitarian cyclists – with leisure and infrequent cyclists more unlikely to support pro-cycling efforts. Additionally, as highlighted earlier in the text, policies perceived to disadvantage the private car are often highly unpopular among car drivers.

The goal of this framework is to limit destructive policy vagueness – while allowing for some vagueness where useful. At higher policy levels and while building successful coalitions, there is often an interplay between vagueness and specificity which can effectively induce reforms while overcoming potential stalling and setbacks due to competing interests. Under the veil of vagueness, planned ambiguity argues that information is a critical resource for political players and can, for strategic reasons, be allocated with different degrees of specification (Christiansen and Klitgaard, 2010).

When designing policy frameworks, vagueness of another kind also is essential: flexibility. Building flexibility into how policy goals can be achieved and not being overly prescriptive about the specific implementation of policies can often help induce creativity and innovation. It is also essential for designing policies that fit local contexts.

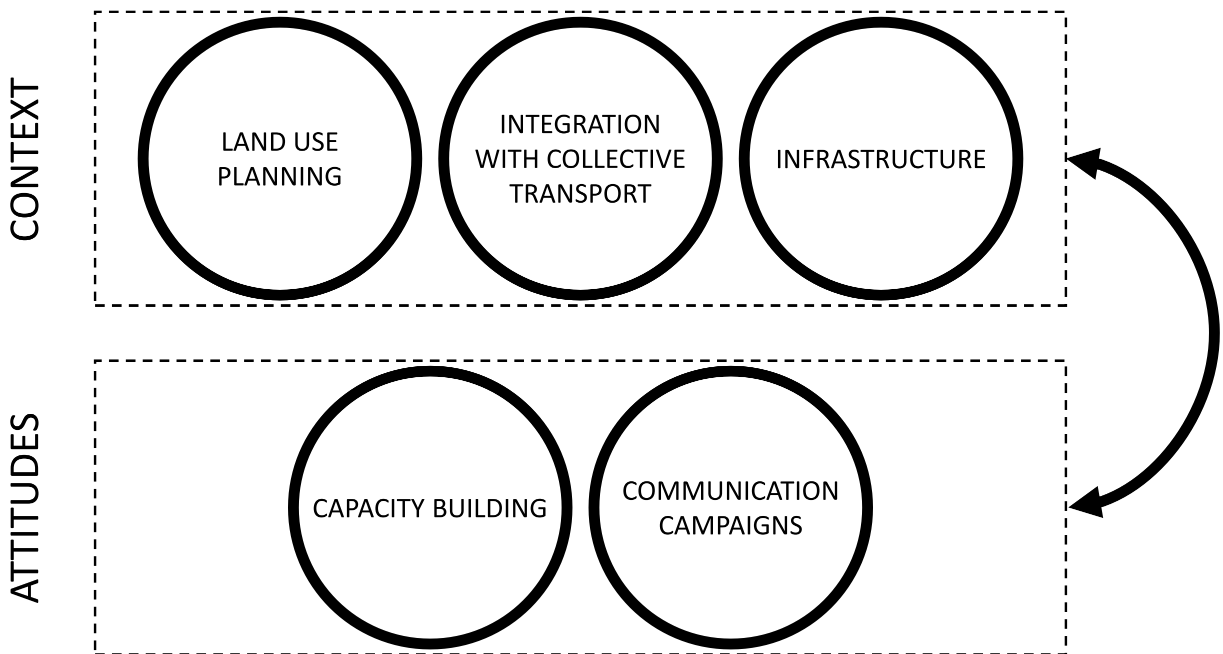
On the other hand, policy makers should avoid vagueness when describing the ultimate target or desired impact. Vague goals can act as a perverse incentive for policy makers as it makes analysing the impact of the policy more troublesome, thus making it more difficult to assign blame if it is unsuccessful. It also makes it much more likely that the policy is ineffective.

Similarly, at the level of specific policies, lack of clarity is a recipe for failure. It is essential to clearly define policy goals and specify the expected outcomes of particular measures; so that one can then measure the results and determine the effectiveness of the implemented measures. Policy vagueness – to the extent that it allows for entirely divergent interpretations and fails to define the tangible measures of the expected impacts (e.g., benchmarks, targets) – can constrain the success of the ultimate policy goal (Monyei, Oyedele, Akinade, Ajayi and Luo, 2019). It should be noted that the expected outcomes can result from interrelated, additive policies working together towards a common goal and are not always easily quantifiable. Some of these goals can and should be qualitative. Qualitative goals can be more challenging to measure and can often only be done through proxies and other mixed methods approaches.

