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Our Roads Are Choking Us

Re-imagining transport systems to cut carbon emissions and drive climate change.

The global transport sector, particularly road transport, contributes significantly to global greenhouse gas (GHG) emissions and air pollution, causing serious health issues like respiratory and cardiovascular diseases, especially in highly urbanised areas.

Transitioning to electric vehicles and micro-mobility solutions, with the support of proper infrastructure and regulations, is crucial for reducing carbon emissions and improving the urban transport system.

In-vehicle telematics and smartphone apps that provide emission feedback can help incentivise drivers to adopt sustainable driving habits. A global carbon credit market can help achieve the same goal by letting individuals and companies monetise their emission reduction.

More than half of the world's GHG emissions have risen in the period after the United Nations Framework Convention for Climate Change (UNFCCC) was signed in 1992. The transport sector is one of the most significant contributors to these emissions, accounting for 25 percent of global carbon dioxide (CO_2) emissions. In 2021, over 7.8 billion tonnes of CO_2 were emitted globally by the sector, which happens to be the third largest emitting industry behind energy and electricity.

Within the transport sector, road transport is the highest contributor at 75 percent of global transport emissions. In Singapore, for example, its road transport system accounts for 14 percent of total GHG emissions and related air pollution.[1] To contribute to the 2016 Paris Agreement goal of limiting global warming to 1.5°C, Singapore is targeting an 80-percent reduction in road transport emissions by 2050.[2] This is a laudable target for a country that sits in a region where air pollution is rising from the overwhelming and exponential increase in the use of internal combustion engine (ICE) vehicles. Throughout Southeast Asia, road transport emissions have grown more than any other sector. In

Vietnam for instance, in tandem with its economic progress, emissions have nearly doubled since 1980, with road transport accounting for the bulk of it.[3]

Road transport-related air pollution arising from the burning of fossil fuels creates an array of negative environmental and health impacts. In fact, fine particulate matter ($PM_{2.5}$ and PM_{10}) arising from road transport emissions is associated with premature mortality[4], with their cumulative effects reported to increase the risk of cardio-respiratory morbidity and mortality.[5] There is an urgency therefore to implement strategies that transition to a low-emission transport system. The urgency is paramount for populations living in highly urbanised areas such as Singapore, Kuala Lumpur, and the numerous cities in the low- and middle-income countries across the region that are disproportionately exposed to the burden of climate change, particularly urban heat and air pollution.

Every effort is needed to mitigate rising road transport-related emissions. The role of in-vehicle telematics providing feedback to drivers on their personal emissions alongside dynamic financial incentives can play a significant role in driving the necessary emission reductions to achieve important climate change targets. Similarly, transitioning to electric vehicles, particularly electric micro-mobility, will play an important part in this journey to achieve net-zero emissions.

DRIVING CHANGE: ADDRESSING THE CAR*-BON ISSUE

The societal challenge to mitigate GHG emissions by 2030 and attain net-zero emissions by 2050[6,7] is a significant one, highlighting the urgency to deliver pragmatic solutions. At the University of Melbourne's Transport, Health, and Urban Systems Research Lab (THUS), we have established a number of responses to drive the needed change.

The first response is to tackle the 'low-hanging fruit', such as the emissions/air pollution arising from drivers on the road transport system. In collaboration with industry and government partners, THUS is implementing an intervention trial which is the first, globally, to deliver vehicle emission feedback to drivers using a smartphone app. The technology integrates vehicle emissions alongside a financial incentive, which we know from our earlier research is the key to observing changes in driver behaviour (refer to box story).

The information on vehicle emissions is fed into a sophisticated model that calculates emission reductions accurately and in real time, which is then delivered to the driver. The driver or end-user is therefore kept updated of his or her net emission reductions on a quarterly and yearly basis, furnished with a concrete metric (e.g., how many trees need to be planted to mitigate their vehicle emissions) with which to measure and modify driving behaviour. At the population level, drivers will be able to monitor the impact of their adoption of the technology in terms of their own contribution to emission reductions and fuel savings.

