Electric Two-Wheelers, Sustainable Mobility and the City

Stefan Bakker

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.81460

Abstract

Congestion, lack of accessibility, social equity, air pollution, as well as rising CO_2 emissions are some of the key issues urban transport policymakers face. Motorised two-wheelers and their accessibility benefits are often ignored in this discourse or seen as undesirable for reasons of pollution, noise, road safety and driving behaviour. Cycling, on the other hand, is viewed positively, yet faces substantial social and political barriers, and is suitable mainly for shorter trips. This chapter explores the role electric two-wheelers (including pedelecs, e-mopeds and e-scooters) can play in urban vehicle ecosystems, using the sustainable mobility paradigm. Compared to traditional transport planning, this paradigm has a stronger focus on aspects such as accessibility, people, streets as a space, city liveability, as well as environmental impacts. The analysis is based on existing literature in the academic and policy realm and a comparison with other transport modes including motorcycles, bicycles, public transport and cars. It includes cases from China, Vietnam and the Netherlands, each of which have distinct mobility system characteristics. Possible policy instruments to facilitate further deployment of electric two-wheelers are discussed as well. This chapter thereby helps filling a gap in transport, sustainable development and climate change mitigation literature, in which electric two-wheelers have not been well covered to date.

Keywords: e-bikes, electric two-wheelers, urban mobility, accessibility, sustainable transport, transport policy

1. Introduction

Substantial changes in urban mobility systems are required across the globe in order to reach sustainable development goals (SDGs) and climate change objectives. Indeed, sustainable urban transport is essential to achieve SDG targets related to urban access, reduced health impacts from air pollution and road traffic crashes, clean energy, inefficiency of fossil fuel subsidies, resilient infrastructure, climate change measures and sustainable cities and communities [1].

Exposure to ambient air pollution results in 4.2 million deaths annually [2], and 9 out of 10 urban dwellers breathe air that does not comply with the WHO standards. The transport sector is the largest contributor to PM2.5 pollution [3], with, for example, the economic cost of air pollution from road transport in OECD countries estimated at close to USD 1 trillion per year, measured in terms of the value of lives lost and ill health [4]. In addition, physical inactivity is responsible for 3.2 million deaths annually [5]. Data on noise impacts are limited; however, the health effects from exposure to noise are substantial. In the European Union, 65% of the urban population is exposed to noise above 55 dB, leading to an estimated 1–2 million DALYs annually [6]. Other concerns related to urban transport include increasing congestion and lack of accessibility, social equity and transport justice [7], urban liveability, habitat fragmentation [8] and energy security or oil price vulnerability [9].

At the global level, urban (passenger) transport contributed about 2 billion tonnes of CO_2 in 2015 or one-quarter of total transport emissions (including international aviation and maritime transport) [4]. In order to meet the Paris Agreement climate change targets of staying well below 2° and aiming for 1.5°, total transport emissions have to be limited to 2–3 billion tonnes in 2050 from approximately 8 billion tonnes today [10]. As transport is where emissions are rising the most rapidly among all sectors, this is a major challenge.

Traditionally, transport planning has been focussing on providing infrastructure to meet a projected future demand for transport. As Banister argued in his seminal article, 'The Sustainable Mobility Paradigm' [11], addressing the above-mentioned challenges requires fundamental shifts in transport planning. This new paradigm involves, among others, focussing on accessibility of opportunities in the urban space rather than mobility and vehicular travel per se, management of travel demand, considering street as a 'space' rather than a road and including environmental and social concerns in transport project evaluation.

Most literature on sustainable mobility considers modal shift away from cars to more environmentally benign modes. Within this, there is a significant and growing amount of research on cycling, with bicycles also enjoying a good reputation with policymakers in most countries. Motorcycles, on the other hand, are, by and large, ignored in sustainable transport research, as well as in policy discussions and climate change literature, although some researches are acknowledging its importance in meeting climate change objectives [12]. Since 2010, more literatures have been published on electric two-wheelers, such as e-bikes and electric scooters, which assess their potential impacts on the mobility systems and the environment, user motivations and aspects such as safety and driver behaviour [13].

This chapter aims to add to existing literature by (1) assessing qualitatively how electric two-wheelers (E2W) can contribute to sustainable urban mobility and (2) reviewing policy options to enhance the role of E2W.