The PATH Assessment Framework

More specifically related to light mobility policies, the Partnership for Active Travel and Health, or PATH (n.d.), framework provides policy makers with a clear framework for transitioning towards active mobility and, more broadly, light mobility. It includes five main pillars (Figure 12) aligned with the theoretical framework to induce the behaviour change presented above (see Figure 9 and Figure 10) that seek to change the **context** of urban mobility and the **attitudes** of urban dwellers, policy makers and experts. These context and attitude components reinforce each other and can create a virtuous cycle. As highlighted earlier, *changes in context* can induce changes in attitudes and behaviour by changing the provision of conditions that reward and encourage some behaviours and penalise and discourage others. At the same time, *attitudinal shifts* are a catalyst for new or increased changes to the existing context to further reflect the values and desires of the populace.

Figure 12. Partnership for Active Travel and Health (PATH) assessment framework



Source: Figure adapted from PATH (n.d.).

Context components

In terms of changing the urban mobility **context**, there are three overarching, complementary components which, when used together, can ensure that the environment allows users of light mobility to travel around the city in a safe, enjoyable and useful manner that meets their needs:

Land Use Planning: Ensure proximity and quality of access. Walking is the connective tissue of urban mobility. Even when relying on vehicles of different kinds for urban mobility, most trips require at least a small walking component. Ensuring that opportunities can be accessed easily and that the land use is designed to ensure proximity to different activities and destinations provides the baseline to move in diverse ways depending on individual capacities and preferences.

Integration with Collective Transport: Underpin sustainable mobility for longer trips. Whether active or not, light mobility transport can have lower travel ranges than large, motorised transport. Integrating high-quality collective transport systems with local connectivity can help create compelling travel conditions and high-quality travel experiences for people walking and cycling and using other forms of light mobility. Individuals can maintain accessibility to far-away opportunities using collective transport while relying on light mobility to reach closer opportunities.

Infrastructure: Ensure safety, security, accessibility and ease. This component includes the built environment, comprising both physical (e.g., sidewalks, light mobility lanes, parking) and “hidden” infrastructure (e.g., speed management, prioritisation, legal framework). Together they ensure that users can easily and safely travel to their destinations without risking their physical and mental well-being and without being disadvantaged in terms of effort and access to opportunities.

Attitudinal components

These three components must be accompanied in parallel by strategic communication engagement to encourage **cultural and attitudinal shifts** that ensure that light mobility becomes a viable alternative in the eyes of more significant portions of the population. There are two main components to this strategy:

Capacity building. Citizens need to be educated on changing laws and policies to ensure they can safely use any new, or more broadly available, light mobility alternatives. Policy makers, urban transport designers, and engineers also need to be trained to consider these alternative modes of transport.

Communication campaigns designed to support a shift in mobility habits. Technical designs and plans and the imagery they connote can strongly influence public opinion (Siemiatycki et al., 2016). As such, it is critical to clearly communicate the goals of policy changes with the public and all other relevant stakeholders and to maintain an open line of communication at all stages of planning, design and implementation. It is also critical to continue the communication campaigns after the implementation. Habitual travel behaviour is prone to inertia. Giving more people access to information on new alternatives and ways to try them out is an essential lever for encouraging sustained behavioural shifts.

The next section explores policies in practice for these five overarching goals in more detail.

Ensure fairness in transitions

Even while assuming that a particular policy direction results in a move towards a more equitable and just system, it is essential to consider how it will affect individuals/groups – particularly during the transition period, which tends to be a long, slow, unequal process in urban policy. In this practical application, the equity impacts during the transition period should be carefully considered, even if it can be proven that the transition from car-oriented development will result in more-just transport outcomes.

Who can be asked to give up what, and under what conditions? This is a particularly pertinent question, especially given the strong cultural support for preserving or increasing car use (Schwanen, Banister and Anable, 2012). As Mullen et al. (2014) highlight, measures that promote active travel and other light mobility alternatives would likely also restrict the way cars are used – causing, at the very least, short-term discomfort or perceived decreases in well-being for a significant portion of society. These restrictions, under certain conditions, could entail varying degrees of sacrifice by those who are negatively impacted, particularly in terms of their accessibility.

Carefully communicating why the changes are occurring and why they are needed is paramount. Additionally, by analysing the potential impact on society at large as well as specific groups of interest, policies can be defined to ensure that they do not further disadvantage those who are already most disadvantaged. An indicator like the Target group Position Index (TPI) proposed by Pritchard, Zanchetta and Martens (2022) is one tool that can be used as part of *ex ante* and *ex post* analyses to understand better how population subgroups are faring in relation to the rest of the population. This and other indicators can help policy makers ensure that proposed policy changes effectively deliver more-just outcomes and that changes targeting specific groups are delivering on these promises.

