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Final Report

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EXECUTIVE SUMMARY

1. Abstract

In the era of new mobility, promoting Electric Vehicle [EV] usage is considered a promising policy to mitigate roadside carbon dioxide [CO₂] emissions, improve energy efficiency, lower operational costs and enhance passenger experiences. Promoting e-mobility has, as a consequence, become a central concern in government agendas across the world including Hong Kong. The growth in the number of electric private cars in Hong Kong has taken off since 2014; there has been a dramatic increase from 614 to 12,341 in 2019. However, spatial planning guidelines for EV charging infrastructure remain elusive, hampering the greater popularisation of electric vehicles. In this project, we aim to understand public acceptance of EVs, the current supply and demand of public charging facilities, and institutional constraints from various perspectives, we also ultimately promote e-mobility in Hong Kong.

To understand the supply side (i.e., institutional and spatial constraints) of public charging infrastructure in Hong Kong, we collected charger information from the Environmental Protection Department [EPD] in April 2019, including the number of chargers of different speed levels and suppliers (i.e., whether they were Tesla chargers or not). Then we used geographic information system (GIS) to geocode and visualise their distribution over Hong Kong. Accessibility analysis was conducted to understand the landscape of public charger accessibility – the ease of reaching a public charging within a limited timeframe (e.g., 5 minutes) on foot. To understand the public acceptance of EVs and the demand for public chargers, a questionnaire survey was conducted to collect public opinions of EV owners, other car owners, and members of the public more generally. Then we used the collected data to predict the demand for public chargers using the ordered probit model. With the supply and demand estimates, we estimated a location-allocation model for the selection of optimal sites for the spatial deployment of public charging facilities.

Our model achieved a coverage rate of 99.95%, with a decent accessibility level. Our results suggest that there need to be a strategic spatial deployment of more charging infrastructure: a

total of 5,840 new standard chargers, 354 new medium chargers, and 1,245 new fast chargers need to be installed across all potential sites (including both existing and new EV charging stations). A total of 939 new locations, especially in the New Territories, are required to establish EV charging infrastructure in addition to the 318 car parks that have existing EV charging facilities. In addition, we note that several new towns suffer from a particular deficit of charging facilities given the potential high demand of EVs.

To gain a better picture of the EV development in Hong Kong, we also identified several key stakeholders in the EV development with a focus on the deployment of charging infrastructure, including government units, lawmakers, EV charging facility suppliers, car park managers, EV owner alliances. With representatives from each stakeholder, we conducted an in-depth, semi-structured interview. From the interview, we learn a number of key messages from different perspectives. Interviewee from government expresses their difficulties in advocating the policy and coordinating the cooperation among different sectors including private enterprises, legislative council, property management companies, car park management and consumers. The representative from lawmakers (a member of Legislative Council of Hong Kong for the Transport constituency) expressed the opinion that the advancement of e-mobility in Hong Kong is greatly confined by charging supply, as it determines how practical potential adopters can enact their purchasing plans. He further demanded that the government formulate a master plan on EV promotion. For charging facility suppliers, their top concern is the unprofitable nature of the EV charging market because of the dominance of government and the two electricity companies who supply the public chargers for free. This can be seen as a distortion of the market and, in turn, largely discourages private investment interests. Our interviewee from car park management companies stated a lack of financial incentive to surrender parking revenue for reservation of charging space for EVs. Lastly, the EV owner alliances are more concerned with problems of accessing to public charging facilities and the lack of real-time information of charging status of public chargers.

Based on our research, we provide a number of policy recommendations that integrate accessibility planning strategies into e-mobility promotion in Hong Kong.

2. Layman Summary on Policy Implications and Recommendations

Capturing the contextualised characteristics of public charging facility deployment in Hong Kong will make the facility deployment scheme more realistic, which would help ease potential users' concerns regarding the driving range of EVs and enhance their popularity.

From our study, including questionnaire survey with existing EV owners, and an in-depth interview with the EV user alliance, we learnt that the current key obstacles to greater public acceptance and user experience of EVs are as follows:

- Access to public charging facilities
- Information pertaining to the charging status of public chargers
- Ability to actualise home charging

In addition, we also learnt that the main concerns for potential EV owners from our public questionnaire surveys. The key concerns included:

- Access to public charging facilities
- Price and subsidies
- Knowledge of EV operation

From both existing and potential EV users, we reveal that access to public charging facilities is one of the key concerns of both groups. Strategic spatial planning is one of the key areas to be pushed forward if we are to promote greater e-mobility. With a better choice of locations of public EV charging stations that accommodate the respective spatial characteristics of urban areas, alongside properly disseminated information about where they are, consumers would be more likely to accept EVs; this would result in the greater development of an e-mobility culture.

The urban development of Hong Kong is complex, with diversified spatial development features and multiple social activity characteristics. One single EV public charging deployment approach is apparently incapable of addressing either the geographical variations in existing

charging networks or potential EV charging demand. To accomplish the optimal allocation of charging facility resources, we divided the whole region into three spatial contexts for formulating a strategic spatial deployment of public charging facilities: (1) The Central - Wanchai CBD and East Kowloon CBD²; (2) new built-up areas and urban renewal zones; and (3) new towns.

- **The Central - Wanchai CBD and East Kowloon CBD²** demonstrated promising charging supply intensity. However, the main concern over the two districts was the overcrowding parking sites and the resultant occupation of charging spaces. To alleviate the lack of charging supply certainty, the compact urban development and high walkability features of CBDs are utilised in spatial planning strategies. It is suggested that public charger deployment should be spread out with a higher number of locations and a smaller quantity of outlets at each location. This strategy is expected to scatter the charging vehicles across the area to prevent accumulation of both parking and charging demand in major car parks within the areas.
- **New built-up areas and urban renewal zones** were the next focused spatial setting in our strategic plan. We referred in particular to areas planned and built after 2011, when the charging enabling infrastructure concession on gross floor area [GFA] was launched. The policy has generated constructive momentum among new building developments to install enabling infrastructure in preparation for future charger deployment. This is seen as a means by which to expand the EV charger network at a lower cost. Two typical examples identified in the optimisation model are the Kwun Tong renewal area and Sau Mau Ping new housing estates.
- **New town developments** were found to have the most pressing need for public charging services. These communities, including Tai Po, Tsuen Kwan O and Tuen Mun, were discovered to have severe shortage of public chargers, while their demographic composition and large population bases have yielded a significant EV charging demand. We propose that standard or medium chargers should be installed in greater number across new town areas to satisfy the destination and overnight charging demands of these residential communities.

Apart from the strategic spatial planning proposal, we recommend a number of measures to

enhance charging supplies and promote EV adoption from the perspectives of (1) institutional, (2) commercial, and (3) EV users.

- **Institutional:** A master plan with clear goals on EV promotion is pressingly needed to rectify the existent indecisive policy directions and the limited progress of e-mobility in previous years. The current EV market requires economic incentives to fuel up the development of EV related industries. Private facility suppliers could hardly profit from the dominance of free charging provision and, therefore, the master plan including a timetable to move towards charged charging should be initiated as soon as possible. Reasonable tax concessions and deployment cost reimbursements could also stimulate private market engagement in public charging services. The GFA concession could be expanded to above ground parking areas that possess charging enabling infrastructure. Further financial benefits could be granted to motivate the private sector to meet the 30% charger ratio in car parks. The current HK\$2 billion earmark on home chargers could be extended to the construction of extra power supply facilities with a greater grant amount. Renewing contracts with car park management to include EV-prioritising protocols could provide an action ground as well as appropriate compensation to the companies. The unification of real-time charger status platforms mitigates the daily usage friction that limits the charger navigation of EV drivers and practises the Internet of Things and open data promotions.
- **Commercial:** For home charging, semi-public charging facilities operating with well-defined cost recovery schedules could be a substitute for personal chargers in housing estates without private ownership of parking spaces. Apart from the expansion of charger supplies, ensuring their valid supply is another aspect that would strengthen functional supply of charging facilities. A smart charging layout is proposed to enhance the accessibility of charging facilities in car parks by dispersing charger installation over further sites so as to contain the impact of overcrowded parking sites.
- **Users:** The current first registration rate concession limits could be altered to make EV purchase more affordable. Considering the users' budget and current tax environment, publicity from dealers and the government to encourage selection of more economic EV models should also be strengthened in order to induce more EV purchases. Nurturing a

regular and frequent charging habit does not only preserve the longevity of battery life, it also reduces the inelasticity of each charge by avoiding people topping up vehicles which have extremely low batteries at quick charging sites. EVs could also be used in driving tests to enrich the e-mobility experiences of potential buyers. Housing managements are equally important publicity target as their understanding on government policies increases the approval rate of charger installation proposals.

行政摘要

1. 摘要

推廣電動汽車的應用能有效減少路邊二氧化碳排放、提高能源效率、節約營運成本和提升乘客體驗，促進電子流動已成為包括香港在內的世界各國政府的項重要議題。香港的私家車發展自 2014 年起急速發展，在五年間從 614 輛急劇增加到 2019 年時的 12,341 輛，惟缺乏充電設施仍為限制電動車普及的一個主要瓶頸。我們旨在瞭解電動車在香港的供求關係，並綜合考慮體制與空間背景的限制以及公眾對於電動車的認可，為充電設施的空間優化選址建立區位配置模型。

從供應角度（即制度和空間限制），我們收集了環保署 2019 年 4 月的充電器資訊，然後利用地理資訊系統顯示不同速度和供應商（即特斯拉）充電器的分佈。我們進一步使用可達度分析以瞭解各小規劃區的電動汽車充電供應現狀。從需求角度，我們將會以問卷調查香港居民對於電動汽車的接受程度，從而在統計模型中估算公眾在個人、家庭和地區層面對電動汽車的購買意願。在取得供求預測後，我們建立了一個選址分配模型以計算最優化的設施空間佈局。我們發現，為達到 99.95% 的電動汽車充電器需求覆蓋率我們一共要安裝 5840 個新標準充電器、354 個新中型充電器和 1245 個新快速充電器。此外，除了現有的 318 個具備電動車充電設施的停車場外，還將需增設 939 個新的供應地點，尤其是為滿足在新界的充電需求。

为了更好地瞭解香港電動汽車的發展情況，我們亦選取了電動汽車發展中的幾個主要持份者，包括政府組織、議員、充電設施供應商、停車場管理公司及電動車主聯盟。我們與各持份者代表進行了半結構式的深入訪談，並從當中獲取了一些關鍵的發現。首先，對充電設施供應商而言，市場充斥由政府及兩間電力公司提供的免費服務，使商業模式難以盈利，大大降低投資者的投資意欲。其次，政府受訪者亦反映在宣導政策和協調私營企業、議會、物業管理公司、停車場管理和消費者等持份者的合作方面存在困難。最後，電動車主團體尤為關注取用公共充電設施和公共充電器實時充電狀態資訊方面的問題。

根據我們的研究結果，我們將提供多項政策建議，以提升充電設施的可達度規劃，以助香港更進一步推廣電動車輛。

2. 對政策的影響和建議

在公共充電設施的投放規劃中考慮香港電動車發展的背景特徵能使設施方案貼合實際，進而更悉切地解決消費者對行使里數方面的疑慮，從而促進電動車普及發展。通過本研究的問卷調查及深入訪談，我們發現現有電動車主要主面對以下三方面的困難：

- 使用公共充電設施
- 充電器狀態的資訊
- 安裝家用充電器

而潛在電動車買家則面對下列問題：

- 使用公共充電設施
- 車價及補貼
- 使用電動車的相關知識

不論現有車主還是潛在買家，我們不難發現取用公共充電設施皆為他們的頭號難處。故此，公共充電站的策略性空間規劃能適應不同地區的發展特徵，在推廣電動車應用中至

為重要。為達致最佳選址分配，我們針對三類土地提出充電器投放策略。

- **中環灣仔商業中心及東九龍商業中心**兩地的現有充電網絡皆甚為理想，但兩處受停車位不足及佔據充電車位問題所影響，故本研究建議提升該區充電站的密度，以分散充電需求，避免堆積在區內主要停車場。
- **新建成區及重建區**為另一項策略的重點區域，由於自 2011 年起新建成的樓宇多數已裝有充電基礎設施，故能以較低的成本興建充電站，主要的新建成區包括秀茂坪的安達邨及安泰邨、鄰近的觀塘則為重建中的舊區。
- 報告發現**新市鎮區**是本港最需要公共充電站的區域，這些地區包括將軍澳、屯門、大埔等多為住宅區，本研究建議在新市鎮投放大量充電器，以滿足龐大的充電需求。

除了上述策略性裝置方案，本研究亦提出了一系列提升充電設施供應及電動車需求的政策，主要涉及 (1) 體制、(2) 業界及 (3) 用家。

在**體制**方面，政府在推廣電動車方面缺少整體計劃，為電動車發展定下明確目標。現時市場極需經濟誘因，公共充電網絡充斥免費服務，令商業模式難以進入市場盈利，故政府應盡快制定時間表將市場及早轉為收費充電。對裝有充電基礎設施停車場提供的樓面面積寬免可由地底停車場擴大至所有樓層的停車位。政府亦可向充電服務公司及業主提供稅務寬免或成本折扣，以吸引私人市場投於資源發展充電網絡。現時的二十億元補貼方案亦可進一步提升新設供電裝置個案的補貼上限，以推廣住所充電。為推廣智慧城市及公開資料，政府應推廣一個統一的充電器狀態平台，以方便車主日常使用。

在**業界**方面，半公共充電站可為不能安裝私人充電站的屋苑提供一個可盈利的選擇。停車場在安裝充電站時亦可考慮使用更智慧的鋪設方法，分散放置充電機以讓盡量多的車位可以觸及。

為吸引**電動車用家**，現時的首次登記稅寬免可略作上調。適度的教育和推廣能提醒車主頻繁充電，養成良好保養電池的充電習慣。有意購買車動車的市民亦可多留意較低價的款式。定期約見業主代表推廣政府最新的政策能幫助業委會了解安裝充電器的詳情，增加批准充電器工程的個案。

CHAPTER 1 INTRODUCTION

1.1 Background to Study

1.1.1 E-mobility in Hong Kong

The merits of EV in greenhouse gas regulation and roadside air quality improvement as a consequence of its emission free operation have been widely appreciated by the government, the private sector, and academia. The then Central Policy Unit [CPU] of the Government (2015) described Hong Kong as “the world’s most suitable place for using EVs” given its compacted urban form, moderate climate and technological support from the Mainland China. The current EV fleet has been predominantly purchased for private use with just 2.28% EVs on the streets being used for businesses (goods vehicles) or public transit (Transport Department [TD], 2019). In September 2019, the electric private car fleet in Hong Kong accounted for 12,341 vehicles, a dramatic increase from the 614 vehicles recorded five years ago (TD, 2014; TD, 2019). According to the Environmental Protection Department [EPD] (2019), by the end of 2019, there were 64 models of electric private car produced from 13 vehicle manufacturers available in the market. However, EVs only contribute to a tiny portion of private cars in the territory; 2.16% of all registered private vehicles (TD, 2019). The market share of EV is incomparable to conventional combustion vehicles as well as to those in advanced e-mobility countries such as Norway, where 49.1% of new passenger cars registered were pure EV or plug-in EV in 2018 (Lambert, 2019). Therefore, how to increase public acceptance of EV and expand the EV market is imperative for both government and EV companies.

1.1.2 Government EV policy

In an informal discussion with a professional working in the TD of the Government, the person opined that the provision of on-street charging facilities should be considered in the strategic spatial planning of public EV charging facilities. Such planning should be led by EPD, and TD will follow up on the provision of on-street parking if the Government formulates a policy. In addition, a holistic plan of public EV charging facilities should be worked out and promulgated

to the public at large by the Government if it is going to promote the greater use of EV.

It has been 10 years since the Government paid attention to e-mobility. In 2009, the Steering Committee on the Promotion of EVs led by the Financial Secretary was formed in Hong Kong to propose EV development strategies and coordinate stakeholders across sectors (EPD, 2019). Government promotion of private EV adoption throughout the years has, in general, addressed two domains; the first registration tax [FRT] of EV purchases, and the construction of charging facilities. The first policy catalyst can be dated back to 1994, when the government initiated a full exemption in FRT of EVs (CPU, 2015). The tax incentive enjoyed repeated extensions until 2017, when the complete waiver was replaced by a tax concession capped at HK\$97,500. **Figure 1** highlights the fluctuations in monthly EV registrations from 2014 to 2019. The first wave of notable boosts in the number of EV registrations emerged in mid-2014, following the government's lead of adopting EVs and the announcement of expansion to the charging network in the 2014 Policy Address. The steady growth of the private EV fleet ended with a sudden drastic peak of 2,964 registrations in March 2017, the final month in which the tax exemption was in operation. The monthly registration figure plummeted to zero in the first month after the policy switch. In April 2018, the government attempted to restore EV adoption by introducing the "One-for-One Replacement" Scheme that offers a higher tax concession of HK\$250,000 to vehicle owners replacing their old vehicles with EVs (EPD, 2019). Starting from early 2019, the number of EV registered vehicles had shown some early signs of recovery.

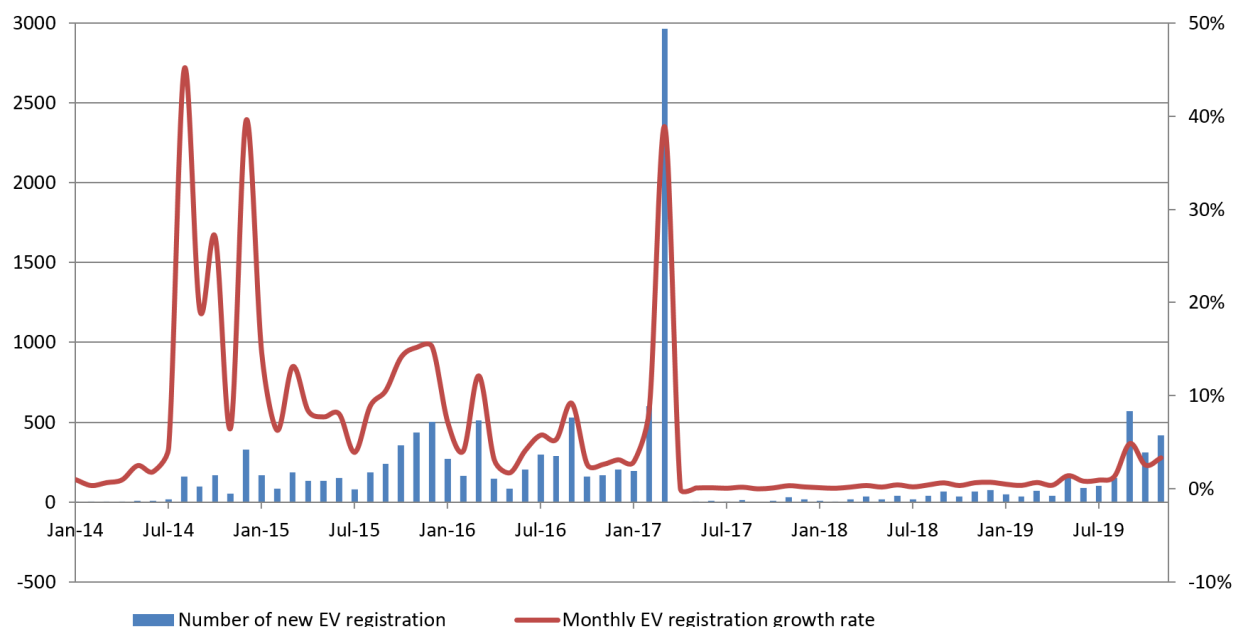


Figure 1. Monthly electric private car registrations and growth rate¹

Concerning the provision of charging facilities, the government has provided gross floor area [GFA] concessions to property developers who have provided charging infrastructure in underground car parks of new development projects since 2011 (CPU, 2015). A specification was also added to the Planning Standards and Guidelines in 2011 recommending a 30% charging facility supply rate in car parks.

More recently, in the 2019 Budget Plan, the sum of HK\$120 million was put aside for erecting another 1,000 charging outlets in government car parks over the subsequent three years, alongside a HK\$2 billion subsidy in the Policy Address to facilitate the construction of private charging facilities. The latter is expected to provide 60,000 parking spaces in private housing developments and eventually equip one-fourth of parking spaces with EV chargers in three years.

Note that all the aforementioned institutional policies and constraints are taken as parameters in our location-allocation models detailed in **Section 4.4**.

¹ Source: Numbers of EV registration are summarized from Monthly Traffic and Transport Digests of TD

1.1.3 Spatial contexts

The location of existing EV charging facilities spreads across an array of building types, including but not limited to government buildings, commercial centres, shopping plazas/centres, industrial centres, housing estates, hotels, transport hubs, gardens/parks, and amusement parks. **Table 1** summarises the distribution of the 2,242 public EV chargers of standard, quick, medium and Tesla types across the 18 districts as of April 2019. The EV charger categorisation herein employs government definitions; standard chargers refer to charging outlets connecting a 13A household socket; medium chargers refer to charging outlets offering a power rate below or equal to 20kW; and quick chargers refer to charging outlets providing charging power above 20kW. In terms of management entities, existing charging facilities are located either in privately managed car parks or government car parks operated by TD, the Government Property Agency, the Leisure and Cultural Services Department, the Electrical and Mechanical Services Department, the Housing Authority, the Tourism Commission or the Highways Department.

Table 1. Number of chargers by types and districts (as of April 2019)²

District	Standard	Medium	Quick	Tesla	Total*
Central and Western	62	110	38	28	210
Wan Chai	58	79	35	41	172
Eastern	37	101	52	25	190
Southern	4	11	27	27	42
Kowloon City	68	9	33	25	110
Wong Tai Sin	24	46	9	4	79
Kwun Tong	209	77	24	57	310
Yau Tsim Mong	101	67	50	51	218
Sham Shui Po	15	42	37	12	94
Tsuen Wan	22	54	9	18	85
Kwai Tsing	25	11	33	16	69
Sai Kung	24	31	25	12	80
Sha Tin	58	30	38	28	126
Tai Po	46	21	16	0	83
North	58	25	12	4	95
Tuen Mun	12	10	17	6	39
Yuen Long	50	33	18	6	101
Islands	9	103	27	9	139

² Source: EPD online list of Locations of Chargers for Public Access

Total	882	860	500	369	2,242
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Note: *Sum of standard, medium and quick chargers.

In addition to current EV charging facilities, we also consider potential sites for public chargers in the future. Accordingly, we gathered information on regional car parks. Both existing and potential sites for public charging facilities serve as supply constraints (e.g., spatial constraints) in our location-allocation models. More information of the supply side analysis is in **Section 4.2**.

1.2 Literature Review

In this section, we review relevant works in two main categories: (1) factors affecting public acceptance of EV (e.g., the intention of adopting an EV in car purchase decisions); (2) location-allocation models (which are used in our study to derive the optimal sites for the deployment of public EV charging facilities).

1.2.1 Factors affecting EV adoption intention

EV adoption is usually defined as the behavioural response to EV (as a technological innovation) comprising support, use or purchase (Huijts et al., 2012; Schuitema et al., 2013). Extensive research has applied various theories and contextualised numerous factors, such as operational, attitudinal and personal characteristics, in influencing consumer EV adoption intentions. We summarise five categories of factors that have been demonstrated to significantly influence consumers' EV adoption intentions or preferences.

Technological considerations include performance characteristics such as driving range and charging times, whereas EV technical qualities and operation costs include considerations such as vehicle costs, maintenance costs and charging costs. For instance, vehicle quality attributes including vehicle body type, design, safety, carbon emissions, energy source and energy efficiency are the main factors consumers evaluate when making a purchase decision (Abotalebi et al., 2018; Aksen et al., 2016; Burgess et al., 2013; Caperello & Kurani, 2011; Carley et al.,

2013; Egbue & Long, 2012; Graham-Rowe et al., 2012; Jensen et al., 2013; Lane & Potter, 2007; Noppers et al., 2014; Peters & Dütschke, 2014; Schuitema et al., 2013; Skippon & Garwood, 2011; Zhang et al., 2011). Among the performance characteristics, the limited driving range of EVs is the main barrier to adoption based on extensive empirical evidence (e.g. Lieven et al., 2011; Moons & De Pelsmacker, 2012). This also leads to ‘range anxiety’; the fear of depleting the EV’s battery in the middle of a trip. This concern has resulted in substantial attention being drawn to the issues of instrument improvement and the need for greater EV charger location planning.

In addition to technological and operational factors, consumer personality has also proved significant in determining adoption intentions. The socioeconomic background of respondents has been addressed in nearly all survey-based adoption research and is a significant predictor of EV purchase intentions. Studies have indicated that well-educated, high income, middle-aged males have the highest desire to own an EV (Anable et al., 2011; Axsen et al., 2016; Carley et al., 2013; Ensslen et al., 2015; Moons & De Pelsmacker, 2012; Plötz et al., 2014; Tal & Nicolas, 2013). Further, the expression of personal identity and the symbolic meaning of EV driving have also been shown to strengthen EV purchase intentions. For instance, some scholars have found that certain consumers perceive an EV purchase as an opportunity to actualise their environment-oriented or technology-oriented lifestyles (Axsen et al., 2016; Lane & Potter, 2007; Priessner et al., 2018; Schuitema et al., 2013). Studies have also demonstrated higher EV purchase desire among innovative people who tend to be more responsive and accepting towards new technologies (Anable et al., 2011; Englis & Philips, 2013; Hardman et al., 2016; Morton et al., 2017; Skippon & Garwood, 2011).

In line with the theory of planned behaviour, prior experience should also play a role in characterising EV acceptance (Thøgersen & Ebsen, 2019). This theory (Ajzen, 1991) assumes that customer behaviour intention is determined by factors including attitudes, subjective norms and the perceived consequences of decisions. In this context, customers’ attitude towards EV is largely affected by prior knowledge and experience. Considerable research has shown that prior knowledge of EV and environmental issues increases EV acceptance, with more informed individuals being more likely to buy alternative fuel vehicles (e.g. Axsen et al., 2016; Caperello

& Kurani, 2011; Carley et al., 2013; Egbue & Long, 2012; Lane & Potter, 2007). Relevant knowledge of the new technology also helps consumers to appreciate the aesthetics and functions of EV and influences reactions to typical stereotypes of EV (Burgess et al., 2013; Carley et al., 2013). Knowledgeable consumers tend to downplay the shortcomings of EV ownership, such as higher vehicle costs and behavioural modification for the charging routine, while emphasising the merits of energy efficiency. In general, greater knowledge about the innovation creates more robust EV affinity. However, current studies have mainly perceived user experience from drivers' perspectives. Judging from the specifications of trialability in the diffusion of innovation theory (Rogers, 2003), user experience as an EV passenger should also be incorporated as a form of partial exposure to the innovation that governs the adoption decision of potential technology adopters.

Environmental consciousness is a fundamental aspect of attributable personal psychologies. Axsen et al. (2016) affirmed its role by demonstrating that strong environmental awareness and stringent requirements regarding a vehicle's energy source are more commonly found among pioneering adopters than less enthusiastic groups. Climate change awareness has been suggested to raise EV acceptance among people concerned about the environmental impact of their vehicles (Axsen et al., 2016; Egbue & Long, 2012; Hardman et al., 2016; Jansson, 2011; Jensen et al., 2013; Krupa et al., 2014; Lane & Potter, 2007; Moons & De Pelsmacker, 2012; Skippon & Garwood, 2011). In addition, the positive environmental image of EVs would reinforce the internal values of consumers who hold pro-environmental beliefs or other worldviews symbolised by EVs (Burgess et al., 2013; Caperello & Kurani, 2011; Carley et al., 2013; Schuitema et al., 2013; Skippon & Garwood, 2011).

Finally, adoption inclination is augmented by contextual factors such as the provision of financial incentives and charging infrastructure. Favourable policies such as tax incentives, manufacturer rebates, and reduced purchasing and fuel costs incentivise EV demand by providing economic benefits to consumers (Abotalebi et al., 2018; Mersky et al., 2016; Priessner et al., 2018; Sang & Bekhet, 2014). Wee et al. (2018) found that a subsidy increase of US\$1,000 would enhance EV adoption by at least 5% at the state level relative to the national average. These contextual factors have been proven to bring concrete impacts to the EV-friendliness of

citizens, which is why we intend to incorporate an institutional dimension in the promotion of EV acceptance among citizens. As for access to chargers, a number of scholars have examined charging infrastructure in their methodologies, but failed to define this contextual measurement in terms of accessibility. The closest consideration of charger accessibility, by Mersky et al. (2016) was to simply count the number of charging points; this was shown to have the greatest effect on consumer adoption.

1.2.2 Location-allocation model

How to optimise the location of charging facilities is a critical issue in the deployment process and this problem is widely explored in existent literature. The majority of published studies working on locating EV charging stations derived their models or methods from fundamental facility location models. The classic models include (1) the p-median model, which aims to minimise total travel costs - whether in terms of total distance, time or budget (Dong et al., 2014; Hanabusa & Horiguchi, 2011; Phonrattanasak & Leeprechanon, 2012); (2) the covering model, which aims to maximise the coverage of user utility (Xu et al., 2013), or the total amount of charging hour access to the facilities for users (Giménez et al., 2014).

Research on the optimal location of EV charging stations has been reliant on location-allocation [LA] models because it is essentially a problem of how to maximise the coverage of the charging facilities given that a number of resources – such as land and budget – are limited. Some of the classic facility LA models include the p-median models and the covering models, which encompass the set-covering model and the maximal covering-location model. The p-median models are the most frequently used methods to address the LA problem of how best to locate EV public charging facilities. The major concern of these models is to minimise the total cost of the system. The term ‘cost’ is expressed in various ways – to minimise total travel costs such as in terms of total distance time or budget (Dong et al., 2014; Hanabusa & Horiguchi, 2011). Chen et al. (2013) developed a parking-based assignment method to determine public charging facility locations in Seattle with the model objective being to minimise EV users’ station access costs. Feng et al. (2012) presented a charging station planning model based on a weighted Voronoi diagram and used minimum users’ loss as the objective.

Covering models are another popular approach to demonstrating problems with the deployment of public charging facilities. Their advantage over the p-median model is that they can incorporate the service radius in the model design. In the studies that employed a covering model (Liu, 2012), a service radius of the charging facility was predefined. Unlike the ‘minimise’ objective in the p-median model, the covering model optimises the distribution of charging facilities in order to either maximise the coverage of user utility (Xu et al., 2013) or to maximise the total number of charging hours that users can access the facilities (Giménez et al., 2014).

Related to this research project, the research team has undertaken previous case study work in Beijing. The PI (Dr. He) and the Co-I (Dr. Kuo) published a paper ‘Incorporating institutional and spatial factors in the selection of the optimal locations of public electric vehicle charging facilities: A case study of Beijing, China’ (He et al., 2016). In this paper, data were collected through census surveys and site visits in Beijing as well as through several in-depth interviews with key stakeholders in EV development. The information was then incorporated into a location model to select the optimal location choices of public EV charging stations using different models. The approach used in that paper is, with a number of improvements, used in this study. First, we conducted a questionnaire survey to help us understand public acceptance and the primary concerns of existing and potential EV users. Second, we used questionnaire data and micro-census data in the demand prediction model. Third, in the location-allocation model, we differentiated the capacity of each charging site (e.g., how many chargers are needed in each charging site). Fourth, we differentiated the charging speed according to main speed types (i.e., fast, medium, and standard).

