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**How Does Asia's Transport Sector Respond to COVID-19 for Achieving Greater Resilience and New Opportunities?**
(Background Paper for EST Plenary Session-2)

**Final Draft**

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This background paper has been prepared by Prof. Peter Newman, Curtin University, Australia, for the 14th Regional EST Forum in Asia. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

# Sustainable Shared Transport Resiliency and Operating Considerations Post-Pandemic

*Background Paper for the Fourteenth Regional EST Forum in Asia, October 2021, Virtual.*

## Contents

## Acknowledgements

# Executive Summary

Since the COVID-19 pandemic was announced by the World Health Organisation governments around the world have responded with various forms of restrictions to slow the spread of the virus. Transport agencies have been on the frontline of these restrictions and have responded in many creative ways outlined in this paper. These restrictions have also caused a range of mobility and behavioural changes, some of which are likely to continue post-pandemic, such as greater localisation, reduced long haul travel, more online interaction, and work from home arrangements. COVID-19 has provided a unique opportunity to rethink mobility and the provision of transport services, and this report touches on a number of such areas.

In particular it is clear that shared transport modes need to have high levels of cleanliness both as part of pandemic responses and going forward to support a return to high levels of patronage. This will involve a range of considerations such as: the need to collect and analyse passenger and freight data to review passenger limits and timetabling; review of station and vehicle layouts, services, and disinfection protocols; allowing for contactless and seamless ticketing and replacing next stop buttons; staff education and training; and integration of non-motorised individual modes. The next step in transport will be to manage vaccine passports so that confidence in crowded areas and services can be restored.

Asian cities have been significantly affected by COVID-19 with a near halt to public mobility along with severe restrictions to cross border movements. The key question is "*what will it take for transport to recover, and when it recovers, how can it be improved to be more resilient and to serve people, their communities, and their economies in a more sustainable and equitable way?*"[1] Of particular interest is digitisation and electro-mobility. Digitisation will likely focus on the use of human-centred data to allow transport agencies to better understand the movement of people and goods to inform traffic management, and the development of digital infrastructure to support work-from-home approaches.

The Ministry of the Environment in Japan has initiated the development of an online platform on sustainable and resilient recovery from COVID-19, with support from the UNFCCC, to provide a list of initiatives that countries are implementing.[2] During pandemic times, digital infrastructure will be key to identifying outbreaks through social tracing, and in post-pandemic it can be used to facilitate better community planning, improved transport services and better urban logistics and e-commerce.

When considering the opportunities for electro-mobility post pandemic there are a number of promising areas including the electrification of private, commercial and shared transit vehicles. Advances in battery technology have allowed a new generation of trams to be developed that not only avoid the need for overhead gantries to provide power but also replace tracks in roads (originally needed to overcome

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[1] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[2] IISD (2020) Ministerial Launches "Platform for Redesign" to Overcome Climate Change, COVID-19, International Institute for Sustainable Development.

issues with cobblestone streets) with rubber-tired options balanced by advanced stabilisation and guidance systems, such as in the Trackless Tram.[3]

This is not where the innovation ends, but rather it only begins by ensuring clean and efficient vehicles are used for shared modes that can be designed to serve corridors. Such corridors provide the opportunity for the development of a string of vibrant station precincts that provide a range of development opportunities, along with recharging facilities for electric vehicles, helping to replace highly congested car dependent road systems while delivering urban regeneration. Re-evaluation of all old projects will be needed as now all projects will need to pass the test to see if they can be net zero with electro-mobility. This will mostly involve examining how to electrify all old transport systems running now on gasoline and diesel. It will also mean that the local systems that feed into transit corridors will need revamping to assist local centres around stations.

The COVID-19 response and post-pandemic strategies will call for a range of new stakeholder roles across the transport sector and the developing world will have the opportunity to leapfrog technologies and capture numerous benefits associated with renewable energy, urban greening, electro-mobility, AI and data analytics, distributed ledgers, and a range of enabling technologies. It is clear that there needs to be a focus on three key areas: distributed renewable energy, storage and distributed energy markets; electro-mobility and associated infrastructure; and the application of rapidly evolving smart city technologies. Investment will need to have assessment processes that enable rather than drive-away these innovations. Such changes will need new partnership processes that enable all levels of government to work with private finance and business, in close collaboration with communities, whose local values need to drive all development and help create local enterprises.

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[3] Newman, P., Hargroves, K., Davies-Slate, S., Conley, D., Verschuer, M., Mouritz, M. and Yangka, D. (2019) The Trackless Tram: Is It the Transit and City Shaping Catalyst We Have Been Waiting for?. Journal of Transportation Technologies, 9, 31-55.

# 1.  Introduction

Since the COVID-19 pandemic was announced by the World Health Organisation (WHO) in March 2020,[4] governments around the world have responded with various forms of restrictions on human movement and interactions, ranging from city wide shutdowns to restrictions on the size of gatherings, in order to slow the spread and contain the virus.[5] Forcing behavioural changes and transforming the way people communicate, work and live, these restrictions have substantially affected mobility, providing a unique opportunity to revise and rethink transport related approaches and strategies.[6]

Such impacts have called for reconsideration of a range of transport related areas, such as: perceptions of acceptable pollution levels in cities caused by transport fuels; perceptions around the appeal and use of active modes of transport; perceptions around the use of shared transit options; and implications for the freight and logistics sector.[7] As with many sectors of the economy it is important for the transport sector to explore and understand various options to manage the new and changing systems that emerge from the pandemic, and to improve the current systems at an environmental, economic and social level.

Given the significant disruption caused by COVID-19 it is very likely that some of the altered behaviours and patterns may endure, such as a greater focus on localisation, reduced travel, and higher levels of staff working from home, each will have an implication for the transport sector.[8] With less face-to-face interaction, many workplaces and educational facilities have adapted to online communication and learning, making previously largely overlooked, and long advocated, option to work-from-home now a mainstream mode.[9]

It is important to understand that from a transport perspective there is much to learn from the COVID-19 experience, such as the fact that many cities experienced the lowest level of air pollution in living history due to travel related restrictions. For instance Wuhan China saw a 63 percent reduction in air pollution,[10] and in Delhi the level of PM2.5 was within the recommended WHO guidelines for the first time in decades.[11] Given that the majority of air pollution is a result of transport energy choices it is likely that there will be a strong focus on transitioning away from fossil fuel use in transport towards electro-mobility.