In this chapter, we adopt the following approach. The e-bike is a relatively new vehicle and in fact represents 'the most rapid uptake of alternative fuelled vehicles in the history of motorisation' [13]. E2W thereby change urban mobility ecosystems or regimes, including the vehicle fleet composition, mobility options and urban planning. As a new mobility option for both passenger and freight (e-cargobikes), it has the potential to replace trips by other modes, notably bicycles, motorcycles, public transport and cars but also small trucks and vans. In addition, E2W may support other modes such as public transport by providing convenient first and last mile mobility. We particularly look at shifting from motorcycles to E2W as a way to maintain space-efficient (passenger) mobility on two wheels, yet in a cleaner fashion; however, shifting away from other modes may also be significant.

2. Conventional and electric two-wheelers: current situation

Two-wheelers powered by a combustion engine, including mopeds, scooters and motorcycles, play a key role in transport in many parts of the world. In South and Southeast Asia, the share of two-wheelers in the passenger vehicle population is particularly high, for example, 72% in India [14], 87% in Indonesia and 95% in Vietnam (95%) [15]. The fleet is growing by up to 10% annually in several Asian countries. In Europe, 12% of all registered vehicles are powered two-wheelers, though almost half of these are >250 cc [14] and often used for touring and sports purposes rather than utility mobility. In Brazil, 26% of the vehicle population are motorcycles and in North America, only 3% [14]. In China and Southeast Asia, two-wheelers account for more than a quarter of total passenger transport activity (measured in passenger-km) in 2015, more than any other mode [12].

A motorcycle uses seven times less space compared to a car [16] and is more energy-efficient, even when accounting for a higher average occupancy of cars. Nevertheless, motorcycles are significant sources of air pollution, noise and CO_2 emissions and are involved in a large share of road crashes.

In many cities in Asia, motorcycles are the preferred mode of transport by a large share of the population [17]. In dense cities, for example, Hanoi, accessibility to jobs by motorcycle is higher than by any other modes [18]. It enjoys higher status than a bicycle and is considered more convenient, particularly for hot and humid weather conditions. Motorcycles are relatively affordable and can be acquired by most households, thereby making it an equitable mode of transport.

In European cities, motorcycle mode share is often low, however rising in recent years. Amsterdam is a case in point, with about 2% of trips in 2016 by mopeds and scooters, which is a doubling compared to 2008. Moreover, such two-wheelers are involved in 16% of road crashes [19]. Although there are plans and strong public support to ban mopeds and scooters from using bicycle lanes, as of mid-2018, these are still allowed on all bike lanes and are not required to wear helmets. The users are relatively diverse, that is, they include all age and income groups.

At the same time, electric two-wheelers are gaining importance and already take a significant modal share in some countries in 2015, notably China (7%) and 2–4% in Denmark, the Netherlands and Japan [20]. China dominates E2W sales with about 30 million and a stock of about 250 million [17], followed in sales by Europe with 2.3 million, while the rest of the world accounts for about 1 million in 2015 [13].

These are predominantly e-bikes, which fall roughly in two categories: pedal-assisted bicycles (also called pedelecs) or throttle-controlled electric mopeds with the option of pedal power (often for regulatory purposes). The former are the most common in Europe, while in China and some Southeast Asian countries, e-bikes of the latter types are dominant. The speeds are up to 20–25 km/h for pedelecs and up to 45 km/h for e-mopeds, and the weight ranges from 20 to 45 kg. Electric scooters are capable of higher speeds and often fall in a different vehicle category than e-bikes.

To explore the characteristics of different E2W markets and their role in the mobility system, we examine—briefly and in broad terms—developments in China, Vietnam and the Netherlands.

In China, petrol-fuelled motorcycle bans in many cities in the early 2000s—starting with a sales ban in Shanghai in 1996 [21]—have resulted in a large and fast uptake of especially scooter-style e-bikes, with a 15–25% trip mode share in major cities [22]. They have become popular as well in cities where conventional motorcycles are still allowed (**Figure 1**). E-bikes have pedals and are classified as nonmotorised vehicles, thereby there is no requirement to wear helmet nor for licencing, and they can use bicycle lanes. E-bikes are used by a wide range of user groups, in small, medium and large cities, also as access mode for public transport. However, in general two-wheelers are used more by lower-income groups [23].