1.3 Structure of the Report

The structure of the report comprises eight chapters and eight appendices. **Chapter 2** presents the objectives of the research and outlines the key procedures to realise these targets; **Chapter 3** describes the methodology employed in the data collection, demand estimation and spatial optimisation; **Chapter 4** presents the findings of this study, including the survey results, supply analysis, the demand estimation model, the spatial optimisation solution and the limitations of

the research; **Chapter 5** summarises the perspectives of stakeholders as garnered from our in-depth interviews; **Chapter 6** provides policy implications based on our findings; **Chapter 7** concludes the report; and **Chapter 8** reports public dissemination engagements. **Appendix I** presents the survey questionnaire; and **Appendices II to VIII** comprise the interview transcripts.

CHAPTER 2 OBJECTIVES OF THE STUDY

2.1 Research Objectives

There are five objectives to this study, with the last objective being our main goal. The objectives are listed below, all of them were achieved by the time that this report was written.

1. To understand the current Hong Kong government's stance on e-mobility and the institutional context for the provision of public EV charging stations
2. To analyze the spatial constraints of public EV charging stations in Hong Kong
3. To survey public acceptance of EV and estimate the demand for EV charging stations
4. To incorporate factors affecting the supply and demand of EV charging points (i.e., institutional context, spatial constraints, and public acceptance) in a location-allocation model to select the optimal sites.
5. To provide policy recommendations for the spatial planning of EV charging facilities in the future

2.2 Research Outline

In this research project, we focused on the market for electric private cars because it accounts for 97.72% of all electric registered vehicles in Hong Kong as of September 2019. Nevertheless, in our in-depth interviews, some interviewees mentioned electric commercial vehicles; given it is in the context of EVs development in Hong Kong, we briefly reported interviewees' comments on the electrification of commercial vehicles. In addition, facility deployment in the private and public sectors usually follows different rules, so charging facilities that are deployed for private use or serve a specific group of people (e.g., company employees) are not within the scope of this study. Through this report we used the term EVs for private EVs specifically, and the charging facilities in this project refer to those constructed for public use.

To achieve the aforementioned objectives, we used both quantitative and qualitative methods. The quantitative methods refer to the location-allocation model, which required a set of

supply and demand estimates for public EV charging facilities in Hong Kong. To obtain the supply estimates, we collected location and capacity information of both current EV charging points and public car parks. To obtain the demand estimates, we conducted an online survey among those who have a driver's licence. The survey consisted of a valid sample of 982 persons, including 238 EV owners and 744 potential EV owners. Based on the survey data, we estimated a demand model using an ordered probit model. Using the estimated parameters we forecasted the EV demand using the 2016 micro-census data and then aggregated the demand at neighbourhood level across the whole region. With the supply (taking into consideration the charging speed of the chargers) and demand information, we estimated a location-allocation model and generated a set of spatially optimal charging facilities. With the optimal locations derived from our models, we evaluated the spatial planning of current public EV charging facilities by comparing existing charging facilities with our results.

In addition to quantitative analysis, we also employed qualitative analysis in our project so that we could understand the current development EV from multiple perspectives, including the views and options of key stakeholders in EV. Using a semi-structured interview approach, we interviewed a number of stakeholders to get different perspectives. Each interview lasted from half an hour to 2.5 hours. In general, we chose interviewees who would provide views from suppliers' and consumers' perspectives. The different perspectives offered us insights into the extent to which the current supply of public charging facilities falls short of demand as well as the kind of actions that the Government and industry may take to move forward electric mobility.

Based on the spatial modelling results and the interviews, we proposed a number of policy recommendations, which we hope Hong Kong can use to build an e-mobility friendly city and achieve low-carbon transport in the near future.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Quantitative Analysis

The ultimate goal of quantitative analysis in this report is to solve the spatially optimal charging points by a location-allocation [LA] model through the process we called spatial optimisation. In order to provide inputs for the model we first needed to conduct supply and demand analysis so that we had suitable inputs for the LA model.

3.1.1 Supply analysis

3.1.1.1 Data collection

To identify the potential location sites for installing public charging facilities in the future, we gathered public car park information from the GeoCommunity Database [iGeoCom] of the Planning Department. The public charger information from EPD as of April 2019, including a number of chargers of different speed levels and suppliers (i.e., the Tesla chargers), was combined with the iGeoCom dataset to pinpoint existing charging facilities. The operational dataset in the spatial optimisation model comprised 2,285 car parks in total; 318 were equipped with charging facility/facilities.

Aside from the spatial location of car parks, the number of available parking bay in car parks also determines the potential capacity for charging supply. Therefore, we retrieved the number of private car or van parking spaces from TD for later use in the location allocation model. After combining the existing and potential charging sites, we had a picture of the supply of charging facilities with different charging capacities that were accessible to the public.

3.1.1.2 Mapping and visualisation

We utilised the Geographic Information System [GIS] platform to map out the spatial location of charging sites and conducted spatial analysis to identify the major supply hotspots. This data was

later compared with the demand landscape to examine whether the current deployment was reasonable and what improvements in spatial distribution could be made.

3.1.1.3 Accessibility analysis

To further articulate the charger accessibility parameter, we operationalised a physical accessibility analysis based on the difficulty of reaching them in a given spatial unit. Chargers were classified into four groups (i.e., quick, medium, standard, Tesla) as charger types are expected to affect the charging behaviour of EV users. The absolute number of chargers was used to define the charger supply in each spatial unit. We constructed the impedance metric by using the network travel time between charging stations and centroids of Tertiary Planning Units [TPUs] to simulate the maximum walking distance an EV driver would be prepared to undertake to reach a charging point. Search radii of 5, 10, and 15 minutes were imposed on the built-in network analysis module of ArcGIS. Travel time was estimated at uniform walking speed of 4.8 km per hour.

3.1.2 Demand analysis

3.1.2.1 Questionnaire survey

An online survey was launched in March 2019 to collect data pertaining to public acceptance of EV and the EV usage behaviour of early adopters from an online survey panel, EV user alliances, and social media communities (e.g., Facebook and Telegram). The questionnaire consisted of four parts, namely (i) purchasing intentions, (ii) travel and charging behaviours, (iii) demographic information, and (iv) supplementary information. Part (i) included questions about the vehicle ownership status of respondents and a series of Likert Scale evaluations concerning purchase intention, knowledge on EV, attitudes towards EV, subjective norms, personal norms, perceived behaviour, personal beliefs, and political and technological expectations. The Likert Scale was comprised of 7 levels to allow a neutral stance. An open ended question was added at the end of this section to receive proposals that increased public acceptance of EV. Part (ii) focused on extracting vehicle usage, parking, and charging habits of car owners while part (iii)

enumerated the socio-demographic background of respondents including various personal and household characteristics. Options of attributes in part (iii) conformed to variables in the 2016 Population By-census and enabled demand projection based on census results. Part (iv) concluded the questionnaire by enquiring as to the source of access to the survey, the affiliations of concerned groups, and their willingness to participate in later research components. Respondents who did not hold a full driving licence were screened out from the survey to ensure sufficient knowledge of the topic. The full questionnaire in Chinese is attached in **Appendix I**.

3.1.2.2 Demand estimation

We adopted an ordered probit model because our dependent variable was an ordered variable. It ranged from 1 to 7, and indicated an individual's intention to buy an EV in the next five years. Following the notation in Greene (2008), we have

$$y^* = \mathbf{x}'\boldsymbol{\beta} + \varepsilon$$

where $\mathbf{x}$ refers to the explanatory variables and ε is assumed to be normally distributed and follow $N \sim (0,1)$. The probabilities are as follows:

$$\begin{aligned} \text{Prob}(y = 1 | \mathbf{x}) &= \Phi(-\mathbf{x}'\boldsymbol{\beta}), \\ \text{Prob}(y = 2 | \mathbf{x}) &= \Phi(\mu_1 - \mathbf{x}'\boldsymbol{\beta}) - \Phi(-\mathbf{x}'\boldsymbol{\beta}), \\ \text{Prob}(y = 3 | \mathbf{x}) &= \Phi(\mu_2 - \mathbf{x}'\boldsymbol{\beta}) - \Phi(\mu_1 - \mathbf{x}'\boldsymbol{\beta}), \\ &\vdots \\ \text{Prob}(y = 7 | \mathbf{x}) &= 1 - \Phi(\mu_6 - \mathbf{x}'\boldsymbol{\beta}). \end{aligned}$$

After we estimated the probability of an individual choosing an EV, different techniques could be used to forecast aggregate demand based on the prediction of individual behaviour. One of the general types of aggregation procedures is sample enumeration (Koppelman 1974; Ben-Akiva and Lerman, 1985), which predicts the aggregate probability a_i of a community i by averaging the individual's probabilities:

$$a_i = \frac{1}{N_i} \sum_{n=1}^{N_i} \text{Prob}(Y = 1 | \mathbf{w}_{in}) \quad \text{Eq. (1)}$$

where N_i indicates the number of qualified individuals (i.e., ages 18 or above) from community i in the census sample (i.e., 5% census data of 2016 from the Government) and $\mathbf{w}_{in}$ denotes the socio-demographic attributes of the n -th individual from community i .

Finally, a community's aggregate EV demand can be obtained by multiplying the aggregate probability by the total population of interest in that community. In our study, the total population of interest refers to those who are 18 years old or above and process a driver's licence. Since the census in Hong Kong has no information about driver's licence over geographical units, we used a territorial average in Hong Kong and assumed that all communities had the same level of persons with driver's licence; calculated as 30.8%³.

After estimating the demand for EV, we also predicted the demand of EV using a public charger. Our formula for the estimation of the public charging facilities (D^d) was as follows:

$$D^d = D * P^d * P_{pub} \quad \text{Eq. (2)}$$

Where:

D is the demand of EV in each geographical unit;

P^d is the percentage of EV charging on a single day, assuming the same rate for all geographical units;

P_{pub} is the percentage of EV using public chargers, assuming the same rate for all geographical units.

In particular, we estimate P^d and P_{pub} based on the charging behaviour of existing EV

³ The ratio is calculated from 2,319,906 full driving licence holders in September 2019 from the Monthly Traffic and Transport Digest of the Transport Department and 7,524,100 total population in mid-2019 from the Census and Statistics Department.

owners from our survey.

3.1.3 Spatial optimisation: Location-allocation model

With constraints derived from our supply and demand analysis as well as the forecasting demand, the location model was developed. The decisions in our problem were: whether EV charging facilities had to be built at a car park, how many chargers had to be installed (in addition to the existing ones), and how the demand points should be allocated to the car parks with charging facilities. Our model considered car parks with existing charging facilities and other potential car parks to accommodate new chargers. The demand for a demand point can be split and allocated to multiple car parks.

Our location model requires the following **sets and parameters**:

I = set of demand points;

J = set of car parks (including both car parks with existing EV chargers and potential car parks);

$\bar{J}$ = set of car parks with existing chargers;

K = set of types of chargers (standard, medium, and quick);

h_i = estimated number of EVs which required charging in a day at demand point i ;

d_{ij} = distance from demand point i to car park j ;

q_{jk} = number of existing chargers of type k at car park j ;

Q_j = maximum number of chargers at car park j ;

μ_k = number of EVs that can be charged per day per charger of type k ;

D = the coverage radius of a charging facility;

J_i = set of car parks that are located within the coverage radius of demand point i , i.e.,

$J_i = \{j \in J: d_{ij} \leq D\}$;

f_j = fixed cost of establishing charging facilities at car park j (0 if car park j has existing charging facilities);

c_{jk} = unit cost of adding a charger of type k at car park j ;

B = total budget for establishing the new charging facilities; and

M = penalty of charging demand shortfall (per EV).

Our model optimised the following **decision variables**:

x_{ij} = number of EVs from demand point i allocated to car park j ;

s_i = charging demand shortfall at demand point i ;

$y_j = \begin{cases} 1 & \text{if car park } j \text{ is equipped with EV charging facilities,} \\ 0 & \text{otherwise} \end{cases}$; and

z_{jk} = number of chargers of type k to be added to car park j .

The **formulation** of the location model is as follows:

$$\text{Min } M \sum_{i \in I} s_i + \sum_{i \in I, j \in J} d_{ij} x_{ij} \quad (1)$$

Subject to

$$\sum_{j \in J_i} x_{ij} + s_i = h_i \quad \forall i \in I \quad (2)$$

$$\sum_{i \in I} x_{ij} \leq \sum_{k \in K} \mu_k (q_{jk} + z_{jk}) \quad \forall j \in J \quad (3)$$

$$\sum_{k \in K} (q_{jk} + z_{jk}) \leq Q_j y_j \quad \forall j \in J \quad (4)$$

$$\sum_{j \in J} (f_j y_j + \sum_{k \in K} z_{jk}) \leq B \quad (5)$$

$$y_j = 1 \quad \forall j \in \bar{J} \quad (6)$$

$$x_{ij} = 0 \quad \forall j \in J \setminus J_i \quad (7)$$

$$y_i \in \mathbb{B} \quad \forall j \in J \quad (8)$$

$$z_{jk} \in \mathbb{Z}^+ \quad \forall j \in J, k \in K \quad (9)$$

$$x_{ij}, s_i \geq 0 \quad \forall i \in I, j \in J \quad (10)$$

Objective (1) was to minimise the penalty on EV charging demand shortfall and the demand-weighted travel distance to charging facilities. M was set to be larger than d_{ij} as the priority was to first minimise the EV charging demand shortfall. Then the accessibility to charging facilities was optimised. Constraint (2) states that the charging demand of a demand

point is allocated to charging facilities within the coverage radius; if the charging demand cannot be fully satisfied by the charging facilities, charging demand shortfall is measured. Constraint (3) imposed a condition that the total charging demand allocated to each car park should not exceed the maximum number of EVs that could be charged per day at the car park. Constraint (4) imposed the space constraints that limit the number of chargers at each car park. Constraint (5) imposed a financial budget constraint. Constraint (6) recorded car parks with existing charging facilities. Constraint (7) ensured that no changing demand of a demand point could be allocated to a car park beyond the coverage radius. Constraints (8) to (10) stated the natures of the decision variables.

Table 2 illustrates the parameters used in our case study. We used two popular EV models⁴ with medium battery capacities to estimate the number of EVs that could be charged by each type of charger. We excluded night-time charging (8 hours) and stipulated the daily vehicle flow of quick chargers due to their short charging duration. We included only the potential population with level 7 purchase intention in the demand estimation, so that we only captured the certain future EVs in our model. In the optimisation model, a total budget was given for allocating chargers of different types and costs into the optimal locations. Since there is no record or plan specifying the financial resources dedicated to EV charger installation in private car parks in coming years, we estimated the total amount to be spent on charging facilities based on the latest government figures in the 2019 Budget Plan. As mentioned in **Chapter 1**, the government has reserved HK\$120 million to expand the charging network of government car parks. With reference to the government-private EV charger ratio of September 2019, we proportionally estimated the budget for erecting charging facilities in private car parks and computed a total budget of HK\$350,877,193⁵ across the two categories of car parks. Cost estimates were retrieved

⁴ We made reference to Tesla Model 3 Standard Range+ (55kWh) and Nissan Leaf (40kWh). For a complete charge from 0% to 100% battery power, the former model takes 40 minutes to an hour at DC quick chargers, 7 hours at medium chargers, and 16 hours at standard chargers (Tesla Guide HK, 2019); whereas the latter model takes 8 hours at medium chargers and 18 hours at standard chargers, and takes 40 minutes to charge to 80% (Nissan, 2020).

⁵ According to a written reply from the Secretary for the Environment to a Legislative Council question on 4 December, 2019, there were 857 public chargers in government car parks and 1,649 public chargers in private car

and averaged from our interviewed facility suppliers. We further set the maximum charging spot ratio at 30% from the Planning Standards and Guidelines and a 5-km coverage distance based on the charger density and planning instruction in the Netherlands⁶ and Beijing⁷.

Table 2. Parameters used in our case study

Parameter	Value
Number of EVs that can be charged by a standard charger per day	1
Number of EVs that can be charged by a medium charger per day	3
Number of EVs that can be charged by a quick charger per day	16
Purchase intention score used to estimate the EV charging demand	7
Maximum proportion of EV charging spots at a car park	30%
Coverage distance	5km
Fixed cost of establishing charging facilities at a car park	HK\$ 40,000
Unit cost of a standard charger	HK\$ 3,000
Unit cost of a medium charger	HK\$ 10,000
Unit cost of a fast charger	HK\$ 135,000
Total budget	HK\$ 350,877,193

The location model was solved by IBM ILOG CPLEX to obtain an optimal solution. We measured the solution performance using the following metrics:

- **Daily shortage** (in number of EVs): charging demand that cannot be satisfied by charging facilities, i.e., $\sum_{i \in I} s_i$
- **Coverage (%)**: percentage of charging demand that can be satisfied by charging facilities, i.e., $\sum_{i \in I} (h_i - s_i) / \sum_{i \in I} h_i$
- **Average distance to EV charging facilities (m)**: average distance to EV charging facilities (only charging demand which could be satisfied was considered), i.e., $\sum_{i \in I, j \in J} d_{ij} x_{ij} / \sum_{i \in I, j \in J} x_{ij}$

parks (The Government of the Hong Kong Special Administrative Region, 2019), making 34.2% public chargers managed by the government. The total budget is calculated from \$120m divided by 0.342.

⁶ The Netherlands has the highest EV charger density in the world with an interval of 5.18km (19.3 charging stations per 100km) (McCarthy, 2018).

⁷ The *Action Plan for Promoting EVs in Beijing (2014-2017)* specifies a service radius of 5 km for public charging facilities (The People's Government of Beijing Municipality, 2014).

3.2 Qualitative Analysis: In-depth Interviews

A series of face-to-face interview were arranged to capture the views and insights of EV stakeholders on e-mobility development in Hong Kong. Major categories of interviewees included:

- Government units
- Lawmakers
- Charging facility suppliers
- Car park managers
- EV owner alliances

The interviews took 30 minutes to 2.5 hours and were undertaken in a semi-structured format. Stakeholders were consulted on EV usage habits, factors considered when installing chargers, costs and procedures for charger installation in residential and public car parks, perceptions on government EV policy, pricing schemes of charging service, and EV market prospects, where perspectives and focused areas in individual interviews corresponded to interviewees' identities.

CHAPTER 4 RESEARCH FINDINGS

4.1 Findings from Questionnaire Survey

4.1.1 Summary statistics

A total of 982 valid responses were received from the survey, which could be further divided into EV owners (N=238), internal combustion engine vehicle [ICEV] owners (N=327) and non car owners (N=417). Due to the low car ownership rate in Hong Kong, not to mention the low EV ownership rate, we used convenience sampling methods, as our samples are not representative of the population's distribution. The upside of such a sampling approach is that could obtain more samples directly relevant to our research topic – EV development. The opinions of EV owners and other car owners provided a more realistic picture of current and potential EV users' experiences. Of course, we also included those who did not own a car but hold a driver's license as another category of potential EV users.

Table 3 offers a comparison between characteristics of our survey recruits and that of the Hong Kong population. In our survey, the recruited samples were more likely to be male, younger, and economically more capable. In particular, only a handful of respondents (<10%) were 55 or above, whereas nearly 70% of interviewees held a bachelor's degree or higher, which is 3.5 times more than the average of the territorial population. Nearly all of the respondents had economic engagement either through being employed or self-employed and thus the relevant economic well-being parameters were above the territorial average. One-third of the respondents earned a monthly income over HK\$40,000 and 70% of them were home owners. The rate of private housing dwellers was also higher than the Hong Kong average. Recruited licensed drivers came from larger families with an average household size of 3.2 persons. The average car ownership among all respondents was around 0.7 and 15% of respondents stated an affiliation to environmental concern groups.

Table 3. Statistical summary of sample characteristics

	Percentage (%) or mean	
	All respondents (N=982)	Hong Kong Population ^a
Personal characteristics		
<i>Gender</i>		
Male	64.97	45.10
Female	35.03	54.90
<i>Age</i>		
18 to 34	36.64	26.71
35 to 54	53.84	37.20
55 and above	9.52	36.09
<i>Educational attainment</i>		
Below university	30.86	77.78 ^b
Bachelor degree	48.88	16.99
Postgraduate degree	20.26	5.23
<i>Marital status</i>		
Single	38.75	39.93
Married	61.25	60.07
<i>Employment status</i>		
Employed	87.45	51.22 ^b
Self-employed	9.08	6.27
Others	3.47	42.50
<i>Monthly income (HK\$)</i>		
Less than 25,000	36.72	74.80 ^c
25,000 to 39,999	32.00	12.45
40,000 and above	31.28	12.75
Membership of environmental group	15.8	--
Household characteristics		
<i>Housing type</i>		
Public rental	15.41	30.36
Subsidised home ownership	17.65	15.30
Private permanent	66.12	52.99
Others	0.82	1.35
<i>Housing tenure</i>		
Owner-occupier with outstanding mortgage	40.10	16.65
Owner-occupier with no outstanding mortgage	32.14	31.84
Tenant	26.22	46.98
Others	1.53	4.53
Household size	3.231	2.8
Number of cars	0.709	--

Note: ^a Population characteristics as in 2016 Population By-census. Personal characteristics percentage was computed from population aged above 18, if not stated otherwise. Household characteristics percentage was computed in number of households; ^b Among population aged above 15 due to data grouping; ^c Among working population

Table 4 provides a comparison of the sample sub-groups; the EV owners, ICEV owners, and carless respondents. EV owners had the highest proportion of males among the three groups, while the gender split was more even amongst ICEV owners. EV owners tended to possess higher educational level as the group had the lowest share of below university attainments and the highest share of postgraduate degree holders. In terms of employment status, EV owners were twice as likely to be an employer or a self-employed person. It follows, that the associated economic welfare attributes are also greater than those of the other two groups. Half of them had a monthly income over HK\$40,000 and 75% of them lived in private residential units. The proportion of renters among EV owners was the lowest amongst the three groups. This reflects the fact that our sample was, in general, drawn from a group of people of higher socioeconomic status [SES].

The comparison also resulted in some intriguing observations. Firstly, although no direct relation between family size and vehicle choice was expected, the average household size of EV owners was larger than those of ICEV and carless families. Thirdly, concerning the number of vehicles in a household, EV families owned 1.267 cars on average, compared to 1.067 in ICEV households. The figures indicate that EV owning families are more likely to have multiple vehicles, which is consistent with our common understandings.

Table 4. Statistical summary of EV owners, ICEV owners and non-car owners' characteristics

	Percentage (%) or mean		
	EV owners (N=238)	ICEV owners (N=327)	Non car owners (N=417)
Personal characteristics			
<i>Gender</i>			
Male	76.89	57.80	63.79
Female	23.11	42.20	36.21
<i>Age</i>			
18 to 34	35.04	42.20	33.17
35 to 54	55.13	47.71	57.93
55 and above	9.83	10.09	8.89
<i>Educational attainment</i>			
Below university	23.11	29.05	36.69
Bachelor degree	50.42	51.07	46.28
Postgraduate degree	26.47	19.88	17.03
<i>Marital status</i>			

Single	36.60	42.20	37.26
Married	63.40	57.80	62.74
<i>Employment status</i>			
Employed	82.28	90.52	87.98
Self-employed	14.77	7.34	7.21
Others	2.95	2.14	4.81
<i>Monthly income (HK\$)</i>			
Less than 25,000	21.37	31.69	49.28
25,000 to 39,999	28.63	35.38	31.25
40,000 and above	50.00	32.92	19.47
Membership of environmental group	15.13	11.93	19.18
Household characteristics			
<i>Housing type</i>			
Public rental	11.02	13.76	19.18
Subsidised home ownership	13.98	16.51	20.62
Private permanent	75.00	68.20	59.47
Others	--	1.53	0.72
<i>Housing tenure</i>			
Owner-occupier with outstanding mortgage	43.64	37.92	39.81
Owner-occupier with no outstanding mortgage	31.36	34.56	30.70
Tenant	23.73	25.08	28.54
Others	1.27	2.45	0.96
Household size	3.462	3.181	3.139
Number of cars	1.267	1.067	0.113

4.1.2 Usage profile of car owners

This section summarises vehicle usage behaviour, including the charging and parking habits of vehicle owners. **Figure 2** demonstrates the brands of EV ownership among the survey respondents. The dominance of Tesla in the local market is proven in the survey result, with nearly 70% of the EV owners driving a Tesla. The rest of the market is made up of car makers such as BMW and Nissan. A majority of vehicle owners used their cars for daily commuting and around 30% of them have stated that leisure travel was their primary reason for vehicle ownership (**Figure 3**). Comparing the daily driving distance of EV owners and ICEV owners, **Figure 4** shows trips of longer daily mileage from EV owners; 46% drive for at least 60km each day, while only 36% of ICEV drivers reach that distance.

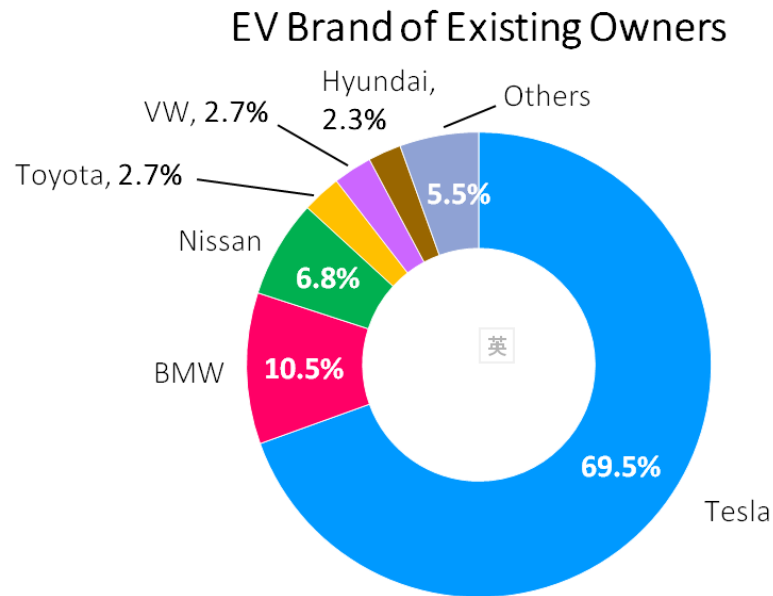


Figure 2. EV brand of existing EV owners

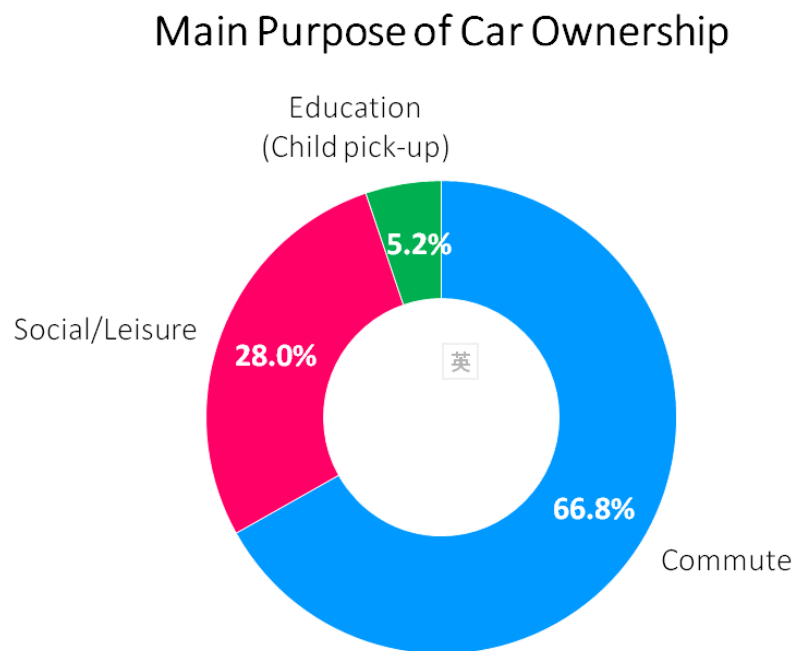


Figure 3. Main purpose of car ownership of vehicle owners

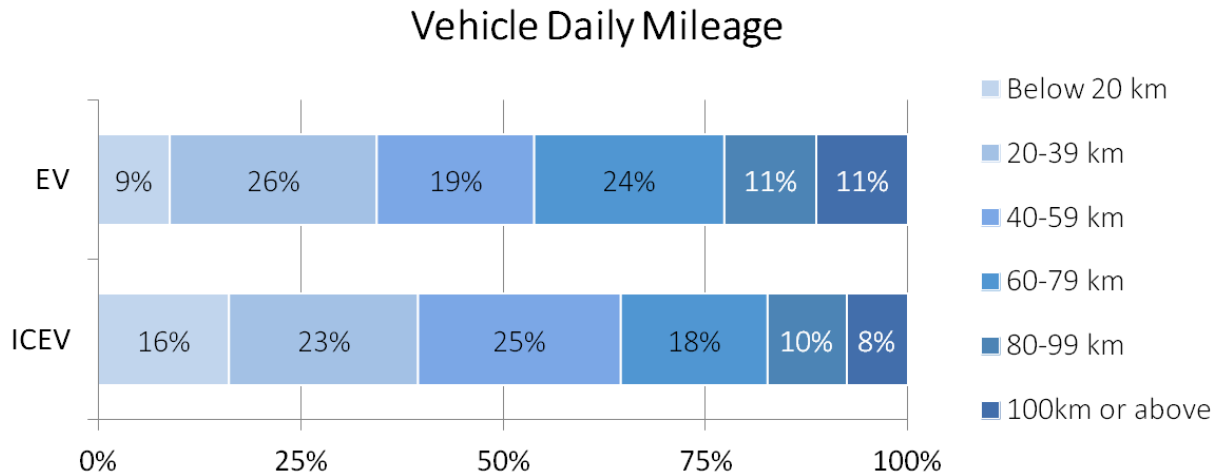


Figure 4. Vehicle daily mileage of EV and ICEV owners

With regard to the charging behaviour of EV owners, **Figure 5** shows that most EV drivers start charging their vehicles at 20-39% battery level. Although a large portion of EV owners are satisfied with a recharge to 80-99%, a similar share of EV drivers are only satisfied once their vehicle is fully charged (**Figure 6**). In terms of charging frequency, **Figure 7** depicts a very diverse pattern of charging intervals among EV owners; on average, they charge every 4.18 days. As a prominent part of this research, the location where recharging takes place is denoted in **Figure 8**. About 43% of existing EV owners charges their car at their home or workplace, and one-fourth of them visit charging outlets in shopping malls. This may be due to convenience or due to the fact that a number of shopping centres have installed quick chargers in their car parks. The remaining drivers (33.3%) charge at other car parks including commercial buildings and government car parks. The current charging venues of EV owners were also compared with their preferred charging site. 74.6% EV drivers preferred charging at their home or workplace but only 43.7% of them were able to actualise their desire. This indicates a shortfall in home and workplace charging services which drives EV owners to use charging services outside their two top preferences. Such a situation can be explained by reference to the parking that is available to general car owners in Hong Kong (**Figure 9**). Only 2.5% of the surveyed vehicle owners have a garage attached to their homes; a natural venue for installing a home charger. Around 35% of car owners rent a parking space for night-time parking. Though 61% drivers own a parking space, where they can build their personal chargers, feedback from our in-depth interviews (**Chapter 5**) suggested that the actual rate of successful installation of chargers in residential buildings is

alarming lower than the parking space ownership rate. Therefore, owning a park space does not equate with satisfactory charger ownership rate.

