ROCKY MOUNTAIN INSTITUTE

ENERGY FOUNDATION
能源基金会

PUTTING ELECTRIC LOGISTICS VEHICLES TO WORK IN SHENZHEN

Background Volume: Setting the Stage for Full Utilization of ELVs in Shenzhen

ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

AUTHORS

AUTHORS

Qiyu Liu, Ross McLane, Dave Mullaney, Zhe Wang

* Authors listed alphabetically. All authors from Rocky Mountain Institute unless otherwise noted.

CONTACTS

Zhe Wang **zwang@rmi.org**
Qiyu Liu **qliu@rmi.org**
Dave Mullaney **dmullaney@rmi.org**
Ross McLane **rmclane.contractor@rmi.org**

SUGGESTED CITATION

Zhe Wang, Qiyu Liu, Dave Mullaney, Ross McLane. *Putting Electric Logistics Vehicles to Work in Shenzhen: Setting the Stage for Full Utilization of EVs in Shenzhen,* Rocky Mountain Institute, 2020.

All images from istock unless otherwise noted.

MAJOR PARTNERS

Shenzhen Electric Vehicle Operating Association

Shenzhen Electric Vehicle Operating Association engages in six sectors including public transportation, taxi, logistics, rental, charging, and technical services and establishes communication platforms for government and enterprises, organizes industrial investigations and key discussions, develops industrial standards and specifications, and participates in policymaking. It strengthens the integration and cooperation between upstream and downstream players of the new energy vehicle industry chain, and promotes the healthy and orderly development of the new energy vehicle operation industry in Shenzhen.

National Engineering Laboratory for Electric Vehicles

Authorized by the National Development and Reform Commission in 2008, the National Engineering Laboratory for Electric Vehicles was established on the basis of the Electric Vehicle Engineering Technology Center of Beijing Institute of Technology. The National Testing and Management Platform for New Energy Vehicles built by the Laboratory provides data support for the research of new energy vehicles technology and the making of industrial policies.

ACKNOWLEDGMENTS

The authors thank the following individuals/organizations for offering support on this work.

DST Vehicle Rental (Shenzhen) Co., Ltd.

Innovation Center for New Energy and Smart Internet Vehicles of Shenzhen

JD Logistics

Xuehong Ji, North China University of Technology

Cheng Li, China Academy of Transportation Sciences

Dong Ma, Vehicle Emission Control Center of Ministry of Ecology and Environment

Potevio New Energy (Shenzhen) Co., Ltd.

Mengqing Shen, Research Institute of Highway, Ministry of Transport

SF Express

Shenzhen Car Energy Net Service Co., Ltd.

Shenzhen China Electric Green Energy Battery EV Operating Co., Ltd.

Shenzhen Pengdian Yueneng Energy Technology Co., Ltd.

Shenzhen Shuimu Huacheng Electric Transportation Co., Ltd.

Shenzhen TGood New Energy Co., Ltd.

Shenzhen Xinneng Logistics Co., Ltd.

Zhanhui Yao, China Automotive Technology & Research Center

Special thanks to Energy Foundation China for funding this series of reports.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In recent years, China has placed significant emphasis on improving both the environmental sustainability and operational efficiency of its logistics industry. The government from the national to local level has sought to promote logistics efficiency and sustainability through multiple pathways including improved mode shares, enhancement of the operational capabilities of logistics providers, and launching various green freight demonstration projects.

Simultaneously, as electric vehicle technologies increasingly mature, China's electric vehicle (EV) industry has begun to evolve from being highly policy dependent to a more sustainable state in which vehicle and service quality are key business drivers. This combination of technological development and policy resolve has led to rapid adoption of electric logistics vehicles (ELVs), especially electric trucks and vans, in Chinese cities.

This scaled adoption represents an inflection point in China's long-running efforts to reduce urban air pollution, energy use, and CO_2 emissions. Furthermore, both EV production (including logistics vehicles) and the deployment of supporting charging infrastructure have emerged as key pillars to minimize the economic damage from the COVID-19 pandemic and to achieve high-quality, green economic development.

As the first city in China to vigorously promote the adoption of ELVs, Shenzhen has deployed an innovative mix of strong government support and competitive market mechanisms to achieve exceptional ELV fleet growth, charging infrastructure deployment, and business model development.

In order to support Shenzhen's continued progress toward its goal of full electrification of logistics vehicles and to heighten global awareness of the city's successes, Rocky Mountain Institute carried out an in-depth analysis of Shenzhen's ELV market in 2019. This resulted in the report *A New EV Horizon: Insights from Shenzhen's Path to Global Leadership in Electric Logistics Vehicles,* which RMI published in June 2019. One of the key goals of that report was to describe ELV driving patterns and suggest measures such as policy modifications, infrastructure enhancements, business model developments, and technology innovations that would enable ELVs in Shenzhen to fully replace internal combustion engine (ICE) vehicles.

Building on the foundation of *A New EV Horizon,* this body of research uses a similar approach that combines data science with stakeholder interviews to analyze the effects of four key factors (policy, infrastructure, vehicle technology, and business models) on ELV utilization and ELVs' ability to fully replace ICE vehicles. Based on that analysis we make recommendations on approaches to support accelerated ELV replacement of ICE delivery vehicles in Shenzhen and globally. The results of that analysis will be released as the following series of six reports:

- Background Volume: Setting the Stage for Full Utilization of ELVs in Shenzhen
- Policy Volume: Utilization Subsidies as a Lever to Accelerate the ELV Market
- Infrastructure Volume: Enabling ELV Utilization through Well-Planned Charger Deployment
- Vehicle Quality Volume: Identifying Pain Points in ELV Performance That Reduce Utilization
- Business Model Volume: Improving Utilization of ELVs through Innovations in Business and Ownership Models
- Summary Volume: Charting a Path to Fully Electrifying Goods and Logistics Delivery

As a background document, this report briefly introduces major policies implemented in Shenzhen and progress achieved in the adoption and use of ELVs in the city. We introduce the total cost of ownership (TCO) of electric logistics vehicles and ICE vehicles, discuss the role of utilization in driving future TCO superiority of ELVs, and explore current utilization of ELVs in Shenzhen through analysis of vehicle telematics data.

We do this to set the stage for a deeper analysis of four key factors affecting ELVs' utilization: Shenzhen's operational subsidy policy, the suitability of charging infrastructure to ELV needs, vehicle failures and maintenance downtime, and ownership models of ELVs (leasing versus operator ownership). Subsequent reports in this series will focus on each of those individual factors.

