Voices

Driving a sustainable road transportation transformation

Strategies to sustainably transform road transformation often focus on electrification and environmental benefits. However, transportation is also intricately linked to socio-economic aspects of sustainable development and electrification poses its own challenges. This Voices asks: what actions are required to steer a clean, safe, efficient, and inclusive transformation of road transportation?

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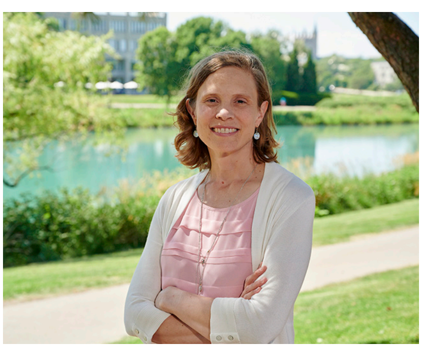
Focus on moving people, not vehicles

The traditional practice of transportation engineering in urban areas has been a bottom-up approach. This mostly follows an infrastructure supply-based method, which hinges on the parameter volume-to-capacity (V/C) ratio calculated using passenger car units (PCU) over every road link in the given urban area. This calculation can identify the hot spots of congestion and then suggest road infrastructure-based interventions like road widening, flyovers/underpasses, elevated road corridors, etc. However, time has shown that such interventions are very short term and not sustainable and do not solve the problem of traffic congestion; rather, they only shift the point of traffic congestion to some other location. Moreover, this also encourages higher personal vehicle ownership and usage and results in more kilometers traveled per vehicle, thereby further resulting in higher fossil fuel consumption and tailpipe emissions. Thus, these interventions to reduce congestion in the short term ultimately lead to negative health impacts for people and in overall degradation of livability. Since the current car ownership levels in developing economies like India are still much below the saturation levels observed in developed economies like the USA, any road infrastructure measures adopted only leads to an increase in car ownership and usage. Therefore, following India's National Urban Transport Policy recommendation to "focus on moving people rather than vehicles," a top-down approach with primary focus on management of travel demand is an ideal alternative to achieve sustainable mobility. This essentially means focusing on minimizing the number of vehicles on road and total vehicle kilometers traveled by all motorized modes, while increasing the share of trips made via sustainable modes of transport.



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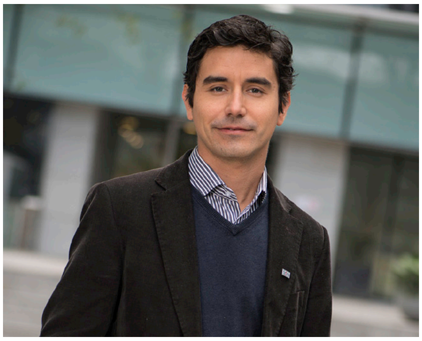
Responsible sourcing of lithium-ion battery minerals

Vehicle electrification is central to decarbonization strategies. Life-cycle assessments routinely conclude that electric vehicle (EV) per mile greenhouse gas (GHG) emissions are lower than emissions from gasoline-burning vehicles, even when accounting for lithium-ion battery production. These analyses, however, may miss negative environmental effects that arise from producing these batteries in ever-growing numbers. In particular, not all such effects tie directly to GHG emissions. For example, mining for the minerals used in EV batteries can decrease water quality and availability. Mining can encroach on other uses for land, such as agricultureand forestry. Moreover, given the heavy degree of overlap between where minerals mining may expand and the territories of Indigenous and peasant peoples, extraordinary care must be taken to protect the rights of historically exploited groups in the quest for more minerals. Furthermore, establishing a *secure* supply of minerals that are responsibly sourced is a challenge. Notably, most mining of critical minerals essential for electrification occurs outside of the United States and Europe, two regions aggressively pursuing vehicle electrification. Will we replace oil with minerals as the source of energy insecurity? Throughout this vehicle electrification transition, it is essential to anticipate and prevent environmental and social damage from mining using a framework like the life-cycle assessment to pursue unconventional sources of minerals (e.g., seawater, brines) in sustainable ways and to hasten widespread recycling of EV batteries.



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Public policy for sustainable shared mobility

Shared-mobility services such as ride-pooling, ride-sourcing, and bike-sharing have the potential to increase social welfare by reducing the negative externalities that stem from excessive car use, but this will not happen by itself without a strong involvement by the public sector. People choose shared-mobility options because of comfort, convenience, and safety; the car-based modes such as ride-sourcing can, however, increase motorized traffic levels. The social equity effects of shared mobility are also multifaceted, as on the one hand these modes provide more travel options to people that do not own cars, but on the other hand personal income greatly influences their adoption and frequency of use.