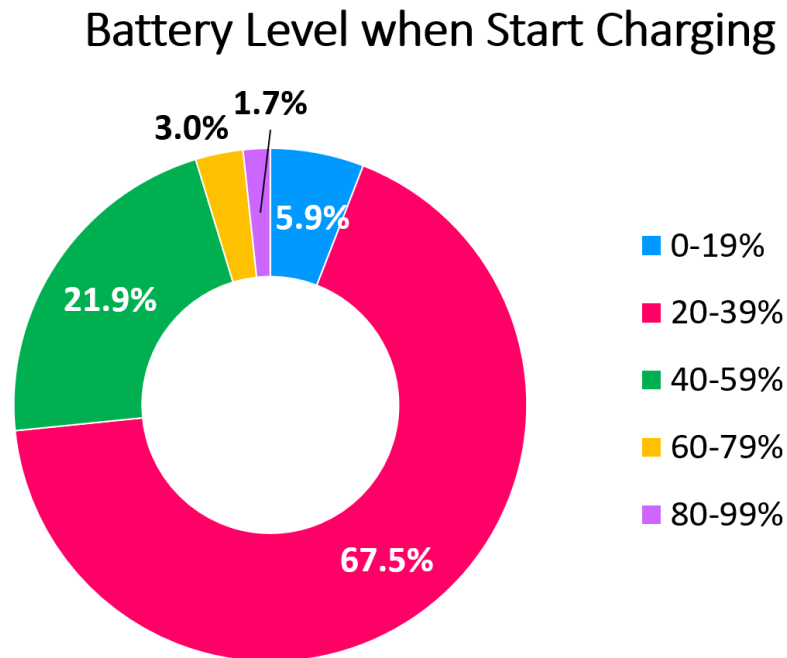


Figure 5. Battery level when EV owners start charging

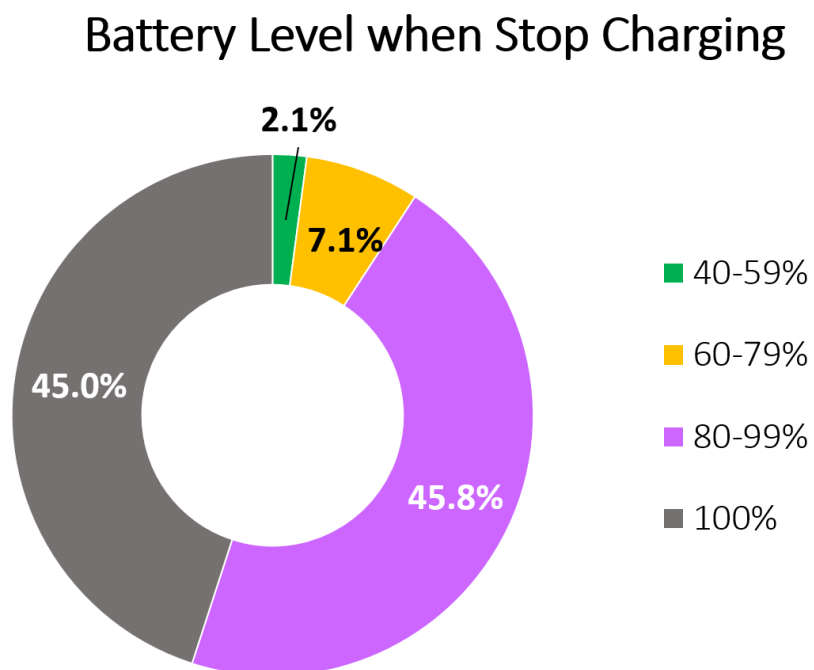


Figure 6. Battery level when EV owners stop charging

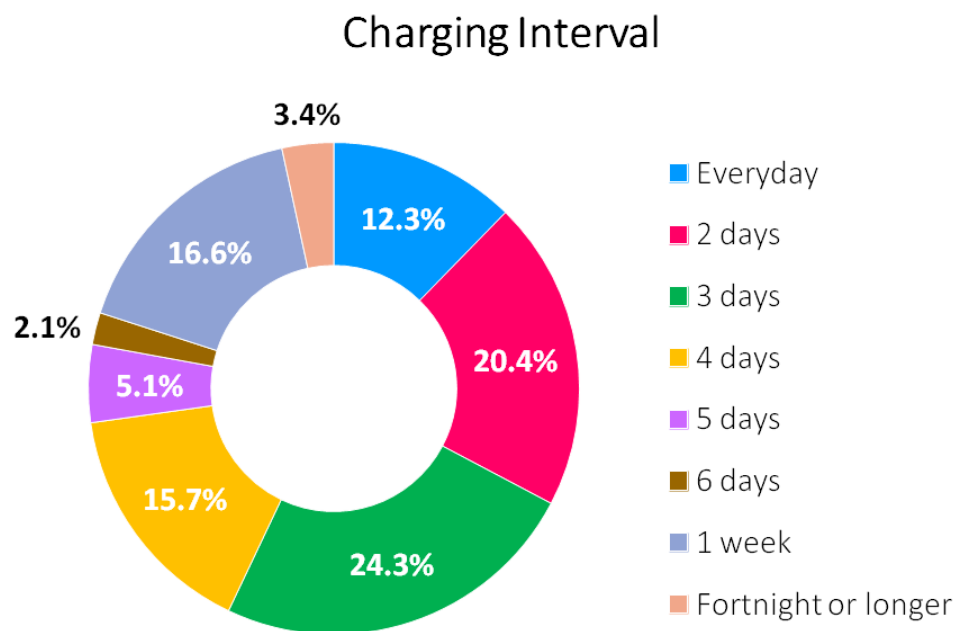


Figure 7. Charging interval of EV owners

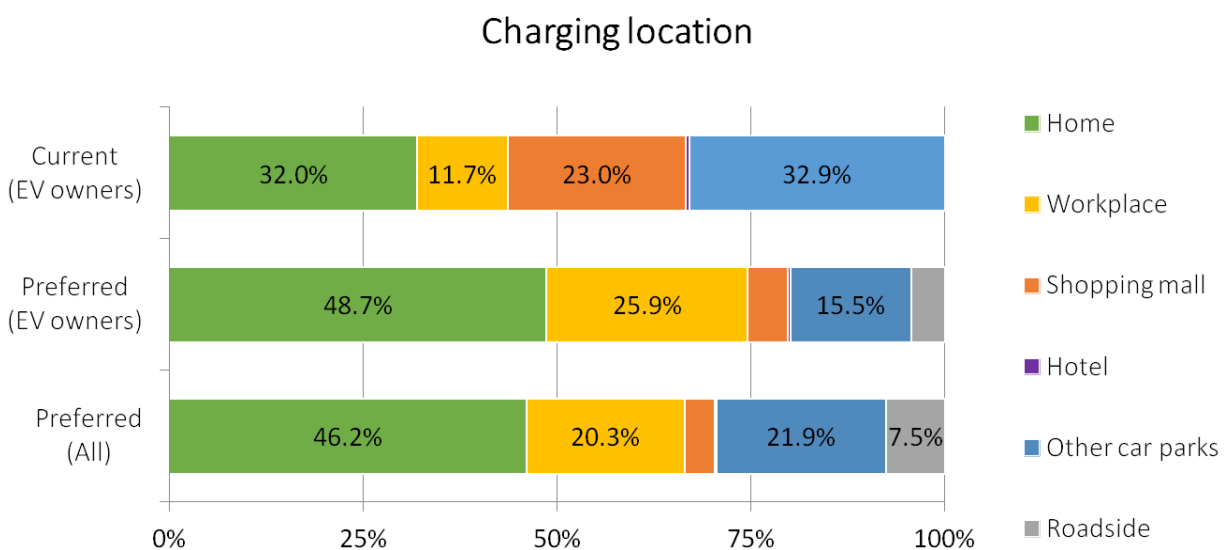


Figure 8. Current and preferred charging locations of EV owners and all respondents

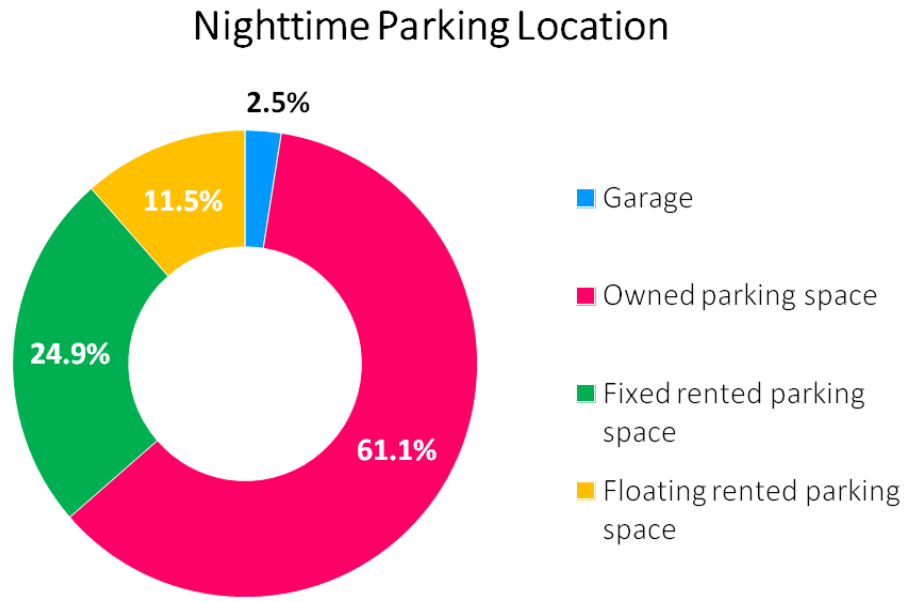


Figure 9. Nighttime parking location of car owners

4.1.3 Public Acceptance of EV

Focusing on the public acceptance of e-mobility, this section reports the parameters that measured the EV affinity of interviewees. Over 60% of the non-EV owners have tried an EV either through driving one or travelling as a passenger (**Figure 10**), demonstrating a high level of EV exposure in our sample.

Prior EV Experience as Driver or Passenger

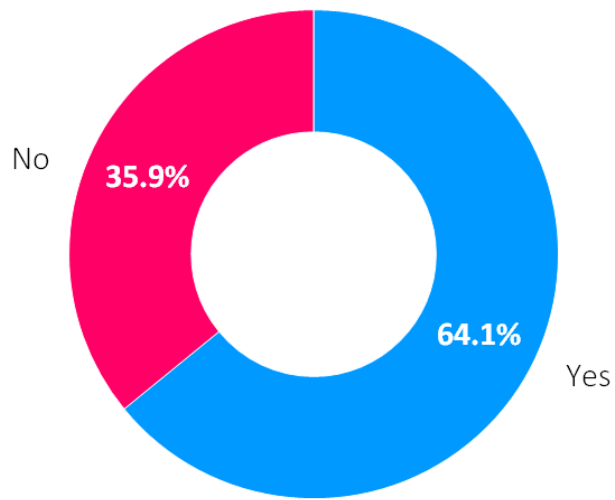


Figure 10. Prior EV experience as driver or passenger of non-EV owners

In our survey, the EV purchase intention of respondents was elicited in two ways; their inclination to buy an EV as their next car, or to do so within the coming 5 years. Feedback attained across a 7-point scale from the whole sample as well as in the three sample sub-groups is visualised in **Figures 11** and **12**. With regard the intention of purchasing an EV as the next car, the vast majority of the existing EV owners had a positive attitude (5 to 7 point) with only 4% of them expressing a negative intention (1 to 3 point), and 13% being neutral (4 point). This shows a strong inertia within the EV community that first-hand EV experience sustains long-term demand for the alternative fuel vehicle. Half of the ICEV owners were interested in adopting EV as their next vehicle purchase and roughly 60% of the carless individuals would consider purchasing EV as their first car. The results for a purchase within 5 years shared similar pattern across the respondent groups, though the positive attitude share decreased in all the sample sub-groups, given the more urgent temporal condition. Even so, more than half of the interviewees stated a positive EV purchase intention for the next 5 year period.

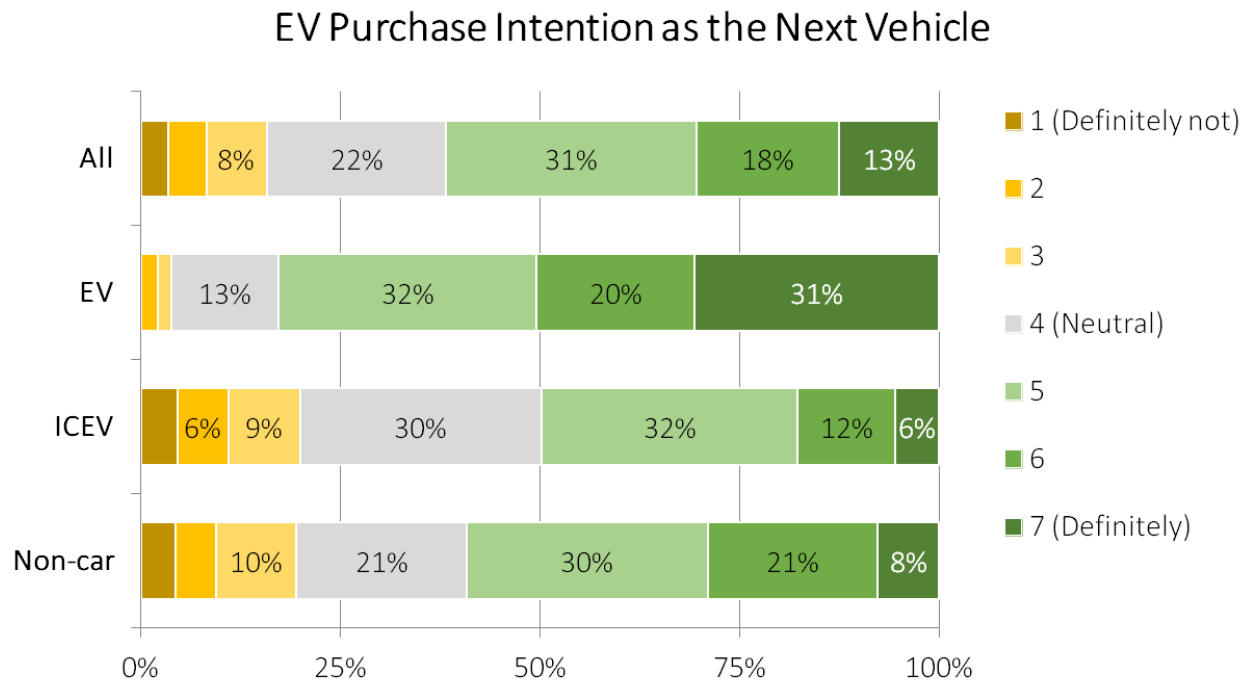


Figure 11. EV purchase intention as the next vehicle

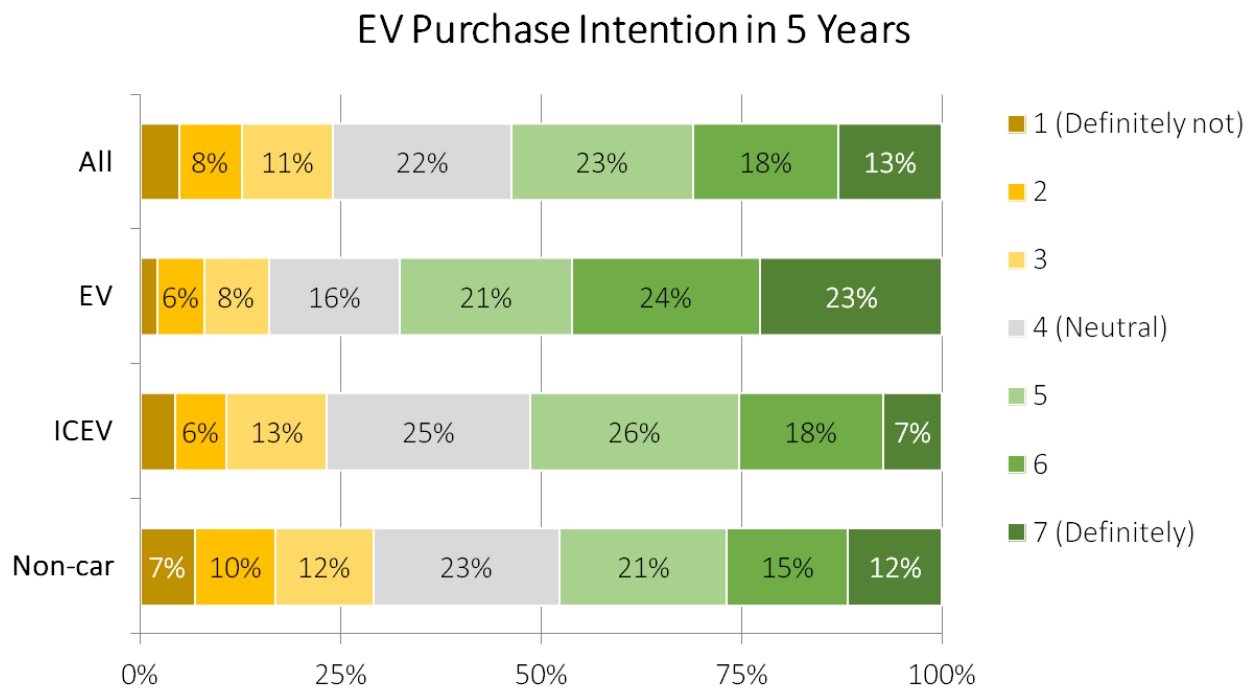


Figure 12. EV purchase intention in 5 years

With regard to the brands favoured by potential buyers, Tesla was the most preferred EV brand among interviewees by a considerable margin as depicted in **Figure 13**, followed by BMW

and Nissan. This result is consistent with the current market share in Hong Kong as illustrated in **Figure 2**. Most respondents who reported a certain degree of EV adoption intention were willing to allocate HK\$200,000 to HK\$400,000 on EV purchase (**Figure 14**). Under the current “1 for 1” tax concession scheme, that budget range is sufficient for more economised models including the Tesla Model 3 (HK\$275,000) and Nissan Leaf (HK\$299,315)⁸, whereas higher-end series EVs such as the Tesla Model S 75D may cost as much as HK\$882,000⁹.

Results from the Likert Scale questions in **Table 5** offered some insights on price sensitivity and other psychological dimensions of respondents. Among some of the key considerations in preparing for a vehicle purchase, new EV buyers were expected to be more stringent on the vehicle cost than the other factors. That is different from the mentality of existing EV drivers who regard the availability of charging infrastructure as the prime concern. The “greener” lifestyle of EV owners has been verified as their environmental conscience is distinguishably higher than those of non-EV owners, respectively scoring 0.561 and 0.478 higher in the two personal norm statements, though they may not devote themselves to more formal environmentalist associations as suggested by the sample characteristics. Both the EV drivers and other licensed drivers agree that owning an EV involves some difficulties; charging is generally perceived as cumbersome. Current EV owners are especially sentient on the issue of insufficient charger supply. A lack of relevant knowledge on EV to facilitate a purchase is also impairing the confidence of interested drivers to consider EV. There is also a solid desire for exemption of FRT and better charging infrastructure amongst potential EV adopters.

⁸ Estimations made by HKEVN with reference to then vehicle price (4 March, 2019).

⁹ Estimation made by TOPick with reference to then vehicle price (1 March, 2018).

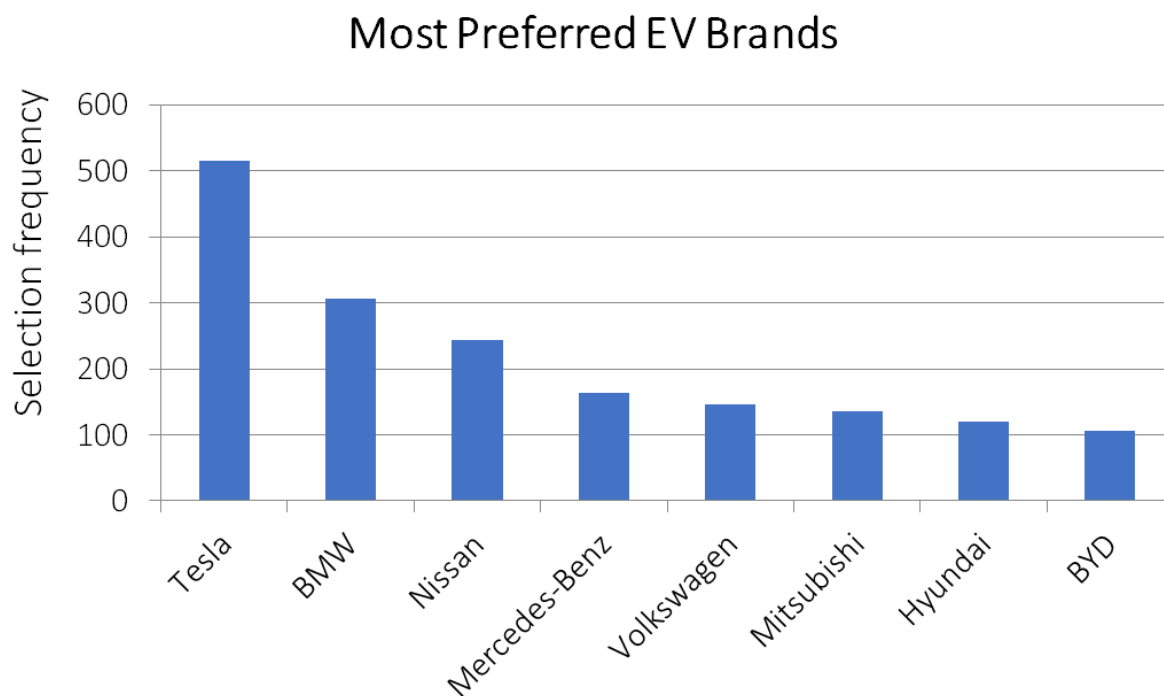


Figure 13. Most preferred EV brands

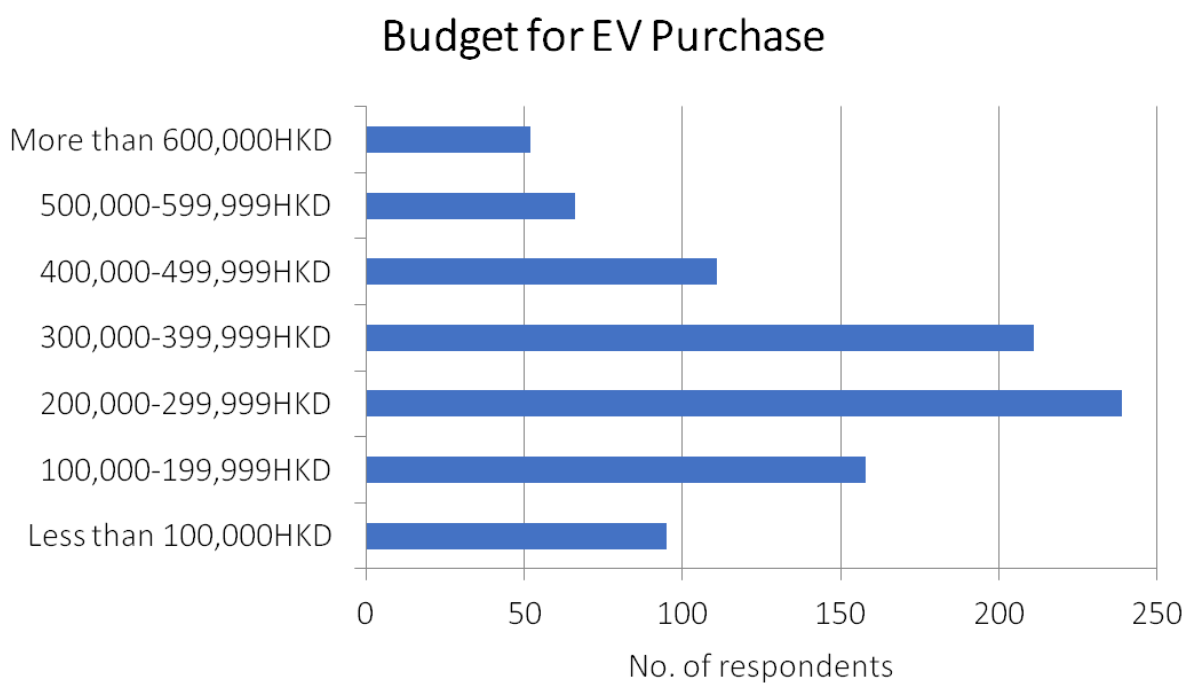


Figure 14. Budget for EV purchase

Table 5. Statistical summary of selected scalar questions

	EV owners (N=238)		Non EV owners (N=744)		All (N=982)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
How important are these factors in influencing your EV purchase decision?						
Vehicle price	5.803	1.208	6.009	0.999	5.959	1.056
Charging infrastructure	5.911	1.133	5.806	1.178	5.832	1.168
Subsidies	5.555	1.468	5.578	1.140	5.572	1.226
Personal norm						
If I own a car that is not fuel-efficient and environmentally friendly, it sometimes gives me a bad conscience.	4.983	1.646	4.422	1.478	4.558	1.539
I feel a strong obligation to only buy/own an environmentally friendly car.	5.038	1.508	4.560	1.441	4.676	1.471
Perceived behaviour						
There are many problems and difficulties connected to owning an EV.	4.874	1.709	4.922	1.402	4.910	1.482
Charging an EV at my own premises is cumbersome.	4.874	1.746	5.073	1.618	5.024	1.651
Charging an EV at public charging stations is cumbersome.	5.046	1.447	4.958	1.488	4.980	1.478
There are too few charging stations for EV in Hong Kong.	5.874	1.319	5.495	1.457	5.587	1.434
Charging stations for EV are hard to find.	5.231	1.441	5.315	1.417	5.294	1.423
Knowledge						
With the knowledge I have about EV, I will feel safe buying an EV.	5.387	1.316	4.301	1.499	4.564	1.529
Expectation						
I will only purchase an EV if the first registration tax is fully exempted.	5.034	1.572	4.965	1.324	4.982	1.388
I will only purchase an EV if more public charging facilities become available.	4.861	1.504	5.370	1.251	5.246	1.334

Note: Questions asked respondents to rate statements in a 1 to7 Likert Scale, with 7 being the highest agreement level.

4.2 Supply Analysis

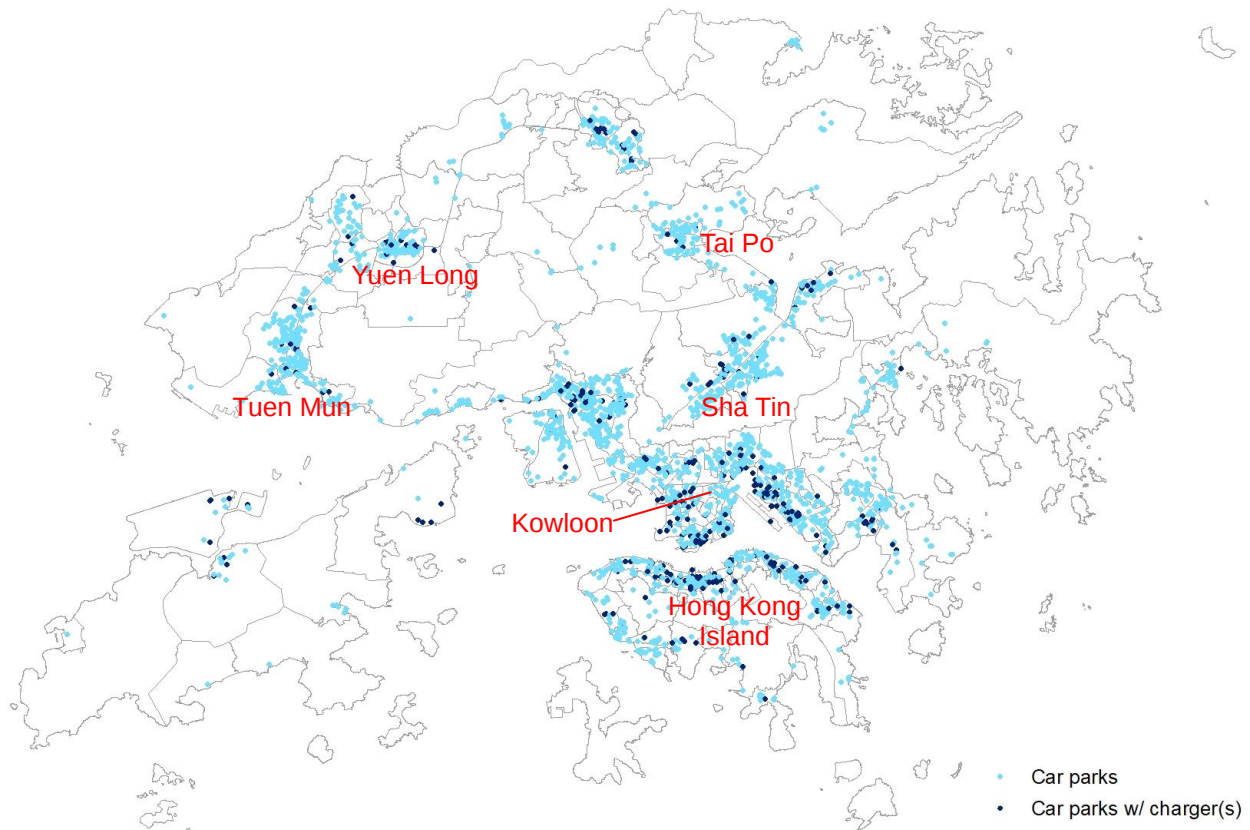
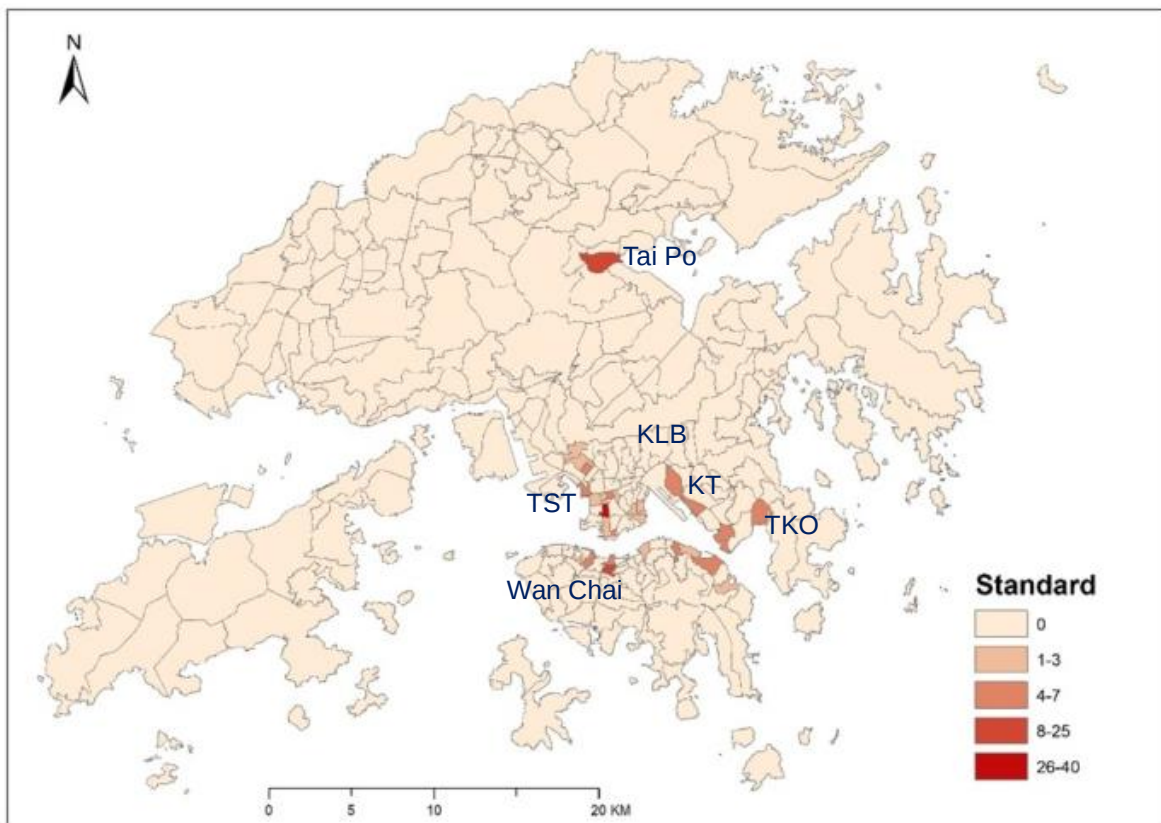