INTRODUCTION

THE URGENCY OF PROMOTING ELV ADOPTION

As China's economy has grown and evolved over the last 30 years, so has its transportation sector, and that growth in scale and complexity has been accompanied by a growth in energy use and CO_2 emissions. In 2017 the total energy consumption of China's transportation sector was 313 Mtoe and CO_2 emissions were 889 million tons, accounting for 16% and 9.6% of the national total, respectively.[1]

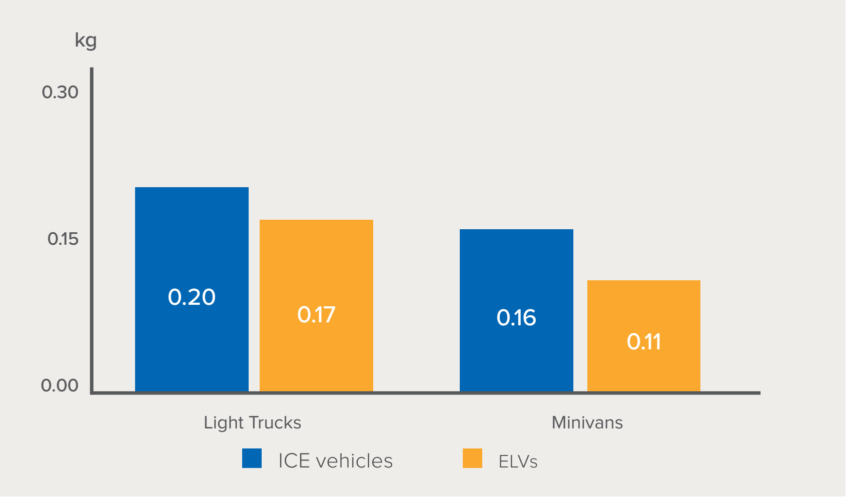
While the scale of China's 2017 transportation energy consumption and emissions is substantial, considerable room for growth remains. In 2015, for OECD countries, transportation accounted for 28% of CO_2 emissions.[2] Many analyses, including RMI's *Reinventing Fire: China* report, project that, if left unaddressed, China's transport emissions will converge to OECD levels as a share of emissions,[3] resulting in 3.3 billion tons of CO_2 emissions per year in 2030.

Due to the structure of the Chinese economy and its role in global manufacturing and industry, freight transportation accounts for 60% of the country's total transport emissions,[4] and is a major culprit in its urban air quality problems. Furthermore, as China's e-commerce industry continues its rapid development and goods transport continues to increase as a share of total urban transportation demand, urban logistics will become an increasingly important driver of CO_2 emissions, air pollution, and traffic congestion. Therefore, it is critical to both improve the operational efficiency of the logistics sector and, at the same time, reduce its emissions intensity.

As vehicle technologies and battery energy density have improved substantially over the last decade, the electrification of logistics vehicles has become an increasingly viable approach for cities to achieve the complementary goals of reducing carbon emissions and improving air quality. At present, minivans and light trucks are the primary vehicles used in China for urban deliveries and are increasingly being electrified.

Exhibit 1

CO_2 Emissions per km of ICE Vehicles and ELVs

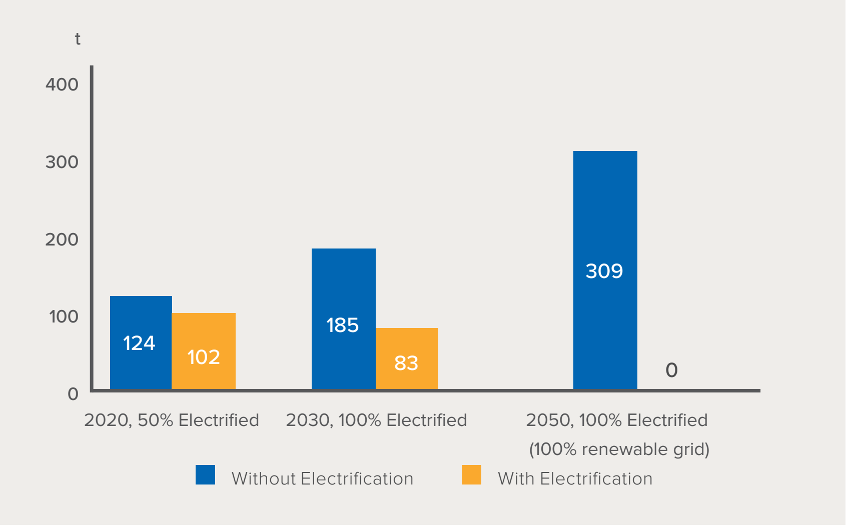


Despite the relatively high carbon intensity of China's electricity, due to the substantial role that coal combustion plays in power generation, electric minivans and light trucks can significantly improve the emissions performance of urban freight delivery. Compared with ICE vehicles of the same size, electric minivans and light trucks can reduce unit carbon emissions by 15% and 30%, respectively (Exhibit 1).[5]

Shenzhen, a major technology hub on the Southeastern coast of China and the home of some of China's top EV manufacturers, is a global leader in the deployment of electric vehicles, including ELVs. According to *Shenzhen Blue*, the city's sustainable development master plan, ELVs in Shenzhen will account for 50% of the city's total freight vehicles by the end of 2020,[6] decreasing annual particulate matter (PM) emissions by 22 tons (Exhibit 2) and CO2 emissions by more than 500,000 tons (Exhibit 3).[7]

Exhibit 2

PM Emissions Reduction Potential of Logistics Vehicle Electrification in Shenzhen[i]

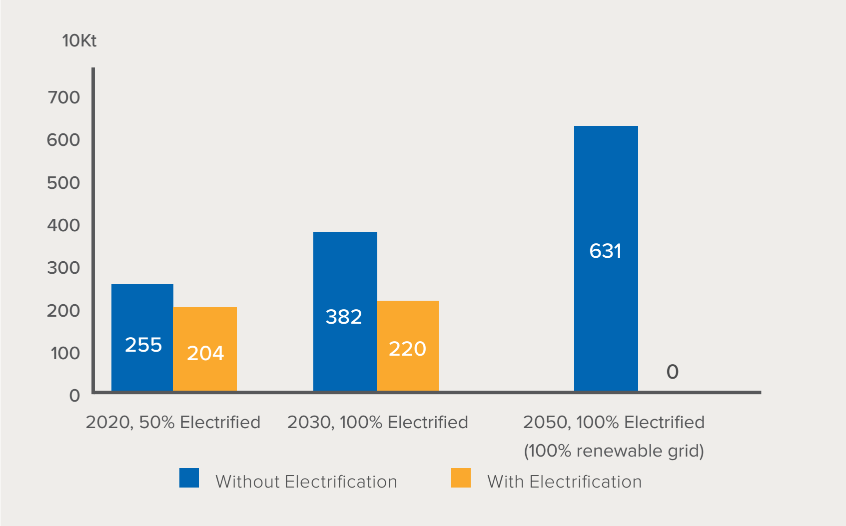


If Shenzhen continues to vigorously promote the electrification of logistics vehicles and achieves 100% electrification by 2030, and a fully decarbonized grid by 2050, its CO_2 emissions would decline by about 6 million tons (Exhibit 3).[8]

[i] This analysis includes only vehicle tailpipe emissions and smokestack emissions from power plants, which may occur outside of densely populated urban areas and therefore have lesser health impacts. It excludes other, more difficult to measure, sources of PM such as road dust.