Due to COVID-19 a spotlight has been shone on the cleanliness of shared transport options, which has historically been a factor that affects patronage. Post-pandemic there will be a range of efforts to respond to health concerns in shared transport options in order to get cities moving again. The requirement to

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[4] WHO (2020) Timeline: WHO's COVID-19 Response, Online, World Health Organisation (WHO).

[5] OWD (2020) Policy Responses to Cornavirus Pandemic, Online, Our World in Data, 3rd August 2020.

[6] Zhang, J. and Hayashi, Y. (2020) Impacts of COVID-19 on the Transport Sector and Measures as Well as Recommendations of Policies and Future Research: Analyses Based on a World-Wide Expert Survey, May 27, 2020, Social Science Research Networks (SSRN).

[7] Newman, P., Hargroves, K. and Conley, D. (2020) Changing the course of Asia's transport sector through transformational change, Background Paper for the UNCRD Thirteenth Regional EST Forum in Asia, November 2020.

[8] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[9] Zhang, J. and Hayashi, Y. (2020) Impacts of COVID-19 on the Transport Sector and Measures as well as Recommendations of Policies and Future Research: Analyses Based on a World-Wide Expert Survey, SSRN.

[10] Cole, M., Liu, B., and Elliott, R (2020) Wuhan's lockdown cut air pollution by up to 63% – new research, The Conversation, 13 may 2020.

[11] Lombrana, L. and Warren, H. (2020) A Pandemic That Cleared Skies and Halted Cities Isn't Slowing Global Warming, Bloomberg, 08 May 2020.

provide sanitised shared transport services during the pandemic response has provided an opportunity to design, implement and improve a range of measures that will continue to enhance patronage of such services post pandemic, such as: protective clothing for staff and passengers, station entrance track-and-trace applications, temperature checks, enhanced online reservation options, increased disinfection and cleaning practices, penalties in place for not wearing masks, and quick response to localised outbreaks.[12]

Post pandemic such measures can be used to not only reduce the risk of future spread of such a virus, but also to mitigate a range of health concerns which will provide a safer and cleaner shared transport system. Along with electrification this will be a key element of the shift globally away from individualized private transport and towards shared transit options in cities.

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[12] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

## 2. Effects of COVID-19 on Travel and Mobility in Asia

Across Asia, lockdowns due to COVID-19 have been implemented in order to restrict movement of residents to trips deemed essential (essential services, shopping, medical services, providing care). Shared transport systems introduced mandatory mask wearing and increased cleaning of equipment and vehicles, however not all countries reduced patronage due to the severe need for shared transit services.

Significantly for economies in Asia, as a result of the COVID-19 pandemic international tourist arrivals in many developing countries has been reduced by 80-90 percent.[13] Cities in China experienced shared transit rider reduction periods of up to 90 percent, while Singapore's Mass Rapid Transit system had a maximum decrease of 80 percent.[14] Globally, passenger air transport fell to nearly zero in April, 2020 and as of October, 2020 had recovered just 20 percent relative the previous year.[15] The impact of COVID-19 on the world's mobility is yet to be fully appreciated however it is clear that it has had a significant impact on local and regional transport Many cities responded by enforcing strict restrictions on mobility, especially shared modes like metro's and subways' trains and us services, affecting millions of people around the world.

The freight and logistics sector was also significantly affected by border restrictions, increased sanitation requirements, and increased delivery expectations, at a time when many have turned to online shopping. According to Earley and Newman, "*The question that remains is, what will it take for transport to recover, and when it recovers, how can it be improved to be more resilient and to serve people, their communities, and their economies in a more sustainable and equitable way?*"[16]

Mobility in Asia was impacted across all modes ranging from pedestrian movement between precincts to private vehicle and plane travel between states and countries. After initial severe and often total lockdowns to curb spread of the disease, governments have attempted to balance pandemic measures while returning transport and mobility towards normal function. The relaxing of travel from one's home called for adaption of public mobility vehicles, including public transport systems, shared ride services and eventually planes – private mobility operation remained a relatively safe mode, though some jurisdictions placed capacity caps on private vehicles.

Mobility will be lower after the pandemic compared to before due to increased working from home and lower international traffic[17], although the application of disease mitigating actions can make public transport COVID-19 safe and help return normalcy to mobility.[18] The International Association of Public Transport (2021) recommends development of disease risk assessments and mitigations for all

[13] UNCTD (2021) 'COVID-19 and Tourism: An Update - Assessing the economic consequences, United Nations Conference on Trade and Development, 2021.

[14] Gkiotsalitis K (2020) Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions, Transport Reviews, Vol. 41, 2021 – Issue 3

[15] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[16] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[17] Falchetta, G.; Noussan, M. (2020) The Impact of COVID-19 on Transport Demand, Modal Choices, and Sectoral Energy Consumption in Europe. IAEE Energy Forum 2020

[18] UITP (2020) Public Transport is COVID-Safe, UITP Policy Brief, October 2020.

transport systems.[19] Budzynski et al 2021 amalgamates initiatives and actions made by various governments and authorities across the world to mitigate disease spread in public mobility to comprehensively outline how public transport must act on COVID-19 and other diseases to provide safe service:[20]

1. Analysis of passenger logistics via service lines to various degrees of essential locations – workplaces, schools and recreation places.

2. Continuous review of passenger limits in service vehicles.

3. Introduction of dynamic timetables utilising data from passenger logistics and vehicle limits.

4. Redesigning vehicle layout to improve disease mitigation – distancing seating and directing passengers to avoid transmission.

5. Redesigning service stations and stops to encourage distancing of people.

6. Revising ticketing methods – utilising cashless and contactless payment methods, including online pre-booking, eventually eliminating driver-passenger-public node interaction.