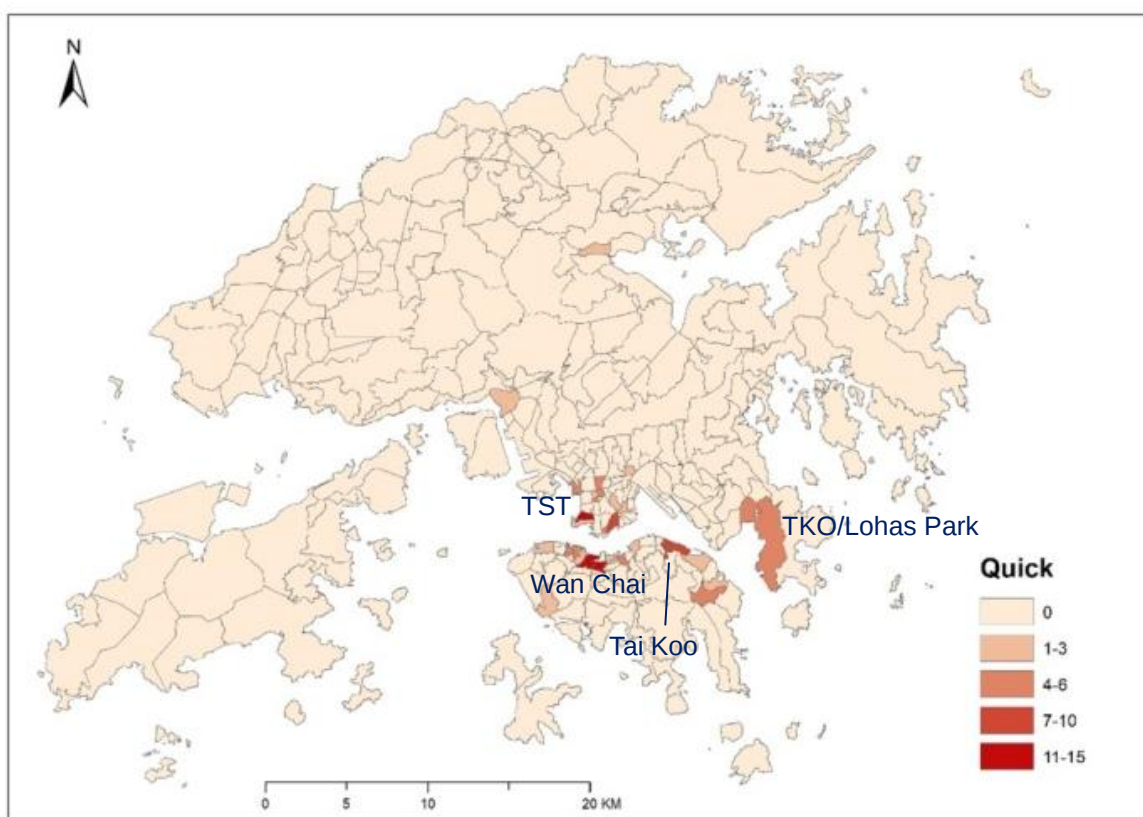
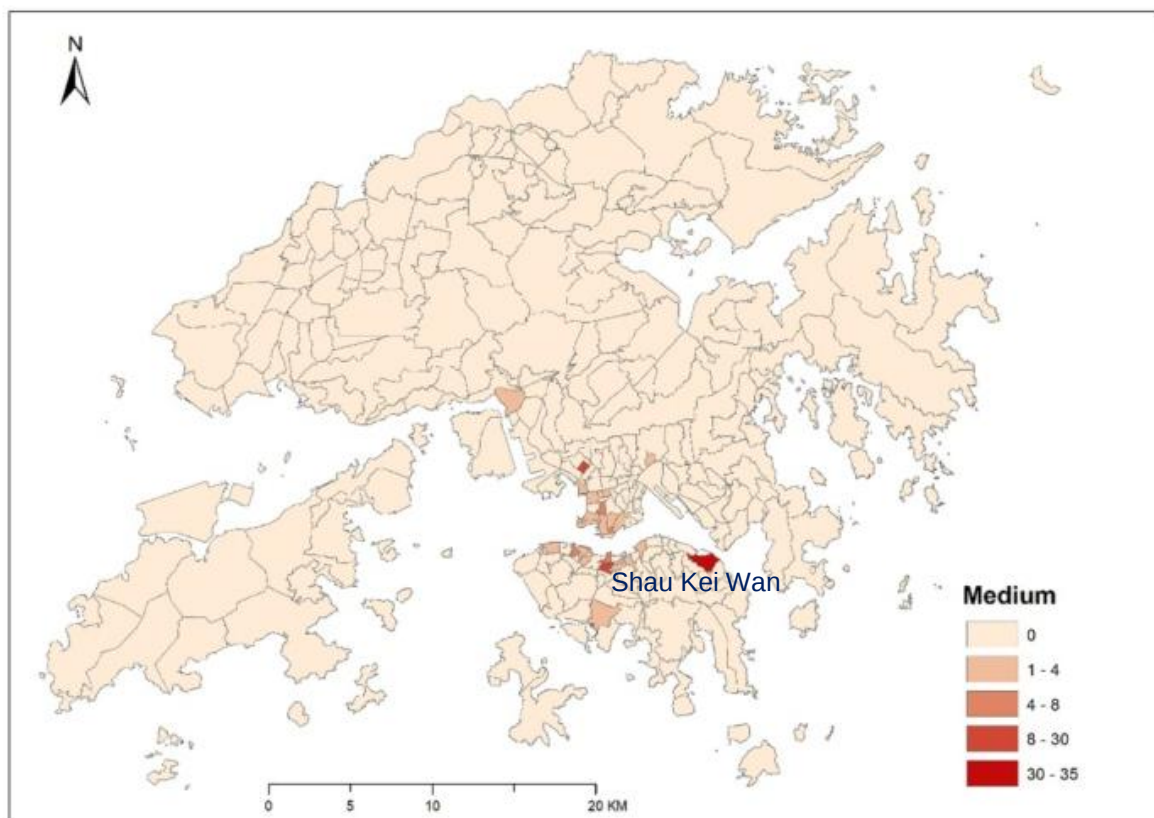
Figure 15. Charging facilities and car parks distribution in Hong Kong

The distribution of existing EV chargers and publicly accessible car parks essentially resembles the urban land development pattern (**Figure 15**). Kowloon and the Hong Kong Island have a relatively higher density of public chargers. On the other hand, access to the public charging network is visibly lower in the New Territories, even in town centre areas like Tuen Mun, Yuen Long, Tai Po and Sha Tin.

The accessibility analysis results shown in **Figure 16** affirm the proximity of EV chargers in communities along the Victoria Harbour. Within a 5-minute walking distance, there is an abundance of standard chargers in Wan Chai, Tai Koo and Shau Kei Wan on the Island side, and Tsim Sha Tsui [TST], Kowloon Bay [KLB], and Kwun Tong [KT] on the Kowloon side. A majority of TPUs in the New Territories could not reach a public EV charger within the walking distance parameters set except Tseung Kwan O [TKO] and a notably hotspot in Tai Po – Po

Heung Estate has 25 chargers right near the TPU centroid. The mapping of accessibility to quick chargers largely overlapped that of the Tesla chargers due to the fact that Tesla superchargers and three-phase wall connectors constitute a significant portion of fast chargers. Quick chargers cluster in the Central-Wan Chai CBD and areas with high-end shopping malls and real estate projects, including Tsim Sha Tsui, Olympic, Tai Koo, Tseung Kwan O and Lohas Park. The above findings reflect an imbalanced supply landscape of public charging in Hong Kong that generates inconvenience for EV owners especially in the New Territories.





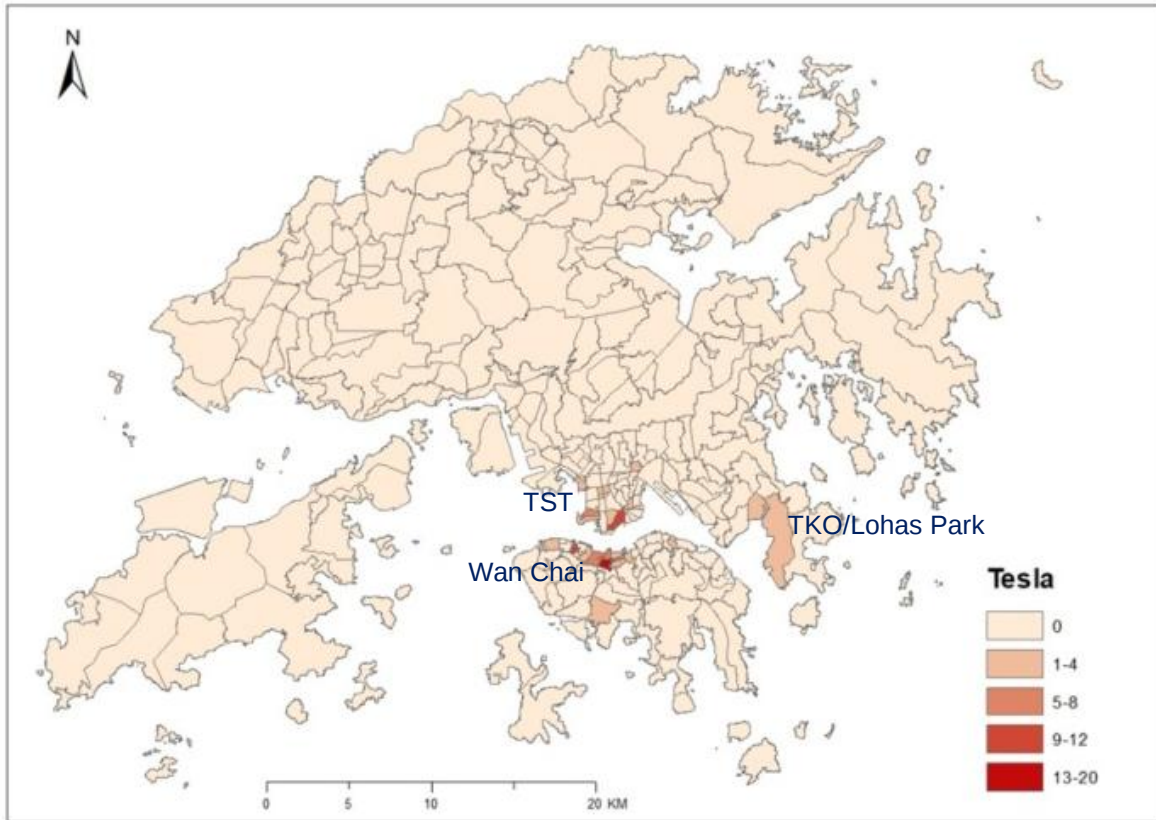


Figure 16. Number of EV chargers within 5-minute walking distance at TPU level

4.3 Demand Modelling Results

To estimate individual and zonal demands of EV, we used the data from the questionnaire survey mentioned in **Chapter 3**.

Our dependent variable was the intention to buy an electric vehicle in the next five years¹⁰. As summarised in the literature review, there are many factors affecting the decision to adopt an EV. In addition to being informed by the literature, we selected the variables to be included in

¹⁰ Although we also asked the respondents in the questionnaire whether they will buy an EV as their next vehicle, we regard this decision to be less relevant to our goal of spatial planning due to the lack of timeline of “purchasing the next vehicle”, compared to “purchasing an EV in the next five years”.

our prediction model based on another rationale – the variables are enumerated in the micro Census data, where we based the territorial demand prediction on. (Method explained in **Section 3.1.2.2** in **Chapter 3**.)

A statistical summary of the explanatory variables of the final observations in the modelling part (N = 935) are presented in **Table 6**.

Table 6. Summary of dependent and explanatory variables in final models

	N	Percent (<i>for discrete variables</i>) or Mean (<i>for continuous variables</i>)
<i>Intent to buy an EV within the next 5 years</i>		
1 (lowest intension)	45	4.81
2	73	7.81
3	108	11.55
4	213	22.78
5	218	23.32
6	168	17.97
7 (highest intension)	110	11.76
Independent variables		
<i>Gender (ref. = male)</i>		
Male	604	64.60
Female	331	35.40
<i>Age (ref. = 18-34)</i>		
Ages 18-34	347	37.11
Aged 35-44	321	34.33
Aged 45 or above	267	28.56
<i>Education (ref. = diploma, high school or below)</i>		
Diploma, high school or below	287	30.70
Bachelor	462	49.41
Postgraduate	186	19.89
<i>Marital status (ref. = single)</i>		
Single	346	37.01
Married	566	60.53
Other marital statuses	23	2.46
<i>Employment status (ref. = employee)</i>		
Employee	827	88.45
Self employed	84	8.98
<i>Housing type (ref. = public housing)</i>		
Public housing	309	33.05
Private housing	618	66.10
Other housing types	8	0.86
<i>Tenure type (ref. = renters)</i>		
Renters	235	25.13

Owner with an outstanding mortgage	371	39.68
Owner with no outstanding mortgage	306	32.73
Other tenure types	23	2.46
Family size	935	3.22
Number of children in the household	935	0.53
<i>Income (ref. < HK\$ 40,000)</i>		
Less than 25,000	345	36.90
HK\$ 25,000 - 40,000	308	32.94
HK\$ 40,000 or above	282	30.16
<i>Residential district (ref. = Sha Tin)</i>		
Central and Western	98	10.48
Eastern	88	9.41
Islands	11	1.18
Kowloon City	60	6.42
Kwai Tsing	45	4.81
Kwun Tong	64	6.84
North	34	3.64
Sai Kung	57	6.10
Sha Tin	110	11.76
Sham Shui Po	33	3.53
Southern	32	3.42
Tai Po	38	4.06
Tsuen Wan	56	5.99
Tuen Mun	53	5.67
Wan Chai	18	1.93
Wong Tai Sin	42	4.49
Yau Tsim Mong	25	2.67
Yuen Long	71	7.59
<i>Workplace district (ref. = Sha Tin)</i>		
Central and Western	173	18.50
Eastern	67	7.17
Islands	18	1.93
Kowloon City	50	5.35
Kwai Tsing	37	3.96
Kwun Tong	108	11.55
North	18	1.93
Sai Kung	22	2.35
Sha Tin	71	7.59
Sham Shui Po	33	3.53
Southern	31	3.32
Tai Po	15	1.60
Tsuen Wan	55	5.88
Tuen Mun	23	2.46
Wan Chai	99	10.59
Wong Tai Sin	12	1.28
Yau Tsim Mong	89	9.52
Yuen Long	14	1.50

The estimates are reported in **Table 7**. A number of individual attributes turned out to be statistically significant. Age was one of them: older respondents (i.e., ages 35 or older) were less likely to buy an EV within the next five years compared to their younger counterparts. This confirmed the views espoused in previous literature that EVs are more favoured by younger people (Curtin et al., 2009; Hidrue et al., 2011; Ziegler, 2012). Marital status was another significant personal attribute. Compared to single people, married respondents were more likely to buy an EV in the near future. This finding is consistent with car purchase decisions in general in Hong Kong, where car ownership tends to change along with significant moments in individuals' life cycles. Employment status also mattered. Self-employed individuals were more likely to buy EVs compared to employees and those of other employment status.

Household characteristics were also important when it came to EV purchasing decisions. In particular, housing type and tenure type were important. Interestingly, those who lived in private housing and other housing types were less likely to become EV owners in the near future, compared to those who lived in public housing. This result may sound a bit counterintuitive because people who live in public housing estates are of lower income and thus possess less affordability to purchase a car. However, upon closer examination, we found that a growing number of public housing estate car parks under the government have equipped EV chargers, thus accelerating the accessibility of charging facilities in public housing communities. Compared to tenants of other tenure types, home owners (regardless of mortgage status) tended to be more willing to buy an EV within the next five years. This reflects the strong desire of home ownership in Chinese society; once home ownership is secured, car ownership is next big purchase (e.g., He & Thøgersen, 2017). Lastly, personal income was also statistically significant, but only at a marginal 10% level.

We also included home and workplace locations (at the district level) in the model. From the number of coefficients that were statistically significant, we can see that residential district is more of a determinant than workplace district, which implies that people from the same residential districts have more similar EV purchase tendencies. From the residential districts, compared to the reference group (i.e., Sha Tin district, which was chosen as the reference), a few districts were positively related to EV purchase decisions, including Central and Western,

Kowloon City, Sai Kung, Sham Shui Po, Tai Po, Tuen Mun, and Yau Tsim Mong. The geography of these districts suggests that respondents from the three main regions in Hong Kong (i.e., Hong Kong Island [where Central and Western district is located], Kowloon [where Kowloon City, Kwun Tong, Sham Shui Po, and Yau Tsim Mong are located], and the New Territories [where Sai Kung, Tai Po, Tuen Mun are located]) showed a positive sign of buying an EV (compared to the reference). This finding suggests that when installing public EV charging facilities, we should avoid concentrating them in some central locations because the context of Hong Kong may be different from other cities where demand is mainly concentrated in the urban core (see He et al., 2016). In terms of workplace districts, only two districts were statistically different from the reference: the Islands and Sham Shui Po. The former reflects the importance of connectivity because this district is geographically detached from the three main regions and the connection requires water transport. Such remote location lowers people's intention to buy an EV.

Table 7. Estimates of factors affecting EV demand from ordered probit model

	Coefficients	Std. Err.	p value
Independent variables			
<i>Gender (ref. = male)</i>			
Female	-.0708	.0743	0.340
<i>Age (ref. = 18-34)</i>			
Aged 35-44	-.1874**	.0939	0.046
Aged 45 or above	-.2416**	.1029	0.019
<i>Education (ref. = diploma, high school or below)</i>			
Bachelor	.1319	.0845	0.119
Postgraduate	-.0747	.1110	0.501
<i>Marital status (ref. = single)</i>			
Married	.3286***	.0945	0.001
Other marital statuses	.0923	.2382	0.698
<i>Employment status (ref. = employee/other statuses)</i>			
Self employed	.2804**	.1251	0.025
<i>Housing type (ref. = public housing)</i>			
Private housing	-.1945**	.0799	0.015
Other housing types	-.5197	.3780	0.169
<i>Tenure type (ref. = renters)</i>			
Owner with an outstanding mortgage	.2534***	.0915	0.006
Owner with no outstanding mortgage	.2024**	.0939	0.031
Other tenure types	.0280	.2287	0.903
Family size	.0601	.0372	0.106
Number of children in the household	.0317	.0634	0.618
<i>Income (ref. < HK\$ 40,000)</i>			
HK\$ 40,000 or above	.1857**	.0881	0.035
<i>Residential district (ref. = Sha Tin)</i>			

Central and Western	.7137***	.1642	0.000
Eastern	.1382	.1544	0.371
Islands	-.2415	.3367	0.473
Kowloon City	.6189***	.1782	0.001
Kwai Tsing	.2524	.1882	0.180
Kwun Tong	.2761***	.1680	0.100
North	.1287	.2091	0.538
Sai Kung	.3358*	.1763	0.057
Sham Shui Po	.5042**	.2107	0.017
Southern	.1608	.2154	0.455
Tai Po	.5456***	.2004	0.006
Tsuen Wan	.1647	.1758	0.349
Tuen Mun	.4344**	.1830	0.018
Wan Chai	-.0362	.2752	0.895
Wong Tai Sin	.1663	.1957	0.396
Yau Tsim Mong	.4277*	.2357	0.070
Yuen Long	.2738	.1709	0.109
<i>Workplace district (ref. = Sha Tin)</i>			
Central and Western	.0394	.1580	0.803
Eastern	-.2404	.1824	0.188
Islands	-.6808**	.2774	0.014
Kowloon City	-.1782	.2027	0.379
Kwai Tsing	-.1803	.2145	0.401
Kwun Tong	-.0251	.1616	0.877
North	.1365	.2787	0.624
Sai Kung	-.1067	.2600	0.681
Sham Shui Po	-.4529**	.2222	0.041
Southern	-.2149	.2279	0.346
Tai Po	.0486	.3005	0.871
Tsuen Wan	.0507	.1918	0.792
Tuen Mun	-.1825	.2651	0.491
Wan Chai	-.0304	.1674	0.856
Wong Tai Sin	-.3744	.3253	0.250
Yau Tsim Mong	-.1377	.1697	0.417
Yuen Long	.4581	.3238	0.157
Model summary			
N	935		
Pseudo R ²	0.0395		
Log likelihood	-1644.4179		
LR chi ²	135.33		
Prob > chi ²	0.0000		

Note: *** p < 0.01; ** p < 0.05; * p < 0.1

Based on the modelling results of demand for all TPUs in Hong Kong, we have visualised EV demand in the maps which follow. **Figures 17** portrays the TPU level EV demand probability at the highest intention (Likert scale = 7) levels within the next 5 years. **Figure 17** shows that the

East Kowloon areas including Kowloon Bay and Kwun Tong have a significantly higher proportion of strong EV purchase intention. Over the New Territories, Tseung Kwan O [TKO], Tuen Mun, Tin Shui Wai, Tai Po and Tsing Yi were identified as high demand hotspots. Despite being the wealthiest region in the territory, most areas on the Hong Kong Island only yield moderate intensity of high EV demand.

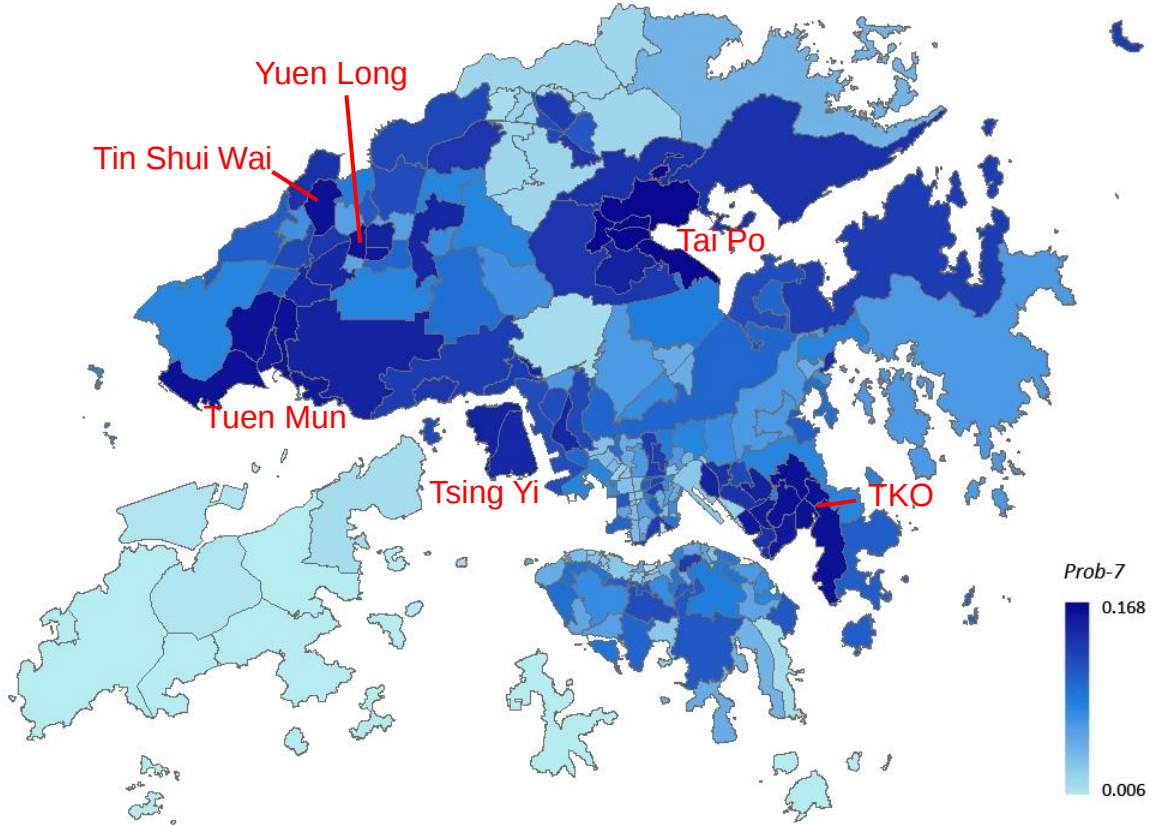


Figure 17. Probability of TPU population with highest demand intention

For our parameters in Eq. (2), based on our survey, we noticed that EV owners on average charge their EV every four days. Therefore, on a daily basis, 25% of the EV owners need to charge their vehicle's battery (P^d). In addition, we also noticed from stakeholders' feedback that about 50% of EV owners use public charging facilities (P_{pub}). Following Eq. (1), we calculated the demand for public charging facilities in all neighbourhoods in Hong Kong (**Figure 18**). **Table 8** summarises the daily charging demand for public chargers. **Figure 18** shows that high public charging demand exists in Tuen Mun, Tin Shui Wai, Tai Po and Lohas Park (Tseung Kwan O). It was further noted that a street block in Tseung Kwan O produced the highest daily public charging demand, followed by one in Tai Po.

Table 8. Statistical summary of daily charging demand at street block level

	Mean	Median	Max.	Min.	Std. Dev.
Demand (No. of EVs)	13.628	5.980	174.383	0.300	19.546

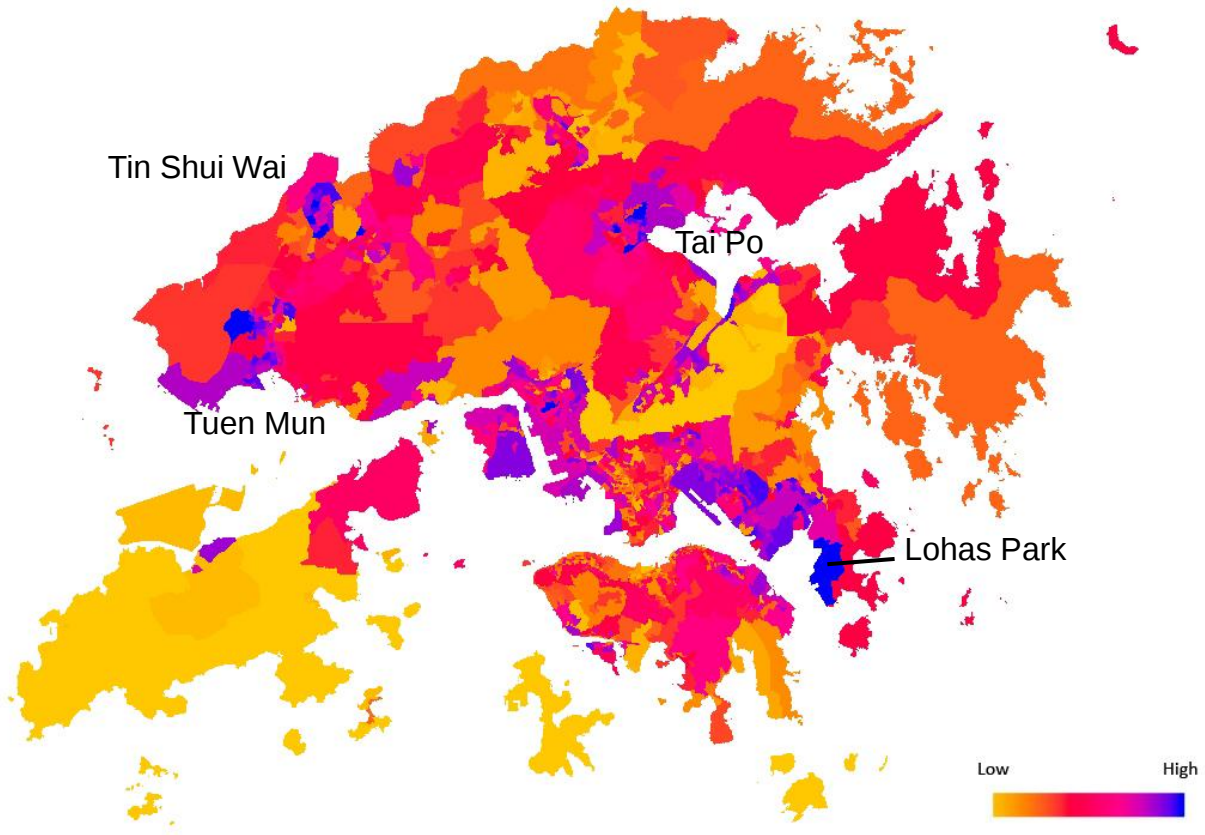


Figure 18. Map of street block level demand for public charging facilities

4.4 Optimised Location Allocation

The optimal locations for EV charging stations and the demand allocation at street block level obtained by our location model are presented in **Figure 19**. **Figures 20 to 22** further annotate the quantity of new chargers required by charging speed.

The optimal solution suggests that, in addition to the 318 car parks which have existing EV charging facilities, 939 new locations need EV charging infrastructure to satisfy EV charging demands. Among the established charging points, 84 are subject to expansion, indicating an

accessible location yet an undersupplied capacity. In total, 5,840 new standard chargers, 354 new medium chargers, and 1,245 new fast chargers need to be installed at existing and new EV charging stations. These numbers significantly exceed those of existing public EV chargers in Hong Kong: 882 standard chargers, 860 medium chargers, and 500 fast chargers. Our solution suggests that the current supply of public charging facilities is insufficient and that there is an urgent need to establish charging infrastructures and facilities at new locations to satisfy upcoming EV charging demands in Hong Kong.

We further analysed the performance of the optimal EV charging facility plan. From this optimal solution, the demand coverage rate was 99.95% with only 10.81 of EVs' charging needs being unsatisfied daily, and the average distance to EV charging facilities being 170.60m. The shortage points were located at Cheung Chau, an outlying island and a street block unit in the furthest north of the territory near Heung Yuen Wai. The very high coverage and short distance to EV charging facilities suggests that this optimal EV charging facility plan provides EV users with high accessibility to facilities.

The spatial distribution of the proposed new charging locations (red dots in **Figure 19**) basically follows the urban development of Hong Kong – along the two sides of the Victoria Harbour and in the major town areas of the New Territories namely Sha Tin, Ma On Shan [MOS], Tseung Kwan O [TKO], Tuen Mun, Yuen Long, Tai Po and Sheung Shui. Two particular areas see sparse deployment of new chargers; Central-Wan Chai CBD and the CBD2 in Kowloon Bay and Kwun Tong. This is primarily because of these areas existing abundance of chargers (green dots). This result can be attributed to two reasons: first, the two districts enjoy concentration of major shopping malls and commercial buildings, in which these two building types constitute a prominent share of charging locations in Hong Kong; second, our model estimates charging demand according to the demographics of residents whilst business districts possess fewer dwelling units and are thus exposed to lower charging demand.

The radial lines in **Figure 19** indicate street block demand allocation to charging points. More visible line segments denote longer distances between demand points and supply facilities. Outlying islands such as the Lamma Island, Peng Chau and Po Toi Island have been excluded

from the assignment since they are only connected to the main regions by sea transport. Due to the denser urban form of the Kowloon Peninsula and Hong Kong Island, most communities there have high accessibility to the charging network. In contrast, more remote rural communities in the Northern New Territories (e.g., Shap Pat Heung, Lam Tsuen, Ta Kwu Ling) are restricted by notably inferior access to chargers.