Exhibit 3

CO_2 Emissions Reduction Potential of Logistics Vehicle Electrification in Shenzhen



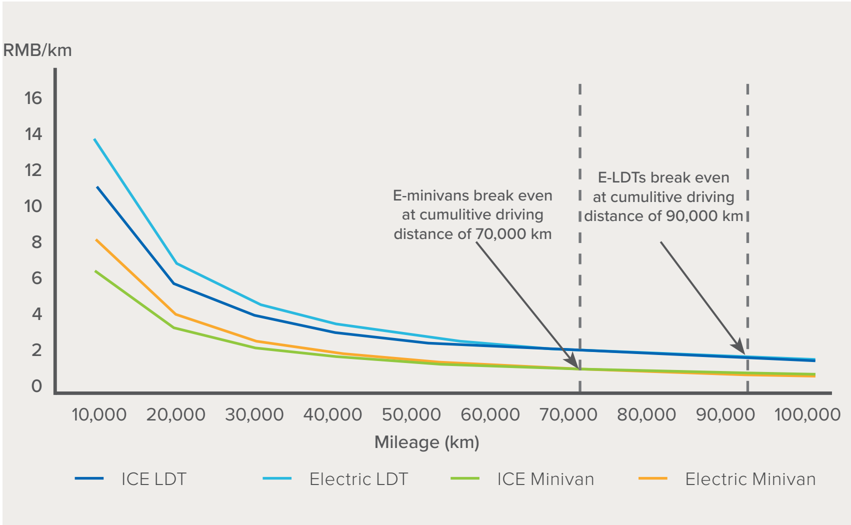
THE IMPORTANCE OF ELV UTILIZATION

In this paper, we focus our analysis on the utilization of ELVs in Shenzhen, outlining both challenges to ELV use and also supportive measures being taken by both public and private sectors. A question that naturally arises from any discussion of utilization, especially when vehicles are being supported with public funds, is what the "right" level of utilization is. After all, the purpose of subsidization is not the purchase of EVs, but rather the retirement of ICE vehicles in favor of EVs. That is only possible if EVs displace the use of ICE vehicles.

One way of defining the right level of utilization is to understand what level produces TCO parity with ICE vehicles—and therefore supports eventual market-led adoption without policy support. If policy can drive utilization to that level, the need for further subsidization is obviated. Under current price structures, ELVs' lower operating expenses are able to fully offset their higher upfront cost at a cumulative distance driven of 70,000 km and 90,000 km for electric minivans and light trucks respectively. That exceeds the actual average use of 40,000 km and 60,000 km, which means a financial loss to the ELV owners (Exhibit 4).

Exhibit 4

Per km Cost Comparison between ICE Vehicles and ELVs



Given that utilization is core to the financial viability of ELVs as well as to their ability to provide public benefits like clean air, utilization rate is a crucial factor to evaluate the success of ELV deployment, and improving that utilization rate has become a core focus of ELV promotion in Shenzhen.

DRIVING FACTORS OF ELV UTILIZATION

The decision to use an ELV over a competitor ICE vehicle and the degree to which it is utilized is driven by many factors. Those factors, and their impact on purchase and use decisions, are:

- **Cost:** The upfront cost premium of ELVs relative to ICE vehicles and their ability to recoup upfront costs through ongoing savings. Currently, lower operating costs favor the use of ELVs over ICE vehicles, but problems in reliability and flexibility often outweigh those operating cost advantages.

- **Reliability:** The ability to use ELVs with reasonable confidence in their capacity to consistently service clients and generate revenue. The reliability of ELVs has improved substantially over the last several years in Shenzhen, but a gap relative to ICE vehicles remains.

- **Flexibility:** The ability to use ELVs in a variety of circumstances and for a variety of tasks. Due to access restrictions that severely limit the usability of ICE vehicles in the urban core, ELVs are the preferred choice of operators for some types of urban logistics activities. However, low vehicle range, high charging requirements, and the inability to safely carry certain types of loads all limit the flexibility of ELVs in regional and metropolitan applications.

- **Safety:** The ability to operate ELVs without specific risks to the operator that do not exist in ICE vehicles (e.g., battery fires or weight-related chassis failures). Similar to reliability, the safety record of ELVs has improved but still falls short of ICE vehicles.

- **User Comfort:** The ability to provide a driver with a vehicle that maintains comfort, employee morale, and retention. In the early stages of ELV deployment, some models were regarded as low-quality vehicles that gave a low-quality user experience. That problem has largely been overcome. In many cases, ELV use is now actually preferred by drivers due to less need to wait for urban entry and the absence of diesel tail pipe fumes.

As Shenzhen formulates its ongoing policy and infrastructure planning, it seeks to ensure that all of the above decision drivers tilt in favor of ELVs over ICE vehicles. It does this through multiple pathways. For example, Shenzhen's ELV promotion portfolio includes providing infrastructure to enhance the ease of charging ELVs, a subsidy to reduce their cost, urban entry permissions that enhance their ability to generate revenue, and vehicle quality requirements that drive improved reliability and safety.

In the following sections, we introduce the ELV market in Shenzhen—with a focus on utilization—and also the policy and infrastructure framework that Shenzhen has devised to enable ELVs to fully replace ICE vehicles on the road.

SHENZHEN ELV MARKET INTRODUCTION

To capture the potential carbon emissions reductions, air quality improvement, and cost savings that ELVs offer, Shenzhen has implemented a package of policies and infrastructure development initiatives in the past five years to incentivize fleets to purchase and use ELVs for urban deliveries. The result of this policy push has been sustained exponential growth in both the ELV fleet and supporting charging infrastructure.

OVERVIEW OF THE ELV FLEET AND CHARGING INFRASTRUCTURE IN SHENZHEN

While Shenzhen is now the global leader in the promotion and adoption of ELVs, in October 2015 the city had less than 300 registered operational battery ELVs. Through a combination of vibrant market activity and strong government support, that number had grown to 70,417 by the end of 2019, with more than 80% of the ELVs being registered during or after 2017.[9] The ELV fleet is composed of 39,363 minivans, 24,330 light trucks, and 5,597 medium vans.