Additionally, there is a need to consider the issue of early adopters. For instance, early adopters of light mobility – who have been incentivised to walk, cycle and use other light mobility alternatives in a car-dominant environment while cities continue to cater to heavy motorised transport – will suffer adverse conditions. They will be more exposed to air pollution and higher risks of vehicular and personal violence. In economics and marketing, the difference between early and late adopters of new products and innovations and the diffusion process has been explored for years (e.g., Stoneman and Diederen, 1994). The late adopters, who tend to be resistant to change and suspicious of the agents of change (Jahanmir and Lages, 2016), wait until they are confident the innovation will not fail before they adopt it. In other words, they tend to reap more benefits than the early adopters of many technological advancements because they adopt them only when they are fully established and the most difficult kinks associated with the adoption have been resolved or, at the very least, minimised.

Transport and urban system innovations or changes should be expected to behave similarly, with the late adopters reaping the most benefit of the old system (i.e., continuing to benefit from the system in place while being minimally affected by the transition being conducted by others). They would then enjoy all the new system's advantages once the transition is complete and they begin to use it as well. To use cyclists as an example, the first adopters risk their well-being by exposing themselves to higher pollution levels and to higher risks by cycling amongst motorised transport without the benefit of appropriate infrastructure. Users of motorised transport may either not expect them to be in these spaces or believe they should not be there. Once critical mass is achieved and up-to-standard cycling infrastructure is built, late adopters will benefit from cycling (more) safely and being less exposed due to the already lower emissions from heavy motorised vehicles (due to mode shift).

It should also be noted that there is extensive literature on socio-technical transitions (for a review of socio-technical ontologies, refer to Geels, 2010). Such transitions can be thought of as system changes that entail not only new or different technologies but also changes in user behaviour, cultural meaning, policies and markets (Geels, 2004). The literature addresses the broader societal developments that impact the selection of new technological regimes, exerting pressure to adapt or perish, and the social impacts of the developments themselves (Smith, Voß and Grin, 2010). Cities transitioning from car-oriented development to more walking, cycling, micromobility and public transport development would fall under this umbrella, as this change would entail a shift in all of the above.

Although these changes are usually not referred to as "socio-technical transitions" within the transportation field, the impacts of these changes are often discussed in similar terms. Geurs et al. (2009) highlight that in addition to the direct implications of a change in the transport system, these changes result in long-term impacts on land use and individual preferences, which are often incorporated into land use/transportation interaction models. One difficulty during transitions, particularly as it relates to the justice considerations of a move towards less-car-oriented policies, is that it has been suggested that unless there is a reconciliation between accessibility and justice – by examining the way conditions are created and looking at issues at a scale that incorporates dimensions beyond the environmental benefits – it is likely to lead to stark inequalities by de facto privileging some groups' choices in mobility (Mullen and Marsden, 2016).

Box 1. Other Assessment Tools and Frameworks for Light Mobility Solutions

In addition to the overall frameworks presented in the text, there are specific tools that can help policy makers both select the right policies and measure their impacts. Two of them are the Health Equity Assessment Toolkit (HEAT) and the Cycle Highway Manual.

HEAT

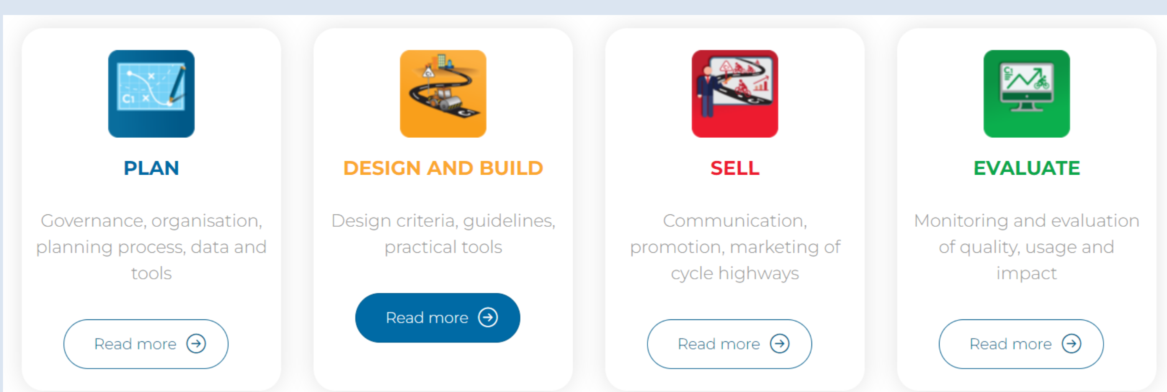
Developed by the World Health Organisation, the Health Equity Assessment Toolkit (HEAT) for walking and cycling is a freely available web-based tool for assessing the economic impact of walking and cycling. It is designed to serve planners, practitioners and policy makers at the national and local levels and can be used from national scales down to sub-city scales. The aim is to make it feasible to conduct robust basic assessments quickly and with minimal user inputs. Importantly, it provides reference values that users can adjust if they have specific local data. Including representative and plausible data ensures the tool is useable "out of the box", even if local data is unavailable.