In the longer term, we propose to establish the sustainability and other UN Sustainable Development Goal (SDG) credentials of the technology. This is likely to occur by developing an advanced methodology for publication by Gold Standard (GS), which is the international voluntary carbon emissions certifier. This is one tangible mitigation strategy that has the potential of capturing and monetising vehicle emissions, if disseminated across road users throughout Southeast Asia. It represents a significant opportunity for cities to re-invest in sustainable healthy transport futures.

Carbon credits: Circulating funds and clean air

Another solution is to create pathways for the monetisation of voluntary and regulatory carbon credits. In this regard, Singapore has made significant progress, and is considered a leader globally, in setting regulatory pricing thresholds for carbon credits that will rise to between S$50 and S$80 by 2030, to establish a carbon tax regime that will gradually push large emitters and their supply chain to reduce emissions by the same year.[8] A limited number of countries globally have followed the same pathway to build carbon taxation and pricing into their respective 2030 and 2050 strategies.

Singapore also operates a carbon exchange, the CIX, which is a subsidiary of Singapore Exchange.[9] In parallel with establishing government-to-government agreements for the procurement of voluntary carbon credits under Article 6 of the Paris Agreement, Singapore also leads the way in establishing a model to allow for voluntary carbon credits to be used to offset carbon taxation for large emitters, to a limit of five percent of their carbon emission tax liability.[10]

Under these frameworks, the defined and measurable carbon emission reductions from individual car drivers can be certified under international standards including ISO 14064, and the certification protocols of the Geneva-based GS, thereby generating a Singapore-based pipeline of voluntary emission reduction certificates to meet the growing demand for such credits on both the CIX and under the direct offset threshold for large emitters.

In this manner, sustainable transport solutions and technologies can assist countries in moving away from fossil-fuelled propulsion over time by reducing direct transport emissions from private vehicles and potentially even heavy goods vehicles. This supports large transport emitters like airlines to navigate the challenges of transitioning to a lower emitting impact. In the future, such voluntary carbon credits could also be transferred under bilateral agreements established between the Singapore authorities and other governments.

MICRO-MOBILITY: BIG PROMISE FOR SUSTAINABLE FUTURE TRANSPORT

Importantly, the vision of sustainable future transport relies on a widespread mode shift from using private hydrocarbon-fuelled motor vehicles such as ICE ones to adopting public transport, walking, cycling, and electric micro-mobility (hereafter referred to as micro-mobility) devices such as electric bicycles (e-bikes) and scooters (e-scooters). Sustainable mobility technologies are a key part of such a shift, and there is a significant and growing body of academic literature on the role

and sustainable impacts of electric micro-mobility. Important aspects researched since the inception of shared e-scooter operations in 2017 (starting with Telepod in Singapore) include the carbon emission reduction potential[11,12], safety aspects[13], contribution to public transport uptake based on first- and last-mile accessibility resolution[14], and the replacement of ICE vehicles. Increasingly, questions around the governance of operating models[15] as well as distributive justice have also been raised, which further requires striking a balance between the benefits and burdens of micro-mobility to stakeholders.[16]

There are also significant challenges in transitioning to a future transport system that is built on clean fuels. We still need to find out much more about micro-mobility. For example, on urban utility, work is required to understand the effects of introducing micro-mobility not only with respect to transport, but more so in the broader urban ecosystem including its impact on employment, education, and equity (where peri-urban dwellers can also enjoy access to public transit). Other knowledge gaps include building a better understanding of the relationship between micro-mobility and the circular economy, identifying micro-mobility's role in the context of cost effectiveness per kilometre travelled and carbon emission reduction, and last but not least, the issue of safety when operating e-bikes and e-scooters in a transport system that has been primarily designed for private motor vehicle use.

As a mode of transport, micro-mobility reduces emissions by creating a mode switch from a higher emitting transport mode, such as a car, to a lower emitting mode of transport such as an e-scooter. The same applies to other shared transport modes such as public trains and buses. The emission reductions are rooted in the ability to create a mode shift during selected journeys or trips. The more mode shifts that occur, the more we reduce our emissions over time. This seems simple, but there are multiple challenges to carrying this out.