7. Improved automation of vehicle services and mechanisms including disabled-access ramps.

8. Redesigning vehicle and station air-conditioning systems to prevent disease spread and disinfect air.

9. Auditing of contact surface materials' ability for harbouring disease, including seating materials, railings, poles, handles and any contact surfaces. The potential for shielding surfaces is discussed in section 4.

10. The rethinking of functional contact spaces and devices, such as stop and door-opening buttons. Their automation or connection to a personal mobile device could mitigate public contact.

11. Disinfection plans for services, to be carried out periodically at appropriate locations, likely terminals or stations.

12. The development of safe operating procedures for staff and mandating of personal protective equipment, including masks and glasses to prevent disease transmission.

13. Auditing of staff uniforms to consider materials' ability for harbouring disease and washability.

14. Educational campaigns to inform passengers of the disease's threats and preventative measures.

15. Funding security for transport services in the event of patronage falling due to disease scares.

16. Promotion of cohesive sustainable transport modes in a network to support vehicle services, including walking and cycling.

17. Education of staff to work under pandemic and disease mitigation conditions.

18. Supporting staff in their increasingly important role to provide safe public transport service.

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[19] UITP (2021) Adopting Long-Term Strategies for Cleaning and Disinfection of Public Transport Systems, Knowledge Brief, August 20121.
[20] Budzynski, M.; Luczkiewicz, A.; Szmaglinski, J. (2021) Assessing the Risk in Urban Public Transport for Epidemiologic Factors. Energies 2021, 14, 4513

Shortall *et al* (2021)[21] elaborate where these measures have been implemented to various degrees, as assessed by governments and authorities on a system-by-system basis. Avoiding overcrowding and improving hygiene are the main objectives and social distancing in vehicles and stations has been accommodated by limiting people capacities across the world through signage and policy, and even enforced with security cameras as in buses in China. The sterilisation of public transport spaces in Asia has been facilitated with widespread provision of hand sanitiser in vehicles and stations, improved air filtration systems, UV light disinfection systems and some use of robots for cleaning, to avoid hazards to staff.

The most prevalent and effective measure for safe transit is the mandating of mask wearing in vehicles and stations (public crowding) to prevent viral emission and intake. The improved capacity management of services has been done with adaptive service to meet demand fluctuation, as in San Francisco and Hamburg where services are adjusted to patronage volumes, prioritising essential lines. Increased frequency of service in New York, Florida and Houston serves to reduce vehicle crowding and increased infrastructure support – such as additional bus lanes in New York and Scotland – accommodates these extra vehicles.

Real-time data between service providers and passengers can inform both parties to improve use of the adjusted service more safely and with greater ease, as in Beijing where passengers can pre-book and stagger their rides and in Fukuoka and Catalonia where passengers can see congestion levels online for trains and buses respectively. Maintaining public transport services is essential to providing equitable mobility to the population and in some cities the heavy reliance on public transport meant that some implementation of COVID-safe mitigations was near-impossible, as exemplified in Mumbai's train capacity reduction resulting in overloading of the bus system and London's bus and tube services' high patronage, low mask adherence and staff sickness lowering the efficacy of mitigations. The effectiveness of individual measures is difficult given they are implemented concurrently, but it is common consensus that combined measures is best practice.[22]

Air travel was severely limited during intense periods of the pandemic, to stem flow of the disease from international sources. The gradual return of flights internationally and nationally will involve some changes to travel behaviour to maintain health standards - similar to that involved in public transport, although higher consequence due to the potential for introducing new diseases to a country or region. The limiting of entrance to countries will place logistical and financial strain on airlines, leading to closure of some routes and increase of prices for travellers. The wearing of masks is widely mandated, as in Australia on any flight[23] and conducting a COVID-19 test with a negative result two days before flying is required by majority of airlines and countries accepting foreign travellers or returning nationals.

The next important step will be 'vaccination passports' to enable a post-Covid transition away from hygiene and social distancing-based approaches. Public transport of all kinds will need to be open only

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[21] Shortall, R., Mouter, N., and Van Wee, B. (2021) COVID-19 passenger transport measures and their impacts, Transport Reviews, Taylor & Francis.

[22] Shortall, R., Mouter, N., and Van Wee, B. (2021) COVID-19 passenger transport measures and their impacts, Transport Reviews, Taylor & Francis.

[23] Australian Government (2021) COVID-Safe Domestic Flying—Domestic Passenger Journey Protocol, Australian Government Department of Infrastructure, Transport, Regional Development and Communications, Australia.

to those who are vaccinated. This will enable people to come back to crowded transit services with confidence.

# 3. Opportunities for human-centred utilisation of technologies for sustainable mobility

As part of the 2020 UNCRD EST Forum in Asia, a range of emerging post-COVID new economy technologies were discussed.[24] This was based on the waves of innovation first noticed following the 1930's depression which gave rise to most of the transport innovations we use today. The next wave of innovations will be about solar, batteries, electro-mobility and smart city technologies that enable the integration of these new net zero systems as well as creating opportunities for employment and poverty relief. These are now rapidly accelerating across the world's cities and regions. In this conference there are opportunities to see how this new agenda can be facilitated.

In the response to COVID-19 there are a number of opportunities emerging on how to improve mobility in the world's cities that are being incorporated into a number of countries COVID-19 recovery plans, as summarised in Table 1.