It seeks to answer the following questions: "If *X* people regularly walk or cycle *Y* amount, what are the health impacts on premature mortality, and what is the economic value?" It performs a health assessment based on changes in physical activity, exposure to air pollution and risks of fatal crashes. It also estimates changes in emissions due to mode shifts. It can be used to assess current or past levels of active mobility as well as changes over time and to evaluate projects. (World Health Organization, 2017)

Cycle Highway Manual

A product of the Cycle Highways Innovation for smarter People (CHIPS) planning project, the Cycle Highway Manual offers professionals a comprehensive framework for developing successful cycle highway planning. It includes state-of-the-art strategies for all stages of cycle highway development, including planning, design, construction, selling, maintenance and monitoring (Figure 13). This knowledge-sharing endeavour includes lessons from Belgium, Denmark, Germany, the Netherlands, and the United Kingdom (CHIPS, n.d.).

Figure 13. CHIPS Cycle Highway Framework



Source: CHIPS (n.d.).

Light mobility policies in practice

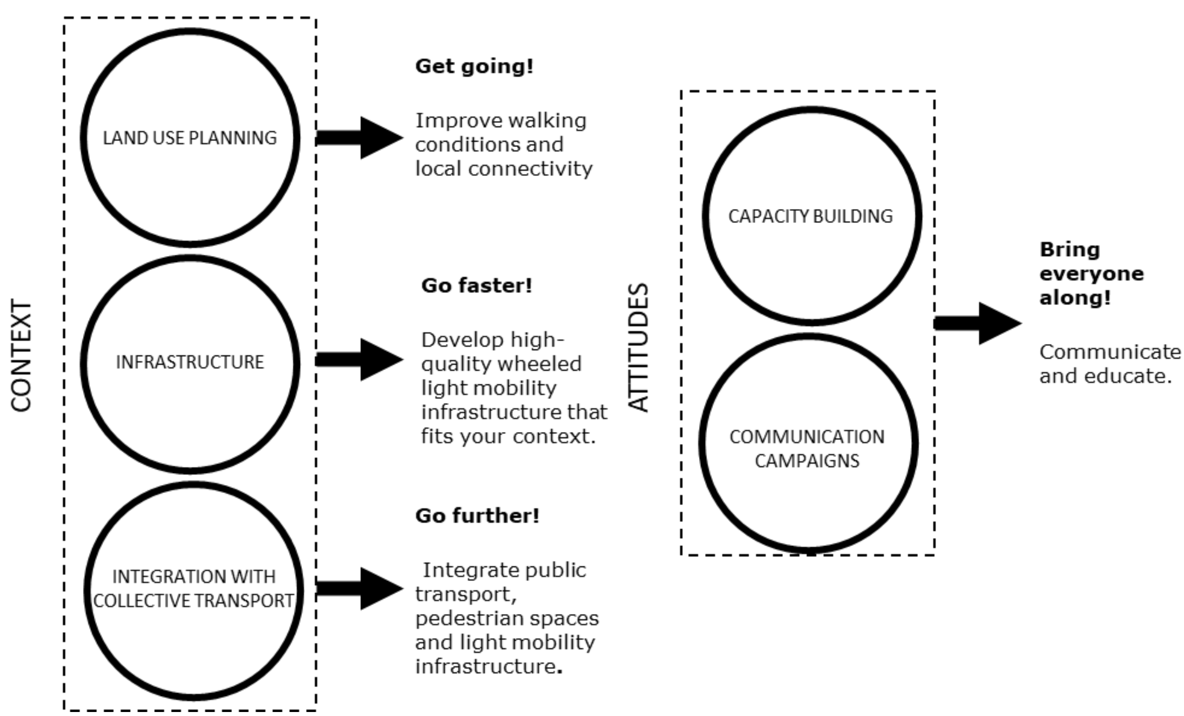
Effective light mobility policies must always be context-dependent and address local needs and desires. This section presents a catalogue of concrete actions that can encourage light mobility in cities and chip away at the car dominance often present. The measures are organised within the PATH framework presented in the previous section and address the context and the attitudes associated with moving lightly in cities (Figure 14).

To move towards light mobility, it is necessary to:

1. "Get going!" – by improving walking conditions and local connectivity.
2. "Go faster!" – by developing high-quality wheeled light-mobility infrastructure that fits the local context.
3. "Go further!" – by integrating collective transport modes with pedestrian spaces and light mobility infrastructure.
4. "Bring everyone along!" – by communicating and educating – providing capacity-building opportunities for experts and the local population.

The rest of this section discusses each of these actions in turn.

