OPEN ACCESS

Management Science COMMENTARY

The Innovation Energy

Beyond the checkpoint: Governing cross-boundary electric mobility in the Greater Bay Area

Yitong Shang,[1,2] Dundun Liu,[3,4,*] Sen Li,[1,5] and Hongcai Zhang[3,4]

[1]The Hong Kong University of Science and Technology, Hong Kong SAR, China

[2]Department of Engineering, University of Cambridge, Cambridge CB2 1PZ, UK

[3]State Key Laboratory of Internet of Things for Smart City, University of Macau, Macao 999078, China

[4]University of Macau Advanced Research Institute in Hengqin, Hengqin 519031, China

[5]The Hong Kong University of Science and Technology (Guangzhou), Guangzhou 511453, China

*Correspondence: zumri.dundunliu@um.edu.mo

Received: July 1, 2026; Accepted: July 22, 2026; Published Online: July 23, 2026; https://doi.org/10.59717/j.xinn-energy.2026.100184

Citation: Shang Y., Liu D., Li S., et al. (2026). Beyond the checkpoint: Governing cross-boundary electric mobility in the Greater Bay Area. *The Innovation Energy* **3**:100184.

A NEW PHASE OF CROSS-BOUNDARY MOBILITY

Cross-boundary private driving is adding a new layer to integration in the Guangdong-Hong Kong-Macao Greater Bay Area.[1] Since 1 July 2023, the Northbound Travel for Hong Kong Vehicles scheme has allowed eligible Hong Kong private cars to travel between Hong Kong and Guangdong via the Hong Kong-Zhuhai-Macao Bridge without a regular quota. In the other direction, the Southbound Travel for Guangdong Vehicles scheme allows approved Guangdong private cars to enter Hong Kong under the entry-into-urban-area arrangement. Separately, the Hong Kong Port carpark supports Park & Fly and will launch Park & Visit from 25 July 2026. The southbound urban-entry quota will also increase from 100 to 200 vehicles per day, while the scheme expands to all nine Mainland cities in the Greater Bay Area.[2]

These measures are usually discussed as convenience policies, tourism policies, or signs of regional integration. That view is correct, but too narrow. As private cars become electric, cross-boundary vehicles are no longer only traffic units. They also become mobile users of parking spaces, chargers, payment systems, insurance procedures, and local electricity networks. The real test starts after the vehicle has crossed the boundary. This work frames these schemes as a coupled system of mobility, energy, and governance, in which policy opening creates destination-level pressures on parking, charging, and local grids (Figure 1).

Figure 1: Cross-boundary electric mobility as a coupled mobility, energy, and governance system in the Greater Bay Area. Northbound Hong Kong vehicles and southbound Guangdong vehicles create more than cross-border traffic flows. As private cars become electric, they also generate mobile demands for parking, compatible charging, digital payment, insurance procedures, and local distribution-grid capacity. The framework shows how policy opening can create asymmetric infrastructure pressures on the Guangdong and Hong Kong sides, how these pressures can be represented through mobility, energy, and governance layers, and how scenario modelling, adaptive infrastructure, managed charging, fairness assessment, and aggregated data sharing can support energy-aware regional integration.

VEHICLES AS MOBILE ELECTRICITY LOADS

Cross-boundary electric mobility should be treated as an energy-mobility issue, not only a transport issue.[3] A petrol vehicle mainly needs road access, parking, and fuel that can be obtained through a mature and relatively standardised refuelling network. An electric vehicle creates a different set of dependencies. It needs compatible charging hardware, available parking time, digital payment, charging information, sometimes reservation, and sufficient local distribution capacity. These needs are not spread evenly across space or time. They concentrate around destinations, holidays, shopping districts, hotels, carparks, and evening charging periods.[4]

Charging compatibility turns this from a planning question into an operational one. Hong Kong and Mainland China do not share a single charging environment. Authorities therefore face choices that are more complex than building more chargers: dedicated chargers for visiting vehicles, multi-standard chargers, certified adapters, or better guidance to compatible sites. Each solution has a cost. Too much flexibility may leave infrastructure underused. Too little will produce queues, detours, and unreliable charging. The right answer is unlikely to be the same at the port, in hotel districts, in residential areas, and along intercity corridors.