While vigorously promoting the use of ELVs, Shenzhen is also actively building out the infrastructure to meet the demand for charging from this rapidly expanding vehicle fleet. By the end of 2019, about 83,000 public chargers had been built in the city—including about 30,000 DC fast chargers.[10]

VEHICLE USE CASES AND BUSINESS MODELS

Currently, ELVs in Shenzhen are mainly used in last-mile applications including e-commerce and package express delivery, retailers and supermarkets, cold chain and fresh goods, and medical supplies in the city.

In terms of ownership, relatively few operators own their own ELVs. Leasing models, including short-term rental, dominate the ELV market in Shenzhen. At present, less than 2% of the ELVs in Shenzhen are owned by the individuals or companies who operate the vehicles. The other 98% are owned by leasing companies.[11] Under this model, ELV leasing firms purchase ELVs and then lease them out to individuals and companies. As part of the lease, they include maintenance services, charging services, and in some cases, even drivers.

Under this model, vehicle users can easily obtain ELVs through monthly rental contracts, which are both affordable and provide significant flexibility to adjust fleet size and composition in response to seasonality of freight shipments. Furthermore, under this model much of the risk associated with EV ownership is transferred to the leasing company that, in many cases, is affiliated with a vehicle OEM and better able to manage that risk.

For example, the risk of battery degradation or vehicle failure all sits with the leasing companies, which have the in-house expertise to cost-effectively deal with those problems. Furthermore, the planning and deploying of charging infrastructure at scale is more easily carried out by large leasing companies, which in turn provide charging as an element of the overall lease package.

Finally, the leasing model is well suited to the cost structure of ELVs. Due to the high capital costs and low operating cost of ELVs, well-capitalized leasing companies are better positioned to own these vehicles than their clients, which are often small-scale logistics businesses or even owner operators with limited access to capital.

POLICY OVERVIEW

As the global pioneer of ELV deployment, in 2015 Shenzhen began to implement a policy framework to support ELVs; and the city has continuously refined that framework over the past five years. The major elements of that framework have been a vehicle purchase subsidy, preferred urban access for ELVs, a subsidy for charger installation, discounted electricity and parking rates for ELV parking, and, most recently, an innovative operational subsidy. Each of those elements are summarized below.

PURCHASING SUBSIDY

Shenzhen began subsidizing the purchase of ELVs in 2015 and has continuously fine-tuned its subsidization policy to support the development of a healthy market. Over the years the magnitude of the purchasing subsidy has been reduced in order to ensure that the subsidy amount remained appropriate as ELV prices fell. Furthermore, the subsidy has also tightened its technical requirements (especially battery energy density) in order to ensure that it continued to drive improvement in vehicle technology and capabilities.

Because EV purchase subsidization at the municipal level is tied to a national subsidy that expired last year, the purchasing subsidy for ELVs in Shenzhen was phased out along with the national subsidy in August 2019.[12] However, unsubsidized ELVs in China are still not TCO competitive with ICE vehicles under average operating conditions. As a result, Shenzhen implemented an operational subsidy that features utilization requirements, described below, to ensure continued TCO superiority for ELVs.

ROAD PRIVILEGES

In order to encourage customers to use ELVs instead of ICE trucks for deliveries, beginning in 2016 Shenzhen restricted access for diesel trucks on many roads in the city. Only vehicles that have been verified as ELVs and registered on Shenzhen's data collection platform are permitted to drive on those roads.[13] For further detail please see discussion of urban access policies for ELVs in RMI's *A New EV Horizon - Insights From Shenzhen's Path to Global Leadership in Electric Logistics Vehicles* report.

CHARGING STATION ESTABLISHMENT

In addition to incentives for the purchase and use of ELVs, Shenzhen also has a framework to incentivize and support the construction of EV (including ELV) charging infrastructure. Since 2013, the municipal government has provided a subsidy for the deployment of charging infrastructure by large-scale players. This focus on scale is to exclude small players that historically were difficult to regulate and created a disorderly market for charging where stations were poorly maintained and experienced safety issues.

The standards to be considered a charging station operator of sufficient scale are continuously developing. As of publication, the latest standards include the following elements:

- Only companies that own chargers with a cumulative capacity of 8,000 kW or more in Shenzhen may apply for the subsidy (the same company can apply for the subsidy again when the total additional installed capacity after the first application reaches 3,000 kW).

- In 2020, for the first time, it is required that construction companies connect the charger telematics systems to the unified charging facility safety supervision platform of Shenzhen and upload operational data in real time.[14]

For companies that qualify, the construction subsidy standard for a DC charging facility is ¥400/kW ($60/kW). The subsidy standard for AC chargers is ¥200/kW ($30/kW) for chargers with capacity higher than 40 kW and ¥100/kW ($15/kW) for chargers with capacity lower than 40 kW.

ELECTRICITY AND PARKING COSTS FOR CHARGING

Beginning July 2018, the Development and Reform Commission of Shenzhen issued a regulation that provided certain concentrated EV charging facilities, defined below, with industrial and commercial electricity pricing of ¥0.17–¥1.03/kW ($0.025–$0.15/kW), depending on the time of day. In order to ensure that those low rates are passed on to customers, and therefore support the TCO advantages of EVs, regulations require that charging station operators charge no more than ¥0.8/kWh ($0.12/kWh) in excess of the cost of electricity they receive from the grid.[15] Due to the competition for customers, charging companies typically charge less than the maximum allowed fee, although this varies by location. Chargers in high demand areas with low land availability, such as in the city center, are able to charge the full allowed service fee.

Three requirements exist in order for a station to be qualified as a concentrated charger:

- The facility should have at least 150 kw of total capacity and at least three chargers.
- The facility should be operated by a registered charging infrastructure operating company.
- Chargers at residential parking at homes or apartments do not qualify. Residential rates apply for residential chargers even if other conditions are met by the facility.

Furthermore, Shenzhen allowed EVs to enjoy two hours of free parking per day in public parking lots and one hour of free road side parking per day.[16] This applies to ELV parking when making deliveries—enhancing their convenience and overall value proposition.

OPERATIONAL SUBSIDY

In 2019 both national and municipal EV purchasing subsidies expired before ELVs had attained unsubsidized TCO parity with competitor ICE vehicles for most duty cycles. To continue to support ELVs' value proposition for commercial operators, Shenzhen designed and implemented China's first ELV operational subsidy. This new subsidy aims to continue to incentivize the purchase and use of ELVs while also driving consolidation and increased operational efficiency in the urban delivery sector. Rather than being paid out at the time of vehicle purchase, the operational subsidy is paid out yearly for three years as long as the vehicle owner remains in compliance with three subsidy conditions.