**Table 1**: Sustainable transport actions by countries as part of a COVID-19 Recovery Plans[25]

| Action | Countries |
|---|---|
| Electric vehicle promotion and charging infrastructure | Bangladesh, P.R. China, Indonesia, Nepal, Pakistan |
| Electric vehicle promotion in rural areas | Bangladesh, P.R. China |
| Renewable electricity—Electric vehicle integration | Bangladesh, Nepal |
| Cycling programs and infrastructure | the Philippines, P.R. China |
| Integrated transport planning | P.R. China |
| Rural road improvements | Bhutan |
| Zero emission shipping | Japan, P.R. China |
| High emission diesel vehicle replacement | P.R. China |
| Transport energy efficiency improvements | Indonesia |
| Financial assistance to transport workers | the Philippines |
| Public utility vehicle modernization | the Philippines |

Of particular interest is two areas, firstly digitisation and secondly electro-mobility including new e-bikes, e-tuk tuks, e-buses and trackless trams. Behind these transport-oriented innovations is the rapidly growing use of renewable energy. In the area of digitisation there will likely be a focus in two areas, namely: the use of human-centred data to allow transport agencies to better understand the movement of people and goods to inform traffic management,[26]especially how to help local traffic to be more enabling of walking and cycling and small transit vehicles, and the development of digital infrastructure to support work-from-home approaches. Digitisation can utilise mobile phone data to build a comprehensive picture of personal logistics for entire cities or communities. For instance, Google has created COVID-19 Community Mobility Reports from mobile data (from android phones), available online for free to help policy makers understand their residents' behaviour.

Bangladesh is promoting improved deliveries of goods and medical services by introducing electric rickshaws and electric boats to its transport system. This e-mobility is being demonstrated in a relatively

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[24] Newman, P. Hargroves, K, and Conley D. (2020) Changing the course of Asia's transport sector through transformational change, Background Paper for the Thirteenth Regional EST Forum in Asia, November 2020, UNCRD.

[25] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[26] Hargroves, K. (2021) Introducing the 'FreightSync Roadmap' - A Pathway to Linking Freight Vehicles and Transport Systems, Project 3.73 – Road Freight and Network Efficiency, Sustainable Built Environment National Research Centre (SBEnrc), Australia.

smaller metro area of Singra and is aiming to provide more reliable mobility in reaction to COVID-19 and climate change, with ambition to roll-out at the national level.[27]

The importance of integrating sustainable personal mobility into a transport network to balance public transport vehicles was exemplified by capacity limits in vehicles during COVID-19, with cycling and other micro-mobility services like personal and crowd-shared electric scooters and bicycles offering to reduce crowding loads in vehicles and improve personal journey tailoring. In The Philippines cycling uptake has increased through the pandemic, to, with cyclists even using locally sourced bamboo for frame construction.[28] With the reduction of public transport services, the public in the Philippines has taken initiative to cycle in large numbers, causing higher bike traffic than intended for current infrastructure.[29] The government is encouraging this uptake, although greater infrastructure investment is the immediate consideration.[30][31]

Personal mobility has seen greater investment in response to the pandemic, as in Barcelona having added 21 kilometres of cycling infrastructure and 12 kilometres of roads designed to give precedence to pedestrians and cyclists above motor traffic. Similarly, cities in across the world (including Bengaluru, Chennai, Sydney, Madrid, London and Berlin) have implemented temporary bike lanes to encourage cycling as a relief to loads on public transport services. Cities in China, Japan and the Republic of Korea have had surges in free bike-share services, offering greater mobility access with lower crowding for the public. [32]

The provision of digital infrastructure is important to allow work-at-home practices which avoid the need for transportation, such as online learning, online shopping and tele-commuting options. A continued push, both in rural and urban areas, to implement strong digital infrastructure will continue to be important even after the present pandemic is over. Such infrastructure will deliver a range of benefits to residents such as improving access to services, such as online banking, education, etc, while allowing them to stay closer to home.

During pandemic times, digital infrastructure is key for identifying outbreaks through social tracing, but in normal times, such infrastructure can also be used to facilitate better community planning, improved transport services and better urban logistics and e-commerce. [33] When considering the opportunities for electro-mobility post pandemic there are a number of promising areas including the electrification of private, commercial and shared transit vehicles. From a purely technological point of view there is much innovation that can be applied. The electrification of trains and trams is well established with more recent efforts focused on the electrification of busses and private cars.[34]

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[27] TUMI (n.d.) COVID Challenge Singra, Bangladesh, E-Mobility Public Transport Improvement Project, Transformative Urban Mobility Initiative

[28] Cabato R, San Diego M (2021) Filipinos are Cycling Their Way Through the Pandemic, Washington Post

[29] Dela Cruz K, Ives M (2020) When the Trains Stopped Cyclists Dodged Manila's Choking Traffic, The New York Times

[30] Huaxia (2020) Philippines promotes walking, biking amid COVID-19 lockdowns, Xinuanet

[31] Lopez L (2020) Philippine coronavirus lockdown boosts calls for a bike-friendly Manila, This Week in Asia

[32] Nikitas A et al (2021) Cycling in the Era of COVID-19: Lessons Learnt and Best Practice Policy Recommendations for a More Bike-Centric Future, Sustainability 2021, 13, 4620

[33] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[34] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy

Advances in battery technology have allowed new generation of trams to be developed that not only avoid the need for overhead gantries to provide power but also replace tracks in roads (originally needed to overcome issues with cobblestone streets) with rubber tired options balanced by advanced stabilisation and guidance systems, such as in the Trackless Tram.[35] However this is not where the innovation ends, but rather it only begins by ensuring clean and efficient vehicles are used for shared modes that can be designed to serve corridors.