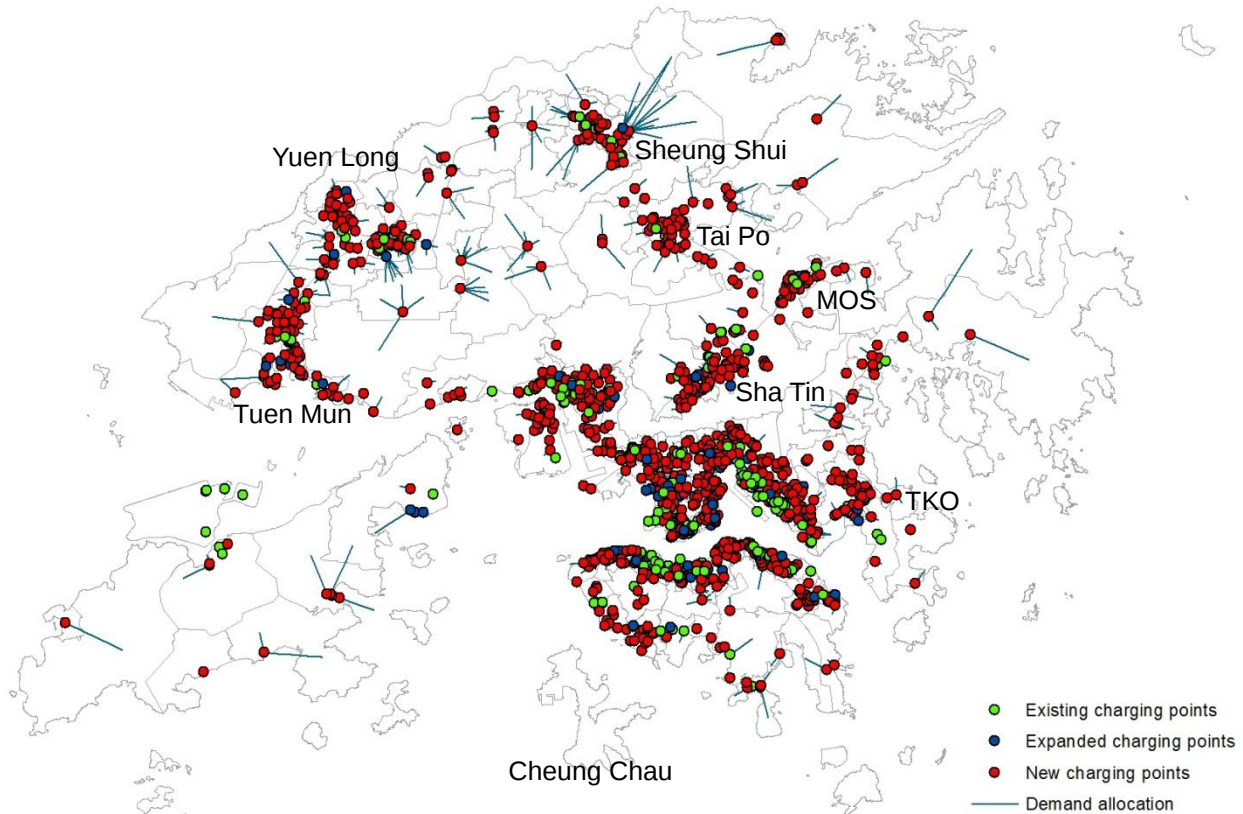


Figure 19. Optimal location allocation solution

Figures 20, 21 and 22 portray the distribution of new standard, medium and quick chargers needed to realise the optimisation plan. In terms of the number of locations, a total of 751 sites need new quick charger installation, compared to 421 sites for standard chargers and 159 sites for medium chargers. However, in terms of construction quantity, no more than ten quick chargers will be placed in the same parking site due to much higher unit costs and their strong ability to absorb demand compared to those of lower charging speed. In contrast, the deployment quantity of standard chargers is significantly higher than the other two charger types, with as many as 106 new installations at the same point. It is found that most of the car parks which require extensive charger introduction are located in residential buildings or housing estate

shopping malls. Concerning spatial distribution, the three types of chargers share similar locational patterns; East Kowloon communities are the top demanding areas for new chargers of all three speed levels. **Figure 22** shows that many more quick chargers will be needed in East Kowloon, especially in Yau Tong, Sau Mau Ping, and inland parts of Kowloon Bay and Kwun Tong where the residential communities are located. **Figure 21** shows that there is an overall lower demand for medium chargers as compared to quick and standard chargers. Sau Mau Ping, Tsim Sha Tsui [TST], and North Point are areas identified with greater need for medium chargers. The whole Tseung Kwan O [TKO], Tai Po and Yuen Long also show much room for deploying quick chargers. For standard chargers (**Figure 20**), the strong demand in Tseung Kwan O and Sau Mau Ping remains, with Tuen Mun also having an exceptional need for new standard chargers to satisfy local demand. This demand was not observed with regard to the quick chargers.

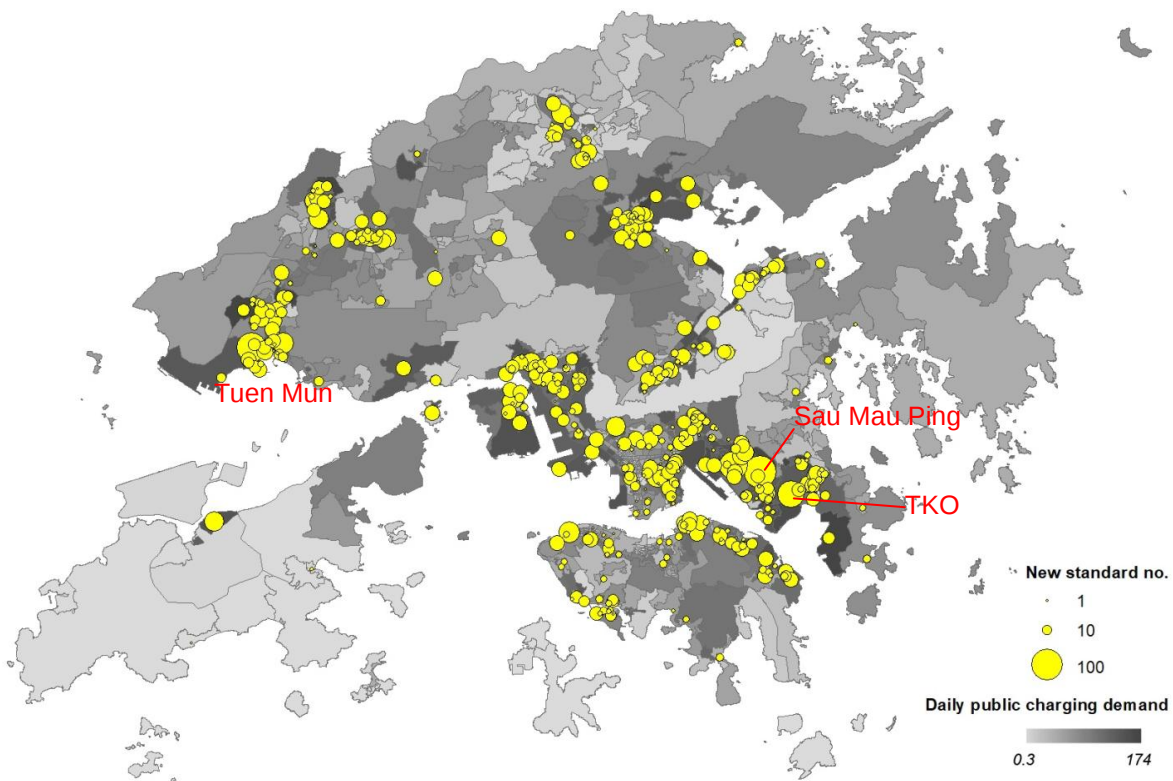


Figure 20. Distribution of new standard chargers

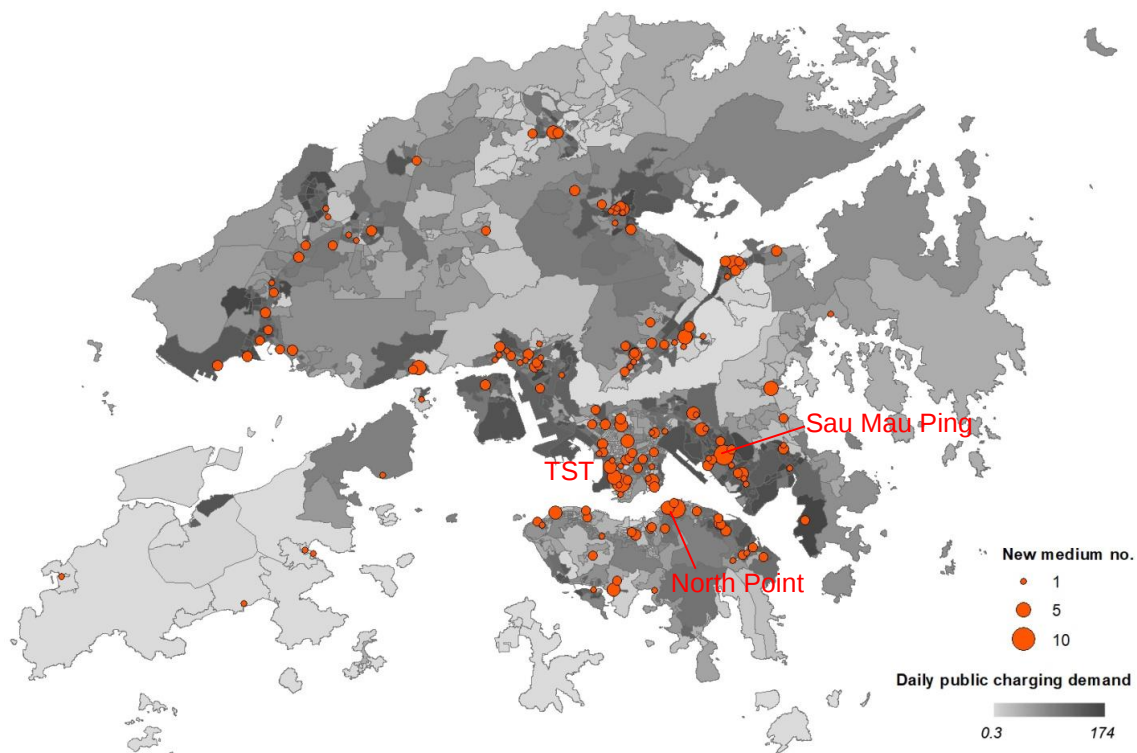


Figure 21. Distribution of new medium chargers

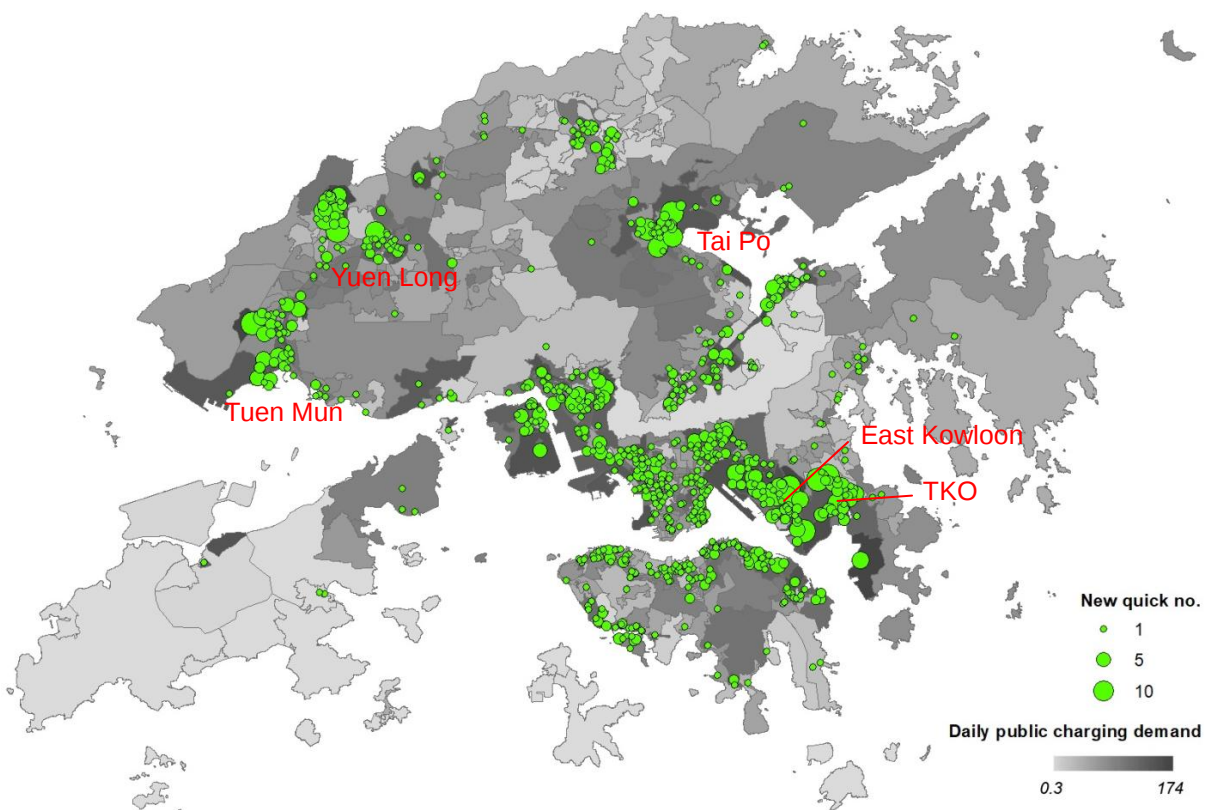


Figure 22. Distribution of new quick chargers

4.5 Limitations of the Study

While this study has filled in a number of research gaps, there is still room for improvement. We separate the discussion into three aspects: (1) supply; (2) demand; and (3) spatial optimisation.

Supply: On the supply side, the list of existing and potential sites may not cover all of the current chargers and viable parking grounds for public access. As mentioned above, the charger location list we based our geocoding on is compiled from voluntary reports of the industry. That piece of data from EPD may not include the most complete and up to date of public charger information. For instance, despite wide media coverage as the largest Tesla Supercharger hub in the city, the twenty quick chargers at the Hyatt Regency Hotel in Sha Tin which were commissioned in August 2019 were not included in the EPD list even by January 2020.

Concerning the supply-side model parameters, the three categories of chargers were divided according to the government standard. However, to our knowledge, quick chargers could be further classified into AC and DC powered outlets, with DC chargers providing substantially quicker charging speeds but also having much higher unit costs. Such disparities in cost and supply capacity among quick charger models were not differentiated in our computation constraints. Instead, same parameters were imposed on the quick charger group regardless of the current type. In terms of the daily service amount parameters, the figures are stipulated based on the time needed for a complete charge of battery from 0% to 100% for the two referenced EV models, Tesla Model 3 and Nissan Leaf. Yet it is acknowledged that, in practice, drivers initiate charging before batteries are exhausted and that, as a result, the usage frequency of chargers could be higher than our model assumption. However, considering the common cases of access blockage by ICEVs or fully charged EVs reported in social media EV user groups and highlighted by multiple interviewed stakeholders, it was justifiable to adopt the current simple average vehicle flow assumption.

Another relevant parameter is budget utilisation. We estimated the total budget for deployment from the HK\$120 million sum allocated for government car park charging expansion and spent the budget according to the stipulated unit cost of each charger type. However, the government plans to install 1,000 new chargers using the earmarked amount. In other words,

each charger would cost HK\$120,000, compared to the total cost of HK\$50,000 for constructing a medium charger suggested by the facility suppliers. The model simulation is expected to allow more chargers to be provided due to a lower unit cost than the government scheme.

Demand: The current EV demand estimation is large. The projection based on street block demographics suggests a total of 177,000 EVs in the next five years; 13% of the recruited (licensed drivers of Hong Kong) reported a definite purchase intention within that time frame. Whether the inclination stated in the questionnaire responses is realised in genuine purchase actions will determine the precision of this estimation. It is sensible that the realistic demand would be discounted and thus the current projection tends to overestimate future EV demand. However, statistical evidence concerning EV purchase is still unattainable, as the low market penetration rate of EV in most countries prevents scholars from acquiring revealed preference data to compare against stated preferences (Anable et al., 2018). In future studies, incorporating the discrepancy between stated intention and actual behaviour would enhance the precision of demand modelling. The factor is not explored in the above computation due to the considerations that (i) the discount ratio only imposes linear modifications to the estimated demand and does not disrupt the spatial landscape of the demand-supply relationship (Andrenacci et al., 2016); and (ii) construction of chargers is bounded by predetermined budget constraints and demand shortage has been fed back.

We also did not consider drivers' personal preferences in selecting public charging outlets. Proximity is the only factor valued in the model, while real life charging location choices may also depend on charging price and speed, venue type (e.g., shopping malls may be preferred over industrial centres) and social activity schedules. Constraints on preferences are not reflected due to the lack of supporting evidence which addresses local contexts. Future studies could elicit the statistical implications of charging prices, speed and venue on selecting specific EV chargers. Traits not input to the quantitative model have been compensated by the qualitative analysis from in-depth interviews to further inform our proposed policy recommendations.

Spatial optimisation: to match the demand and supply points, we applied the Euclidean distance calculation instead of driving distance. This may not reflect the actual travel path of

reaching charging sites from demand points. Future studies could implement location allocation analysis on a network dataset to simulate genuine charging journeys.

CHAPTER 5 PERSPECTIVES OF STAKEHOLDERS

Informed by our questionnaire survey with existing and potential EV users, we understand that charging infrastructure is a key bottleneck for EV development. To gain a better understanding of why there is insufficient charging infrastructure, we paid particular attention to stakeholders in this business. In this chapter, we report on the in-depth interviews with key stakeholders in EV development (with a particular focus on stakeholders involved in the deployment of public charging facilities) in Hong Kong, including government units, lawmakers, charging facility suppliers, car park managers, and EV owner alliances.

5.1 Government Units

The Environmental Department and EPD jointly formulate the primary EV policy in Hong Kong. According to the interviewee from the EV section of EPD, Senior Engineer Steven Chow Yam-wai, EVs are being promoted in Hong Kong predominately out of environmental concerns, i.e., to improve roadside air quality and reduce overall carbon emission. Therefore, considering the fact that over 90% of air pollution comes from commercial vehicles, the government pays much more attention on electrifying commercial vehicles such as franchised buses and light goods vehicles [LGVs]. As a result, we see a disparity in supporting policies between private and commercial vehicles, with commercial vehicles receiving more solid economic benefits. According to the spokesman, maturity of technology is the main rationale that the government bases its resource allocations on.

EV application to commercial use cars, although benefitting from more favourable policies from the Government, has remained in a preliminary stage due to heavier vehicle weights and their greater power requirements. Previous trials on electric bus and minibus have failed to provide equivalent service intensity to their traditional-fuel counterparts. Therefore, on top of the full FRT exemption and the 100% profit tax deduction in the first year of purchase, the government is emphasising on trial schemes for commercial vehicle firms to facilitate hand-on experience that accelerates EV technology advancement and adaptation to the local operation.

The schemes include a HK\$300 million Pilot Green Transport Fund and a HK\$180 million fund for testing EVs on franchised bus routes. These initiatives from the government are critical at this stage of commercial EV adoption as the private sector sees no financial benefit in these projects.

Although the government is dedicated to adopting EVs in commercial uses, the interviewee noted that the promotion could not be forceful. The introduction of EVs needs to respect the operational functions of commercial vehicles as their primary task is to provide pleasant transportation services. On the other hand, for the more mature electric private car market, the government has been gradually reducing tax incentives in an attempt to promote a more independent business cycle.

Apart from vehicle-specific policy incentives, EPD is also working with other government departments (i.e., TD, Government Property Agency, Leisure and Cultural Services Department, etc.) to expand the public charging network in government car parks and is now planning on actualising roadside parking space charging. The government advocates the user-pays principle and all currently free-of-charge public charging services are being encouraged to adopt a charged business model on EV chargers in longer term. However, due to the undersupply of existing charging facilities and the need for a more comprehensive legal basis, there is no immediate plan or timetable for putting this vision into practice. Alongside the expansion of the public charging network, the government is also working towards the promotion of home/workplace charging in order to realise the aforementioned policy vision. The interviewee mentioned that older buildings constitute a major problem in enabling home charging, as 90% of new buildings planned after 2011 have charging enabled infrastructure which benefits from the GFA discount. The scheme offers GFA concessions to qualified property developments that have prepared all the supporting components in underground parking areas to meet charging infrastructure requirements. However, installations in older residential buildings that do not already possess the pre-requisite infrastructure, require construction work in their public areas and such schemes tend to be declined by building management due to costs and potential disputes. In response, the latest HK\$2 billion earmarked for upgrading private estate parking facilities seeks to remove barriers to constructing personal chargers in housing estates.

The interview transcript is attached in **Appendix II**.

5.2 Lawmakers

We interviewed LegCo member (Functional Constituency - Transport) Frankie Yick Chi-ming (**Appendix III**). He described EV application as an “irreversible trend”. He noted that the UK has the target of banning fossil fuel vehicle sales by 2035, and that multiple car manufacturers have announced that they are ending the production of fossil fuel vehicles between 2040 and 2050. The slow progress of EV application in Hong Kong is attributed to the lack of a master plan on e-mobility promotion. Clear goals and the policy measures needed to help achieve these goals should be stipulated in a holistic plan.

The presently underwhelming charging supply is undoubtedly among the factors that hinder EV adoption. The lawmaker raised the view that, in most cases, home charger construction applications are not endorsed. Existing buildings have limited power reserve capacities, and it is difficult to adjust transformer sizes as they are determined before structures are built. It follows that, for new buildings, preparing for charging power consumption is much easier and can be achieved at a lower cost. Regarding the current policy of encouraging the provision of charging infrastructure in buildings through GFA concessions, he recommended that the government should expand the eligible sites to parking areas on all floors, instead of only underground car parks. A mandatory requirement to equip all parking spaces with EV infrastructure in the Buildings Ordinance has also been proposed. To ensure the effectiveness of the recent HK\$2 billion subsidies on residential charger installations, the government should encourage Incorporated Owners [IO]’s endorsement of applications, or even require IOs to action proposals whenever an incoming request is received. Concerning the operation of public charging services, though he agreed that the free service is no more than a temporary attraction to arouse EV usage, uncertainty on business model influenced by a distanced mass adoption outlook causes few entrepreneurs regard charging service provision as a profitable business right now.

On the demand side, the interviewee admitted that the removal of first registration tax [FRT]

exemption is a heavy blow to the purchase desires of consumers. However, he sees the reduction in tax incentives as an opportunity for vehicle producers to lower their EV prices in order to capture market demand. He believes that this will be contributive to EV adoption as more affordable vehicle models would mean that there is an increase in EV popularity. Given that, the HK\$97,500 concession is considered too scant, he proposed that it should be raised to HK\$150,000 and \$250,000 for the One-for-one Scheme.

Between boosting charger supplies and increasing EV demand, he believes that the former is more fundamental as potential buyers will not even consider purchasing an EV if the practical needs of charging are not satisfied.

5.3 Charging Facility Suppliers

Informed by our questionnaire survey with existing and potential EV users, we understand that charging infrastructure is a key bottleneck for EV development. To gain a better understanding of why there is not sufficient charging infrastructure, we paid particular attention to stakeholders in this business.

Three charging facility suppliers were interviewed, Hong Kong Electric [HKE], Hong Kong EV Power Limited [EV Power], and Hong Kong Electric Vehicle Network Limited [HKEVN], the interviews are transcribed in **Appendices IV, V and VI** respectively.

As one of Hong Kong's two main electricity utility companies, HKE engages in the EV industry through the provision of both electricity and charging facilities. HKE supplies electricity over the Hong Kong Island region and offers consultation on estimated loading and supporting device installation to customers interested in installing chargers. In addition, they also provide twelve sites for public EV charging. As a company trying to introduce EV into daily operation, HKE admitted that there are a number of drawbacks in the actual usage of EV. In the current pilot scheme, the company has introduced electric light goods vehicles [LGVs] and light buses. Compared to conventional diesel vehicles, the general disposal flexibility of an EV fleet is lower

owing to charging needs. Service reliability and the driving range of EVs are also lower than ICEVs as the battery for commercial EVs is bulkier than EV private cars. The second interviewee was Cliff Wu, General Manager of EV Power, a leading EV charging facility provider in Hong Kong and supplier to charging facilities in government car parks. EV Power has 53 locations – containing almost 200 charging outlets - in their charging network. The company sells and operates charging facilities and invests in semi-public charging in private housing estates via monthly subscription plans. The third supplier, HKEVN, is a more online-based firm that sells charging applications and runs a charged charging site in Tsim Sha Tsui. Reviews from the three interviewees are summarised as follows.

Home charging: All three interviewed charging service suppliers recognised the challenge faced by EV owners who desire home charging. The first concern is power capacity, as the loading of the building may have already exhausted supply limits. In such case, applicants have to construct extra power supply facilities for their building which incurs costs of around HK\$100,000. Not only is this a financial burden, it also creates fairness issues, as later installers may need to bear the cost of power supply facilities when the power reserve is completely consumed, while the earlier installers who exhausted the capacity are unlikely to share the cost derived from new installations. Seeing such service gaps, EV Power initiated the Residential Apartment Scheme [RAS] to equip charging facilities and infrastructure in shared parking spaces in housing estates to operate under various pricing methods. The scheme is also applicable in dwellings with mostly rental parking spaces, where residents may not be willing to invest in a personal charger. The second concern is objections from IO. The IO may not have adequate knowledge and experience of handling private charger applications, not to mention the possible costs that arise from charging enabling infrastructure such as cabling work and meters. IO may be reluctant to cover the costs of construction in common areas of buildings.

Public charging network: Alongside supplying home charging, the two charger suppliers also invest in the public charging network. The top concern raised by practitioners was the unhealthy provision of free charging service and how this represses the commercialisation of the market. The government and the two electricity companies are now supplying public chargers for free, which makes it almost impossible for private investors to profit from operating charging

networks this they are discouraged from joining the market. The interviewee suggested promoting the private market of charging provision through offering financial incentives to facility suppliers and property owners.

Illegal occupation of EV parking spaces: Another problem is the ineffective charger deployment subjected to occupation of charging spaces. Given the general lack of parking spaces in Hong Kong, built charging points may be parked in by ICEVs (**Figure 23**). On some occasions, the occupying car may also be an EV but the owners have not removed their EVs from the charging space after charging is complete (**Figure 24**).



Figure 23. ICEVs occupation of charging spaces¹¹

¹¹ Source: Tesla Fan Club Facebook group

又到中又走馬燈都停晒，不如襯食飯時間揸走俾有須要嘅人用丫，請各師兄不妨留意下高抬貴手🙏



Figure 24. Overtime occupation of parking space by fully charged EVs¹²

Charging habits: An interviewee identified a common charging habit among public network users; to top up their batteries from a very low level using quick chargers. It is suggested that this practice is harmful to battery preservation. A healthy charging cycle is regular and frequent, preferably initiated at around 50% battery level.

5.4 Car Park Managers

Car park management companies stand at the frontline of EV charging activities. The

¹² User's complaint "Even the scroll display on the medium charger has stopped. Please fellow EV drivers do a favour to others and leave the charging spaces for users in need during lunch time."; Source: Tesla Fans Club Facebook group

interviewed company, CP Parking, manages car parks in both subsidised home ownership housing estates and government buildings (**Appendix VII**). Car park managers supervise daily operation of the car parks, perform flow management, and provide operational advice to property owners who wish to install EV chargers. However, key installation decisions, for instance, whether or not to install charging facilities, and the quantity and type of chargers, are decided upon by the property owners, or collectively by the owners' corporations, building management companies, or the government. In other words, parking companies bear no direct cost in the charger installation process, except the temporary suspension of slots under construction work or the manpower needed to communicate with the property owner. In terms of revenue, though most chargers operate for free and, for those that do not, the charging fee may not be directed to the parking management, the increased parking volume from charging visitors is expected to generate extra parking income.

One message that was made very clear in the interview was that EVs are no different from other vehicles from the perspective of parking management. As a matter of fact, not every visit of an EV results in the charging service being used, and charging slots are also regular parking spaces when the chargers are not in use. Though car park managers follow the EV prioritising protocol to guide ICEV drivers away from chargeable slots when the car park is not full, they have no incentive to harm their revenue and retain vacant charging spaces for (unforeseeable visits of) EVs when all other parking spaces are occupied. It was also admitted that the actual enforcement of the prioritised parking rule varies among different managements. Regarding drivers' behaviour, the building type of the car parks and the nature of travel activity were all observed to determine parking duration and impact on whether charging took place during a given parking session. For instance, most drivers parked for short visits at government car parks due, for instance, to the purpose of their visit being the submission of documentation. They may not have sufficient parking time to get a significant charge. In contrast, drivers tend to park longer at places such as shopping malls as the involved activities (e.g., dining, movie watching) take more time and, as a result, there is a greater reason to initiate a charge.

5.5 EV Owner Alliances

Charged Hong Kong is a non-profit EV user alliance which aims to accelerate EV adoption and promote cleaner air in the territory of Hong Kong. We consulted the Chairman of the organisation, Mark Webb-Johnson, for the perspective of EV users in Hong Kong (**Appendix VIII**).

According to the information possessed by the group, about half of its members have enabled home or workplace charging, while the other half primarily use public chargers. Talking about the general deployment strategy, Charged Hong Kong believes that public charging is only a short, or medium term measure to support the adoption rate. Each EV owner should eventually install a home/workplace charging; though this might be slower, it would be (personally) more economical, and could be supplemented with much faster public charging.

EV owners charging at home/workplace have reverted to the alliance a higher usage satisfaction comparing to those relying on the public network. Proffering an explanation, the interviewee believed that the essence of driving is to achieve convenient transport, so the hassles involved in searching for a charging space and queuing for charging will eventually disincentive driving or purchasing an EV. He stressed the advantages of home/workplace charging which could address 95% of the charging needs. However, the hurdle blocking personal charger installation, especially for home chargers, lies in their obtaining permission for the installation from building management. Renters also do not have either the willingness or right to invest in their rented parking space. He added that the acceptance of charger installation applications by housing management has not increased despite the EV impetus of recent years. The interviewee urged the government to particularly address the issue of reluctant approval from building management since previous attempts from private individuals were time consuming and there was also no mutually profitable solution.

Though the chair advocated a charged model on public charging service for the sake of the long term betterment of the market, the free-of-charge service that presently exists was described as a double-edge sword to promoting e-mobility in Hong Kong. On the one hand, the free service acts as an incentive to purchase EVs. On the other hand, the interviewee pointed out that

commercial deployment would not be feasible under strain competition from widespread free services. Another primary issue with public charging is the low certainty of service provision. The shortage of parking spaces has driven ICEVs to occupy chargeable slots which blocks access to charging for EVs. Two measures were proposed to solve this problem. First, to implement the concept of shared charging in public car parks. Under the current layout of charging points, chargers are installed in consecutive slots. By stretching the deployment and placing the charger in the middle of multiple parking spaces, the same quantity of sockets could provide much more coverage on the parking floor as drivers parking reasonably close could all gain access to the outlet. Second, to include EV prioritisation in car park management contracts so that parking management is obliged to enforce EV prioritised arrangements and are able to get reimbursement for so doing.

Navigating to a charger is already a difficult task itself, as currently there is no single platform that offers the location and status report of all public charging points in Hong Kong. Taking the example of the China Light and Power's [CLP] online platform (**Figure 25**), only the usage status of chargers operated by the company is shown, whereas that information for facilities from other suppliers is not displayed. As a result, drivers need to switch from app to app when searching for a vacant charging location. EV drivers long for a unified charger location platform upon which they, charger providers, and vehicle companies can exchange information about charger availability.