First is that the vehicle be used productively: only ELVs driving 15,000 km/year in the city of Shenzhen are eligible. In order to verify compliance with the requirements of the operational subsidy, Shenzhen has established a platform to collect and analyze telematics data. Data sharing by the owners with this platform is a requirement for subsidy eligibility. This data, in turn, supports not only subsidy eligibility calculation, but also lays the foundation for evaluating and improving policy measures such as preferential access regulations for ELVs and logistics-specific charging network design. The second is that the vehicle belong to a large-scale fleet—only fleets with substantial numbers of vehicles are eligible for the subsidy. Finally the vehicle receiving the subsidy must be of sufficient quality as measured by a series of quality indicators, most importantly battery density. The details of this eligibility framework are discussed more in depth in the following volume.

At a high level, our research indicates that the policy has successfully driven increased ELV utilization, maintained TCO superiority for ELVs relative to ICE vehicles, and supported the deployment of higher-quality vehicles. The policy does not appear to have meaningfully driven market consolidation. In the next volume of this report, we review this policy in depth, discuss its impacts on the market, and analyze if it has accomplished its other stated goals.

ELV UTILIZATION IN SHENZHEN

As discussed above, utilization is key for ELVs to reduce both direct costs to the operator as well as external costs to society from freight transportation. As with most EVs today, ELVs have higher capital costs, but lower operating costs, than their ICE competitors. In order to be cost-effective, they must obtain utilization such that cumulative operating costs savings exceed incremental up-front costs.

Under current capital and operating cost structures in Shenzhen, that cost parity arrives at a utilization of approximately 14,000–18,000 km per year.[17] Furthermore, governments subsidize ELV adoption because the social costs of air pollution and carbon emissions from diesel vehicles are unacceptably high. However, growing the ELV fleet alone is not sufficient to eliminate those high external costs; ELVs must displace diesel vehicle kilometers driven. For that reason, both public and private sectors are aligned in their interest to increase the utilization of ELVs and reduce their total internal and external cost.

In this section we combine analysis of ELV operational data with stakeholder interviews on ELV utilization, to understand both the trend in ELV utilization as well as opportunities to enhance that utilization.

INTRODUCTION TO DATA SOURCES FOR THIS ANALYSIS

In this research, RMI partnered with China's National EV Data Platform at the Beijing Institute of Technology and the Shenzhen ELV Data Monitoring Platform to analyze ELV utilization and identify pathways to improving it. The data under analysis was generated by 25,643 ELVs in 2018 and 49,290 ELVs in 2019, all operating in the city of Shenzhen and transmitting telematics data at 30-second intervals.

Furthermore, we supplemented this data analysis with interviews and surveys of stakeholders such as rental companies, fleet and vehicle operators, charging station operators, and suppliers. Based on this approach we discuss the status quo of ELV utilization in Shenzhen and make recommendations for future improvements.[18]

As mentioned above, the utilization rate of ELVs is a key metric that indicates the efficiency and feasibility of replacing ICE trucks with ELVs. However, utilization is not necessarily straightforward to define. Conceptually an efficiently utilized vehicle will perform the maximum amount of productive work in a given time period. However, since it is difficult to have an accurate assessment of the amount of productive work done, we use a few metrics as proxies. Those metrics are:

- share of days in which a truck operates (referred to as operating days);
- hours of operation per operating day; and
- average daily driving distance on operating days.

COMPARATIVE ANALYSIS OF ANNUAL OPERATING DAYS

The most obvious indicator of poor utilization is a vehicle that never drives. For that reason the first metric of utilization is the share of days in which a vehicle actually operates, which we define as driving more than 5 kilometers. Vehicles register and connect to the data platform throughout the year. Therefore, to normalize for the age of the vehicle, rather than simply counting operating days for each vehicle, the research team adopted the method of dividing the number of operating days by the total number of days since it first connected to the platform.

We refer to this metric as share of operating days. Vehicles with a zero share of operating days were excluded from analysis as they were viewed as likely the product of a failure either in the data transmission or recording systems, or potentially a vehicle that had suffered an accident or maintenance problem that ended its useful life before it connected to the platform.

While there is some variability, a large number of ELVs in Shenzhen have a relatively low share of operating days. As shown in Exhibit 5, only 25% of all ELVs had a share of operating days of 80% or higher, while 40% had a share less than 50%. Only 10% of all ELVs achieved a 90% share, the average share for ICE trucks of the same size. While the data on ELVs show an increased share of operating days in 2019 compared with 2018,[19] the gains were small and there is still significant progress needed to match the utilization rate of ICE vehicles.[20]

However, when discussing these results with vehicle operators, these numbers seemed to understate actual ELV utilization. In surveys and interviews, most vehicle operators indicated that an ELV typically operated 24–25 days per month. This is much closer to the 90% share of operating days that surveys indicated was typical for ICE trucks of the same size.

Interviewees suggested that this low utilization, and the discrepancy in observed share of operating days versus what was reported in interviews, may be in part due to the purchase subsidy phase-out process over the last year in Shenzhen. Before the operational subsidy was announced, but after it was widely known that the purchase subsidy was being discontinued, many companies chose to purchase ELVs despite not actually having an immediate use for them.

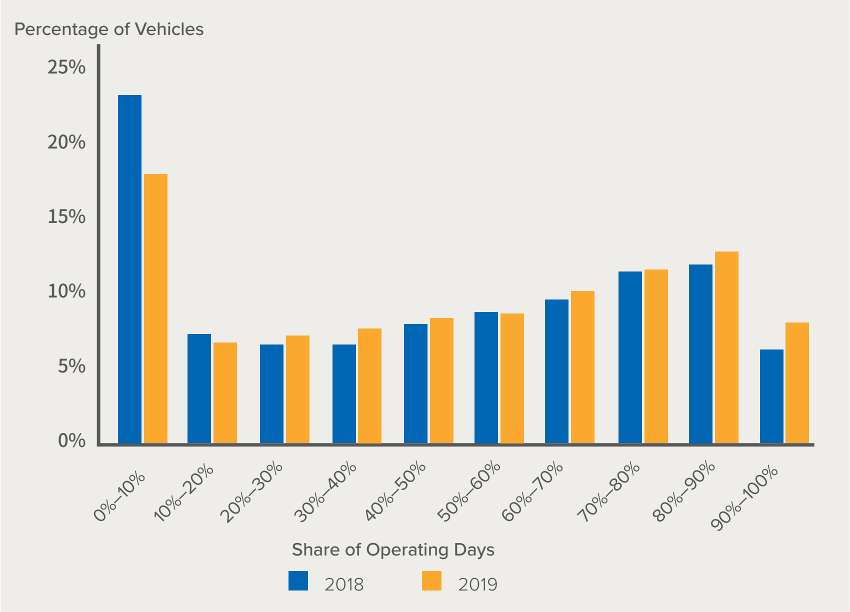
This made the vehicles purchased inconsistent with the actual demand for goods delivery. If that explanation is correct, it is reasonable to expect that those vehicles will go into service as the existing ICE fleet is retired or sold for second-life applications. This explanation is supported by a reduction in the share of the ELV fleet that was idled in 2019 over 2018 (Exhibit 5).