Such corridors provide the opportunity for the development of a string of vibrant station precincts that provide a range of development opportunities, along with recharging facilities for electric vehicles, such as micro-mobility options, cars, light commercial vehicles and the trams themselves.[36] In particular electric micro-mobility options will be important for many Asian cities to provide local transport and reduce the use of cars for short trips, with some 46 of journeys by car in the USA being 3 miles long or less.[37] Currently the greatest uptake of electric mobility has been in China, as shown in Figure 1.
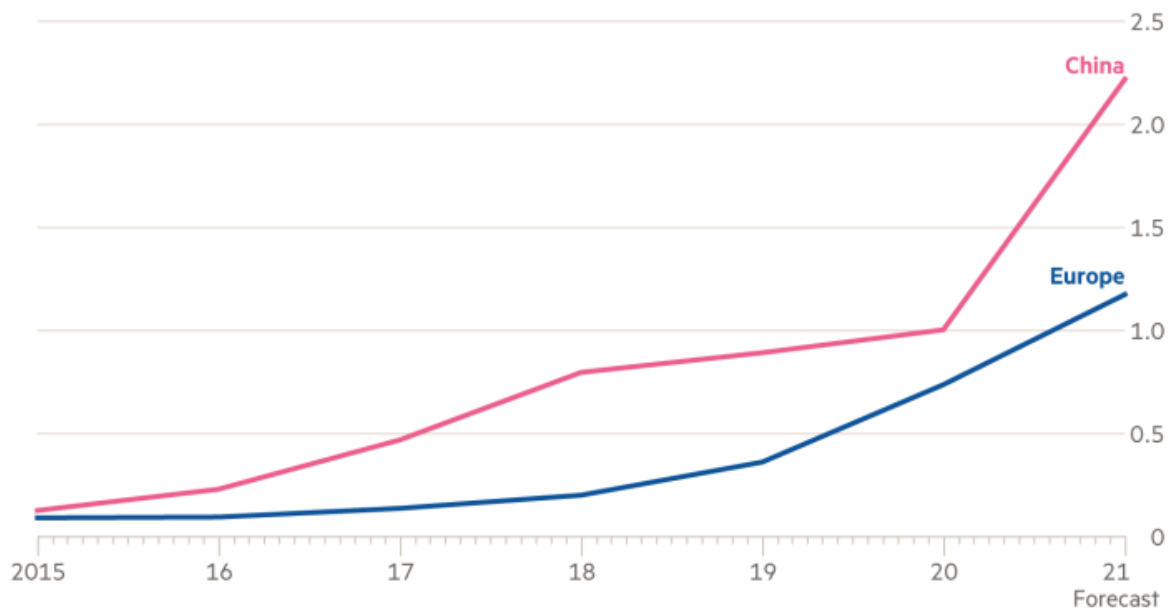


**Figure 1**: Sales of battery electric vehicle in China and Europe in millions (2015-2021)

*Source*: LMT cited in Campbell, P. and Miller, J. (2021)[38]

Such precincts can provide services and allow people to reduce travel to central areas, helping to replace highly congested car dependent road systems while delivering urban regeneration.[39] According to Newman (2020)[40], "*This has been a major agenda for most cities for the past 20 years but new electro-mobility is now enabling this agenda and thus is likely to be a big part of future urban economic development strategies*".

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[35] Newman, P., Hargroves, K., Davies-Slate, S., Conley, D., Verschuer, M., Mouritz, M. and Yangka, D. (2019) The Trackless Tram: Is It the Transit and City Shaping Catalyst We Have Been Waiting for?. Journal of Transportation Technologies, 9, 31-55.

[36] Glazebrook, G. and Newman, P. (2018) The Future City, Urban Planning, Volume 3, Issue 2, Pages 1–20.

[37] Ajao, A. (2019) Everything you wanted to know about scooters and micro-mobility. Forbes, 01 February 2019.

[38] Campbell, P. and Miller, J. (2021) 'Electric Vehicles: the revolution is finally here', Financial Times, 04 October 2021.

[39] Newman, P., and Kenworthy, J (1989) Cities and Automobile Dependence, An International Sourcebook, Gower; Newman, P., and Kenworthy, J. (1999) Sustainability and Cities: Overcoming Automobile Dependence, Island Press; Newman, P. and Kenworthy, J. (2015) The End of Automobile Dependence: How Cities Are Moving Beyond Car-based Planning, Island Press.

[40] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

With the rapid increase in online shopping and the need for parcel delivery services which are done using road based vehicles such precincts present the opportunity for parcel hubs with parcels carried on trams and trains and delivered to stations for people to collect on the way home from work or other trips. Such multi-function precincts can benefit from advanced data management using artificial intelligence and machine learning to interrogate data captured via sensors to manage energy, water, waste, transport, and to continuously learn from users. Thus, Newman (2020)[41], "*The centres become something like a set of neural networks that are constantly improving the ecosystem in which they operate*".

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[41] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

# 4. Best practices and lessons from mitigation of COVID-19 for resilient mobility in Asia

In response to COVID-19 a range of protocols have been developed that seek to mitigate the negative effects while maintaining transit services in an effort to balance economic and public health outcomes. Measuring the effectiveness of such actions to mitigating the spread of the virus via shared transport is however difficult due to it being the early stages of the response and multiple efforts need to be coordinated across cities and nations.[42]

Due to a number of complimentary factors, including the level of globalisation and interconnectivity of the world's peoples, the COVID-19 virus spread rapidly with some promising examples of digitisation and electrification facilitating rapid responses.[43] For instance Singapore successfully utilised digital services for disease surveillance to inform and implement public instructions and policies to curb the spread of the virus.[44]

Rapid responses by authorities were shown to be critical in curbing the spread of the disease. The suspension of public gatherings and shared transport services, especially in emergency zones, was undertaken in cities around the world and shown to be an effective measure. Notably, shared transport modes were a key connector between Wuhan and surrounding cities.[45] During the pandemic countries and cities responded differently with nation-wide lockdowns in India,[46] reductions to shared transport activities by 80 percent in Hanoi, seat pre-booking for trains in Beijing,[47] and in Guangzhou services were maintained with 50 percent capacity and increased as appropriate.[48]

In many countries tracking measures were put in place that included location sign-in applications and track-and-trace applications using smart-phones. In Taiwan, citizens who were in hotspots or quarantine were tracked to improve virus-spread data and quarantine control respectively.[49] The tracking of citizens meant that virus-spreading hotspots could be identified and contained, including the closure of hubs exposed to the virus. The Taiwanese Government utilised 'disease logistics' and other data to enact quick and firm actions while maintaining transparency with the population – improving adherence of rules and demonstrating effective leadership.[50]

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[42] Royal Academy of Engineering (2020) A rapid review of the engineering approaches to mitigate the risk of COVID-19 transmission on public transport, National Engineering Policy Centre, Royal Academy of Engineering.