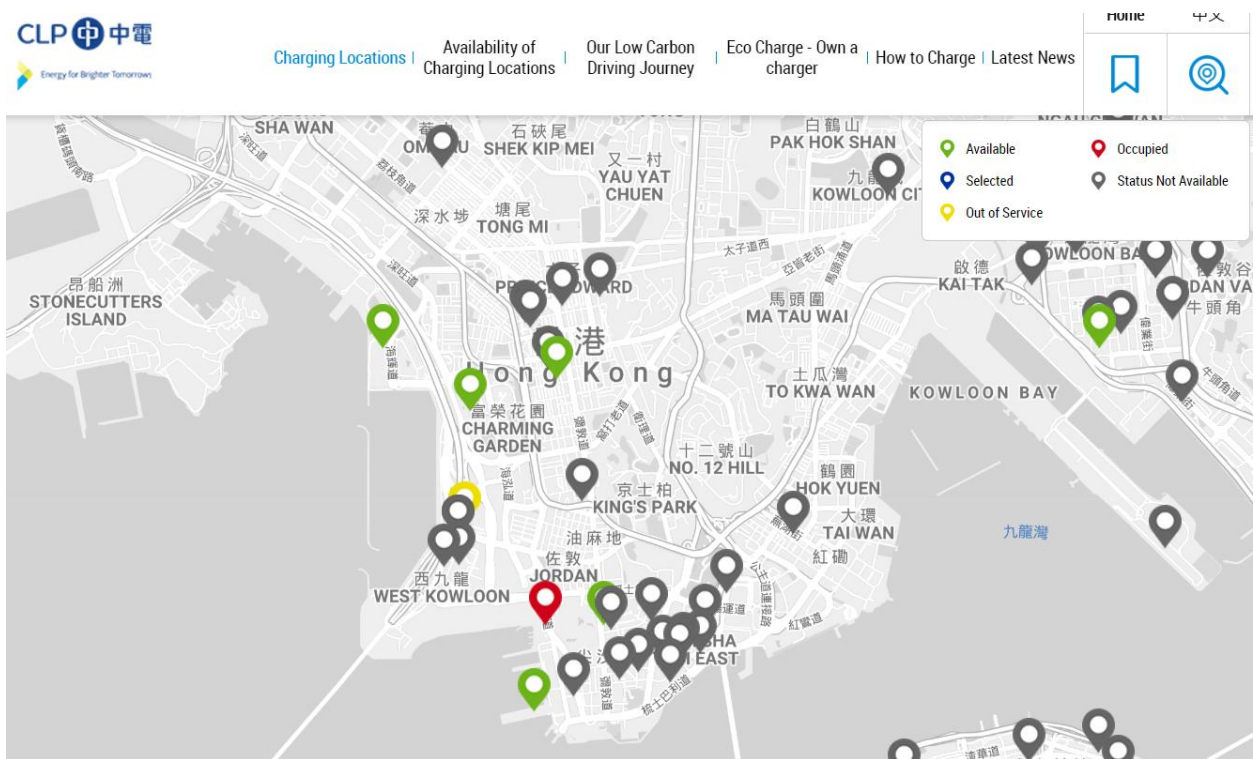


Figure 25. CLP charging location status online platform¹³

¹³ Source: CLP website (<https://services.clp.com.hk/ev/en/charginglocations.html>)

CHAPTER 6 POLICY IMPLICATIONS AND RECOMMENDATIONS

Promoting electric vehicles is an important adaptation strategy to improve roadside air quality and reduce greenhouse gas emissions in the era of climate change. Thus far, the electrification of automobiles in Hong Kong has been structured as an environmental issue – to improve air quality and reduce carbon emissions. For this reason, EPD is the leading proponent of EVs where other government units are, as yet, less involved. It is also important to the economy of Hong Kong as it can provide employment opportunities in green businesses. This research, therefore, is important for the popularisation of EVs and e-mobility in Hong Kong. In this chapter, we aim to provide policy implications and recommendations which could be of great value to several government units, including but not limited to the EPD, the Planning Department, and the Transport Department.

One major difference between EVs and traditional vehicles is their refuelling (recharging) method. Unlike the acquisition of diesel fuel, which is restricted by the physical location of gas stations, electricity flows around the city almost without terrestrial friction. One major obstacle faced by EV drivers currently is prompted by the lack of vents to gain access to the power source. Regarding this challenge, our spatial optimisation result offers a geographical solution for placing these “vents” – public charging facilities. In addition, this study provides a series of timely suggestions for strategic planning before the promulgation of Hong Kong 2030+ that will “Updat[e] the territorial development strategy to guide planning, land and infrastructure development and the shaping of the built environment of Hong Kong beyond 2030” (www.hk2030plus.hk); within which EV charging facilities require strategic coordination between transport and land use planning.

Our recommendations are structured into three sections. First, we compared the results of our spatial optimisation analysis with existing public charging facilities and highlighted neighbourhoods which suffer from considerable shortfalls of supply in order to suggest the strategic spatial planning of the public charging network. Second, we provide policy recommendations on charging service supply. Third, we propose measures promoting EV adoption demand through the further cultivation of an e-mobility friendly society. Both supply

and demand implications are formulated by addressing concerns from existing and potential EV users, industry, and government units.

6.1 The Strategic Spatial Planning of the Public Charging Network

In this section, a strategic spatial plan of public charging facilities is proposed according to the major findings of this research, the spatial distribution of existing charging sites, the probit model analysis, the visualisation of projected EV demand, and optimised location allocation. We divide the plan into three spatial contexts and make deployment recommendations that reflect the characteristics of each setting.

CBD and CBD2

Our optimisation results not only pinpoint shortfalls in current charging facility planning, but also reflect the fact that the two CBDs of Hong Kong (Central-Wan Chai CBD and CBD2 in Kowloon Bay) have been equipped with ample charging capacity. The abundance in charger supply in the CBD areas could be attributed to the concentration of major shopping malls and commercial buildings, given that these two building types already constitute 48% of charging locations in Hong Kong. In order to sustain and further enhance charging provision in these areas, we suggest continuous examination of workplace charging demand due to potential differences in usage behaviour as well as the adoption of a strategic deployment method focused on the CBD areas.

Our results from the spatial optimisation model offer novel insight on allocating chargers that could help address local issues of overwhelming parking demand and concentrated workplace charging demand. Our results reveal that there can be a much wider coverage of quick chargers which would enhance accessibility to fast recharging options. This quick charging deployment strategy reinforces the current policy framework by enabling proximate access to satisfy occasional emergency charging needs in the middle of EV journeys. We believe that dispersing charger deployment from high demand car parks could also contain the present

situation whereby there is both recharge queuing and crowding out by ICEV occupation. Scattering the charging supply venues is especially helpful in areas with saturated car parks. This approach could prevent the overlapping of major parking and charging demand when EV drivers flood into the same car parks. This deployment strategy may alleviate the tense charging vacancy in luxurious land use, such that more workplace charging could be demonstrated in substitution to home charging and, in the broader picture, the strategy could further arouse EV adoption.

New built-up developments/Urban renewal areas

Despite being called “new towns”, plenty of new town developments date back to the last century, for instance, the Sha Tin new town development commenced in the 1970s. The second spatial setting in our strategy is the new development zones planned after 2011. As stated in **Chapter 4**, East Kowloon has been identified as a key area for future charging network construction. Despite the abundance of public chargers along the coastal belt of Kowloon Bay and Kwun Tong where the commercial clusters are located, the more inland part of Kwun Tong, Ngau Tai Kok, Lam Tin, Yau Tong and Sau Mau Ping have not been covered by charging facilities. Our optimisation model proposes a vast amount of new charging points over the inland zone, Kwun Tong and Sau Mau Ping, where two new housing estates, On Tai Estate and On Tat Estate, are located. The new built-up area is pinpointed not only because it generates new travel destinations and potential enhanced EV demand from the new resident population, but also due to the underlying convenience of installing chargers in new buildings. Benefiting from the GFA concession policy, basically all buildings constructed since 2011 be they public rental estates or private developments, have EV charging enabled infrastructure. This allows chargers to be installed much more readily. By tracing these new development zones, the strategic placement of chargers can be optimised at minimal cost.

New towns

From our probit model and demand estimation, we learnt that positive EV demand in Hong Kong is not highly centralised in the urban core; rather, it is more evenly distributed across different districts of the three major regions (i.e., the Hong Kong Island, Kowloon Peninsula, and the New

Territories). When matched with the location allocation result, we found a strong overlapping of new charging points (red dots in **Figure 19**) and new town developments, which have been identified to cluster with high public charging demand street blocks. Considering the concentration of residential estates in new towns, car parks in these areas are more likely to serve as driving destinations and night-time parking venues. Therefore, forthcoming public charger deployment should be prioritised in new town areas.

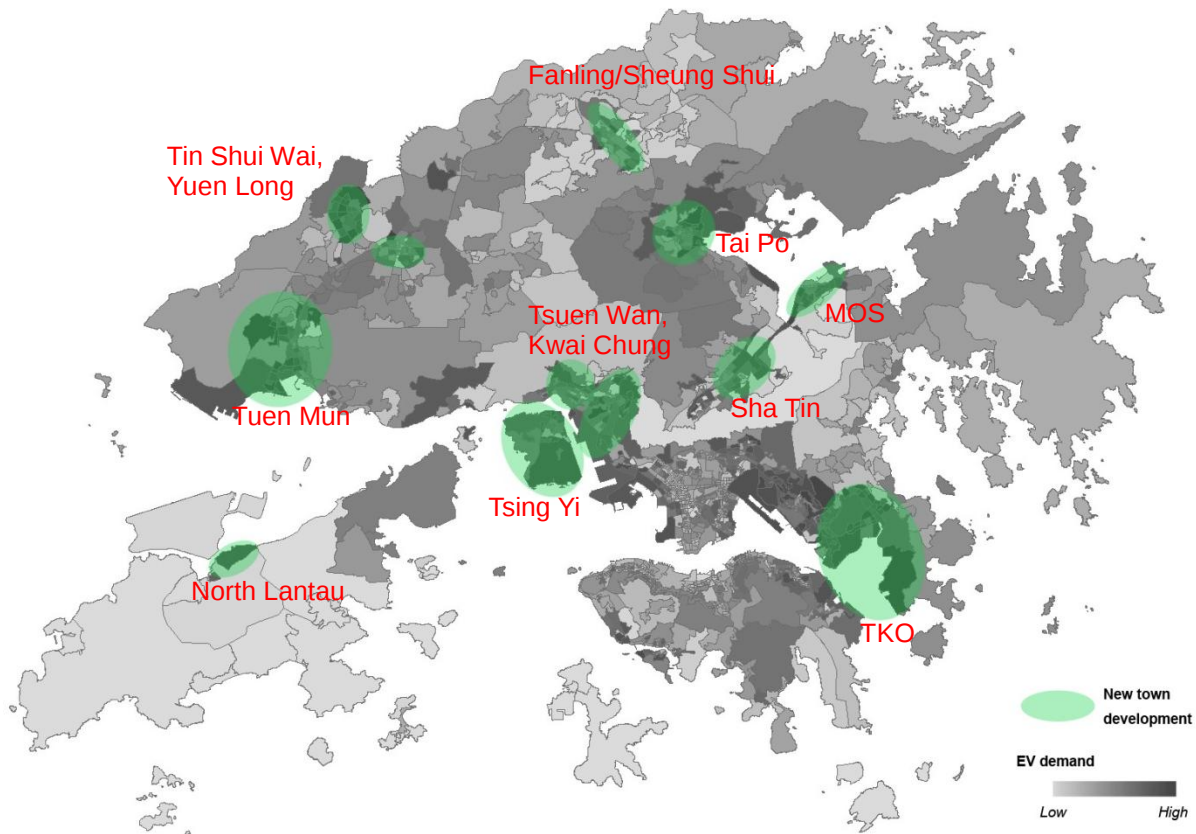


Figure 26. New towns in Hong Kong

In particular, four new towns in the New Territories, namely Tseung Kwan O, Tai Po, Tuen Mun and Yuen Long, are analysed as having major charger shortage for actualising the optimal plan. These areas have one trait in common: they are satellite town centres with considerable populations¹⁴. In our demand estimation, these communities are revealed to contain the leading

¹⁴ According to 2016 By-census data, Tseung Kwan O has 398,479 population, Tai Po has 270,728 population, Tuen Mun has 487,407 population, and Tin Shui Wai has 286,232 population.

public charging demand, yet available existing chargers are scarce. We highlight the location of these areas due to consideration of their relatively isolated locations which incur long commutes add travel for social activities in the main urban area. Greater battery depletion as a result of these factors generates a more pressing need for recharging from EV drivers travelling to and from these new towns in the New Territories. Therefore, we recommend installing a combination of standard and medium chargers to compensate for the presently unsatisfied local charging demand and quick chargers to respond to emergency exhaustion after long commuting. According to our interviews with facility suppliers, standard or medium chargers are more advantageous to mass deployment due to their lower costs; such deployment would precisely address the perceived charging problem in new town areas.

Apart from the deployment suggestions inspired by the optimisation output, we recognise that the promotion of e-mobility goes beyond the single-dimensional spatial context. Interlocking institutional, economical and even cultural influences also shape the driving pace of EV application in the city. Therefore, in the follow subsection of this chapter, we propose a series of practical recommendations to the supply and demand side of e-mobility in light of the in-depth interview findings presented in **Chapter 5**.

6.2 Enhancing Charging Supply

Towards a profitable EV charging market

Multiple stakeholders stressed the importance of an incentivised commercial market. A simple rational is that private enterprises will only engage in charging network provision if the business is profitable or they are given financial benefits. For public charging facilities, the current prevalence of free services is diminishing the room for profit. In order to rectify the adverse competition, the government must stipulate a timetable to gradually transit from free to charged charging service provisions to release a market signal attracting interested firms. The timetable should be included with a holistic plan on the entire issue of EV development. It should include clear milestone targets and corresponding policies whether they relate to tax incentive,

infrastructural investment, or publicity. Cumulatively such measures will help to ensure the gradual progression of EV uptake. To facilities suppliers and property owners, financial subsidies could be the most direction motivation that the government can offer, for example, cost reimbursement to facility suppliers and tax or rate concessions to property owners deploying chargers. This approach could first reduce the costs born by the public sector, as originally the government has to pay the full cost of deployment. By providing economic incentives to the market, the same deployment effect could be achieved with lower spending. Secondly, the approach could result in a substantial increase in potential charging sites on private lands. More specifically and with reference to charging enabling infrastructure, we can already see the progressive impacts from the GFA concession on new buildings, which is linked to the monetary sales profit of property developers. To take one step further, the GFA concessions criteria could be expanded from the current position of solely applying to underground car parks to include car parks at all levels (including both under- and above- ground). Similar financial incentives could be imposed on the 30% charger ratio specification in car parks from the Hong Kong Planning and Standard Guidelines, which are only advisory in nature as the Guidelines have no statutory power.

The promotion of home charging is interrelated to the issue of public charging. Despite the convenience brought by home charging, many existing EV owners are prevented from owning a personal charging facility due to external obstacles. Two major hurdles have been identified, which are (1) disapproval from IO and (2) lack of car park ownership. First, from the interview with EPD, the recent HK\$2 billion subsidies are targeted towards covering construction costs on public space in pursuit of appeasing financial concerns from IO. We recognise the potentially constructive impact of the subsidies on financing incurred construction work in public areas of residential buildings. However, the current sum is capped at HK\$30,000 per parking space, which may not be sufficient for installation work that involves construction of extra power supply infrastructure. Therefore, we recommend complementing the current scheme by granting larger subsidies to applicants whose buildings have insufficient remaining electricity capacity. Addressing the second hurdle, we suggest the wider introduction of semi-public charging sites for car parks where most residents renting their parking space. For housing estates where most residents do not have ownership rights over their parking spaces, installing a personal charger

may not be viable. Therefore, to cope with charging demand within these estates, and with reference to some monthly subscription plans on the market such as the RAS of EV Power, providing charging facilities in public parking spaces in estate car parks would be a more practical way to enable home charging. The chargers could be funded and owned by the management company or the IO, with a reservation platform for residents. In the early phase of operation, a charging fee could be set higher and chargers could be open to the public to enable a shorter cost recovery period. In general, we believe pending charger constructions would receive easier approval from IO in the future as more new buildings are equipped with basic charging infrastructure that reduces the extra cost incurred by later work.

Incentivisation could also take place at the car park management level. The enforcement of EV prioritising measures is currently dependent on the voluntary willingness of management companies. EV-friendly specifications can be added to contract renewal processes and compensation could be offered to car parks reserving vacant charging slots.

Smart layout in car parks



Figure 27. Example of common charging point layout¹⁵

In response to the existent shortage of parking spaces and the resultant occupation of charging spaces, existing charging point setups require acceptance of a new placement idea. Most charging facilities are attached to a fixed parking space highlighted in front and usually consecutive parking slots are installed with chargers. This traditional setup is rigid in the sense that it is very difficult, and often impossible, for EVs to use the charger if the designated parking slot is occupied. There have also been cases of poorly parked cars paralysing two charging slots at the same time reported in online communities (**Figure 28**). To overcome these problems, the

¹⁵ Source: Wenweipo (<http://paper.wenweipo.com/2016/06/17/HK1606170016.htm>)

proposed charging point layout (**Figure 29**) offers greater flexibility to charger access and alleviates blockage of service by vehicle occupation. Chargers are installed at the centre of adjacent parking spaces and enable more scattered distribution across the parking floor. Under this plan, one charger could feed either parking space from the surrounding ones, meaning that as long as one out of three (green) or four (yellow) eligible parking spaces is vacant, EV drivers could gain access to the charger facility. Depending on the actual setting, chargers using this layout may even cover more viable spaces should users possess longer charging cables. Though the diffused planting of chargers is expected to incur higher expenditure on cabling, this layout secures a supply of chargers especially in car parks that have high demand or have no exclusive usage rules on chargeable spaces.



Figure 28. Occupation of two charging spaces by an EV¹⁶

¹⁶ Source: Tesla Fan Club Facebook group

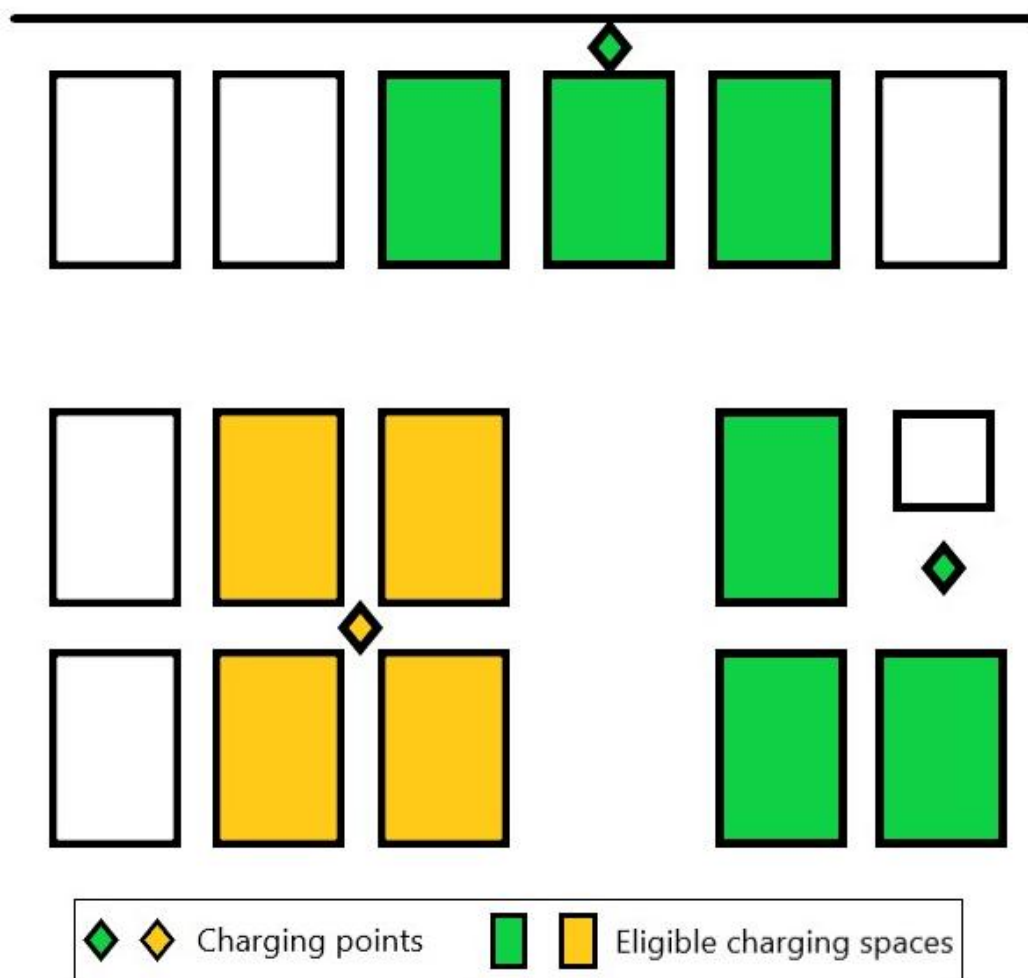


Figure 29. Proposed charging point layout¹⁷

Application of user-oriented technology

From our interviews, it was found that some smaller scale management companies and even the government do not have detailed usage records of their charging facilities. Wider application of usage monitoring devices is a foundational step for implementing the Internet of Things, and would enable charging behaviour big data analysis as well as performing load management. In assisting the building of a smart city in Hong Kong, the availability of precise and timely access

¹⁷ Source: Research team

to charger status information will assist EV owners to navigate to nearby vacant chargers. However, the present segregated charging supply market fails to unify gathered data to a single dissemination source and this prohibits the existence of a user-friendly process by which to find vacant charging facilities. EV drivers have instead to switch between multiple applications powered by their respective charger suppliers to find vacant slots. Further frustrating the users is the fact that some platforms on the market do not display the status of parking spaces and visitors may find the charging points occupied by non-charging vehicles upon arrival. A more integrated and user-friendly platform is required that provides comprehensive real-time charging status for all public chargers.

6.3 Promoting EV Demand

To promote public acceptance and better charging behaviour, education and training is important. Given that EV is a new mobility, even existing EV users may not have best knowledge of how to use an EV or when to charge their vehicles' batteries. Nurturing good charging habits will relieve some charging pressure by better preserving battery life and lessening inelastic urgent charging demand. Expert opinions suggest a frequent charging habit to recharge the EV before reaching the 50% remaining battery level is better than the more common practice of quick top up recharges at near exhaustion level. With a more regular charging habit, drivers could constantly maintain their EVs at a high battery level in preparation for unforeseeable disposal. Shortening the recharge interval also diminishes reliance on fast charging service as medium or standard chargers are already capable of accommodating the smaller charge that arises from more frequently charged EVs. This is especially advantageous to home charging where EV owners could benefit from more affordable options. However, judging from stakeholders' observations and our survey results, this charging mode is not widely advocated by general EV owners, probably due to their lack of knowledge and limited availability of secured charging places. Better education from EV sellers and the government is, therefore, essential. The government could also promote publicity pertaining to relevant car usage and charging tips in locations such as TD Licensing Offices, Vehicle Examination Centres, and the Regional Offices of government departments.

Marketing of the latest programmes and news of EV is another key process that is needed to ease concerns of access to charging facilities amongst existing EV users. Regular meetings to educate IO and real estate managing companies about charger installation procedures and information on the latest financial assistance available may induce smoother approval of installation applications.

In terms of EV promotion to non-EV owners, measures could be formulated with the aim of expanding EV exposure as prior experience is proven to be a stimulus to EV adoption in our study and other case studies from overseas (Thøgersen & Ebsen, 2019). For example, by using EVs in driving tests or as integral part of motoring courses, new licensed drivers who may subsequently become private vehicle buyers could gain first-hand experience of driving EVs; this may heighten their purchase intention. Non-EV owners may also be reluctant to invest a large sum of money on luxurious EV models. Our survey results show a match between intended EV purchase budget and the tax free price under the current concession scheme. Therefore, the government and car dealers should place the marketing focus on lower-end models, particularly those falling within the range of tax concession, to attract more adoption from the latent demand group. In addition, the government might consider re-instating a heavier subsidy or granting a larger tax reduction (e.g., FRT) for first time EV buyers.

CHAPTER 7 CONCLUSION

How to optimise the deployment and operation of current and future EV charging infrastructures has been a long pending challenge for academics, environmentalists, stakeholders and policy makers. This study proposes a planning method framework to optimise the deployment of EV charging infrastructures under certain institutional and spatial constraints in Hong Kong. We integrated both quantitative and qualitative methods to explore the current situation of EV chargers from demand and supply perspectives and, from so doing, hereby recommend deployment of potential chargers in Hong Kong. In addition, with the aim of enhancing drivers' EV adoption intentions, we also conducted in-depth interviews with stakeholders and consumers to gain a more comprehensive view of the current situation and challenges; this further informed our proposals for the future improvement of EV charging facilities.

From the supply analysis, we discovered an imbalanced supply landscape of public charging in Hong Kong that generates ongoing inconvenience for EV owners who need to use charging facilities – this is especially true in the New Territories area. Through spatial visualisation, we found that public charging facilities are relatively scarce in New Territories even over high-dense town centre areas (i.e., Tuen Mun, Tin Shui Wai, Tai Po and Sha Tin) compared with those in Kowloon and the Hong Kong Island. Our accessibility analysis helped us to understand the most accessible EV chargers within 5-min walking distance in TPU scale. In addition, it revealed that the majority of neighbourhoods (approximated at TPU level) in the New Territories cannot access a public EV charger within the 5-min walking distance irrespective of charger type desired. One exception is a notable hotspot for standard charger accessibility in Tai Po - mainly attributed to the existence of 25 chargers in Po Heung Estate (public housing). Although relatively abundant chargers are available in Hong Kong Island and Kowloon, there is still an imbalanced supply of EV chargers in these urban areas. For instance, we found that standard chargers are mainly clustered in Wan Chai, Tai Koo and Shau Kei Wan on the Hong Kong Island side, and clustered in Tsim Sha Tsui, Kowloon Bay, and Kwun Tong on the Kowloon side. In addition, quick chargers are heavily clustered around the Central-Wan Chai CBD and areas with high-end shopping malls and real estate projects. The actual utilisation and temporal variation may deserve further examination.

From the demand analysis, we estimate drivers' intentions of buying an EV at individual and neighbourhood level based on an ordered probit model. **At the individual level**, both personal and household attributes were found to be significant. Several individual characteristics confirmed their effect in the Hong Kong context. For instance, gender has a significant effect in models: female are less likely to adopt EV than their male counterparts. In addition, age and level of educational attainment are significant. EV owners aged below 35 find EVs more acceptable, while individuals holding university degree are also more likely to purchase EVs. Several household characteristics were shown to be significant. We found that, generally, household income has a marginally positive significant correlation with EV purchase intention while household size also positively correlated with this decision. In addition, the number of cars in a household increases the chance of purchasing an EV but the effect is negative for non EV-owners (although only statistically significant at 10% level). More interestingly, our results indicate that households living in private housing tend to be less likely to purchase an EV, compared to those who live in public housing. This may be explained by the growing number of public housing estate and estate car parks directly managed by the government which are equipped with EV chargers; accelerating the accessibility of charging facilities in public housing communities, and echoed in one of the supply hotspots in Tai Po –Po Heung Estate (public housing estate). Finally, **at the neighbourhood level**, we also collected each respondent's home and workplace location in the model (**Table 7**). Overall, we found residents in the Central and Western, Kowloon City, Sai Kung, Sham Shui Po, Tai Po, Tuen Mun, and Yau Tsim Mong districts tended to purchase an EV. People who work at Islands and Sham Shui Po district are significantly less likely to purchase an EV. Potential explanations for this difference may be related to the economic, social and topographic characteristics of each district; this is another broad topic that lies beyond the scope of this project.

Faced with the imbalance between supply and demand of current deployments of EVs, we developed a location-allocation model to suggest an optimal allocation plan when allocating and operating future EV charging facilities. Our allocation solution proves effective: 99.95% of the area of Hong Kong is covered and residents only need to travel 170.60m on average to access a public EV charging facility. Specifically, a total of 5,840 new standard chargers, 354 new medium chargers, and 1,245 new fast chargers need to be installed in both existing and new EV

charging stations to satisfy EV charging demands. Second, in addition to the 318 car parks which have existing EV charging facilities, 939 new locations, especially in New Territories need to establish EV charging infrastructure to address the existent shortage of accessible EVs. The spatial allocation of those new charging locations basically follows the urban development of Hong Kong – along the two sides of the Victoria Harbour and in major new towns in the New Territories, namely Sha Tin, Ma On Shan, Tseung Kwan O, Tuen Mun, Yuen Long, Tai Po and Sheung Shui. Two particular urban areas see sparse deployment of new chargers, which are the Central-Wan Chai CBD and the CBD2 in Kowloon Bay and Kwun Tong. This is primarily because of the abundance of existing chargers and the fact that our model is based on residential population rather than jobs (that is, the small number of residential population in the CBD and, to a lesser extent, CBD2 would generate a relatively low charging demand based on our model).

Based on the aforementioned findings as well as our in-depth interviews with multiple stakeholders, we have a number of policy recommendations. Our first list of recommendations focuses on the **strategic spatial planning** of public EV chargers. The recommendations aim to address the imbalanced spatial planning of EV charging infrastructure across the region. We built a location-allocation model to make deployment recommendations for (1) CBD/CBD2, (2) Urban renewal areas, and (3) new towns, respectively. The details of our recommendation in these three types of areas are contained within **Section 6.1**.

Our third list of recommendations is aimed to foster greater **public acceptance** of e-mobility and hence **demand** of EVs. Firstly, we found that the number of chargers publicly accessible (e.g., available within five minutes of walking distance of an individuals' residential district) to be highly significant in affecting people's purchasing intentions. Therefore, we should make more effort to build more public charging facilities. Secondly, a special marketing strategy is needed to attract potential EV consumers. Policies like using EVs in driving tests or as an integral part of motoring courses would expose people to EVs and may be an effective way in promoting their desire to purchase EVs in the near future. Expanding the low-end EV market also fits consumers' budgets and suits the current tax concession scheme, while the FRT concessions could also be altered and increased (i.e., raising the tax deduction level). Thirdly, nurturing a regular charging timetable may help relieve pressure on the charging network and

help to better preserve battery life.

Our second list of recommendation focuses on **supply**. Two major hurdles to installing home charging facilities have been identified; disapproval from IO and lack of car parking space ownership. Therefore, we recommend complementing the current scheme by granting larger subsidies to applicants whose buildings have insufficient spare electricity capacity. Semi-public charging facilities could be introduced to car parks that are comprised of predominantly rented parking spaces. For public charging, the current service is largely free and hence not profitable. To a certain extent, such free provision of electricity is a distortion of the market and comes at a cost to other users. In order to attract more investment in the development of EV charging facilities, the government needs to gradually adjust charging fees. Further, subsidies need to be offered so as to lower the cost of charging infrastructure – to both suppliers and property owners. For example, the government might provide cost reimbursement to facility suppliers and tax or rate concessions to property owners. Incentivisation could also take place at the car park management level. The enforcement of EV prioritising measures is currently dependent on the voluntary willingness of management companies.

Policy recommendations on the supply side are also proposed to ascertain valid connections to public chargers. In response to the prevalent shortage of parking spaces and the resultant problem of the occupation of charging spaces, a smarter layout for car parks is crucial to effectively utilise limited space. The traditional setup is rigid in the sense that EVs face substantial problems in accessing the charger if the designated parking slot is occupied. To address this we proffered, in **Section 6.2**, a layout alteration that offers greater flexibility to charger access and alleviates blockage of service. This may give potential directions for layout improvements to charging facility suppliers and car park management companies. A user-oriented charger location platform is also desperately needed so that existing EV owners may receive full data with regard to the real time availability of appropriate charging points.