Figure 14. From a light mobility framework to concrete actions



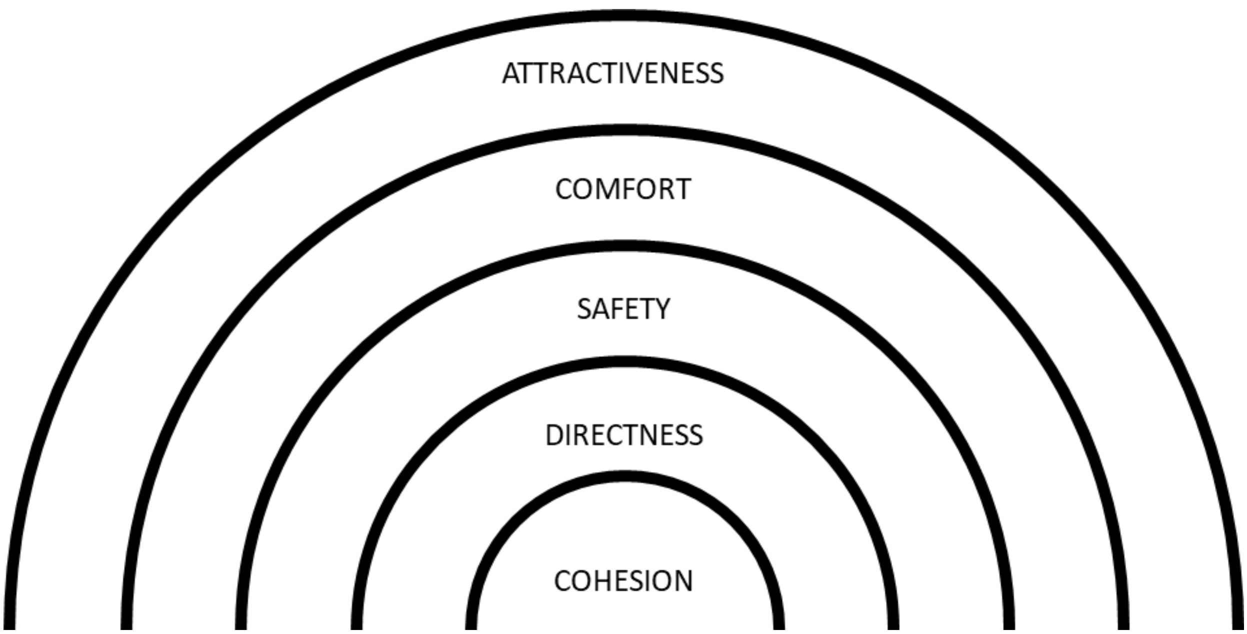
Get going! Improve walking conditions and local connectivity

Walking is at the centre of any urban mobility policy. Although it is often omitted from transport statistics, most people walk, and walking is an essential part of most trips. Whether one is walking to a shared vehicle stop (e.g., scooters, bikes), walking to and from parked personal vehicles (e.g., cars, bikes), or accessing collective transport, most people are pedestrians for at least a short segment of their trips. Ensuring people can safely, securely and enjoyably walk to their destination or transport mode of choice sets the stage for all other potential transport modes.

As such, the shift towards light mobility must be accompanied by a reaffirmation of the right of pedestrians to move freely, safely and securely. Policy makers need to ensure that pedestrians are not further marginalised with the entrance of new mobility alternatives into the urban sphere and that pedestrians are not subjected to further violence by these new light mobility alternatives (ITF 2023).

From an infrastructure perspective, CROW's (2016) network requirements are a great starting point and can be generalized as being critical requirements for any light mobility network, regardless of whether it is pedestrian infrastructure, cycling and wheeled mobility networks, or networks for light vehicles more broadly. As shown in Figure 15, any network should be cohesive, direct, safe, comfortable and attractive.

Figure 15. Requirements for light mobility infrastructure



Source: Figure adapted from CROW (2016).

1. **Be cohesive**. A cohesive network provides its users with a link between all potential origins and destinations in a city (and beyond). This includes integration with collective transport (and other mobility alternatives), consistent wayfinding, lack of barriers, and availability of route choices.
2. **Be direct**. A direct network minimises any detours while travelling by allowing users to travel as directly as possible. By being direct, policy makers can ensure that the slowest modes are not further disadvantaged by people needing to travel farther than those in faster modes. And it can maximise the likelihood that faster, non-motorised light mobility travel times will be competitive with motorised modes.

3. **Be safe**. A safe network ensures the health and safety of its users. It should not cause crashes; on the contrary, it should help prevent crashes and ensure that if there are crashes, severe injuries are avoided.
4. **Be comfortable**. A comfortable network is free of the bottlenecks, nuisances or shortcomings that might otherwise force its users to exert additional effort – such as slopes, uneven surfaces and excessive stopping.
5. **Be attractive**. An attractive network that is enjoyable to use increases the likelihood of it being used. The attractiveness is context-dependent and can vary from person to person. It includes how the network is integrated into the environment, the road surface, and perceived security.