The problem is therefore not only whether Hong Kong or Guangdong has enough chargers in aggregate. Aggregate numbers can hide local mismatch. A charger at the wrong location, using the wrong standard, behind an unfamiliar payment interface, or unavailable during peak visiting hours is not useful to the driver who needs it. Similarly, a parking policy that works for local vehicles may not work for visitors who are less familiar with neighborhood restrictions, charging etiquette, or enforcement rules. Cross-boundary EV mobility exposes these frictions because the vehicle crosses one boundary, but its infrastructure needs are distributed across many local systems.

TWO DIRECTIONS, TWO BOTTLENECKS

For Guangdong, the challenge is spatial uncertainty. Early northbound trips may cluster around Zhuhai, Hengqin, and the bridge area, but that pattern will not remain fixed. Hong Kong drivers may continue to Zhongshan, Guangzhou, Shenzhen, Foshan, or other cities. Their charging demand may appear at hotels, shopping centers, tourist sites, residential carparks, and intercity corridors. The risk is not simply the total amount of electricity used. Even a modest number of visiting EVs can create pressure if they arrive on the same holiday afternoon, park in the same district, or charge during the same evening peak.

This uncertainty matters because transport integration often develops faster than local infrastructure adjustment. A route can be opened by policy, but parking capacity, charger availability, grid connection, signage, app access, and user familiarity are local problems. A city may appear ready at the regional scale while still having weak points at specific destinations. For visiting EV drivers, the weak point may not be the port crossing itself. It may be a hotel carpark with no compatible charger, a shopping center where chargers are occupied, or a tourist district where the remaining driving range is enough to arrive but not enough to leave comfortably.

Hong Kong faces a different bottleneck: density. The initial scale of southbound urban entry is small, but Hong Kong's road space, parking supply, and land resources are already tight. In April 2026, the government said the arrangement had a daily quota of 100 vehicles, with each vehicle allowed to stay for up to three days. By the end of March, it had received about 6,300 applications and issued more than 5,000 permits. The same response stated that Hong Kong had 83 Guobiao-standard charging points and considered them sufficient for the then-current level of Guobiao-standard EV charging demand.[2]

These numbers do not point to immediate system-wide disruption. Their importance is that the schemes are still early enough to be shaped. If visiting EVs concentrate in a few tourist districts, public carparks, or hotel areas, the pressure will appear locally before it appears in regional traffic statistics. A visiting vehicle needs more than road access. It needs a parking space, a compatible charger, a workable payment method, clear driving guidance, and reliable insurance procedures if something goes wrong.

The policy risk is to treat northbound and southbound travel as two separate transport schemes. They are better understood as one cross-boundary energy-mobility system. Guangdong needs to know where Hong Kong EVs go after they leave the port. Hong Kong needs to know where Guangdong vehicles park and charge after they enter the city. The bottlenecks differ, but the underlying logic is the same: uncertain vehicle flows can become concentrated pressure at specific places and times.

Figure 1. Cross-boundary electric mobility coupled system framework

A GOVERNANCE AGENDA FOR ENERGY-AWARE INTEGRATION

The priority is not a grand smart-city platform. It is a shared scenario model for cross-boundary EV mobility. Such a model could combine booking records, port flows, likely destinations, parking capacity, charger locations, charging standards, and local grid constraints.[3] Its purpose would not be to predict one perfect future. It would ask practical questions. What happens during a holiday surge? What if the quota doubles again? What if compatible chargers are available at the port but not near hotels? What if most visiting EVs arrive in the same commercial district? What if a rainy weekend, a major concert, and a long charging dwell time all occur together?