While interviewees and survey respondents indicated that ELVs that are actually in operation are more fully utilized than our data analysis suggests, they did agree that they could not fully replace ICE vehicles. First, EVs feature high battery weights and the current generation of ELV chassis, especially light trucks, is not able to handle some of the dynamic forces generated during normal vehicle operations. Therefore, ELVs could only be loaded with about 60%–70% of the weight that ICE vehicles of the same size could carry.[21]

Second, due to lost productivity from limited range and required charging time, ELVs on average were not able to replace ICE vehicles on a 1:1 ratio even for delivery tasks that they were physically able to carry out.

Exhibit 5

Share of Operating Days of ELVs in Shenzhen 2018 and 2019



Taking a step further in the analysis and segmenting utilization by vehicle type yields further insights into the underlying trend. One key insight is that minivans, in terms of their share of operating days, generally are better utilized than light trucks (Exhibit 6).

There are several reasons for this superior utilization. First, the duty cycles of minivans are more amenable to electrification than light-duty trucks (LDTs). Minivans are mainly used for express parcel deliveries and in "Uber of Freight" (the most used Chinese platform is called Huolala) applications. In both scenarios, loads are relatively small and of lower density and routes traveled are typically lower-velocity, lower-distance patterns in the urban core. Light trucks, on the other hand, haul heavier and denser freight longer distances at higher speeds—often in suburban areas. These differences drive differential utilization in three main ways:

- **Subsidy eligibility and structure:** First, only kilometers driven within the city of Shenzhen count toward operational subsidy eligibility. LDTs spend much of their time driving in the greater Pearl River Delta. As a result, even though their routes are longer than minivans, their subsidy-eligible kilometers per route are oftentimes lower than minivans driving shorter distances.

  Secondly, the operational subsidy is calculated according to the size of the vehicle battery pack, with a marginally decreasing payment per kWh. Because LDTs need larger battery packs, the overall subsidy is lower relative to vehicle price than for LDTs. These two factors combine to make the operational subsidy less valuable to LDTs and therefore less effective in driving utilization.

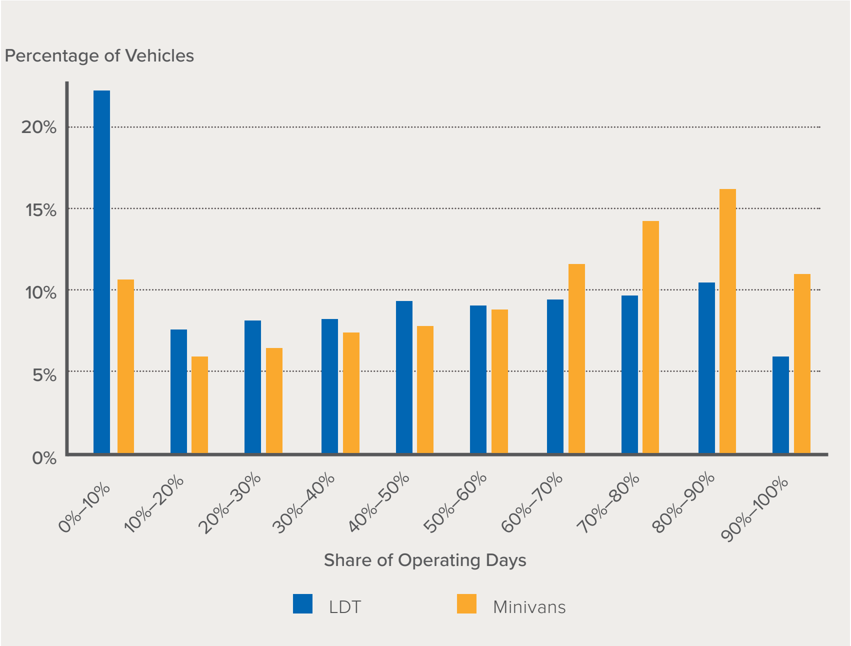
- **Urban access:** One of the key drivers of ELV adoption and use is heavy restriction of access for ICE vehicles to the city proper (see our previous report *A New EV Horizon* for a comprehensive discussion of those regulations and their effect on ELV adoption). Because LDTs operate regionally, they are often not required to enter the urban core, negating the incentives for ELV use that those access restrictions create.

- **Vehicle capabilities:** As alluded to earlier in this report, ELV chassis are in some cases not up to the dynamic forces created by heavy battery packs and heavy loads during sharp turns. Because LDTs have both heavier battery packs and heavier denser loads, this problem disproportionately affects them.

As a result of those three factors, electric LDTs are typically only used when urban access is required. The impacts of those three factors on the market can be seen below as light duty trucks annual operating days (Exhibit 6).