Paving the path for micro-mobility's success

First, the development of new transport infrastructure requires capital investment. One way to finance the switch is via carbon credits which higher emitters can purchase to offset their emissions, thus financing more development in sustainable transport solutions (STS). The second challenge is ensuring that the existing urban and transport infrastructure is adapted to the introduction of micro-mobility vehicles in a planned and organised manner.

A third challenge, which is growing, is that of regulation and recognising that micro-mobility vehicles bring benefits, as well as issues. In the initial phase, e-scooters and e-bikes have often been deployed and operated in grey legislative and regulatory frameworks that have not considered the negative externalities that they can introduce to the transport system with their growing adoption. It is essential that the negative aspects are recognised in the planning stage before deploying micro-mobility vehicles, thereby avoiding the negativity that emerges without consistent and workable regulations prior to their deployment. This is why stakeholder involvement in the planning for micro-mobility is so critical.

Fourth, as a result of regulation, traffic and urban data feedback systems need to be adapted and adjusted to ensure any new deployment can be monitored. This would ensure that the systems are calibrated to meet new regulations, such as when sending as well as receiving updated sustainability data points. In fact, without sufficient data, micro-mobility initiatives may result in public disenchantment. This, in turn, reduces the success of micro-mobility programmes and their ongoing deployment.

We observed such an occurrence in Paris in 2023, which resulted in the existing micro-mobility infrastructure being dismantled. This unfortunate outcome was largely due to a weakness in regulatory definitions of vehicles that had only recently come into existence. For instance, rentable mobility devices that made their Parisian debut in 2020 shared the same 'private vehicle' classification that came into being in the early 20th century to address parking issues. This classification resulted in a lack of requirement for fleet management and designated parking spaces, leading to e-scooters strewn willy-nilly and souring public sentiment on micro-mobility. What happened in Paris would be akin to the Land Transport Authority in Singapore or the Department of Motor Vehicles in the US classifying rentable e-scooters as private vehicles, which would likely result in similar outcomes as what transpired in Paris.

Determining the carbon value of e-scooters

While significant, the challenges discussed are not insurmountable, especially considering the potential long-term revenues from certification in micro-mobility projects which can be re-invested in research and urban infrastructure to develop safer and more sustainable transport. To highlight an example, an initiative by the Mobility Research Partnership that not only supports the integration of micro-mobility within the transport system, but has also led to an amendment to AMS-III.BM, is a UN Clean Development Mechanism-approved methodology that recognises two- and three-wheeled transport modes such as e-scooters and e-bikes, and their contribution to emission reductions.[17] The amendments specifically allowed for the inclusion of e-scooters as a certifiable project activity under GS rules. E-scooter operators can thus begin generating GS Voluntary Emission Reductions for micro-mobility modes of transport. These are then tradeable on a variety of global carbon exchanges as carbon credits.

To enable the inclusion of e-scooters by GS into the amended version of AMS-III.BM, new formulae have to be developed to determine the emissions reductions from combining lower emitting transport modes. To demonstrate this, the new formulae calculate the uptake of public transport such as buses and trains as a result of micro-mobility trips made. This is a critical point as micro-mobility provides last-mile solutions that connect public transport infrastructures, thus facilitating the use of public transport. In addition to the uptake of public transport, the new formulae should also calculate the reduction in private ICE vehicle ownership as a result of micro-mobility trips made.

CONCLUSION

The significance of delivering an intervention that delivers reductions in transport-related air pollution cannot be underestimated. Implementing smart financial incentives–such as smart apps that can be tailored to individual behaviour–can deliver net reductions at a low cost. The intervention has significant scalability and can therefore be delivered across urban settings, particularly low- and middle-income countries in Southeast Asia. It has the potential for a global scale-up of an intervention that leads to reductions in greenhouse gas and particulate emissions, thus representing an important opportunity for cities

to invest in sustainable healthy transport futures.