Within Southeast Asia, Vietnam has the highest share of motorcycles in the vehicle fleet [15]; however, e-bikes are not yet popular. The main users are those that do not have access to motorcycles. A key user group is students, who find these more convenient than the bicycle while it does not require a licence, registration or helmet, as is the case for motorcycles. E-bikes (**Figure 2**) are often of type that could be considered a hybrid between scooter-style and bicycle-style e-bikes. They have pedals, yet these are rarely used. There are two-wheeler lanes in some cities; however, in general they have to mix with other traffic. There are no specific policies to promote electric two-wheelers. A ban on motorcycles is planned in the city centre of Hanoi in 2030; however, whether this will cover e-bikes is not clear.

In Europe, most e-bikes are of the bicycle style. Weather is less of a barrier to cycling compared to Asian countries; however, e-bike extends the range of trips that can be covered by

Figure 1. Guilin, China: both conventional and electric motorcycles are used.

Figure 2. Hanoi, Vietnam: two-wheelers in mixed traffic, although on some roads space is allocated by mode.

Figure 3. Amsterdam, the Netherlands: bike lanes are used by bicycles, mopeds and electric bikes.

bicycle, in distance and user groups. Looking at the Netherlands, e-bikes sales are increasing rapidly and in 2017 account for about one-third of bicycle sales [24]. Although in the early days of e-bikes it was mostly the elderly buying E2W, in recent years, its popularity is spreading to many other groups, including students, commuters and parents of young children. Approximately half of the km travelled is for recreational purposes [24]. E-bikes, just as mopeds, are allowed on the bicycle lanes (**Figure 3**); however, as of July 2018, speed pedelecs need to use the main road in urban areas.

3. The potential role of electric two-wheelers in sustainable urban mobility

In this section, we review how E2W fits in a sustainable urban mobility system. Based on Banister [11], we focus on aspects of accessibility, as well as social and environmental sustainability.

Most trips in cities across the globe are less than 10 km, and many are shorter than 5 km. In the Netherlands, over 50% of car trips are shorter than 7.5 km [24], and in medium-sized cities such as Rajkot and Visakhapatnam (1–2 million population) in India, nearly 80% of all trips are below 5 km [25]. Even in the United States, known for their relatively low density and sprawl, 35% of all car trips are less than 5 km and 60% are below 8 km [20]. Trips up to 5 km are generally considered to be suitable for cycling. E-bikes can extend the range of trips currently or potentially undertaken by bicycle [24, 26] by reducing barriers such as hilly terrain, weather, low speed, physical strain and bad air quality [13]. At the same time, e-bikes can replace trips by motorised modes such as motorcycle, car and public transport.

Mode shift impacts vary, as shown in emerging literature. In Chinese cities where petrol-fuelled motorcycles are not allowed, e-bikes are displacing bus trips, yet also a significant share of trips by car/taxi and bicycle [13]. Some of the factors that impede use of bicycles are also barriers to using e-bike, for instance, heat, rain and air quality [26]. In Sweden, more than 50% of e-bike users in both urban and rural areas report replacing car trips, across different trip purposes [27]. An analysis of studies in Europe shows that the proportion of e-bike trips that replace car trips ranges from 16 to 76% [28].

Two-wheelers provide accessibility benefits over cars and public transport. Especially in dense cities in Asia and Europe, bicycles and motorcycles are more affordable, flexible, reliable and often faster than cars. In addition to reduced space require for parking, motorcycles use 3.4 times less road space than cars in Hanoi [29]. Two-wheelers are thereby much more space-efficient than other private vehicles, even when considering a slightly higher average occupancy rate for cars. In the longer term, mobility based on two wheels thus has an impact on land use and urban development and enables denser and liveable cities as opposed to 'sprawling car-dominated cities' [20]. Therefore, mobility modes and transport planning are strongly related to more fundamental questions around urban development and the future of cities.

Other positive impacts of e-bikes—compared to car or motorcycle travel—for individuals and society include health due to physical activity [13] and social interaction in the public space [30], although both these effects are less strong than for bicycle travel. In the economic realm, electrification of transport is a key strategy to reduce oil consumption and improve energy supply security.