Exhibit 6

Comparison of Share of Operating Days in 2019 between Minivans and Light Trucks

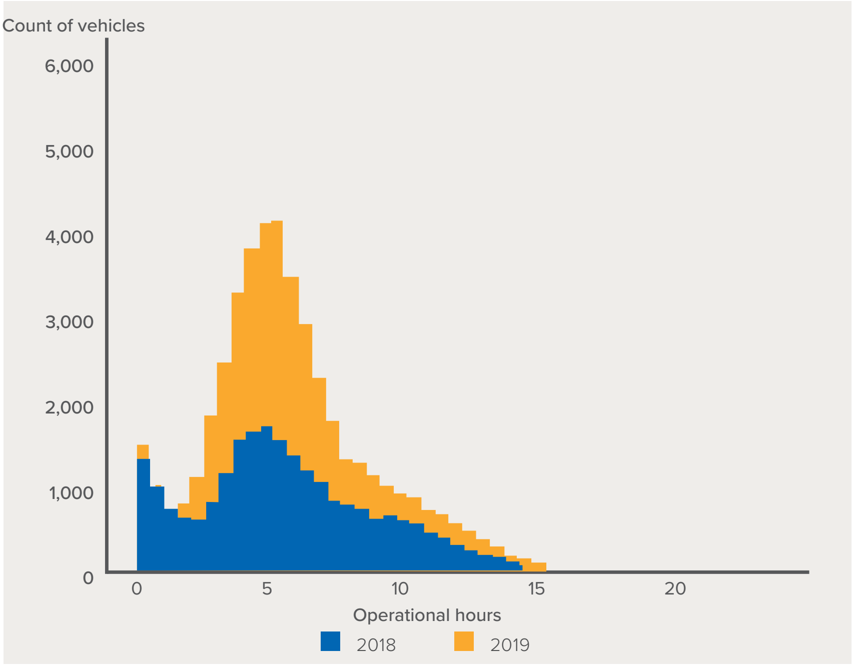


COMPARATIVE ANALYSIS OF DAILY OPERATIONAL HOURS

For each operating day of a vehicle, the time interval between its first non-zero speed transmission and last non-zero speed transmission on that day is defined as its daily operational hours. In 2018–2019, the median daily operational time of an ELV in Shenzhen was approximately five hours. While there was some improvement in average daily operating hours between 2018 and 2019 (Exhibit 7), ELVs still significantly lag an average of 10–14 hours compared with ICE trucks as reported in interviews.[22]

Exhibit 7

Distribution of Daily Average Operational Hours of ELVs in Shenzhen, 2018 and 2019



COMPARATIVE ANALYSIS OF DAILY DRIVING DISTANCE

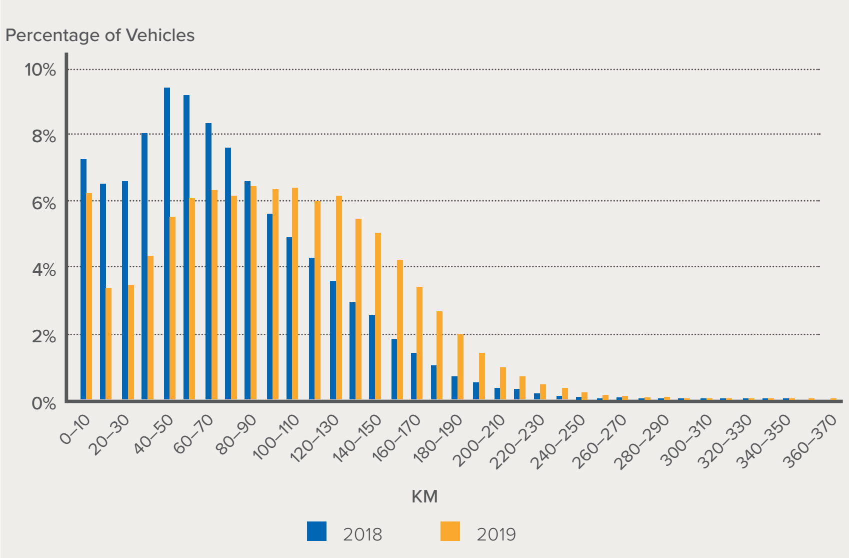
Daily driving distance is another metric for utilization that describes how far a given vehicle drives on an average operating day, as calculated by the change in its odometer reading on the first and last ping from its telematics box. This metric has improved substantially recently, with the average daily driving distance of ELVs in Shenzhen increasing by approximately 25% from 50–60 km in 2018 to 70–80 km in 2019 (Exhibit 8).[23]

Although it is still less than the average daily driving distance of 120–160 km of ICE delivery vehicles reported in interviews and surveys, there has been a significant improvement.[24] In order to understand the reasons for the increasing driving distance, surveys and analysis of delivery fleets using ELVs in Shenzhen were carried out by the research team.

Our analysis showed that several factors were at play in creating the trend of improving utilization. First was continuous improvement in battery energy density and ELV range on a single charge. Second was improvement in the charging infrastructure that serves these vehicles (discussed in depth in the following Infrastructure Volume). These two improvements combined to reduce logistics companies' ELV range anxiety and led to increased driver acceptance of ELV's operational capabilities. Third, under the incentive structure of the operational subsidy policy, increased utilization is financially rewarded. This has led vehicle operators to attempt to meet the eligibility threshold of 15,000 km, resulting in an improvement of overall fleet utilization.

Exhibit 8

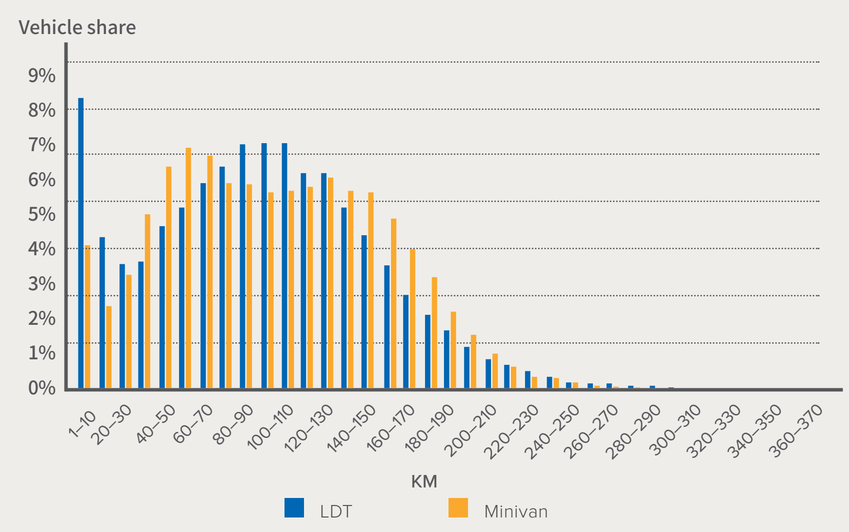
Daily Average driving distance Distribution of ELVs in Shenzhen



At the same time, it is worth noting that daily driving distance of electric vans has improved more than electric trucks and on average electric vans exceed the daily driving distance of electric trucks (Exhibit 9), despite the fact that ICE trucks travel longer daily distances than ICE vans. This is largely for the same reasons as discussed above in the operating days section, where both vehicle technology and policies were more suited to electrification of vans than trucks.

Exhibit 9

Daily Average driving distance Distribution of LDTs and Minivans in Shenzhen in 2019



This lack of success in driving full utilization of electric trucks relative to the success of efforts in driving the utilization of vans should be a focus for policymakers in future iterations of subsidization—especially since these diesel trucks are disproportionate sources of air pollution in cities. As the range and chassis design of light-duty trucks progresses, this market segment will become capable of greater utilization. As that happens, improvements to the operational subsidy framework, paired with a regional, rather than municipal, approach to access rights will become key elements of a strategy to drive light e-truck utilization.