Go faster! Develop high-quality wheeled light mobility infrastructure that fits the context

In many cities, wheeled light mobility infrastructure tends to be much more disconnected than other transport network layers, including motorised road lanes and pedestrian and rail networks (Natera Orozco, Battiston, Iñiguez and Szell, 2020). As a result, the disconnected components have limited use and usefulness. There are limited resources for investment, and there are several competing interests, including maximising trip coverage to satisfy existing demand and maximising safety, i.e., minimising potential conflicts (Folco, Gauvin, Tizzoni and Szell, 2022a).

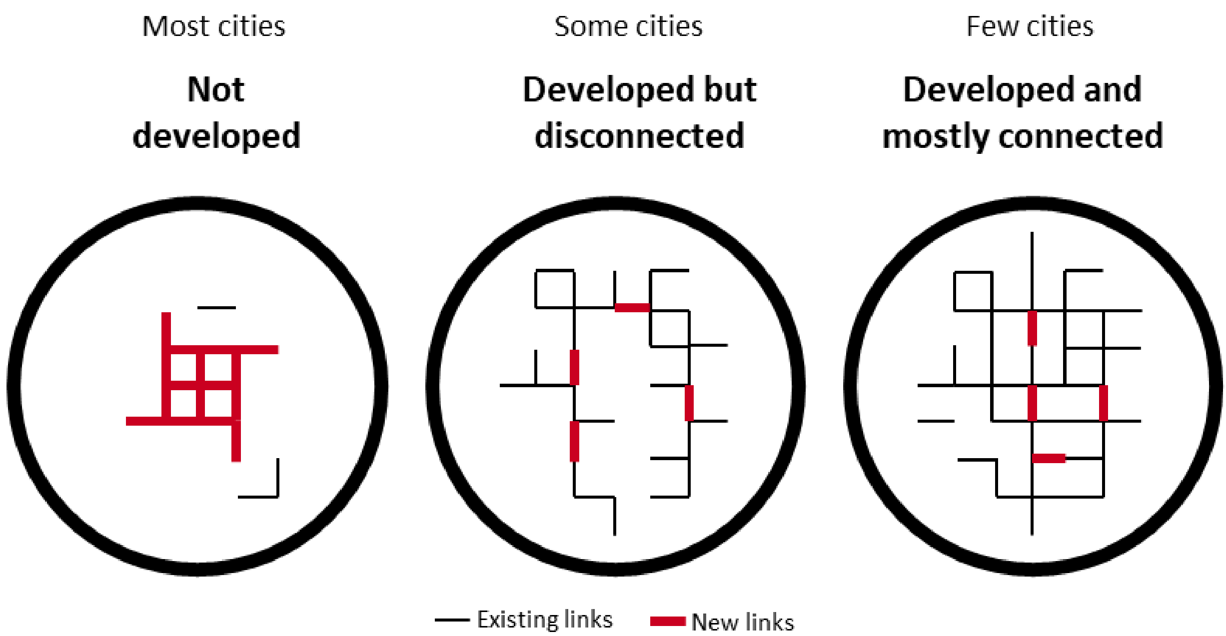
Local knowledge and hands-on planning experience will always be necessary for any transport network development. However, previous experiences condition the realm of what is seen as possible and introduce biases. As a result, data-driven cycling networks are an important tool that should be explored. Complementing the hands-on planning approach with data-driven analysis can help overcome these biases and could result in more cost-effective interventions.

Recently, several quantitative methods have been developed to model the growth and improvement of urban cycling networks with different characteristics, including underdeveloped or non-existing cycling networks (Szell, Mimar, Perlman, Ghoshal and Sinatra, 2022), somewhat developed but disconnected networks (Natera Orozco et al., 2020), and highly developed networks (Vybornova, Cunha, Gühnemann and Szell, 2022) (Figure 16).

Different priorities and trade-offs result in different outcomes (Folco, Gauvin, Tizzoni and Szell, 2022b). In cities that lack a developed wheeled light mobility network, a strong effort should be made to ensure that the newly created network is connected to the greatest extent possible and allows access to important and popular points of interest. Under these conditions, it is more likely to be perceived as functional and more likely to be used. This, in turn, is positive because, in the contested arena of road space allocation, the rapid uptake of users can help mitigate negative perceptions regarding the usage of these networks.

Focusing light mobility network investments in neighbourhoods with existing demand and popular support is much easier than in areas with low backing (Wilson and Mitra, 2020). At the same time, the distribution of cycling infrastructure can exacerbate existing inequalities and create the impression that cycling is only for particular social groups. Piecemeal development, without clear overarching strategies, has also been found to increase the amount of investment necessary to develop a cohesive and high-quality network (Szell et al., 2022). As such, cities and regions must avoid "random-like" sporadic investments. Small and focused investments without systemic strategic plans leave the network with little to no resilience (i.e., no room for disruptions), and by connecting only developed areas, they reinforce existing transport inequities (Natera Orozco et al., 2020).