Environmental benefits are substantial as well, in particular for climate change, air quality and noise. Compared to conventional motorcycles, electric two-wheelers emit substantially less CO_2 emissions per km (on a life cycle basis), even when powered by coal-based electricity [31]. Indeed, over 80% of the 29 million tonnes of CO_2 savings in 2017 by all types of electric vehicles globally are due to e-bikes in China [17]. For Vietnam, e-bikes are identified as the option with the second-largest CO_2 abatement potential in the transport sector [32]. Kerdlap and Gheewala [33] show that in Thailand, deploying a fleet of 13.6 million electric motorcycles to replace an equivalent fleet of conventional petrol-powered motorcycles between 2015 and 2030 could reduce two-wheeler life cycle CO_2-eq emissions by approximately 42–46%. Globally, it is estimated that in 2050, 22% of urban passenger travel can be by (e) bike, compared to 6% in the base case. This results in 300 $MtCO_2$ reductions in 2050 and USD 1 trillion in savings from vehicle purchase and operation and construction and maintenance of infrastructure [20]. Moreover, meeting the Paris Agreement targets requires 70% of global

http://dx.doi.org/10.5772/intechopen.81460

two-wheelers to be electric [17]. It should be noted that in peer-reviewed literature on climate change mitigation, however, there is limited attention for the role of electric two-wheelers.

Urban air pollution impacts are significant as well. The health impact of particulate matter on a person-km basis is lower than other modes that include petrol-powered cars, even for a coal-based electricity grid [34]. Finally, e-bike can reduce noise significantly [35], as conventional motorcycles and cars are key sources of urban traffic noise.

Table 1 presents a qualitative assessment of the sustainability aspects of electric two-wheelers discussed above, in comparison with other modes. It should be noted that this comparison is for illustration purposes only, as the modes cover different trip distances and impacts may differ considerably depending on local circumstances, particularly transport planning and environmental standards. Public transport modes are bus, tram and metro. Paratransit covers a variety of more informally organised transport such as motorcycle taxis, three-wheelers and minibuses, which are sometimes used as feeder mode for high-capacity public transport. Equity assessment is based on typical costs of travel, including ticket prices for public transport and total costs of ownership for private vehicles. In space efficiency, both parking and road space are considered. Lower CO_2 emissions also imply improved energy efficiency (i.e. reduced resource consumption) as well as energy security. Public transport first and last mile trips often involve 'active' modes such as walking or cycling. Other environmental impacts, such as pollution from battery production, are not explicitly considered here.

In the above assessment, road safety has not been taken into account. A meaningful comparison between modes is not possible as often multiple modes are involved in one road crash. In addition, among countries, road crash rates and fatalities for all modes differ by more than an order of magnitude. That said, motorcycles are often associated with safety concerns, and globally 23% of the 1.3 million road deaths were drivers or passengers of motorised two- and three-wheelers [36]. In the Netherlands, an increase in road deaths in 2017 was associated

Mode	Typical trip distance	Equity	Space efficiency	Air pollution	CO_2 emissions/ energy use	Noise	Physical activity
Walking	<1.5	+++	+++	+++	+++	+++	+++
Cycling	1–5	+++	+++	+++	+++	+++	+++
E2W	1–15	++	++	+++	+++	+++	+
Motorcycle	1–15	++	++	+	+	0	0
PT + NMT	1–20+	++	+++	++	++	++	++
PT + paratransit	1–20+	++	+++	+	+	+	+
Paratransit	1–5	++	++	0	+	+	0
Car	1–20+	+	0	+	0	+	0

Notes: PT, public transport; NMT, nonmotorised transport; 0, lowest rating; +, low rating; ++, medium rating; +++, high rating.

Table 1. Environmental and social sustainability impacts of urban transport modes.