CONCLUSIONS AND FURTHER RMI ANALYSIS

Enabling enhanced ELV utilization, and the full replacement of the ICE fleet with ELVs, are top priorities for policymakers in Shenzhen. As logistics electrification becomes a focus in cities globally, this will become an issue that other cities will need to tackle. RMI is supporting efforts in Shenzhen with analysis of four factors identified as crucial to driving future improvement in ELV utilization.

Further Development of the Operational Subsidy: The EV purchase subsidy has been phased out nationally, but ELVs have not yet achieved unsubsidized TCO parity for the majority of urban duty cycles. Given the need for continued subsidization but also a desire to rapidly drive the market to full TCO parity, the operational subsidy has emerged as an area of intense focus for cities and provinces in China.

RMI's research will ensure that other cities have a clear view of how Shenzhen implemented the operational subsidy, support Shenzhen in evaluating the market's reaction to the policy, and suggest further improvements that could enhance its effectiveness.

ELV Charging Network Development: Although charging infrastructure in Shenzhen has grown by leaps and bounds, the journey was not painless and is not yet complete. RMI's research will support Shenzhen with analysis of ELV charging demand to understand more fully how both public and private sector players can effectively meet ELV charging demand—both for the existing fleet and for vehicles expected to come online in the coming years.

Furthermore, by providing an in-depth analysis of ELV charging patterns, RMI will provide a roadmap to enable other cities to follow Shenzhen's path and avoid the trial and error that Shenzhen experienced as a global first mover.

Technology and Capability of vehicles: RMI's surveys of ELV owners and users show that current ELV models, while much improved over past years' models, still have some problems that limit their ability to fully replace ICE vehicles. These problems include an inability to handle heavy loads at speed, excessive downtime for maintenance, and faster than expected battery degradation.

RMI's research will analyze the importance of vehicle failures as a factor driving reduced utilization and lowered confidence in vehicle capabilities. Our ultimate goal is to present both public and private sector decision makers with data and insight that will catalyze action to make targeted improvements to vehicle quality and overcome the existing confidence gap between ELVs and their ICE counterparts.

Vehicle Ownership Models: As the up-front cost of ELVs remains high at present, and the complexities of maintaining and charging are beyond the capabilities of small operators, rental has emerged as the main model for procuring ELVs in Shenzhen. However, the effect of this new business model on the incentives for operators to achieve maximum vehicle utilization are still unknown.

For example, vehicle leasing may incentivize operators to heavily use fast charging, which leads to more flexibility and short-term revenue generation but accelerates battery degradation. Or again, the operational subsidy is paid to vehicle owners, not operators, and therefore the incentive to drive leased ELVs rather than ICE vehicles may not be fully transmitted to the market. On the other hand, aggregated ownership may enable a smaller, better utilized fleet, as random fluctuations in demand and differing patterns of seasonality are more easily managed.

Therefore, better understanding how to choose and balance rental and self-ownership models in order to maximize ELV attractiveness and cost-effectiveness will play an important role in the future promotion and adoption of ELVs in Shenzhen and other cities in the future.

In the following four reports, RMI will explore each of those topics in depth in the hope that our analysis can support improved ELV utilization in Shenzhen and ultimately lay the foundation for an improved policy and commercial framework for effective ELV use in China and beyond. Our final report in this series will provide a summary of best practices from Shenzhen to support other cities in charting a path to fully electrifying goods and logistics delivery.

ENDNOTES

1. Energy Data by Category, Indicator, Country, or Region, International Energy Agency, 2017.

2. Wenjing Yi, Energy Research Institute of National Development and Reform Commission, *Analysis on Energy Consumption and Current Situation of Transportation in China*, 2017.

3. Energy Saving and Emission Reduction Research Group of Chinese Academy of Engineering, Strategy and Policy Research on Energy Saving and Emission Reduction of Freight Transportation in China, May 31, 2016.

4. Ibid.

5. Interviews with Bitauto, Autohome, and local freight transportation companies in Shenzhen.

6. Shenzhen National Development and Reform Commission, *2018 Shenzhen Blue Action Plan for Sustainability,* 2018.

7. China Electric Power Enterprises Federation, *China Power Industry Annual Development Report,* 2019; China Carbon Trade Net, Don't use EFOM/BM/CM/Emission factors to calculate carbon emission, 2019.

8. Shenzhen Statistics Department, *Shenzhen Statistical Yearbook 2019,* 2019.

9. Registration data of renewable-energy trucks in Shenzhen in 2019, 2020.

10. Shenzhen Electric Vehicle Operation Association, Charging Operation and Relevant Suggestions in the First Quarter of 2019 and 2020, 2020

11. Allison Crow et al., *A New EV Horizon: Insights From Shenzhen's Path to Global Leadership in Electric Logistics Vehicles,* Rocky Mountain Institute, 2019.

12. Shenzhen National Development and Reform Commission, *Implementation Rules of Financial Subsidy for Promotion and Application of New Energy Vehicles in Shenzhen from 2019 to 2020,* 2020.

13. Government of Shenzhen, A notification to publish the "Shenzhen Blue" action plan for sustainability, 2018.

14. Shenzhen National Development and Reform Commission, *Implementation Rules of Financial Subsidy for Promotion and Application of New Energy Vehicles in Shenzhen from 2019 to 2020,* 2020.

15. Guang Dong National Development and Reform Commission, A notification about the electricity price for renewable energy vehicles in our province, 2018.

16. Shenzhen Government, Notice on the implementation of free first-hour temporary parking policy of new energy vehicles on the road side, 2018.

17. Interviews with electric vehicle rental companies and freight vehicle fleets in Shenzhen.

18. Data analysis based on the Beijing Institute of Technology's renewable energy vehicle data platform.

19. Ibid.

20. Research Institute of Road Transportation, Panda Zhilian, *Application Analysis Report of Renewable Energy Logistics Vehicles 2019*, 2019

21. Interviews with electric vehicle rental companies and freight vehicle fleets in Shenzhen

22. Research Institute of Road Transportation, Panda Zhilian, *Application Analysis Report of Renewable Energy Logistics Vehicles 2019*, 2019

23. Data analysis based on the Beijing Institute of Technology's renewable energy vehicle data platform.

24. Research Institute of Road Transportation, Panda Zhilian, *Application Analysis Report of Renewable Energy Logistics Vehicles 2019*, 2019

落基山研究所

16 F, Tower C, Ocean Office Park, No.10 West Jintong Road,
Chaoyang District, Beijing 10020, P.R.China
http://www.rmi.org