CHAPTER 8 PUBLIC DISSEMINATION

8.1 Public Workshop

A policy public forum has been scheduled to be held in April 2020. The workshop is supported by the Hong Kong Institute of Asia-Pacific Studies (HKIAPS) of CUHK. Invited speakers and panelists include government official(s), a LegCo member, academics, industry professionals, consultants, and representative(s) from an EV user alliance.

8.2 Conference Presentation

A paper based on **Chapter 4**, titled “The Demand for Electric Vehicles: Preliminary Findings from a Recent Survey in Hong Kong” was presented at the annual conference of the Hong Kong Society for Transportation Studies (HKSTS), December 14-16, 2019 (Hong Kong).

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APPENDIX I QUESTIONNAIRE IN CHINESE

在香港使用電動車問卷

第一部份 購買意向

1. 你持有香港身份證嗎？	☐ 有		☐ 沒有	
2. 你擁持有有效的駕駛執照嗎？	☐ 有		☐ 沒有（感謝您的參與，問卷完）	
3. 你擁有私家車嗎（作為車輛的主要駕駛者）？	☐ 有		☐ 沒有	
4. 你的家庭擁有多少輛私家車？	☐ 0 輛	☐ 1 輛	☐ 2 輛	☐ 3 輛或以上
5. 你擁有電動車嗎？（只需私家車主回答）	☐ 有（至 5.1）		☐ 沒有	
5.1. 你擁有哪個型號的電動車？（只需電動車主回答）				
5.2 你曾坐過電動車嗎（作為乘客或駕駛者）？	☐ 有		☐ 沒有	
簡介				
以下問卷將提出一系列的陳述，你將以 1 至 7 的分數表達你對該陳述的態度，如下例：				
今天是晴朗的一天。	十分不同意 十分同意 1 2 3 4 5 6 7			
意向問題				
1. 我對電動車感興趣。	十分不同意 十分同意 1 2 3 4 5 6 7			
2. 我有意在下次買車時購買電動車。	一定不會 一定會 1 2 3 4 5 6 7			
3. 我有意在未來五年購買電動車。	一定不會 一定會 1 2 3 4 5 6 7			
4. 下列各項因素對你決定購買私家車（包括電動車）有多重要？				
汽車品牌	完全不重要 尤關重要 1 2 3 4 5 6 7			
汽車性能	完全不重要 尤關重要 1 2 3 4 5 6 7			
汽車價格	完全不重要 尤關重要 1 2 3 4 5 6 7			

充電設施	完全不重要 1 2 3 4 5 6 7 尤關重要
家人意見	完全不重要 1 2 3 4 5 6 7 尤關重要
朋友意見	完全不重要 1 2 3 4 5 6 7 尤關重要
補貼	完全不重要 1 2 3 4 5 6 7 尤關重要
5. 如你計劃在未來五年購買電動車，你有多少預算？	☐ 100,000HKD 以下 ☐ 100,000-200,000HKD ☐ 200,000-300,000HKD ☐ 300,000-400,000HKD ☐ 400,000-500,000HKD ☐ 500,000-600,000HKD ☐ 600,000HKD 以上
6. 如果你計劃購買電動車，你會選擇哪個品牌？（可選多項）	☐ Tesla (特斯拉) ☐ EuAuto (優奧托) ☐ Mitsubishi (三菱) ☐ Nissan (日產) ☐ BMW (寶馬) ☐ Renault (維信) ☐ BYD (比亞迪) ☐ TAZZARI ☐ Mercedes-Benz (奔馳) ☐ Volkswagen (大眾) ☐ Hyundai (現代) ☐ 沒有傾向
認知因素	
1. 我很了解電動車。	十分不同意 1 2 3 4 5 6 7 十分同意
2. 我知道怎樣評價一輛電動車的質素。	十分不同意 1 2 3 4 5 6 7 十分同意
3. 以我對電動車的知識，我能安心購買電動車。	十分不同意 1 2 3 4 5 6 7 十分同意
4. 我比大部分人更了解電動車。	十分不同意 1 2 3 4 5 6 7 十分同意
態度因素	
1. 對我來說，購買電動車：	
	十分差 1 2 3 4 5 6 7 十分好

	十分沉悶 1 2 3 4 5 6 7 十分有趣
	十分無意義 1 2 3 4 5 6 7 十分有價值
	十分愚蠢 1 2 3 4 5 6 7 十分明智
	十分不專業 1 2 3 4 5 6 7 十分專業
主觀規範問題	
1. 對我重要的人認為：	我不應購買/擁有電動車 1 2 3 4 5 6 7 我應該購買/擁有電動車
2. 外界期望我購買/擁有電動車而非汽油或柴油車。	十分不同意 1 2 3 4 5 6 7 十分同意
3. 很多對我重要的人擁有電動車。	十分不同意 1 2 3 4 5 6 7 十分同意
4. 意見對我重要的人會：	不喜歡我購買/擁有電動車 1 2 3 4 5 6 7 喜歡我購買/擁有電動車
5. 與我相似的人擁有電動車。	十分不同意 1 2 3 4 5 6 7 十分同意
個人規範問題	
1. 擁有一輛不環保和不能源有效的車輛有時令我感到自責。	十分不同意 1 2 3 4 5 6 7 十分同意
2. 我有強烈的義務去購買/擁有一輛環保的車輛。	十分不同意 1 2 3 4 5 6 7 十分同意
3. 根據我的價值觀，購買/擁有一輛環保的車輛是正確的事情。	十分不同意 1 2 3 4 5 6 7 十分同意

感知行為的對照問題							
1. 如果情況許可，我會購買電動車。	十分不同意						十分同意
	1	2	3	4	5	6	7
2. 如果我想，我能夠購買電動車。	十分不同意						十分同意
	1	2	3	4	5	6	7
3. 擁有電動車涉及很多問題及困難。	十分不同意						十分同意
	1	2	3	4	5	6	7
4. 我肯定我能夠：							
駕駛電動車	十分不同意						十分同意
	1	2	3	4	5	6	7
為電動車充電	十分不同意						十分同意
	1	2	3	4	5	6	7
避免用盡電量	十分不同意						十分同意
	1	2	3	4	5	6	7
行為想法問題							
1. 普遍電動車的里程數不足夠供我日常駕駛所用。	十分不同意						十分同意
	1	2	3	4	5	6	7
2. 普遍電動車的里程數間中不足夠供我駕駛所用。	十分不同意						十分同意
	1	2	3	4	5	6	7
3. 汽油或柴油車明顯地比電動車能更快加速。	十分不同意						十分同意
	1	2	3	4	5	6	7
4. 電動車在超車（扒頭）時有困難。	十分不同意						十分同意
	1	2	3	4	5	6	7
5. 電動車比汽油或柴油車安靜。	十分不同意						十分同意
	1	2	3	4	5	6	7
6. 駕駛電動車明顯地比汽油或柴油車更為舒適。	十分不同意						十分同意
	1	2	3	4	5	6	7

7. 電動車明顯地比汽油或柴油車需要更少維修保養。	十分不同意	十分同意
	1 2 3 4 5 6 7	
8. 你如何評價下列電動車的設計：		
Tesla model S	十分難看	十分漂亮
	1 2 3 4 5 6 7	
Tesla model 3	十分難看	十分漂亮
	1 2 3 4 5 6 7	
Volkswagen e-Golf	十分難看	十分漂亮
	1 2 3 4 5 6 7	
BMW i3	十分難看	十分漂亮
	1 2 3 4 5 6 7	
Renault Zoe	十分難看	十分漂亮
	1 2 3 4 5 6 7	
Nissan Leaf	十分難看	十分漂亮
	1 2 3 4 5 6 7	
9. 電動車的日常使用開支明顯地比汽油或柴油車低。	十分不同意	十分同意
	1 2 3 4 5 6 7	
10. 電動車比汽油或柴油車貴。	十分不同意	十分同意
	1 2 3 4 5 6 7	
11. 電動車明顯地比汽油或柴油車更環保。	十分不同意	十分同意
	1 2 3 4 5 6 7	
12. 普遍的電動車充電時間對我來說太長了。	十分不同意	十分同意
	1 2 3 4 5 6 7	
13. 電動車經常在駕駛途中耗盡電量。	十分不同意	十分同意
	1 2 3 4 5 6 7	
個人規範想法問題		
1. 駕駛引致主要環境問題。	十分不同意	十分同意
	1 2 3 4 5 6 7	

2. 駕駛對氣候變化有影響。	十分不同意 1 2 3 4 5 6 7 十分同意
3. 我的車程影響下一代的生活素質。	十分不同意 1 2 3 4 5 6 7 十分同意
4. 如果我減少駕駛，我對環境保護作出貢獻。	十分不同意 1 2 3 4 5 6 7 十分同意
5. 我的駕駛對全球環境問題有影響。	十分不同意 1 2 3 4 5 6 7 十分同意
對照想法問題	
1. 在我的住所為電動車充電很麻煩。	十分不同意 1 2 3 4 5 6 7 十分同意
2. 在公共充電站為電動車充電很麻煩。	十分不同意 1 2 3 4 5 6 7 十分同意
3. 我能夠習慣為電動車充電。	十分不同意 1 2 3 4 5 6 7 十分同意
4. 我沒有耐性去等待電動車充電。	十分不同意 1 2 3 4 5 6 7 十分同意
5. 香港的電動車充電站太少了。	十分不同意 1 2 3 4 5 6 7 十分同意
6. 很難找到電動車充電站。	十分不同意 1 2 3 4 5 6 7 十分同意
7. 我可以在住所泊車時為電動車充電。	十分不同意 1 2 3 4 5 6 7 十分同意
政策與科技期望問題	
1. 我預期在不久的將來會有新政策倡議提升電動車的需求增長。	十分不同意 1 2 3 4 5 6 7 十分同意

2. 「在 2017 年 4 月，政府以上限為\$97,500 的首次登記稅寬減額取代原有的電動車首次登記稅豁免政策。在 2018 年 4 月，以電動車取締舊有內燃引擎私家車的車主可享受更高的首次登記稅寬減額。」我預期在不久的將來電動車會受惠於更多有利的政策。	十分不同意						十分同意
	1	2	3	4	5	6	7
3. 我只會在完全豁免首次登記稅的情況下購買電動車。	十分不同意						十分同意
	1	2	3	4	5	6	7
4. 我只會在有更多公共充電站的情況下購買電動車。	十分不同意						十分同意
	1	2	3	4	5	6	7
5. 我預期電動車科技在未來五年會有明顯的進步。	十分不同意						十分同意
	1	2	3	4	5	6	7
6. 我預期電動車的生產成本在未來五年會明顯地降低。	十分不同意						十分同意
	1	2	3	4	5	6	7
7. 我預期電動車的里程數在未來五年會明顯地提升。	十分不同意						十分同意
	1	2	3	4	5	6	7
8. 我預期在未來五年會有更多公共充電站。	十分不同意						十分同意
	1	2	3	4	5	6	7
9. 我預期電動車的充電時間在未來五年會明顯地減少。	十分不同意						十分同意
	1	2	3	4	5	6	7
自由題							
1. 提出 3 項會顯著提高你購買電動車的可能性的政策或科技轉變。							

第二部份 出行及充電習慣

1. 你的日常單程通勤需時多久？	☐ 30 分鐘以內	☐ 30-60 分鐘	☐ 多於 1 小時	☐ 不定
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2. 你的日常駕駛里數（全天）約為多少？（只需私家車主回答）	☐ 20 公里以下 ☐ 20-39 公里 ☐ 40-59 公里 ☐ 60-79 公里 ☐ 80-99 公里 ☐ 100-119 公里 ☐ 120-139 公里 ☐ 140 公里以上																				
3. 你使用私家車的主要目的是什麼？（只需私家車主回答）	☐ 工作 ☐ 接送孩子上學 ☐ 休閒娛樂 ☐ 其他（請註明）																				
4. 在晚間，你通常在哪裏泊車？（只需私家車主回答）	☐ 我在所住屋苑擁有停車位 ☐ 我在所住屋苑外擁有停車位 ☐ 我在所住屋苑租用固定停車位 ☐ 我在所住屋苑外租用固定停車位 ☐ 我在所住屋苑租用不固定停車位 ☐ 我在所住屋苑外租用不固定停車位 ☐ 我的獨立屋/村屋擁有車房																				
5. 在日間，你通常在哪裏泊車（A-J）？你通常每次會在上述地方停泊多久（1-6）？（如多於一處，請分別列明）（只需私家車主回答）	<table border="0"> <tr> <td>A. 住所</td> <td>B. 公司</td> <td>C. 路邊泊位</td> <td>D. 公共停車場</td> </tr> <tr> <td>E. 私人停車場</td> <td>F. 商場</td> <td>G. 酒店</td> <td></td> </tr> <tr> <td>H. 除公司外的商業大廈</td> <td>I. 除住所外的屋苑</td> <td>J. 其他（請註明）</td> <td></td> </tr> </table> <table border="0"> <tr> <td>1. 1 小時</td> <td>2. 2 小時</td> <td>3. 3 小時</td> <td>4. 4 小時</td> </tr> <tr> <td>5. 5 小時</td> <td>6. 6 小時或以上</td> <td></td> <td></td> </tr> </table> 例子：在公司停泊 5 小時→B5	A. 住所	B. 公司	C. 路邊泊位	D. 公共停車場	E. 私人停車場	F. 商場	G. 酒店		H. 除公司外的商業大廈	I. 除住所外的屋苑	J. 其他（請註明）		1. 1 小時	2. 2 小時	3. 3 小時	4. 4 小時	5. 5 小時	6. 6 小時或以上		
A. 住所	B. 公司	C. 路邊泊位	D. 公共停車場																		
E. 私人停車場	F. 商場	G. 酒店																			
H. 除公司外的商業大廈	I. 除住所外的屋苑	J. 其他（請註明）																			
1. 1 小時	2. 2 小時	3. 3 小時	4. 4 小時																		
5. 5 小時	6. 6 小時或以上																				
6. 如果你擁有/計劃購買電動車，你傾向在哪裏充電？	☐ 住所 ☐ 公司 ☐ 路邊泊位 ☐ 公共停車場 ☐ 私人停車場 ☐ 商場 ☐ 酒店 ☐ 除公司外的商業大廈 ☐ 除住所外的屋苑 ☐ 其他（請註明）																				
7. 現時你通常在何處為你的電動車充電？（只需電動車主回答）	☐ 住所 ☐ 公司 ☐ 路邊泊位 ☐ 公共停車場 ☐ 私人停車場 ☐ 商場 ☐ 酒店 ☐ 除公司外的商業大廈 ☐ 除住所外的屋苑 ☐ 其他（請註明）																				
8. 你的電動車通常多久充電一次？（只需電動車主回答）	<table border="0"> <tr> <td>☐ 1 天一次</td> <td>☐ 2 天一次</td> <td>☐ 3 天一次</td> </tr> <tr> <td>☐ 4 天一次</td> <td>☐ 5 天一次</td> <td>☐ 6 天一次</td> </tr> <tr> <td>☐ 1 週一次</td> <td>☐ 1 週數次（請註明）</td> <td>☐ 半月一次</td> </tr> <tr> <td>☐ 一月一次</td> <td>☐ 其他（請註明）</td> <td></td> </tr> </table>	☐ 1 天一次	☐ 2 天一次	☐ 3 天一次	☐ 4 天一次	☐ 5 天一次	☐ 6 天一次	☐ 1 週一次	☐ 1 週數次（請註明）	☐ 半月一次	☐ 一月一次	☐ 其他（請註明）									
☐ 1 天一次	☐ 2 天一次	☐ 3 天一次																			
☐ 4 天一次	☐ 5 天一次	☐ 6 天一次																			
☐ 1 週一次	☐ 1 週數次（請註明）	☐ 半月一次																			
☐ 一月一次	☐ 其他（請註明）																				
9. 你通常在電量剩餘多少時為電動車充電？（只需電動車主回答）	☐ 0-19% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80-99%																				

10. 你通常把你的電動車充電到多滿呢？（只需電動車主回答）	☐ 充滿 (100%)	☐ 80-99%	☐ 60-79%
	☐ 40-59%	☐ 20-39%	☐ 0-19%

第三部份 人口資料

1. 你的性別是？	☐ 男性	☐ 女性			
2. 你的年齡是？	☐ 24 歲或以下 ☐ 45-54 歲	☐ 25-34 歲 ☐ 55-64 歲	☐ 35-44 歲 ☐ 65 歲或以上		
3. 你的最高教育程度是？	☐ 中學或以下 ☐ 碩士	☐ 文憑/證書/ 副學士 ☐ 博士或以上	☐ 學士		
4. 你的婚姻狀況是？	☐ 從未結婚	☐ 已婚	☐ 鰥寡/離異/分居		
5. 你的住所類型是？	☐ 公屋 ☐ 非住宅用房屋（非住宅樓宇單位/旅館）	☐ 居屋	☐ 私人樓 ☐ 臨時房屋		
6. 你的居所租住權是？	☐ 自置，有按揭供款或借貸還款 ☐ 自置，沒有按揭供款或借貸還款 ☐ 全租 ☐ 合租/二房東/三房客 ☐ 由僱主提供/免收租金				
7. 你的居住區份為	☐ 元朗 ☐ 北區 ☐ 觀塘	☐ 屯門 ☐ 葵青 ☐ 九龍城	☐ 荃灣 ☐ 離島 ☐ 灣仔 ☐ 大埔 ☐ 黃大仙 ☐ 南區	☐ 沙田 ☐ 油尖旺 ☐ 東區	☐ 西貢 ☐ 深水埗 ☐ 中西區
8. 你的工作區份為	☐ 元朗 ☐ 北區 ☐ 觀塘	☐ 屯門 ☐ 葵青 ☐ 九龍城	☐ 荃灣 ☐ 離島 ☐ 灣仔 ☐ 大埔 ☐ 黃大仙 ☐ 南區	☐ 沙田 ☐ 油尖旺 ☐ 東區	☐ 西貢 ☐ 深水埗 ☐ 中西區
9. 你的家庭有多少個成員（除外籍傭工）？	☐ 1 個 ☐ 4 個	☐ 2 個 ☐ 5 個	☐ 3 個 ☐ 6 個或以上		
10. 你的家庭有多少個 0-14 歲兒童？	☐ 沒有	☐ 1 個	☐ 2 個	☐ 3 個或以上	

11. 你的住戶結構是？	☐ 單人住戶 ☐ 由夫婦組成 ☐ 由夫婦及未婚子女組成 ☐ 由父或母親及未婚子女組成 ☐ 由夫婦及其中至少一個父或母親組成 ☐ 由夫婦、其中至少一個父或母親及其未婚子女組成 ☐ 由其他親屬關係組合組成 ☐ 非親屬關係住戶
12. 你的就業狀況是？	☐ 受僱 ☐ 自僱 ☐ 學生 ☐ 退休 ☐ 沒有工作 ☐ 其他（請註明）
13. 你的每月收入（港元）是？	☐ <10,000 ☐ 10,000-14,999 ☐ 15,000-19,999 ☐ 20,000-24,999 ☐ 25,000-29,999 ☐ 30,000-39,999 ☐ 40,000-59,999 ☐ 60,000-79,999 ☐ 80,000-99,999 ☐ $\geq 100,000$

第四部份 問卷來源

1. 請問你從哪個途徑取得此問卷？	☐ 社交媒體群組 ☐ 面談訪問 ☐ 其他（請註明）	☐ 網上論壇 ☐ 電話訪問	☐ 關注團體派發 ☐ 派發單張
2. 請問你是任何一個環境關注組織的成員嗎？	☐ 是	☐ 不是	
3. 你願意參與跟進調查（如有）嗎？	☐ 願意	☐ 不願意	
4. 你願意參與年末的公眾研討會，以了解研究結果嗎？	☐ 願意	☐ 不願意	
5. 如你在以上問題回答「願意」，請提供您的聯絡方法：			

問卷完，感謝您的參與

APPENDIX II INTERVIEW TRANSCRIPT – EPD

現在政府推動電動車有什麼主要方向和目標？

政府推動電動車最主要原因是空氣污染排放，因為電動車在路面沒有廢氣排放，以及其能源效益比較好，可以節省能源。變相來說，除了在空氣方面有貢獻，在減碳方面亦有好處。我們現時來說最主要的目標是與減排有關，未來亦會著墨於減碳，因為始終電動車發電亦有排放，所以是相連的。發電方面用更乾淨的能源，整體來說也可以減碳。至於電動車來說，現時我們主要分開私家車及商用車兩方面。首先，如果以空氣污染物來說，**商用車的空氣污染物排放佔了整體車輛的超過九成，所以政府會重點推動商用電動車**。私家車方面，政府亦會鼓勵，但因為現在私家車的技術比較成熟，商用車則未成熟，所以推行政策的方法就會不同。

現時主要有什麼具體措施？

措施是多方面的。第一件事是我們要分開私家車及商用車的措施，因為兩者處理方法不同，原因是技術及使用方面都不同。首先是稅務方面，現時來說私家車需要繳交首次登記稅，首次登記稅現時提供九萬七千五百元的減免，這個安排會直至明年 2021 年的 3 月。我們亦有一換一計劃，主要是將舊私家車拆車後可以換電動私家車，首次登記稅減免就是二十五萬。換句話說，如果車價是三十七萬七千五百元，他其實就不用繳稅。這樣做是因為不想路面的車輛數量增長。另外，我們會訂立電動車規劃，在香港規劃標準與準則裡面已經訂立了新樓宇的所有車位都應該為電動車準備充電，我們已經預備好電力和線，而且應該要有百分之三十的車位是有充電器，這個已經在規劃署的標準與準則裡面。屋宇署方面在新建的樓宇亦有計劃，從 2011 年 4 月直至現在，新樓宇發展商可以申請樓面面積豁免。全部車位完成所有充電基礎建設，即是所有充電線和預留電力，基本上就可以獲取樓面面積寬免。直至建成後，如果將來車位的用家希望擁有電動車、安裝充電器，他就可以安裝到。

另外，商用車還有電單車直至現在是完全免首次登記稅，因為它們的技術未成熟。至於企業如果購買電動車，購買電動車的費用於第一年就已經可以完全扣稅，不用折舊。政府也推出很多不同的試驗計劃，其中一個就是綠色運輸試驗基金，資助申請人試用商用電動車，當時撥款三億元予該基金。另外一億八千萬就給予巴士公司試用 36 部電動巴士，現在有 33 部已經落地。有些已經

試用完，有些試用後現在仍然繼續運行。舉個例子，有些巴士例如 13 號路線已經有輛比亞迪電動巴士在日常運作，即是已經試用完而沒有問題。可惜試驗結果顯示，譬如它晚上充電，日間不可以全日運作，尤其是夏天需要開啟冷氣，在技術上有限制。小型車譬如私家車的技術其實可以，但重型車譬如大巴士，雙層巴士現時還未有，單層巴士的技術在香港來說也未做到 100% 可以等同一輛傳統的，即使單層巴士仍未做到。所以不同車種有不同措施去嘗試，以前我們環保署亦有跟的士嘗試過一次電動的士，不過那一次還是失敗。電動的士那一次有幾十部比亞迪試用，但結果是不可以做到。因為的士行業分兩更制，二十四小時運作，他們入油的時間很短，但如果要使用電動車，充電需要很長時間，譬如一天需要四個小時充電才可以運行兩更，這樣他們的生意減少很多。而且以當時來說，當年試用的時候車種電池壽命方面與今天的科技不同，當時的電池沒那麼耐用。

另外一項措施就是公共充電器供電動車私家車充電，外面的私人機構會做，我們政府也做，我們現在環保署的網站稱直至十二月的公共充電器數量有二千九百多個。去年二月的財政預算案公佈了我們會在政府停車場加設超過一千個公共充電器，現在開始進行工程。另外一個就是會找地方建設快充站，不過在香港找地比較難。另外一種做法就是嘗試在路邊泊車位安裝充電器，這個財政預算案已經在去年二月公佈。去年九年在施政報告公佈了政府會撥款二十億元資助一些私人住宅樓宇安裝充電器，基本上每個車位的上限為三萬元，每個停車場的上限為一千五百萬元。所有資料都在去年十二月十六日，立法會環境事務委員會的文件裡面，列明我們考慮的申請資格。接下來也會有其他新措施，包括電動小巴。我們打算在專線小巴中實行電動專線小巴私營計劃，剛好在昨日一月二十二日，環保事務委員會的文件披露計劃。昨日的文件還有一件事，關於剛才所說的綠色試驗基金。因為運作了這麼多年，那時基金三億的撥款現在只耗用了一億多，很多人說要發放金錢去改善計劃，昨日在立法會已經討論過，會轉型運作一個新能源車的試驗基金，裡面會有兩方面，一方面會像以前的模式一樣試用電動車，另外就是如果試驗出一些技術已經成熟、可以應用的話會資助應用。因為始終電動商用車很多性能、續航力方面等等均未及傳統柴油、汽油車。私家車方面技術已經成熟，主要是價錢方面貴，但如果商用車的話暫時還未成熟。不過也看到一個趨勢就是輕型貨車亦會很快成熟。

可不可以說政府在電動車政策上，很視乎車種的技術是否成熟？

對，我們要去觀察每種車種，不可以硬性推行電動車，全部電動化，因為很多時候都要視乎車是否能夠配合運作的需要。如果以電動私家車來說，私家車在香港一般是上班下班，或是假日駕車，那麼他的里數不長。而且因為它的車身輕，電池技術慢慢發展到同等重量可以容納更多電，運行就可以更遠。現在的私家車最低限度都是差不多起碼四十度電，有些甚至達到一百度電。如果是私家車這麼輕盈的車，一度電可以運行五公里，四十度電就可以運行二百公里。在香港來說，你一天駕駛到機場來回三次也足夠。至於商用車來說，因為車越重，它每度電運行的公里數就會減少。譬如輕型貨車，它實質上一度電只有大約四公里。所以如果是巴士，一輛單層巴士一度電其實一公里也運行不了。所以挑戰就在這裡，不同的車種的做法也很不同。所以政策上就是，如果是成熟的話就不會再在測試方面著力，因為如果成熟、適合使用的話人們就會自行購買。一般外國政府也是一樣，如果技術成熟的話資助會逐漸減少，因為最後始終要那件事可以自行操作才可以。但如果是不成熟就需要我們推動，原因是如果政府不推動，外面的私人機構亦不會自掏腰包去推動。推動、資助後他就可以獲取經驗，可以繼續改良產品，其實是幫助他加速產品對於香港的適應性、適合性，以及加速成長。而且有這些試驗的話，人們可以接觸，便可以掌握對它的知識、經驗、維修各方面，預備它將來再大規模使用的時候他可以有技術基礎。

現在在制定這方面的政策通常會涉及哪些部門？

其實環境局跟環保署現在就是一個混合體，因為是局署合併。基本上是環境局跟環保署一齊主導電動車政策，立法會那個就是有一個環境事務委員會，裡面其實與環境有關的事宜他都會討論。政府來說，政府支出有幾個途徑都是需要立法會審批。舉一個例子，首次登記稅是有法例的，如果要更改首次登記稅，譬如我免稅也要更改法例，就需要立法會。至於譬如我們成立綠色運輸試驗基金，撥款三億進去，政府也要通知立法會，也要諮詢，所以我們要交出這個環境事務委員會的文件去諮詢立法會，完成之後就是財政預算案，二月尾宣布，宣布之後就要立法會通過這個財政預算案。開會討論後，最快也要直至五月財政預算案才可以通過。剛才我也說過幾項措施，首次登記稅就是運輸署負責登記汽車，那是在 cap.374 的法例裡面。譬如剛才提過的規劃標準與準則，那個便是規劃署。如果是說新建樓宇樓面面積寬免，就是屋宇署。如果是稅務條例裡面有關於第一年要完全扣稅，那個就是稅務局。所以就要視乎甚麼層面就需要甚麼部門配合。我們主導了政策，但政策是會牽涉到其他部門的話就需要配合。

日常推廣電動車的話，在充電器方面成立一些措施做電動車充電的支援，有熱線電話和設計網站擺放資訊，還有環保署有在政府停車場安裝公共充電器。其實政府有很多部門也會做充電器，不只是環保署，譬如運輸署停車場、政府產業署停車場、康文署停車場。有一些情況是我們環保署主導的話，那麼其他部門配合我們的計劃，劃出一些可以安裝充電器的位置，環保署就去安裝或找人去安裝。有些部門又會自己做，例如路政署、康文署有些以前都會自己做，郵輪碼頭那邊以前也自己做了一些公共充電器。我們是主導的，但不是我們完全負責做。政府也有一個綠色政府大廈，新建的政府樓宇我們也要根據規劃準則，我們也會在那些新建樓宇的停車場架設百分之三十的充電器。你知道建樓也要一段時間，所以落成的樓宇不多，所以未能認真看見成效，不過遲些就會有，有新的政府大樓自然就會有新的充電器出現。

與政府以外的其他持份者方面的合作，會有甚麼形式和目標？

持份者要視乎逐項措施有不同。譬如私家車方面，因為技術比較成熟，就沒有甚麼特別可以定期溝通。因為二十億元私人樓宇那個是一個新的計劃，很多外面的業主、管理公司也不知道發生甚麼事，所以我們就會多做一些簡介會、推廣這些，此其一。其餘就是會較多與外面不同的委員會，譬如民政署安排業主委員會，或是電動車充電的供應商開會。如果是商用車，譬如像綠色試驗基金，已經有一個督導委員會，會邀請大學、汽車商會的代表加入，一起提供意見，討論怎樣做好基金，還要批核申請，諸如此類。巴士就是與兩間巴士公司緊密合作，因為車是政府出資購買，但維修保養運作就是巴士公司負責。另外是兩間電力公司，因為電動車充電不只是充電器方面，電力公司亦要提供足夠電力。

現在在電動車市場的規劃、建設充電站上主要是政府主導還是等待市場發展？

充電規劃的話，其實很複雜，因為要分私家車和商用車充電的需要不同。私家車一般來說，最好就在住宅或工作地點充電。很多個案在住宅可以充電，反映的意見都是相當滿意，夜晚可以充電的話就沒有投訴。有一個問題就是有些私家車主購買電動車，但他家裡安裝不了充電器，他購買的時候亦都沒有想過原來安裝充電器這麼困難，可能是租用車位或車位不屬於他。但是**安裝充電器的電線要經過大廈公共地方**，大廈不批准也沒有辦法。這就是為甚麼我們會有一個鼓勵安裝充電器的計劃，我們兩方面進行，一方面就是剛才說過新樓宇預設好所有電線。但現有那些私人樓宇就有問題，**所以才會在去年的施政報告提出了那個二十億的計劃，就是想幫助那些樓宇拉好電**

線，在家裡可以安裝充電器。但如果是商用車方面就很不同，它需要更多電，它亦都沒有那麼多時間充電，所以它就需要去一些快充站，但快充站耗用很多電力，那部設備很大，可能要多起一個火牛房、掣房，這個配套在香港來說就很困難，變相要很多地、很多位置。

如果是私家車方面，現在你會發覺很多都是市場主導，因為其實他有生意就可以做到，譬如外面找他們安裝充電器，等政府的話就要很久，找私人的話比較快。另外私人公司亦發覺這也可以是賺錢機會，就會跟商場聯絡。另外一種就是賣車的，沒有充電的話他不會購買，賣車的公司安裝充電器讓人充電，這也是一種生意的模式。還有私家車和商用車的模式很不同，在商用車方面，永遠是謹慎計算金錢，不划算就一定不會做。所以商用車自己去安裝充電器就做不了，那些如果不是政府主導，很困難。但政府主導亦有一個困難之處，我們安裝充電器，車也需要地方放置才可以充電，沒有地方不可以，這是人所共知的問題。