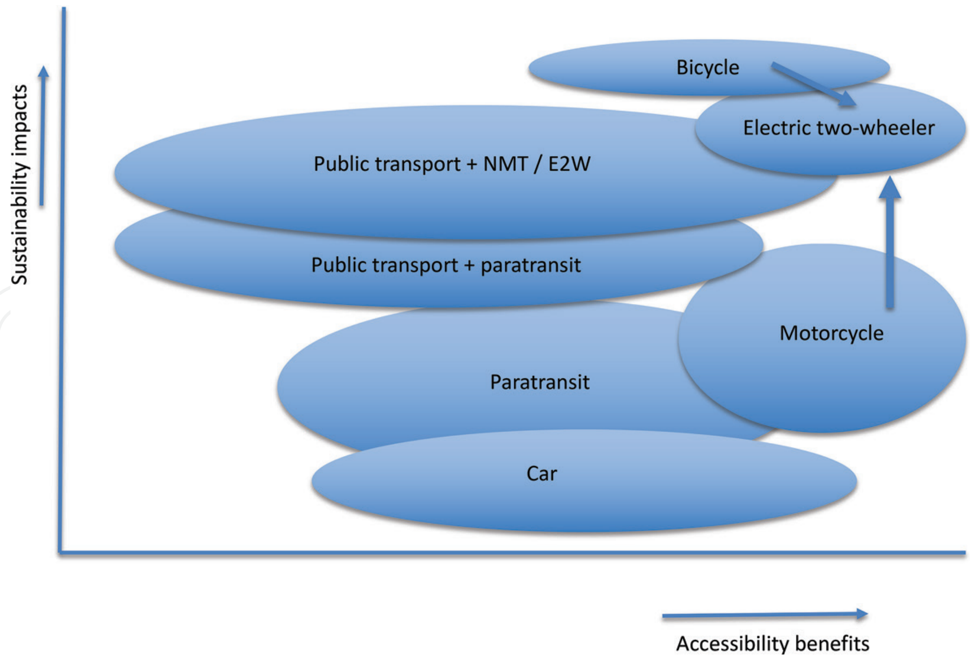

Figure 4. Indicative qualitative assessment of sustainability impacts and accessibility benefits of urban transport modes for trips 2–10 km, on a person-km basis. Accessibility covers travel time including parking and reliability. Sustainability aspects here include equity, road and parking space efficiency, air pollution, CO_2 emissions and fuel consumption, noise and physical activity (see **Table 1**). Larger ovals indicate larger spread in accessibility/sustainability benefits depending on local conditions. All vehicles except E2W are powered by internal combustion engines.

with the rising use of e-bikes among the elderly, as these are more difficult to handle than bicycles [37], with e-bikes taking 30% of total bike fatalities [24]. Unruly driving behaviour, for example, jumping red lights at intersections, is a key concern with e-bike riders as well as bicyclists and motorcycles in various countries [13].

In **Figure 4**, the sustainability impacts as included in **Table 1** are added and compared with accessibility benefits for urban trips of 2–10 km length in a dense city that has a balanced approach to transport planning for the different modes. Accessibility, or the ease of reaching opportunities, covers travel time, flexibility, reliability and ease of parking. The width of the ovals indicates how strongly accessibility depends on local conditions such as congestion, parking options, public transport service quality and urban planning. For example, in some cases a car may be as fast as a motorcycle, whereas in heavy congestion and limited parking availability, a car provides low accessibility.

A key observation from this figure is that E2Ws increase range and comfort of bicycles and improve sustainability performance of motorcycles while preserving accessibility benefits.

4. Policy options

In various countries, a limited number of policy initiatives are taken to promote electric mobility on two wheels. Yet in general, it can be stated there is a lack of policy attention, particularly in comparison to policy and research on other electric vehicles such as cars and buses.

There is a large potential in different regions to expand the use of electric two-wheelers, so what can be done do to harness this potential? Policymakers have a range of instruments that can be deployed [17]. In general, these can be organised by regulatory, economic and informative instruments [38], while for transport, often planning instruments are considered as well [39]. **Table 2** presents a brief overview, after which these options are discussed.

In the realm of regulatory instruments, the strongest policy measure is to ban motorcycles powered by fossil fuels, as implemented in Chinese cities. A phase out of conventional motorcycles and moped sales is considered in the Netherlands [40]. Similarly, a low-emission zone in a city can be designed such that conventional motorcycles will not be able to comply with the required emission standard to be allowed to circulate in the zone. Further, to improve safety for two-wheelers, speed limits for shared roads can be an effective tool, e.g. 30 km/h in urban areas where no dedicated lanes exist. At the same time, helmet use can be made compulsory for vehicles capable of travelling faster than a certain speed, for example, 25 km/h. Finally, electric two-wheelers need an appropriate legal framework in national vehicle legislation. Malaysia, for example, has adopted standards for electric mopeds with speeds in the range of 25–50 km/h, covering safety, performance and national compliance issues [41].

Planning instruments are key as well, for example, allocating dedicated road space for two-wheelers, together with quality standards for existing and new road surface that improves safety [14]. E2W then co-exist with either conventional motorcycles or bicycles, depending on the desired speed range and design of the two-wheeler lanes. For example, in China, e-bikes are often allowed on bike lanes. In addition, two-wheeler mobility can be made

Instrument type	Policy measure
Regulatory instruments	Phase-out conventional motorcycles
	Low-emission zones in cities
	Speed limit 30 km/h on shared roads
	Vehicle standards and registration requirement
Planning instruments	Dedicated lanes for E2W (and bicycles)
	Travel demand management, including traffic calming and parking management
	Dedicated waiting boxes at intersections, optionally with shading
	Electric bike-sharing facilities
Economic instruments	Incentives such as subsidies, tax breaks for purchase or registration of E2W
	Taxation of fuels (petrol and diesel)
Information/communication instruments	Campaigns
	Behaviour change programmes