In terms of policy, some form of road charges for car-based modes are required, in a way that pricing incentives for shared mobility can align fleet size and fare with societal wellbeing. In the case of developing countries, with public transport as the backbone of motorized mobility, the formalization of informal public transport is hard but unavoidable, otherwise the use of smart multimodal solutions like mobility-as-a-service) will be constrained to locations where public transport operates formally, hurting spatial and social equity. Furthermore, the proliferation of ride-sourcing and app-based delivery services has been on the backs of millions of drivers that many times lack social security or labor rights, calling for a formalization of these app-based jobs. All in all, the setting of sustainable and inclusive transport principles through public policy is essential for the right insertion of these shared-mobility modes into our lives.

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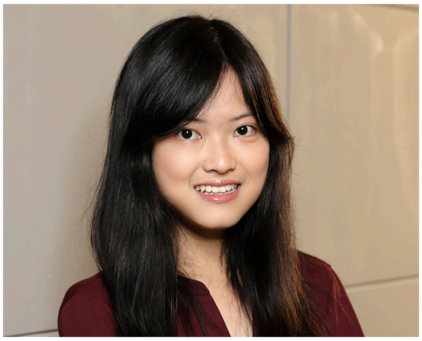
Philippines' electric transport and renewables

Electrification is one of the sustainable solutions to reduce greenhouse gas (GHG) emissions and air pollution from the transport sector. Electrification is crucial as the transport sector accounts for 14% of the global GHG emissions coming from the burning of fossil fuels. For instance, the modernization of the public transport system in the Philippines promises an emission reduction of 75%–87% GHG and 60%–90% air pollutants. Additionally, this is expected to decrease the country's dependence on imported fossil fuels by 33%. From a socio-economic perspective, using EVs offers a safer and more comfortable ride for commuters having several features like air conditioning, speed limiters, accessibility ramps, no-contact payment, cameras, Wi-Fi, and USB ports. Transport modernization also provides opportunities for transport stakeholders such as social benefits for public EV drivers, job creation in the manufacturing of EVs, and new business ventures in EV parts and maintenance. No wonder why the majority of the riding public in the country prefers to ride/own electric over combustion vehicles.

Despite the benefits, economic (e.g., high investment cost) and technological (e.g., charging stations, electricity supply, battery, maintenance) factors challenge the adoption of EVs. Moreover, this transition will significantly increase the electricity demand, which is presently generated from fossil fuels, meaning EVs currently do not run on sustainable energy. In line with the country's plan to increase renewable energy generation to 50% by 2040, huge investments in renewables are therefore needed to power all EVs for the transition to be sustainable.



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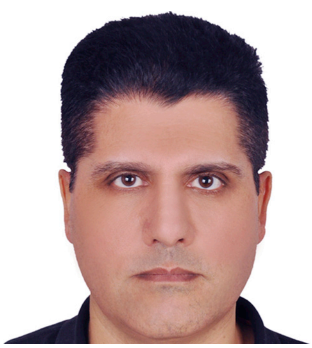
Rising raw material prices could delay EV rollout

Electric vehicles (EVs) offer great societal benefits, like reducing oil dependence for national energy security and decarbonizing road transport systems for climate goals. While EVs continue to grow in popularity, their widespread adoption is still impeded by high vehicle prices—specifically, high battery prices. China is leading the world in EV deployment; the dual-credit policy (i.e., parallel regulation for Corporate Average Fuel Consumption and New Energy Vehicle Credits) will compensate for the forthcoming removal of EV subsidies, maintaining the growth momentum in the local EV market in the next decade. Maturing technology and the economy of scale will continue to drive battery manufacturing costs down as the cumulative installed capacity increases. However, the critical raw materials that are essential to batteries will eventually set practical lower bounds on battery prices. Continued maturation of the existing best battery chemistry NMC (nickel manganese cobalt)-based lithium-ion battery is unlikely to reach the $100/kWh global price target even by 2030. In contrast, LFP (lithium iron phosphate) batteries free of cobalt and nickel are attracting an increasing interest due to their lower price and greater resilience to mineral price surges. Now, LFP is not only widely used in China; many auto giants have also started adopting LFP for their entry-level EV models. To make EVs more affordable, automakers may consider a battery-swap strategy in addition to pursuing nickel- and cobalt-free battery chemistries. Swapping technology decouples battery ownership from the vehicle itself and is considered a critical enabler for electrification in Asia (e.g., e-scooters in Taiwan and e-fleet/e-cars in China). Separating the battery from EVs would considerably lower their purchase prices and solve the charging conundrum, thus further boosting EV acceptance and adoption.