[43] Walcott, D. (2020) How the Fourth Industrial Revolution can help us beat COVID-19, World Economic Forum; Sehmi, G. (2020) Three emerging digital technologies for the new normal in transport, World Bank Blogs

[44] Pung, R. (2020) Effectiveness of Containment Measures Against COVID-19 in Singapore, Epidemiology, Cambridge University

[45] Zheng, R., Xu, Y., Wang, W., Ning, G. and Bi, Y. (2020) Spatial transmission of COVID-19 via public and private transportation in China. Travel Medicine and Infectious Disease; Jiang, F., Deng, L., Zhang, L., Cai, Y,. Cheng C. and Xia, Z. (2020) Review of the clinical characteristics of coronavirus disease 2019 (COVID-19). Journal of General Internal Medicine

[46] Gettleman, J., and Schultz, K. (2020) Modi Orders 3-Week Total Lockdown for All 1.3 Billion Indians, The New York Times

[47] Xinhuanet.com (2020) Beijing Metro Pilots Peak Station Entry Reservations. Xinhuanet.com.

[48] Tran, T., Le, T., Nguyen, T. and Hoang, V. (2020) Rapid response to the COVID-19 pandemic: Vietnam government's experience and preliminary success, Journal of Global Health; ITDP (2020) How China Kept Transit Running During COVID-19, Institute for Transportation and Development Policy.

[49] Wang, C. (2020) Response to COVID-19 in Taiwan Big Data Analytics, New Technology, and Proactive Testing, JAMA Network, Journal of the American Medical Association.

[50] Chen, S. (2021) Taiwan's experience in fighting COVID-19, Nature Immunology

Mask wearing, especially where social-distancing is not possible (such as in dense shared transport services), was quickly recognised as an effective prevention measure and adopted in many countries, with many denying access to shared transport services for people not wearing a mask.[51] Other entrance-control measures include body temperature checks, such as for shared transport passengers in order to quickly identify those that may be symptomatic. Initially this was done through wide implementation of manual checking of temperatures at station entrances using digital thermometers, and in the later stages this was replaced by the use of cameras to monitor entire passengers passing through the station, as shown to be effective in Wuhan.[52]

The cleaning of shared transport service vehicles to avoid transmission of disease is critical both during and after a pandemic, with a number of promising new options emerging. For instance, anti-microbial coatings which have been shown to kill the COVID-19 virus have been employed in the underground system in Singapore. The coating lasts up to 180 days (depending on wear) and can maintain train carriages as microbially clean after daily use, only requiring monitoring of high wear areas such as grasping poles and handles which require more layering or additional sanitation.[53]

Improved ventilation in stations and vehicles can improve air freshness, decreasing the prevalence of viruses and other unwanted contaminants in the air.[54] In China, public buses have been outfitted with virus mitigation AI systems to detect fever and alert the driver, and use filtration systems to sterilise the air using UV light that can sterilise the bus's air in twenty minutes.[55] Together with methods to sterilise and clean shared transport vehicles and stations efforts are also underway to reduce the peak loading of passengers.

The UK Government is considering staggering work hours to spread the commuter transit load on the system,[56] while Singapore has already normalised flexible working hours and the government is now encouraging greater uptake[57] – which will decrease congestion and hence lower rider density, disease transmissibility and overall transport system investment.[58] Reduction of transit loads reduced the level of interaction between people and reduces the chance of virus transmission. Additional measures include contactless payment methods in stations and on shared transport services to eliminate the use of physical currency that can carry viruses.

[51] Howard, J., Huang, A., Li, Z., Tufekci, Z., *et al* (2021) An evidence review of face masks against COVID-19, Proceedings of the National Academy of Sciences of the United States of America; Brooks, J. and Butler, J. (2021) Effectiveness of Mask Wearing to Control Community Spread of SARS-CoV-2. JAMA. 2021:325.

[52] Glover, C. (2021) China to Roll Out Temperature-Taking Infrared Cameras, TechMonitor.

[53] CNA Insider (2020) How COVID-Safe Is Public Transport? Buses, Trains & The Coronavirus, CNA Insider.

[54] Shen, J. (2020) Prevention and control of COVID-19 in public transportation: Experience from China, *Environmental Pollution*, Volume 266, Part 2, November 2020.

[55] Ingham, L. (2020) Coronavirus-fighting smart bus rolled out in China, Verdict

[56] BBC (2020) Coronavirus: Staggered work times considered when lockdown eases, British Broadcasting Corporation

[57] Zoey, L. (2021) Back to the office: 7 things you need to know as Singapore shifts to more flexible way of working amid COVID-19, Channel News Asia

[58] Government of Singapore (2021) Updated safe management measures at workplaces, Government of Singapore.

# 5. Trends and stakeholder roles in shared transport in post-pandemic Asia

***A shift in priorities***

After transit systems were so severely impacted by considerations to reduce virus to human interaction, there will remain human behavioural considerations in the design of systems. Particularly in attempts to taper COVID-19 spread while countries aim to return to normal economic operation, changes in use of transport systems will occur to maintain public health, which are likely to lead to overall increased ridership compared to pre-pandemic levels.

The need is to develop confidence in the public transport system and enable people to move freely in crowded sidewalks, pedestrianized streets, dedicated bike lanes, electric scooter pathways or car-free zones. Digital resources can improve the use of these systems by improving ability for planning and trip coordination and hence efficacy and efficiency of the systems. Government will serve a major role in orchestrating these changes, while third-party stakeholders can provide supportive technical and specialist input. This will ultimately involve vaccination passports.

The Ministry of the Environment of Japan has initiated the development of an online platform on sustainable and resilient recovery from COVID-19, with support from the UNFCCC, that is being managed by the Institute for Global Environmental Strategies (IGES). The platform provides a comprehensive list of initiatives that countries are implementing as part of COVID-19 response and recovery efforts.[59] A recent survey conducted by UNESCAP identified a number of key priorities of governments and experts, as part of such recovery efforts, including:[60]

- The protection of transport workers.

- Adaption to changes in the transport market behaviour.

- Strengthening cross-border connectivity.

- Supporting economic growth, including job creation.

- Increasing the resilience of freight transport.