Table 2. Overview of policy options to promote E2W.

more attractive, for example, by advanced stop boxes for two-wheelers at intersections (see **Figure 1**, right-hand side), which can be shaded in tropical regions to protect drivers from heat and rain. Travel demand management, to make car travel less attractive, is required as well. Measures include traffic calming (e.g. speed bumps), reducing parking supply, fuel taxation and restricting access to roads while allowing two-wheelers, ensuring a lower 'detour' factor for the latter. Finally, electric bikes can be included in bike-sharing schemes.

Financial incentives are another important instrument to promote E2W purchase and use. These can be designed, for example, as purchase subsidies, as done in some provinces in China [21], sales tax breaks [42] or an increase in petrol tax. In countries where motorcycle taxis are common, specific programmes to convert motorcycle fleets in a city to electric two-wheelers can be designed. In the Netherlands, a tax-deduction scheme for employees to buy a bicycle or e-bike exists. For behaviour change policies, incentives are often used in tandem with information instruments. It is argued that key life-changing events, such as moving to a new city or the birth of a child, are often powerful catalysts for behaviour change. Policy instruments can mimic such disruptive change [43], e.g. by pilot programmes with free e-bikes in exchange for car keys, as done in a promotion programme in Switzerland [44] or other incentives and campaigns. At the same time, information and training on road safety are needed for drivers of two-wheelers and other road users, e.g. as part of driver training curricula [14].

5. Conclusions

Electric two-wheelers can play an important role in sustainable urban mobility systems and addressing climate change. However, two-wheelers, including electric, suffer from a bad reputation and a lack of attention from policymakers in many countries. This chapter gives an overview of developments in China, Vietnam and the Netherlands, each with their own mobility system characteristics. Other than China, e-bikes and electric scooters are still in an early stage of development.

Yet there is a large potential: electric two-wheelers can on the one hand address negative impacts of fossil-fuelled motorcycles and cars on air quality, climate and noise while on the other hand extend the distance range of bicycles, by reducing the physical effort needed, which is especially attractive in hilly and tropical environments. In general, compared to other modes, electric two-wheelers score high on key criteria for sustainable mobility in terms of accessibility (flexibility, reliability, and speed), road space use, equity and environmental externalities, although road safety remains a concern.

Finally, this chapter proposes a range of policy measures—regulatory, planning, economic and communicative instruments—that can be used to promote purchase and use of electric two-wheelers. These include for example implementing low-emission zones, phasing out of conventional motorcycles, improving the legal framework, urban planning to increase attractive and safety of two-wheelers and conducting behaviour change programmes that cover both incentives and information for individual users or motorcycle taxi fleets.

http://dx.doi.org/10.5772/intechopen.81460

Acknowledgements

Comments and feedback from the book editor, Kathleen Dematera and Todd Litman, on a draft version of this chapter are greatly appreciated.

Author details

Stefan Bakker

Address all correspondence to: sjabakker@gmail.com

Independent Consultant, Amsterdam, The Netherlands

References

[1] Sustainable Mobility for All initiative. Global Mobility Report 2017. Tracking Sector Performance. Available from: http://sum4all.org/publications/global-mobility-report-2017 [Accessed: 9 September, 2018]

[2] World Health Organisation. Ambient (Outdoor) Air Quality and Health. Key Facts. Available from: http://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health [Accessed: 9 September 2018]

[3] Karagulian F, Belis CA, Dora CF. Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. Atmospheric Environment. 2015;**120**:475-483. DOI: 10.1016/j.atmosenv.2015.08.087

[4] International Transport Forum: Transport Outlook. Paris: OECD Publishing; 2017

[5] World Health Organization. Physical Activity for Health. More Active People for a Healthier World: Draft Global Action Plan on Physical Activity 2018-2030. WHO Discussion Paper. 9 April 2018. Available from: http://www.who.int/ncds/governance/who-discussion-paper-gappa-9april2018.pdf?ua=1 [Accessed: 9 September, 2018]

[6] European Environment Agency. Environmental Noise. Available from: https://www.eea.europa.eu/airs/2017/environment-and-health/environmental-noise [Accessed: 9 September, 2018]

[7] Martens K. Transport Justice. Designing fair transportation systems. New York and London: Routledge; 2017