This scenario-based approach would help shift policy from permission to absorption. Permission asks whether a vehicle is allowed to cross. Absorption asks whether the destination system can handle what the vehicle needs after crossing. For electric vehicles, absorption includes parking turnover, charger access, grid peaks, payment usability, roadside management, and emergency response. These are not abstract concerns. They determine whether a cross-boundary journey feels seamless or frustrating.

The second priority is adaptive infrastructure. More chargers will be needed in some places, especially where demand is repeated and predictable. But deployment should follow observed use, not only political enthusiasm for integration. Boundary facilities are important, but they cannot serve every vehicle that continues deeper into Guangdong or Hong Kong. Parking guidance, charger reservation, dynamic pricing, and managed charging can reduce local peaks before expensive grid reinforcement becomes unavoidable.[5] Temporary measures may also be useful during holidays or large events, when demand is high but not permanent enough to justify fixed infrastructure everywhere.

The third priority is fairness. Cross-boundary driving brings benefits to hotels, restaurants, shopping centers, and tourist attractions. But the costs may fall on residential streets, public carparks, congested corridors, and local power networks. Authorities should therefore map where benefits and burdens appear. For major destinations and districts, visitor spending and parking revenue should be assessed alongside congestion delay, enforcement costs, charger investment, and grid pressure. This would not replace political judgement, but it would make the trade-offs visible.

Fairness also matters between local and visiting users. If visiting EVs occupy scarce public chargers during peak periods, local drivers may experience longer waits. If charging infrastructure is expanded mainly for visitors, local communities may ask who pays and who benefits. If quotas increase without destination-level planning, the burden may be shifted quietly from regional policymakers to district managers, carpark operators, and distribution-grid planners. A credible integration policy should therefore make clear how costs are shared, how local impacts are monitored, and how adjustments will be made when pressure becomes visible.

Data cooperation is necessary, but it does not require exposing personal information. Guangdong and Hong Kong could share aggregated indicators on vehicle flows, dwell times, parking occupancy, charger use, and congestion. These data would allow quotas, guidance, and infrastructure investment to be adjusted before small problems become public frustrations. The most useful data are not necessarily the most sensitive. Even district-level flows, charging occupancy, dwell-time distributions, and peak-hour patterns would help authorities see where pressure is emerging.

IN THE FUTURE

The next stage of Greater Bay Area mobility integration should not be measured only by how many cars are allowed to cross the boundary. The better question is whether those cars can be absorbed by parking systems, charging systems, insurance procedures, and local grids without creating hidden costs. Northbound Hong Kong cars and southbound Guangdong cars are therefore more than a convenience policy. They are an early test of how a region manages mobile electricity demand across different regulatory and infrastructure systems. If the Greater Bay Area handles this well, it will not simply move vehicles more freely. It will show how electrified mobility can be governed as a shared regional system.

AI STATEMENT

During the preparation of this work, the authors used ChatGPT to assist with language editing and manuscript formatting. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

REFERENCES

1. The State Council of China. (2019). Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area. https://www.bayarea.gov.hk/tc/outline/plan.html
2. HKSAR Government. (2026). LCQ10: Implementation of Southbound Travel for Guangdong Vehicles. https://www.info.gov.hk/gia/general/202604/29/P2026042900237.htm
3. Ma J., Kong H., Wang J., et al. (2024). Carbon-neutral pathway to mitigating transport-power grid cross-sector effects. *The Innovation* **5**:100611. DOI:10.1016/j.xinn.2021.100127
4. Chen X., Zhang H., Xu Z., et al. (2018). Impacts of fleet types and charging modes for electric vehicles on emissions under different penetrations of wind power. *Nat. Energy* **3**:413–421. DOI:10.1038/s41560-018-0133-0
5. Powell S., Cezar G.V., Min L., et al. (2022). Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption. *Nat. Energy* **7**:932–945. DOI:10.1038/s41560-022-01105-7

FUNDING AND ACKNOWLEDGMENTS

This paper is funded in part by the Science and Technology Development Fund, Macau SAR (File no. 001/2024/SKL)

DECLARATION OF INTERESTS

The authors declare no competing interests.