- Improving digitalization of transport services.

- Integrating decarbonization and sustainable transport.

According to Earley and Newman[61], such intentions can be aggregated into three main categories of ways to help countries move towards improved connectivity in Asia-Pacific, namely:

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[59] IISD (2020) Ministerial Launches "Platform for Redesign" to Overcome Climate Change, COVID-19, International Institute for Sustainable Development.

[60] Ducrest, A. (2020) Regional Transport Cooperation in Asia and the Pacific. In: Intergovernmental 13th Regional Environmentally Sustainable Transport Forum in Asia, United Nations Center for Regional Development, Nagoya.

[61] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

1) Digitalization: This involves harnessing smart infrastructure, paperless trade, distributed ledgers, and intelligent transport/logistics options.

2) Resiliency: This involves taking advantage of multi-modality, operational connectivity, and transport facilitation at borders.

3) Decarbonization: This involves making better use of rail, waterborne transport, energy efficiency and renewable energy.

As a result financial institutions are increasing their support of such actions as part of agendas to achieve "Net Zero" outcomes (referring to net zero greenhouse gas emissions mainly) that are quickly becoming necessary to attract investment.[62] Very low interest rates are also now available and the era of building back with the Paris Agreement and the SDG's as the agenda, is now much clearer.[63] However, nations must work out what this means in their infrastructure programs.

### *The Role of Cities to Activate Stakeholders*

It is clear that cities are the leaders of change and will be critical in achieving a strong and robust response to COVID-19. Over the last decade a number of cities have focused on responding to climate change through a range of programs and policies with part of this focus now shifting to COVID-19 recovery efforts, with many such efforts meeting both imperatives by delivering recovery outcomes that contribute to reduced greenhouse gas emissions and other social and environmental outcomes.

Such efforts will include the adoption of new processes, technologies and partnerships which according to Newman (2020)[64], "*will flow through the fabric of the city, just as it has in each other wave of innovation, with many setting their recovery agendas to achieve new goals and outcomes in zero carbon and zero poverty that will establish them as leaders*". This will call for a range of new stakeholder roles across the transport sector as the focus shifts away from providing infrastructure and services to private vehicle owners and towards the provision of clean, efficient and fast shared transport options that are designed around corridors of urban regeneration and economic development.

As with the rise of 'automobile dependence'[65] this shift will see the urban fabric that we take for granted forever altered. No longer will sprawling suburbs that are reliant on private vehicles dominate the minds of developers, but rather the attraction of vibrant precincts based around effective shared transport options that aggregate economic and social activity and provide expanded levels of accessibility. In particular the developing world will have the opportunity to leapfrog old technologies and capture numerous benefits associated with renewable energy, urban greening, electro-mobility, AI and data analytics, distributed ledgers, and a range of enabling technologies.

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[62] Earley, R., and Newman, P. (2021) Transport in the Aftermath of COVID-19: Lessons Learned and Future Directions, Journal of Transportation Technologies, Vol. 11 No. 2, April 2021.

[63] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

[64] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

[65] Newman, P. and Kenworthy, J (1989) Cities and Automobile Dependence, An International Sourcebook, Gower

For instance, China has led the way in mainstreaming many of these innovations and has captured the associated economic and social benefits.[66] According to Newman (2020)[67] such an approach has 5 key features, namely: relocalised centres; innovations tailored to the urban form; significantly lower car use; the development of symbiotic partnerships; and the renewal of the manuals of urban professionals.

When considering each of these features from the point of view of stakeholder roles in shared transport post-COVID the following is evident:

*Relocalised Centres*

With the rediscovery of the value of localisation as a result of COVID-19 mobility restrictions it is clear that healthy vibrant cities will be based around interconnected local centres that provide places to work, live and play.[68] Such a focus requires all involved in such centres to have a new relationship with the urban form, one that is far more proactive, inclusive and rewarding - which will provide common good outcomes and mobilise social capital to new levels.

Stakeholders in such centres will be concerned with ensuring a safe, clean and productive system that exceeds the level of accessibility currently afforded by private vehicles. This will prompt greater civic involvement in a range of new areas, such as energy generation, storage and use, managed using smart systems.[69] These smart precinct systems can be linked along corridor (using advanced databases such as distributed ledgers) to provide a rich source of data for AI systems to ensure effective operation and response to outlier events.

*Tailored innovations*

Rather than adopting a one size fits all approach to cities each urban place will have its own combination of innovations that suits the people living and working there,[70] calling for different approaches to stakeholder engagement. For instance, dense urban centres will likely build on the enhanced accessibility available from walking to create multiple destinations shrouded with greenery and equipped with the latest smart city technologies.

Corridor based transit city fabrics will likely focus on creating a system of renewable energy innovations to seamlessly deliver clean and cheap energy to vehicles, homes and businesses. Depending on the focus of the place the level of engagement and involvement of those interacting with it will change calling for flexible and inclusive governance mechanisms.

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[66] Gao, Y., Kenworthy, J., Newman, P., and Gao, W. (2017) Transport and mobility trends in Beijing and Shanghai: Implications for urban passenger transport energy transitions worldwide. In Urban Energy Transitions, 2nd ed.; Droege, P., Ed.; Elsevier: Berlin, Germany, 2017.

[67] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

[68] Newman, P., Davies-Slate, S., Conley, D., Hargroves, K., and Mouritz, M. (2021) From TOD to TAC: Why and How Transport and Urban Policy Needs to Shift to Regenerating Main Road Corridors with New Transit Systems. Urban Science. 2021; 5(3):52.

[69] Newman, P. Density, the Sustainability Multiplier: Some Myths and Truths with Application to Perth, Australia. Sustainability 2014, 6, 6467–6487.

[70] Newman, P. and Kenworthy, J. (19999) Sustainability and Cities: Overcoming Automobile Dependence; Island Press: Washington, DC, USA.

*Less Car Dependant*

The shift away from automobile dependence is likely to bring a different form of social interaction in the world's cities, changing from one where people travel in their own isolated pods between destinations to one where interaction and engagement with others is easy and supported along the journey.