[8] European Environment Agency: Landscape Fragmentation Pressure From Urban and Transport Infrastructure Expansion. Available from: https://www.eea.europa.eu/data-and-maps/indicators/mobility-and-urbanisation-pressure-on-ecosystems/assessment [Accessed: 9 September, 2018]

[9] Leung A, Burke M, Yen B, Chiou Y-C. Benchmarking urban transport oil vulnerability in 11 Asia-Pacific cities. Journal of the Eastern Asia Society for Transportation Studies. 2017;**12**:1005-1022

[10] Gota S, Huizenga C, Peet K, Medimorec N, Bakker S. Decarbonising transport to achieve Paris Agreement targets. Energy Efficiency. 2018:1-24. DOI: 10.1007/s12053-018-9671-3

[11] Banister D. The sustainable mobility paradigm. Transport Policy. 2008;**15**:73-80. DOI: 10.1016/j.tranpol.2007.10.005. https://link.springer.com/article/10.1007/s12053-018-9671-3

[12] International Energy Agency. Energy Technology Perspectives. Paris: OECD Publishing; 2016

[13] Fishmann E, Cherry C. E-bikes in the mainstream: Reviewing a decade of research. Transport Reviews. 2016;**36**:72-91. DOI: 10.1080/01441647.2015.1069907

[14] International Motorcycle Manufacturers Association: The Shared Road to Safety. A Global Approach for Safer Motorcycling. 2016. Available from: http://immamotorcycles.org/sites/default/files/_ftp-pdfs/2016-IMMA_Webversion.pdf [Accessed: 9 September 2018]

[15] Bakker S, Dematera K, Kappiantari M, Nguyen AT, Guillen MC, Gunthawong G, et al. Low-carbon transport policy in four ASEAN countries: Developments in Indonesia, the Philippines, Thailand and Vietnam. Sustainability. 2017;**9**:1217-1233. DOI: 10.3390/su9071217

[16] The World Bank: Motorization and Urban Transport in East Asia. Motor Scooter & Motorbike Ownership & Use in Hanoi. Final report. 2015

[17] International Energy Agency. Global EV Outlook 2018. Towards Cross-modal Electrification. Paris: OECD Publishing; 2018

[18] Nguyen NQ, Zuidgeest M, Van den Bosch F, Sliuzas RV, Van Maarseveen F. Using accessibility indicators to investigate urban growth and motorcycle use in Ha Noi city, Vietnam. Proceedings of the Eastern Asia Society for Transportation Studies. 2013;**9**. http://easts.info/on-line/proceedings/vol9/PDF/P126.pdf

[19] Gemeente Amsterdam. Meerjaren Plan Verkeersveiligheid 2016-2021 (in Dutch). Available from: https://www.amsterdam.nl/parkeren-verkeer/verkeersveiligheid/mjp-verkeersveilig/ [Accessed: 9 September, 2018]

[20] Mason J, Fulton L, McDonald Z. A Global High Shift Cycling Scenario: The Potential for Dramatically Increasing Bicycle and E-Bike Use in Cities Around the World. California: ITDP/UC Davis; 2015

[21] Ruan Y, Hang CC, Wang YM. Government's role in disruptive innovation and industry emergence: The case of the electric bike in China. Technovation. 2014;**34**:785-796. DOI: 10.1016/j.technovation.2014.09.003

[22] Wang J. Electric Two-wheelers in China. In: Presentation at ASEAN workshop on two-wheelers, Manila, November 2017. Available from: https://www.transportandclimatechange.org/download/tuewas-unep-workshop-on-two-wheelers-country-input-china-by-wang/ [Accessed: 9 September, 2008]

[23] Pan H, He X, Wang L. Mobility Improvements by electric two-wheels in public transit under-developed area. In: World Conference on Transport Research—WCTR 2016 Shanghai; 10-15 July 2016; Transport Research Procedia. 2017

[24] Harmsen L, Kansen M. Fietsfeiten. Den Haag, The Netherlands: Kennisinstituut voor Mobiliteit; 2016. Available from: https://www.kimnet.nl/mobiliteitsbeeld [Accessed: 9 September, 2018]

[25] Tiwari G, Jain D, Rao KR. Impact of public transport and non-motorized transport infrastructure on travel mode shares, energy, emissions and safety: Case of Indian cities. Transportation Research Part D. 2016;**44**:277-291. DOI: 10.1016/j.trd.2015.11.004