Similarly, micro-mobility, as a new industry and technology sector launched globally in 2017, also has enormous potential to reduce carbon emissions with micro-mobility trips found to have no carbon footprint when compared to the same distance trips made by other modes of fossil fuel transport. Micro-mobility is also delivering on social and economic factors, thereby meeting many of the UN SDGs. Emerging technological developments suggest that micro-mobility is at the beginning of an exponential innovation and growth curve, with significant improvement in micro-vehicle durability, as well as innovation in micro-vehicle design and sharing models to come.[18] The integration of micro-mobility into future transport systems is likely to be a necessity if cities wish to embrace a zero-emission transport future.

Highlighting these applications provides city leaders with examples of technology that can be delivered across Singapore, Kuala Lumpur, and other urban agglomerations in Southeast Asia. Importantly, the potential to establish the sustainability and other UN SDG credentials of the technologies, including international voluntary carbon emissions certification, could lead to opportunities for new income from trading carbon credits, thereby ensuring ongoing investment in strategies, which contribute to the mitigation of climate change. AMI

REDUCING VEHICLE EMISSIONS: THE SMART TRIAL

The SMART trial, supported by the NSW State Insurance Regulatory Authority, delivers a combination of safety and emission feedback to road users via a smartphone app. The trial uses in-vehicle telematics (technology that captures a vehicle's braking, acceleration, and speed relative to posted speed limits) alongside unique algorithms and financial incentives to modify a driver's behaviour in relation to safety and vehicle emissions.

The SMART trial is a two-year field experiment where drivers are randomly allocated to one of three groups where they will receive: i) safety feedback and financial incentives, ii) safety and emission feedback and financial incentives, or iii) no feedback or incentives (this would act as a control). Figure 1 highlights the smartphone app used in the trial.

Financial incentives to encourage changes in driving behaviour and therefore reduce emissions are based on research from the THUS lab that highlights providing feedback to drivers alone may be insufficient to motivate behavioural change.[19] Rather, combining feedback with financial incentives can deliver potentially important and statistically significant changes in driving behaviour.

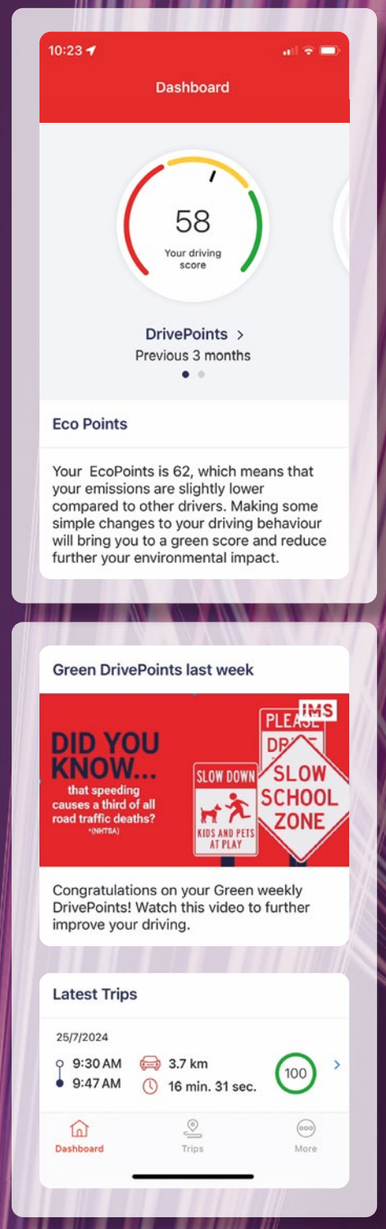

FIGURE 1

The availability of this unique technology that continuously monitors individual behaviour raises the potential for personalised and *adaptive design of incentives* (including emission feedback) as implemented in this trial.

The incentive is structured as penalties for increased emissions–for example, levied as monthly $25 deductions from an endowment of $125 deposited into a virtual driving account. Importantly, the penalties are used to leverage 'loss aversion' and maximise reductions in driving behaviours that increase vehicle emissions or unsafe driving. The personalised financial incentive is tailored weekly to their risk and emission profile, thereby acting as a 'SMART incentive'.

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