It is likely that when people move out of cars and enter the social fabric of a vibrant city they are more likely to be engaged with that community, and more likely to engender a sense of responsibility and contribution to the quality of life of all that live and visit there. However, it will be important for smart technologies to be used to ensure safety, cleanliness, and effective operation of such spaces along with the infusion of arts and cultural artefacts to catalyse interaction and create safe and welcoming spaces.

*Symbiotic Partnerships*

The shift towards vibrant transit precincts and away from automobile dependent sprawling cities will require new partnerships to secure the funding, expertise and collaboration required. In this new model long-term value is created and maintained largely by those that live, work and visit the precinct,[71] rather than by transient interests seeking to capitalise on sporadic periods of economic activity across a city.

In order for complex precincts to function a package of symbiotic innovations and technologies will need to be created and adapted, calling for equally symbiotic partnerships[72] which will call for community-based approaches.[73] Such approaches have been shown to deliver long term effective governance and financing arrangements to be built and maintained.[74]

*Renewal of Urban Manuals*

With a shift in development mindset towards interconnected precincts along effective shared transport corridors will come the need to renew the manuals used to create the urban form. Similar to the new approach to urban development this will call for a new approach to the development of such manuals and call for engagement and involvement from a range of new stakeholders.

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[71] Sharp, D. (2018) Sharing Cities for Urban Transformation: Narrative, Policy and Practice. Urban Policy Res. 2018, 1–14.

[72] Newman, P. (2020) COVID, Cities and Climate: Historical Precedents and Potential Transitions for the New Economy.

[73] Hartz-Karp, J. and Marinova, D. (2012) Methods for Sustainability Research; Edward Elgar: London, UK.

[74] Salter, R., Merson, J., Rauland, V., Odell, P., and Sharp, D. (2019) Engaging Local Communities. In: Decarbonising the Built Environment: Charting the Transition; Newton, P., Prasad, D., Sproul, A. and White, S. *eds*.; Palgrave Macmillan: Singapore.

# 6.   Conclusions and Recommendations

**Overall perspective**

The growth of cities has been the basis of civilization,[75] and cities will now need to create a new future post-COVID. Due to the COVID pandemic, things that were ripe for change now have a new opportunity to be mainstreamed. Perhaps the world can create a new future that addresses the two big agendas of our day in an integrated way: zero carbon and zero poverty. What is certain is that transport will play a big part in that transition and that it will need to be sustainable, shared and resilient.  The innovations outlined in this paper and which appear to be critical to this agenda include:

–   Distributed renewable energy and batteries, as well as technologies that create distributed energy markets;

–   Electro-mobility and especially the associated new electric transit and e-micro-mobility, as well as the old but tried and true walkability;

–   Smart city technology that enables all of these innovations to be integrated, to work better and to create the ecosystems of cities and regions as neural networks that learn and grow, showing us how to make each place in a city or region achieve zero carbon–zero poverty outcomes.

These changes are essentially integrated and can all be cost-effective, as they have shown their prowess at supporting economies in the time of this COVID pandemic. Hydrogen innovations are being targeted by many governments as an important opportunity for industry but are unlikely to be much use for land transport though they will be important for shipping and aviation. These may rapidly move to being cost-effective as they move beyond demonstration phases.[76] But the vast majority of new transport investment over the next two decades will be in electro-mobility and how it is best applied to cities and regions using zero carbon power.

Investment will need to have assessment processes that enable rather than drive-away these innovations. Such changes will need new partnership processes that enable all levels of government to work with private finance and business, in close collaboration with communities, whose local values need to drive all development and help create local enterprises. These processes will be a challenge for all urban leaders, professionals and politicians who must do more than simply wait for such technologies to solve everything. The need will be for solutions that combine this cluster of technologies with locally oriented designs relevant to dense city centres, inner-city corridors, suburban centres with estates for various functions, and peri-urban, rural and remote villages. The human qualities and natural qualities of each place will be at the heart of how these new technologies can create re-localised places and connected corridors between places using these new technologies.

Transport professionals will soon see that they need to rapidly change the manuals of modernism built on a fossil fuel era and are still so prevalent in all engineering designs and statutory regulations. This will be a requirement from all politicians but must be delivered by professionals. It is critical that this

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[75] Hall, P. (2008) Cities and Civilization; Pantheon Books: New York, NY, USA.
[76] Geels, F., Schwanen, T. and Sorrell, S. (2017) Sociotechnical transitions for deep decarbonization. Science 2017, 357, 1242–1244.

happens quickly or else they will miss their early chances to be part of the next economic wave. Places that can quickly focus on how to mainstream their new planning and assessment systems to create new centres of zero carbon–zero poverty urbanism are likely to be the new post-COVID economy winners.[77]

**Recommendations**

*1. Dealing with the short term agenda with COVID*

The necessary steps outlined in this paper include steps to avoid overcrowding in vehicles and stations supporting walking and cycling over cars like banning parking in certain streets, improved hygiene, through disinfection, hand sanitizers, reviews of uniforms and seating materials, mandated mask wearing, education, helping front-line staff, and vaccination passports linked to smart technology.

*2. Dealing with the longer term post-COVID economy*

As outlined above the new economy is rapidly emerging and needs to be facilitated by transport professionals. Re-evaluation of all old projects will be needed as now all projects will need to pass the test to see if they can be net zero with electro-mobility. This will mostly involve examining how to electrify all old transport systems running now on gasoline and diesel. It will also mean that the local systems that feed into transit corridors will need revamping to assist local centres around stations.

*3. Creating opportunities for an integrated electro-mobility, renewable-powered, smart technology systems*

It will be critically important to create working demonstrations of new approaches to transport through new zero-carbon urban developments that can be serviced by zero-carbon transport as well as renewable energy and smart systems that integrate how they can be managed locally. Such projects will require new partnerships to be developed that will enable joint funding and joint management especially around local stations.

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[77] Landry, C. Advanced Introduction to The Creative City; Edward Elgar: Cheltenham, UK, 2019.