Figure 16. Approaches to expanding light individual transport mobility networks in cities



Source: Figure taken from Vybornova (2022).

Physical and hidden infrastructure for safety

In addition to the spatial distribution of the network itself, it is essential to consider the type, quality and condition of the available infrastructure. In addition to the conditions highlighted in Figure 15, a high-quality network should consider the comfort of the interaction at junctions and be coherent in terms of signalling and expectability.

Light mobility infrastructure can be segregated or mixed. When segregated, it can provide various levels of protection from larger and faster vehicles. A dense and complete network will likely include a combination of all of these. As highlighted in the following sub-section, the choice to segregate or not will depend on the hierarchical importance of a particular link in the network (i.e., high-capacity link, main network, or local basic structure), the traffic, and the speed.

Whenever possible, separate light mobility lanes should be encouraged in areas with heavy vehicular traffic; this should be complemented by light mobility-centred areas where priority is given to pedestrians and lighter vehicles over cars. However, differing costs and space availability mean this is unlikely for all cases. Speed management is critical to ensure safety when full segregation is not possible or desired.

Indeed, speed management is one of the most critical infrastructure measures at the disposal of any urban policy maker. It is what is considered *“hidden”* infrastructure. Speed management measures that reduce the speeds of motorised vehicles in cities allow the streets to feel safer for more road users and significantly increase the safety for all. Safe speeds and safe road-user behaviour are two pillars of the International Transport Forum's (2022c) Safe System approach, discussed earlier.

However, implementing these measures can be surprisingly challenging. Misaligned and ill-defined policy and legal frameworks can hinder the implementation of safe-street measures. For instance, in countries and regions where the purpose of roads is legally defined as maximising vehicle throughput (e.g., in Germany), changes that reduce speeds or limit motorised vehicles can be challenging to implement and can be contested in courts. As such, any good policy framework should begin with eliminating, amending or changing policies of this ilk. Furthermore, the public perception of the “right” of vehicle drivers to be prioritised in terms of road space allocation, traffic prioritisation and parking can be challenging to overcome without strong political will and considerable efforts to change the underlying perceptions.

More specifically, to ensure safe light mobility in cities, the speeds, signalisation, priority and traffic amounts should always be core considerations when deciding the level of segregation and mix of different modes.

A vehicle's weight, size and speed are three of the most critical components of crashes and collisions. As weight, speed and size increase, the likelihood of injuries and death also increases. Shifting from heavier, car-like vehicles to light mobility and reducing speeds is, therefore, a move in the right direction. It will improve road transport safety by the simple virtue of reducing the size and weight of the vehicles and thus decreasing the likelihood of deaths and severe injuries should collisions occur. However, as the number of interactions between vehicles increases, the risk of collisions also increases, particularly if people are travelling at different speeds (on a vehicle or not) and where there are large differences in (vehicle) sizes and weights (International Transport Forum, 2022c).

As such, choosing when to combine and mix the infrastructure that users of different vehicle types can use should always be done with consideration for the more vulnerable and exposed road users. Priority should be placed on maximizing the safety and comfort of these users. For instance, in sections with less than 200 pedestrians per hour per meter, it is possible to consider combining pedestrian spaces with slow light mobility options such as cyclists and push scooter users, segregating the space when it is above 100 pedestrians (CROW, 2016). Similarly, bicycles, scooters and other rideables can be combined with faster light mobility alternatives and conventional traffic, but only if the traffic volumes and speeds are conducive to the safe operation of all vehicles.

Go further! Integrate public transport, pedestrian spaces and light mobility infrastructure

There is an enormous potential for countries and cities with extensive and well-performing public or collective transport systems (e.g., large metro systems in the largest cities and frequent rail connections between cities and within regions) to provide better accessibility outcomes to its citizens by encouraging public transport use and the use of light mobility to access or egress these stations by effectively integrating light mobility networks (e.g., cycle lanes) and public transport systems.

Integrating cycling as a first or last “mile” (i.e., access and egress) alternative effectively enhances the catchment area of transport stations (Martens, 2007). This sort of intervention can increase access to opportunities in large urban agglomerations (e.g., Pritchard et al., 2019) and at the regional/national level (e.g., Pritchard, Stępniak and Geurs, 2019).

In the Netherlands, the promotion of bike-and-ride alternatives has resulted in almost half of the trips between homes and train stations being performed by bike (KiM, 2019, 2021). This effective cycling and public integration in the Netherlands, where it is applied consistently across the national space, has been estimated to provide significantly better absolute accessibility to public transport users as a whole – and to result in a more egalitarian distribution of this transport good across larger areas (Pritchard, Stępniak, et al., 2019).