[26] Campbell A, Cherry C, Syerson M, Yang X. Factors influencing the choice of shared bicycles and shared electric bikes in Beijing. Transportation Research Part C. 2016;**67**:399-414. DOI: 10.1016/j.trc.2016.03.004

[27] Winslot Hiselius L, Svennson Å. E-bike use in Sweden—CO_2 effects due to modal change and municipal promotion strategies. Journal of Cleaner Production. 2017;**141**:818-824. DOI: 10.1016/j.jclepro.2016.09.141

[28] Cairns S, Behrendt F, Raffo D, Beaumont C. Electrically-assisted bikes: Potential impacts on travel behaviour. Transportation Research Part A. 2017;**103**:327-342. DOI: 10.1016/j.tra.2017.03.007

[29] Nguyen CY, Sano K, Tran VT, Nguyen VA. Estimating capacity and vehicle equivalent unit by motorcycles at road segment in urban road. Journal of Transportation Engineering. 2012;**138**:776-785. DOI: 10.1061/(ASCE)TE.1943-5436.0000382

[30] Brommelstroët M, Nikolaeva A, Glaser M, Skou Nicolaisen M, Chan C. Travelling together alone and alone together: Mobility and potential exposure to diversity social interaction. Applied Mobilities. 2017;**2**:1-15. DOI: 10.1080/23800127.2017.1283122

[31] International Energy Agency. Global EV Outlook. Paris: OECD Publishing; 2016

[32] Asian Development Bank. Pathways to low-carbon development for Viet Nam. Asian Development Bank. 2017. Mandaluong City, the Philippines. Available from: https://www.adb.org/sites/default/files/publication/389826/pathways-low-carbon-devt-viet-nam.pdf [Accessed: 9 September, 2018]

[33] Kerdlap P, Gheewala S. Electric motorcycles in Thailand. A lifecycle perspective. Journal of Industrial Ecology. 2016;**20**:1399-1411. DOI: 10.1111/jiec.12406

[34] Ji S, Cherry C, Bechle M, Wu Y, Marshall J. Electric vehicles in China: Emissions and health impacts. Environmental Science & Technology. 2011;**46**:2018-2024

[35] Sheng N, Zhou X, Zhou Y. Environmental impact of electric motorcycles: Evidence from traffic noise assessment by a building-based data mining technique. Science of the Total Environment. 2016;**554-555**:73-82. DOI: 10.1016/j.scitotenv.2016.02.148

[36] World Health Organization. Global Status Report on Road Safety. Geneva: WHO Press; 2015

[37] Stichting Wetenschappelijk Onderzoek Verkeersveiligheid. Verkeersdoden Nederland (Traffic fatalities Netherlands, in Dutch). Factsheet. Available from: https://www.swov.nl/feiten-cijfers/factsheet/verkeersdoden-nederland [Accessed: 9 September, 2018]

[38] Givoni M, Macmillen J, Banister D, Feitelson E. From policy measures to policy packages. Transport Reviews. 2013;**33**:1-20. DOI: 10.1080/01441647.2012.744779

[39] Wittneben B, Bongardt D, Dalkmann H, Sterk W, Baatz C. Integrating sustainable transport measures into the clean development mechanism. Transport Reviews. 2009;**29**: 91-113. DOI: 10.1080/01441640802133494

[40] Tweede Kamer der Staten-Generaal (Dutch Parliament). Motie van de leden Dik-Faber en Van Tongeren. Tweede Kamer, vergaderjaar 2016-2017, 34 550 XII, nr. 49

[41] Malaysian Standards. Electric mopeds—Specification. MS Standard 2688. 2018. Available from: https://www.transportandclimatechange.org/wp-content/uploads/2018/07/MS-2688-Preview-1.pdf [Accessed: 9 September, 2018]

[42] Jones L, Cherry C, Vu TA, Nguyen QN. The effect of incentives and technology on the adoption of electric motorcycles: A stated choice experiment in Vietnam. Transportation Research Part A. 2013;**57**:1-11. DOI: 10.1016/j.tra.2013.09.003

[43] Plazier P. Power to the pedals. Perspectives on the potential of e-bike mobility for sustainable and active transport systems [thesis]. Groningen, University of Groningen; 2018

[44] Moser C, Blumer Y, Hille SL. E-bike trials' potential to promote sustained changes in car owners mobility habits. Environmental Research Letters. 2018;**13**:044025. DOI: 10.1088/1748-9326/aaad73

IntechOpen