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Successful transformation of road transportation

The transformation of road transportation has witnessed significant changes in the last two decades. Today, we can see several derivatives of electric vehicles such as pure battery (BEVs), plug-in hybrid (PHEV), and hybrid vehicles (HEV). Fuel-cell electric vehicle (FCEV) is another disruptive vehicle technology that is expected to see higher adoption rates in the next few years, thanks to its fueling protocol (pressurized H_2 gas at 70MPa), which allows fueling the FCEV tank in less than 5 min, and its zero emissions on the road. It seems that electric vehicles, including FCEVs, will dominate the market by 2030.

One of the most challenging actions for such vehicle technique-driven transformation of road mobility is to pair it with suitable sustainable infrastructures. For electric vehicles, they require the installation of charging stations inside cities and on the highways between cities. For FCEV, they require networks of hydrogen refueling stations along the routes. In addition, having an efficient drivetrain is a key factor in the successful transformation of the future road mobility. EVs are known to have >90% drivetrain efficiency due to higher power storage and conversion efficiency, but the efficiency of FCEV drivetrains is merely about 40%–60%. Thus, efforts should be directed toward investing more in the charging and fueling infrastructure, improving the drivetrain efficiency, government support through R&D, and sustainable deployment initiatives (e.g., grants for local communities to build out sustainable hydrogen networks). Tax and subsidy policies can also play a key role in making future road transport more affordable to all.

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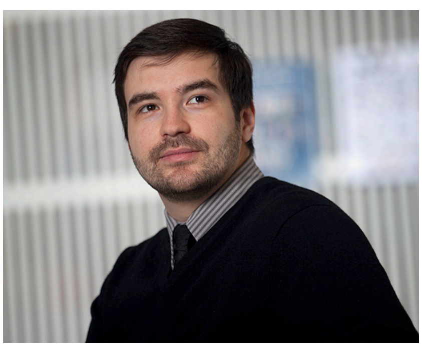
Material challenges in sustainable road transport

Concerns of global warming and fossil fuel dependence have placed strong emphasis on electric vehicles (EVs) as a promising sustainable road transportation solution. While EVs in general avoid the transportation sector's fossil fuel dependency, direct greenhouse gas emissions, and air pollutants, they are not without sustainability risks. Minerals such as lithium, cobalt, nickel, and rare-earth elements needed for batteries and electric motors in EVs are now termed "critical materials" by global economies due to their indispensable role in modern technologies and their susceptibility to supply shortages. The sustainability risks associated with these critical materials for EVs are compounded by their energy-intense extraction and highly concentrated geographic production, especially in countries known for human rights violations in the mining sector, e.g., the Democratic Republic of Congo. In short, the potential for global EV transition is tied to the sustainable supply of these critical material resources. A circular economy approach, which includes strategies such as reuse, refurbishment, remanufacturing, and recycling, can alleviate some of the identified risks by extending the life of components like batteries and by recovering materials from end-of-life vehicle parts. Localized recycling can shrink the EV supply chain and reduce vulnerability to supply disruptions from foreign government actions and natural disasters. Therefore, to ensure the long-term sustainability of EVs, it is important to develop policy instruments that incentivize circularity planning and sustainable sourcing of EV materials by automakers.



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Multi-level and multi-actor adaptive governance

Adaptive actions required to govern a transformation of urban transport systems toward a more sustainable state often rely on coordinating efforts across scales and siloes to adapt to the changing societal context. For example, defining a scheme where users pay for accessing certain roads would depend on a network of actors from the EU, the national level, and the municipal organizations where such a pricing scheme would be implemented. However, adaptability does not solely mean changing as the societal context changes but also aiming to protect and preserve certain aspects of the system. In the context of Finland, protecting the social value of children's independent mobility via public transport, walking, or cycling leads to a plethora of desired mobility impacts, from reductions in carbon emissions to improved wellbeing. On the surface, adaptive governance requires adequate regulation, which assigns clear responsibility to specific actors or allows for experimentation where governance processes can be tested and improved. Beyond the surface of regulation, impactful governance also relies on developing a certain culture. Such a governance culture has to be open for contestation and conflict over social values. In addition, the governance culture must be rooted in understanding fairness, as minimizing adverse effects on the least-advantaged population segments. Thus, a network of governance actors deciding to reduce the amount of parking spots and increase charges would have to account for both above aspects. In practice, the governance network should anticipate conflicts as parking changes cause lifestyle changes among residents while designing the policy to have different pricing schemes for different user groups.

DECLARATION OF INTERESTS

The authors declare no competing interests.