The high uptake of bike-and-ride alternatives in the Netherlands was not achieved by asking individuals to cycle to stations. Several essential factors included infrastructure integration and secure bike-parking alternatives at stations. In addition to the quality of the cycling infrastructure, latent perceptions about cycling and the conditions of the infrastructure are crucial to choosing to cycle to train stations. As highlighted by La Paix, Cherchi and Geurs (2021), ignoring the impact of latent factors would likely lead to overestimating the induced demand due to cycling infrastructure improvement. Furthermore, they found that in the Netherlands, users were much more sensitive to delays during cycling when compared to delays once they reached the stations (La Paix et al., 2021). This is a significant finding with policy implications, particularly in contexts where bike-and-ride is not a considerable transport alternative.

Cycling infrastructure leading to stations should be of high quality and, when possible, should be prioritised over motorised traffic. Cyclists are loath to come to complete stops due to the added effort needed to reaccelerate (Fajans and Curry, 2001). Furthermore, cyclists tend to overestimate the time they wait at intersections. In one recent study, Fioreze et al. (2019) found that this overestimation was significant, at five times the actual waiting time. Putting these two facts together highlights the importance of limiting real and perceived delays in these routes.

The role of shared light mobility

Bike-and-ride options could provide even more value to users than the status quo in the Netherlands. Although almost half of all access trips are cycling trips, most are on private bicycles. As a result, the activity-side access and egress trips only have an approximately 10% share (KiM, 2020). This means that the added value of the bicycle is only achieved on the access side and is not considered at the egress. Relying on shared micromobility options could therefore make bike-and-ride options even more effective at increasing accessibility while also having the potential to reduce the amount of space dedicated to parking at stations.

Bring everyone along! Communicate and educate

The current simplified system with one dominant mode (the car) and all other alternatives relegated to the margins has created an environment of fear.

Car drivers are overwhelmingly responsible for road traffic violence in urban areas, with other motorised vehicles like lorries and large trucks also playing a significant role. Data from the EU, for instance, shows pedestrians are overwhelmingly the victims of traffic fatalities and that most of them are dying at the hands of car drivers. As a result, road users, regardless of their modal choice, are trained explicitly or implicitly through a fear-based approach. Road users learn about the danger posed by the existing traffic mix and are taught ways to mitigate this danger.

Public Training in the use of changing streetscapes

To successfully shift towards more light mobility alternatives in cities requires moving away from this fear-based training to understand how to use all available options, what to consider, and why and when to choose different alternatives. All road users, including children, teenagers, young adults and elderly adults, each with varying capacities and skills, must understand how this space functions for all types of users and not just drivers.

More specifically for children, following the lead of places like the Netherlands and Denmark, it is essential to look ahead and focus on future generations and teach school children how to navigate the urban streetscapes independently. In the Netherlands, it is a common rite of passage to go through bicycle training. It allows children to learn traffic rules and desired behaviours while still young and is an important milestone in their development. Expanding these training efforts to other transport modes at different stages can be conducive to sustained changes in the societal perceptions of what is feasible and acceptable as a mode of transport.

Professional training for policy makers and planners

Finally, capacity building and training of planners and decision makers is essential if cities are to move towards light mobility. These stakeholders make decisions that define the context of how cities' transport systems are designed and function. There needs to be a shift from a mobility paradigm centred on motorised hypermobility and vehicular throughput to one prioritising accessibility and safety.

As highlighted by the International Transport Forum (2023b), it is necessary to address the pervasive moto-normativity that creates an environment that is hostile to all other alternative modes of transport. Car blindness, car blinders and the broader moto-normative lens through which personal mobility, and social participation, more broadly, are viewed worldwide discourage the use of other modes of transport while marginalising those who cannot or choose not to partake in fast motorised travel. On the one hand, the car has achieved such hegemonic power that its role in policymaking and target setting is often invisible. And on the other, even the cars themselves become physically invisible, in a sense. They have become so entrenched in the urban landscape that the general public often systematically overestimates the amount of mobility space allocated to non-motorised modes – while underestimating the space allocated to the car (Szell, 2018). Additionally, much of the violence they impose on all other road users is normalised and remains unaddressed in public and policy discourses.

Policy makers and planners need to remove their car blinders and cure their car blindness so that they can finally see the light.

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Effective Light Mobility Policies in Cities

This report explores how traffic systems and infrastructure can be redesigned and expanded for a broader range of vehicle types, especially "smaller-than-car" or light mobility options. It identifies the potential benefits of making vehicles lighter and diversifying the range of vehicles used for everyday mobility. It also highlights successful policies for encouraging a shift towards urban light mobility in cities. Finally, it presents strategies for implementing frameworks for such policies and highlights measures decision makers should consider as part of their light mobility strategy.

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