在充電收費方面政府會不會有計劃去調整充電站收費的問題？

這方面政府一直對外宣稱我們是會收費的，現在只是暫時免費，是會收費的。但要配套設施成熟後才可以做到，因為政府收費都有很多政策考慮，其實我覺得收費不難，而是在所有的法理基礎上沒有問題才可以。現在兩間電力公司免費都是他們自己每年的決定，其實他可以自己決定收費，這可能是公眾形象或是視乎大家怎樣看，因為始終充電器都數量不是太多，他又不是有這個迫切性。其實政府支持用者自付這個原則，因為當初是推動性質所以是做一個免費的，我們不知道甚麼時候會改，正如那些首次登記稅。我們也不會隱瞞，如果我們知道日期的話會說，但長遠的方案是會收費。

最後，長遠來說進一步推廣電動車的時候會面對什麼困難？

困難的話，私家車方面我認為是充電器，如果買車後可以充電就沒有問題，譬如車主在新樓宇，基本上很多新樓宇是可以充電，但他居住在舊樓，舊樓就沒有。我們從屋宇署得來的數據來說，基本上現在有九成的新樓宇是已經可以安裝充電器，直至去年已經有超過一萬個有充電配套基礎設施的車位落成。當然政府了解到那些問題在哪裡就會想一些辦法，譬如新推出的那個二十億資助計劃，就是因應這個而出現。商用車的困難很多時候就是它的產品未足夠成熟，有些人就說深圳也有一百分之一百是電動巴士，但香港不行，因為在深圳它可以在平路上運行，而且可以到充電站補電。日間補電的話便建設很多個足球場般大的補電站，十幾輛巴士便可以駛進去充電，但

香港不可以這樣，車廠很遠。這主要是技術，所以現在要嘗試新的技術，私人很難去做試用技術，所以政府也要幫忙資助。譬如像電動小巴，以前的電動小巴也是像電動巴士一樣，放置一個電池在車上，夜晚充電後再運行，但發現原來不行，是不足以運行一日的。那也要想一些新方法，有一些新的技術出現了，就是有些電池可以做到超級快充。我們家中有七千瓦的就足夠我充電，但如果是商用車很多時候外面是需要五萬瓦的，即是50kw。如果超級快充則可以做到三十萬瓦的充電速度，300kw。我們現在就是打算將來的電動小巴嘗試這個模式，等同於現在有些巴士是使用超級電容，我們有七輛超級電容巴士正在運行，還有一輛就遲些也會到，總共有八輛。超級電容的理念是，我每次充滿電時電量可能是少的，所以他運行的距離就少，但我很頻密地充電，我來回一次或兩次總站又可以充電後再出去。在車頂有一個集電弓降下來充電五分鐘至十分鐘，它又足以繼續出去來回幾次，這樣的模式。所以一個充電站，這輛小巴充電後，它在一小時內就可以服務幾輛小巴，大家輪流充電、輪流運行。這個充電弓的技術在國內有嘗試過，歐洲亦都嘗試，全世界很多國家的巴士亦嘗試過這個模式，現在開始多這種模式，效果亦相當好。最重要是車不用負擔這麼多電，因為電重，提供少些電就不用負擔這麼多，能源效益也會更好。其實香港的環境很獨特，你留意一下香港的三軸巴士，全世界來說不多，這麼大部還要容納百多人，還要走斜路、開冷氣，在全世界都頗難找到。這些車不是這麼容易可以替代，因為我們不可能忘記運作模式，強行應用電動車，你提供不了那個服務也沒有用，在商用車方面，如果經營模式做不到也推不了。

APPENDIX III INTERVIEW TRANSCRIPT – FRANKIE YICK

電動車科技有什麼發展潛力？電動車適合在香港應用嗎？

現在的討論已經不是關於電動車的潛力，而是電動車是一個無可逆轉的趨勢。英國已經決定自2035年起只準售賣非燃油車，陸續亦有車輛製造商宣佈在2040或2050年後不再生產燃油車，所以將來香港所有二十萬部車輛都會變為電動車。現時的電動車主要分為兩種，一種是全電動車，在私家車上已經有廣泛的應用；另一種使用燃料電池，但在香港應用恐有消防安全上的問題，所以在外國會比較適合。如果在香港，可以在不用進入市區內的重型車上應用。

有什麼因素令香港的電動車發展較世界滯後？

主要是充電問題，價錢雖然是貴但已經一直下降，例如南韓的一些電動車型號好像現代的Ioniq是比較便宜的選擇。現時充電設施不足，很多情況下在居住的地方也不能安裝充電器，雖然是有車主做專程到郵輪碼頭充電，但不可能要每個車主都跨區充電。主要的因素是大廈的火牛房剩餘的電力只能提供少量車位同時充電，雖然電力公司稱可以分配電力的方法提升可安裝的車位數量，而車主亦不會同時充電，但就算能提升，也不可能在全車位都有充電器安裝。而政府現時只為地底的停車位提供樓面面積減免，但為什麼只限制在地位停車場呢？所以我建議政府修訂建築物條例，強制性要求所有停車位都要準備好提供電動車充電。這在新樓宇比較可行，因為在建築期間安裝這些基礎設施成本較低，在建築時就要預計安裝多少個充電車位，再預定火牛房的大小，相對而言，已建成的樓宇則已經決定了火牛房的大小。

交通界對電動車相關業務感興趣嗎？

正如我所講，電動車已經是個大趨勢，業界是感興趣的，因為可以減低燃料成本。現在油費要兩元才能走一公里，的士用的石油氣則大概六毫一公里，而電費只需兩毫便可以走一公里。但將電動車應用在商用車上受技術限制，香港的的士每天兩更走400至500公里，這

就衍生充電的問題。要在哪裏充電？由誰支付充電時的停車費？這些都加進它的營運成本。如果是快充站可以半小時完成充電那就可以在吃飯時間充電，但如果是中速站需要4小時，這就不可行，受它的營運模式限制。我們曾經試過引入比亞迪的電動的士，但當時的車型只有200公里里數，而且電池老化得快，兩三年便下跌到只有七八成效能。但現在我們的新車型有較長的里數，所以計劃在新界和大嶼山建充電站作營運電動的士的試點。另外，我認為綠色小巴亦比較適合試用電動車，因為它有站頭，可解決在哪裏安裝充電器的問題，但仍要滿足路政、消防方面的要求。超過小巴大小的商用車技術則還未成熟。

現時在推廣電動車的各方面面對什麼困難？政府的政策能有效克服這些困難嗎？

在私家車方面，困難是沒有了全免首次登記稅。有些較貴的電動車款在取消全免首次登記稅後價錢可貴近一倍，但亦有人認為免去首次登記稅是傾向有錢人的政策，是在補貼有錢人購買電動車。我是同意減少首次登記稅方面的資助的，因為這樣會令車商有建造低價車款進入市場的動力，要令人覺得可負擔電動車售價才能吸引人購買和推廣電動車。雖然如此，我們也建議將寬免額提升至15萬，因為現時的\$97,500也是太低。一換一計劃則可提升至25萬。但我不同意全免首次登記稅，因為要使電動車價格下降才能普及化。另外，關於充電站的問題。深圳的的士巴士全部使用電動車很大程度是由於有土地興建充電站及政府提供資源，但在香港要找土地建充電站很難。在私人安裝方面，由於未能看到應用的大潮流，所以未必會有很大供應，但電燈公司可能較為樂意投資，主要不是為了提供充電服務，而是賣電。我同意現在政府的規劃，街外的充電器是為滿足緊急充電需求，應該主力使用家居充電，因為可以整晚充電，所以中速便足夠。現時的20億資助的效果很視乎業委會及業主立案法團的同意，但因為安裝充電站面對煩瑣的問題所以業委會一般都不同意。例如，樓宇的火牛房只夠提供30個充電站，那在30個業主安裝後便會用盡火牛房的供電空間，第空間，車主就會投訴，所以為免卻這些後續爭議，業委會很多情況都不同意安裝。所以政府應該鼓勵業委會落實安裝申請，或設定條件要求不可不裝。

現時充電服務主要是免費提供，你對充電服務的發展有何看法？

現在的免費充電只是作早期的推廣用途，將來一定會轉為收費服務，尤其是在屋苑，當然是用者自付。但現在未能看到一個商業模式，未見有人將提供充電服務視為一生意，因為有太多未知數，收錢等方面比較複雜。雖然是有私人市場在車主申請安裝後幫助安裝

，但主要仍是由政府各部門安裝，市場發展還言之尚早，在日後使用率上升後才可以制定收費方法。現在的充電位亦很多時候被其他車輛佔用，但由於整體泊車位不足，而電動車本身數量很少，要專門預留停車位給電動車未免不公平。而路邊的咪錶位安裝充電亦要考慮電力提供的問題，可能需要更粗的咪錶桿，這些技術性細節需要政府去安排。**現時最重要的是政府需要就電動車發展有一個整體計劃**，需要一個整體配套去推廣。稅務寬免能夠吸引用家，而充電器仍然不足，兩者哪一項先行、政策力度等都需要一個整體計劃，亦需要分析用家的接受程度、心理、負擔能力等。**整體來說電動車發展的主導權在政府，因為牽涉太多範疇，民間力量不足以解決**。主要來說先決條件還是充電站，否則吸引不了市民買車，因為車主要先有地方充電才能確保自己可以使用電動車。

APPENDIX IV INTERVIEW TRANSCRIPT – HONG KONG ELECTRIC

可否先介紹一下香港電燈與電動車相關的業務範圍？

港燈在電動車方面的業務以供電為主。港燈現時提供12個公共充電站，分別為6個直流快速充電站及6個交流中或快速充電站，全部皆提供免費充電服務，現階段免費計劃延續至2020年底。另一方面，港燈會為私人充電客戶提供安裝意見，包括估算用電量、計算樓宇的供電是否足夠安裝後的負載及電錶等電力裝置的要求。主要安裝客戶為私人屋苑、商業大廈、酒店及商場。在供電方面，港燈會盡量分配電力以滿足用戶安裝充電器後的電力需求，若預計用電量超出樓宇的供電容量，用戶則需額外安裝供電設施。

港燈在為公共充電站選址時有什麼考慮因素？整個安裝過程有什麼步驟？

港燈在安裝公共充電站時主要有三點考慮：一、車輛續航能力，港燈會盡量減少充電站之間的距離；二、選取方便公眾的位置，如商場；三、安裝在難以提供私人充電設施的社區，如太古城等只有租用車位的屋苑。港燈在計劃安裝公共充電站前會先與政府磋商，在決定充電站位置及得到政府同意後，港燈會向停車場管理公司提出提案，然後向承包商取得報價購買充電機。安裝後的日常運作及維修由港燈負責，用家可致電充電機上的支援熱線。

現時港有否收集公共充電站的使用率資訊？現時有沒有計劃將免費充電改為收費服務？

公共充電站中最常用的為直流快速充電站，可在30分鐘內為電動車提供8成電量。港燈目前暫時未有計劃為充電服務收費，仍需觀察市場發展及會配合政府的政策。

現時公共充電站常有電動車充滿電後逾時佔用，港燈充電站有何措施遏止此情況？

港燈限制了每個直流充電站的使用時間為40分鐘一節，限時結束後會自動終止供電。每個充電站亦有告示提醒非電動車主避免佔用充電車位，個別停車場會放置雪糕筒防止非充電車輛停泊，但實際操作視乎停車場主決定。

現時有意安裝私人充電裝置的私人住宅客戶面對什麼問題？

私人住宅的業主立案法團或管理公司由於不熟悉相關資訊，未必會同意安裝工程。而安裝充電機會佔用樓宇的公共電力，若不敷使用則需要安裝額外供電裝置，先安裝的住戶可優先使用樓宇的剩餘容量，衍生公平方面的考慮。

港燈的智能充電系統提供什麼資訊？

平台提供收費服務及充電站位置，被佔用的車位就算沒有充電亦會顯示為使用中。惟系統的預約功能及負載管理功能已暫時停用。

港燈的公司車隊亦有使用電動車，作為企業，在引入商用電動車隊時有什麼考慮及面對什麼困難？電動車隊與汽油車隊在應用上有何分別？

現時港燈有使用電動車隊作試驗計劃，主要為輕型貨車及小型巴士，但整體可靠度比汽油車仍較差。由於商用車型較大，所需電池體積亦較大及較重，故載貨量比汽油車低，續航力較差，而充電需要到特定位置亦減低營運上的靈活性。但港燈會繼續使用電動車隊。

APPENDIX V INTERVIEW TRANSCRIPT – EV POWER LIMITED

可否先介紹一下你們的業務？

我們的業務不單純是住宅市場，而是統稱為私家車市場，包括一些私人安裝，有一些是由我們投建在屋苑裡作為骨幹的基礎建設，以月費形式提供服務給居民，亦有一些在政府停車場或者是其他商業機構的停車場裡面，我們會架設一些公眾充電站，無論是屬於商場擁有而由我們營運，或是我們自資興建並營運的充電站模式都有。另外在其他用私家車但非住宅用途的類別，包括一些公司用電動車，例如在機場，因為進入機場禁區內的必須是電動車，所以我們在機場禁區內亦架設了超過一百台充電設備，包括快速充電設備以及相關系統。這些都是在我們過去數年主要的收入來源或業務涵蓋部份。而最近一兩年我們亦開展協助商用車進口商由傳統貨車、小巴、巴士引入電動車，在這一方面提供一些技術支援，包括遞交相關文件，或了解最基本電池的電壓、電流等等。從而我們後續亦支援他們在營運上面一些充電站的建設，或保養維護等等的工作。我們亦正在做公共巴士服務，例如村巴或穿梭巴士等旅遊巴士的充電站這方面相關的建設。目前我們自己的充電網絡都已經接近 53 個地點，差不多接近二百個充電設備。

如果我是私人車主，要在我的停車場安裝充電機，是否可以直接聯絡你們公司？

可以。主要有幾種情況我們需要了解，首先有沒有私人車位。如果有私人車位我們可以提供充電設備，以至相關工程。我們亦會幫助他在大廈式物業，處理好所有審批或在電力公司申請新電源這些安排。因為電纜或電源都一定會跨過一些公共空間，以至連接大廈的公共電力系統，所以必須業主立案法團同意才可以施工。過去比較簡單的就是村屋或獨立屋，自己有業權的話，程序及成本會比較低，俗稱這個為一條龍服務。其實現在很多工程公司都會提供一條龍服務，包括提供充電機，及安裝審批等等這些程序。第二種模式就是駕駛者本身沒有自己的車位，可能他是租用車位，一般而言他未必會投入很大成本安裝自己的充電設備，如果他是在我們一些特選屋苑裡面，他就可以利用我們投建的資源和基礎建設，享用我們月費模式的計劃。月費模式顧名思義就是他只需要每個月付固定的月費，前期只需要一個固定的開戶費用，在我們現在的服務計劃裡面，全港二十幾個屋苑裡面，我們的開戶費用大約是五千元。四千五百元是保證金，隨後我們有六個不同形式的服務計劃，有高低用量等等，月費 980 至 1780 元。他需要承諾服務期最少二十四個月，這種模式可以減少業戶/使用者的前期投入，而後續例如保險、電費或充電設備保養費，都由我們

公司一力承擔。充電機不屬於車主，像寬頻機一樣，你不使用的話我就會收回。如果一般個人在停車場安裝充電機，倘若你離開是需要負責遷拆。但因為我們月費裡面承包了遷拆，所以在整體費用，第一，更具透明度，因為你很清楚每個月的支出。第二就是不需要善後，因為所有保險或風險都由我們負責，你不會有額外的成本。對我們來說，因為我們作為投資方和營運者，我們有規模效益，每一個充電機對我們來說可以相對便宜，所以是雙贏局面。第三，對於法團和管理處亦有好處，因為我們在整個建設的過程會在早期得到法團的同意、通過居民大會，再者我們負責所有保險的購置、維修以及協助其處理很多客戶的查詢及技術支援，所以減少他們很多日常工作。對我們來說成本會大減，因為我們可以按大廈情況，最接近電源最低成本的地方裝設，與此同時配合大廈以月租模式收費，或者以時租模式收費都可以，用者自付。

大概是在甚麼時候開始跟屋苑商議？基於什麼考慮選擇安裝的屋苑？

初期在 14、15 年開始，那時候全港電動車數量只得一千多輛，屋苑有一兩輛電動車的時候我們就開始商議。主要我們開始商議的原因是一些屋苑不容許個人安裝充電設備，如果可以安裝的話我們已經會用第一個方法幫他處理。或者就算有些屋苑容許個人安裝，但由於屋苑本身的電力分配系統沒有剩餘足夠的可分配電源，所以需要在投放額外資源去增設電源分配的設施，往往這些支出可能都需要十萬以上。對於個人來說，他沒有任何個人好處。這些情況下我們就會嘗試協商有關投資，當然我們都會視乎我們的投資回報性，但那時候大部份情況都難以計算，我們都只是估計電動車上升的數字。目前我們二十多個屋苑裡面，有部份屋苑有接近十多二十輛電動車在同一個屋苑停車場，但我們知道有些屋苑直至現在也只是一兩輛車。

有沒有車主在那些浮動車位充電後霸佔車位？

絕對有。這個情況在公眾充電站亦都一樣，我們主要在這方面會引入逾時佔用的收費模式，當然我們亦要得到業主方面的同意，在私人屋苑的話就是管理處。例如我們在中文大學范克廉樓外的充電站，中文大學容許最多三小時充電，但續後半小時後繼續佔用充電位，每小時會有 50 元的罰款。我們現在亦有幾個私人屋苑都有引入類似的方式，成效顯著。當然對於用家來說始終都會覺得不便，覺得提心吊膽，兩小時內要回來。如果是月費形式，即是我預留這個車位，則可以大減不確定的支出。兩種模式適合不同屋苑，視乎車位數量以及電源的情況。

如果已經有車位的情況下，安裝一個充電機大概需要多少費用？

如果是個人，在獨立屋或村屋，如果不需要額外申請電力公司電源的話，往往安裝一個充電機的成本大約在一萬元內。這個價錢不包括充電機本身，因為有些車行會送充電機。如果自己購置一部充電機的話，香港市場上大約一萬元。如果是大廈式物業，要視乎停車場規模。一般我們的工程費用範圍大約是兩萬至六萬，視乎車位與電源的距離或者你是否需要額外電力分配裝置。關於電力分配，其實我們建設電源要由一個大電源慢慢分開，如果在細分的部份已經沒有足夠空間，就需要再做新的分配，完成後理論上會有更多公共電力，部份可能都要貢獻轉讓給屋苑，自己只是用部份，但在屋苑的角度就通常需要車主自己支付。但動輒十萬以上的成本則較少車主會選擇，計算成本效益都應該是非常低，出外快速充電繳付停車場費都不需要這麼高的支出。

你們的網上平台會顯示什麼資訊？

我們的程式展示即時點位的狀態，即是有沒有剩餘充電位置。我們有一個充電站的具體地址列表，環保署每三個月會搜羅全香港的公眾充電站點位，主要透過業界自行申報，我們會將其相關資訊加入我們的資料庫一同顯示公共充電位置，方便用家除了使用我們的充電平台之外，亦可以同時間找到最接近的其他充電站。我們的平台會採用會員制，登記後透過程式或智能卡都可以使用我們目前全港 53 個充電站的任何充電設備，包括快速充電或中速充電設備。

收費方面，比較多都是免費的？有沒有引入逾時罰款？

對，九成都是免費。如果電力公司或政府旗下的話，基本上全部都是免費。始終目前公眾充電營運商比較少的主要原因就是太多免費充電，亦包括香港市場比較特殊，tesla 過去幾年都佔了市場份額超過九成半，所以 tesla 自己都有快速充電網絡/超級充電站，早期來說全部都是免費，直接地影響了公眾充電服務營運的可能性，因為資金不足，而且速度及收費都比不上。另一方面，在商場或商業大廈，早期只有他們有資金和誘因裝設，早期商場引入 tesla 充電機的主要原因是希望吸引高端客戶消費，都是一些一級的位置，故 tesla 亦搶佔了很多可以讓我們其他服務供應商建設充電站的位置。以我們目前為例，大部份公共充電站都是物業自己持有，他們會自己出資興建，我們只是透過平台去營運，協助其處理一些用戶上的使用。太古地產、恆基地產、恆隆地產和港鐵都是我們目前充電網絡的合作夥伴。不是很多業主願意罰款，我們亦都受限於業主的意願，否則

未必可以合作。主要原因是他們擔心罰款會影響客戶的消費意欲，客戶可能會選擇沒有罰款的停車場。

如果同一個停車場有不同公司的充電機，它們會不會放在同樣的位置，抑或是分散？

暫時不一定，但我們看到越來越多都是放在一起。一開始可能沒有特別規劃，但現在尤其是新落成的通常會放在附近，方便用家去選擇自己品牌的充電站。很多時候品牌充電站純粹是品牌，其實都是通用的。

車主有怎樣的充電習慣？

香港有全球最密集的 tesla supercharger，有十多個。但使用模式有點不同，初期 tesla 透過 supercharger 去應付一些不能安裝家居充電的用戶，因為香港足夠小，可能充電一次可以運行四至五日，所以香港的使用方式不同。香港人很有趣，香港很小但他們都更喜歡里數長的車款。但理論上香港就算是中速充電機充電一小時都足以運行 40 公里，一日都用不完，泊車可以充電就支持到。我想主要原因是早期直至今天充電的點位，包括公眾充電站都不足。我認為不足其一是有充電車位但被其他車霸佔，這個在政府充電位就比較常見。我想主要原因其實都是車位不足，一時之間亦很難為這麼少的電動車而將所有車位騰空出來，這樣會造成很大的反彈。第二就是因為 tesla 提供超級充電網絡的概念，香港人可能喜歡快所以十分受落。他們可以在 45 分鐘補給 200 多公里，所以在他們的角度來說比在個人住宅充電四至六個小時更好。雖然在住宅晚間充電需要更長時間，但其實他等待 supercharger 的時間比在家裡等待充電的時間更多，但他傾向 supercharger 的概念是他需要的時候就會有，不需要等。我想還是需要教育車主如何理想地使用電動車或充電的基礎建設，主要原因是如果你有家居充電，理論上是不需要依賴公眾充電站，尤其是香港太小了。以我們私人充電每晚的分析，仍有很多用家都是差不多耗盡電量才充電，所以動輒需要充電八至十個小時。目前大概四五成人每一兩日就會充一次電，每次充電兩至三個小時就完成充電。

你們有充電習慣的數據可以分析？

有的。如我們剛才所說，我們亦有投資在屋苑裡面，建設我們的充電網絡。除了充電，我們同時間支援用家在家中用手機應用程式充電和監視自己充電的情況。我們知道他充電的時間、充了多

少電。因為不同車電池的容量差別頗大，由 20 度電至 100 度電，所以它們之間充電的時間可以差距很大。當然電池較小的車會充電比較頻繁，但我們看見比較長途程的車例如 tesla，就算在家中有充電器都未必很習慣每天充電。現在的鋰電池不在低電量時充電才會保養得好，一般都建議不要低於三成，最好在五成以上開始充電，其實一直持續充電就可以。充電機與車之間會一直保持溝通，差不多充滿電就會停止，不會過載車輛。在耗盡電後快速充電會令電池折損得快，用中速反而沒有太大問題。所以如果只依賴公共充電網絡的快速充電設備，電池壽命就會更短。

公眾或電動車用家有沒有良好充電習慣的認知？

我們在很多座談會或網上，例如 facebook，或行家間中都會討論以作市場推廣，但大部份人都不太理會。我們認為有些責任在賣車的公司上，當然他們的說法就未必是教導你，反而是以多用快速充電就不包括保養的形式。但一般不會特別告訴你，因為會影響你買車的意向。

發展充電設施面對什麼困難？

整體而言，目前最大的困境仍是停車位不足，導致很多充電站建設好亦會被浪費，沒有受到有效管理。再者，在公共充電站，因為有太多免費充電服務，令其他公眾充電站投資者難以有效投資。例如在港鐵充電不收費，因為可能在商場物業或乘搭地鐵都已經資助了充電費用。等同於中電、港燈透過電費補貼，政府則透過稅務補貼。但我們私人企業除了充電收費外就沒有其他有能力補貼的地方，因為沒有其他業務支持，正正就是這樣影響了我們業界的發展，因為太多免費。公共充電站有兩種模式運作，其一是以中速為骨幹，因為成本低可以大量投放，我認為這可以大大解決很多車充電的問題。但因為較慢，使用者使用意欲低，還要收費的話可能就更難處理。另外就是很快速的充電設備，我們現在叫 high power chargers 的方式。但這個模式使用電源相對龐大，不是太容易找到合適的點位。與此同時，投資成本相對提高。如果投資高，收費會較高，亦很難估算究竟有多少使用者願意付費充電。投資一定要有收入，但有太多免費公共充電服務，所以收費充電站的誘因就會低，投資者亦會相對保守。在世界各地收費用者自付很正常，我們在國內業務亦很少看見不收費的，政府也已經有立例規管收費。在外國很多時候政府會提供誘因給充電營運商進行建設，如果是開放給公眾使用的充電站可以報銷成本等等，或者有誘因要求電力公司減低充電站電費。但香港暫時來說就沒有這一方面，政府通常自費建設，但其實效益低，因為政府自己建設要全數負擔費用，包括後面的維護。但提供誘因予服務供應商可能只需要付三成至一半的

成本，因為有誘因的話商業模式就會建設。同時，**政府很難透過自己興建去使用私人土地**，我們53個充電站全部都在私人物業上，私人土地肯定多於政府現有的停車場網絡。如果不斷要其他發展商多架設充電站支持環保，我覺得成效不大，因為大家都是商業機構，以利益為先。現在很多新樓都有充電基礎設施，原因是做完這些事後停車場車位可以獲得樓面面積豁免，那個價值是以億計，所以當然會做。因為政府規劃署希望以後停車場可以提供至少三成停車場位予電動車，但三成是指引，沒有約束性，亦沒有任何誘因，對於商業營運模式不是很有效。至於現成樓宇其實不多這類型的政策去扶持一些以私人的方式去投建充電站。

現時對於公共充電站缺少政策支持，你認為可以有甚麼政策去鼓勵到更多公共充電站？

過去政府主要在政府物業，包括公共停車場裝設充電器。現在可能擴展到康文署和兩電增設充電站，每處都裝設一些，但長遠來說以全面補貼形式來實行不是一個理想的方案。即使現在兩電的充電服務不收費，某程度上只是用了其他市民的電費去補貼這些電動車使用者，其實不是一個合適的做法。我們傾向用者自付，政策應該鼓勵人們去安裝，例如按充電站的功率提供補貼。當然不會補貼所有費用，但如果降低了成本就較容易令私人物業安裝。與此同時，現在很多上市公司要講究企業社會責任幫助升值，充電站都是其中一個企業社會責任的表現。我們在商會其實也考慮過不用政府出錢的誘因，例如不徵收有充電站的地租差餉。雖然免稅的模式不是很多錢，但這是持續的誘因。每年都有公屋免租，其實做法都是一樣，那為甚麼不可以用這種模式去支持電動車私人市場的發展？

香港人對低價電動車型的接受程度會不會越來越高？

初時低價車沒那麼容易接受的原因是聯想起來就是電量也低、續航里程低，但現在低價的同時，續航里程也有三、四百。主要是因為一些大廠，如現代、日產，它們電池技術越來越成熟，越來越便宜，而且他們本身是一個一直生產低價車的企業，他們自己本身的生產規模可以壓縮成本到很低，銷售方式來說他們就駕輕就熟。過去都是比較中高端的品牌去生產電動車，最便宜都需要五、六十萬。

APPENDIX VI INTERVIEW TRANSCRIPT – HKEVN

可否先介紹一下現在公司的業務？售賣哪種類型的充電器較多？

我們的產品主要有兩種，一種是手提式充電器，另一種是固定式。固定式就是在商場那種安裝在牆上，車主用自己的充電線連接電動車充電的類型。手提式（便攜式）的好處是如果你在公司和住宅都有一個插頭的話，你就可以接駁插頭在兩個地方都為車充電。換言之，你不需要在不同地方都安裝充電機，價錢比安裝兩部充電機低，即是用一部充電機就可以在兩個地方充電。我們的手提式充電機有幾款插頭，三腳插頭當然比較慢，所以很多顧客會購買工業插頭，藍色插頭那種是中速的。如果要更快的就是紅色插頭，速度會快三倍。最多人購買藍色這一種，但需要視乎車主/車本身的情況，如果要使用紅色這種插頭的話，車需要支持三相的充電器，但其實比較少車款可以做到。大部分的车款只可以單相充電，所以很多人都購買中速的插頭。

現在主要客源有什麼特徵？

主要客戶都是購買手提式充電器，他們很多是居住獨立屋或村屋，安裝工業插頭比較容易，因為是私人地方不需要屋苑業主立案法團批准、購買保險、停車場管理等等這些比較困難的問題。只有數間大公司會提供屋苑的充電設施，我們基本上不會接觸。我們客源通常是客戶有私人地方可以決定所有安裝購買事宜。亦曾經有客戶在屋苑停車場擁有車位，與管理處協商後讓他拉線到車位。他是使用也便攜式充電器，不過這是少有的例子。

那村屋、獨立屋的電力供應等前期工作，客戶又會如何處理，抑或是你們公司負責？包括安裝，費用總共大約多少？

村屋是在自己住宅拉線出來，他們不需要像在屋苑那樣，不夠電力就需要電力公司加掣櫃，這樣成本較高。村屋則視乎住宅本身耗用了多少電量空間，如果足夠的話是不需要作任何調整，只需要拉32A電線出來已經足夠，所以比較簡單。但有些情況是本身住宅已經耗用很大電力，那些則可能要考慮使用比較慢的家用三腳插充電，因為中電經常不希望增加額外電力。費用要視乎工程有多複雜，例如需要鑽牆，或是錶房較難接駁，有的車位可能要穿過兩幅牆，所以安裝價錢會相差很遠。一般客戶都是自己先解決工程方面的問題，如

果是最簡單的工程，大概是四、五千元，加上充電器即是總共大約一萬元都能夠完成。

現在大概每個月的銷量如何？客戶是透過甚麼途徑知道貴公司？

每月平均三至五人，始終現在電動車不是售出很多。大部分客戶都是在網上搜尋充電器知道我們，因為我們曾有產品是與生產力局合作研發，大部份人都是看到那段影片才瀏覽我們的網站。

在公共充電方面的業務包括什麼？你們有沒有徵收霸佔車位的費用？

我們在尖東的一個停車場有一個充電站試點，有兩部固定式充電機。我們與停車場合作，由我們公司提供所有設備，他們讓我們自行管理。充電按分鐘收費，我們有最低收費9元，可以充電半小時，從31分鐘開始就是一分鐘收費3毫。車主充電時間有些可能在30分鐘內離開，有些可能會使用三至四小時。平均可能一個多小時，因為我們收費，而現在外面有很多地方都不收費，所以他們只是在很需要充電的時候才來這裡充電。因為我們以分鐘收費，只要車輛仍然在車位插線，我們就會繼續收費，這變相是閒置罰款，因為我們不希望有人長期霸佔位置但不使用充電機，所以用這個方法令他們只在需要充電的時候才在這個位置泊車。

我們希望了解車主充電的習慣，你們的充電機可以收集到什麼數據？

我們會知道哪個會員充電，他們甚麼時候開始充電，充電多久，用了多少度電，但看不到車輛充電到什麼程度。充滿電的時候，車會自動停，即是由車主導，由車告訴充電機需要停止。

電動車主主要集中居住在市區還是鄉郊地區？

現在來說是村屋比較多，因為他們可以充電，而且他們居住比較遠需要駕車，所以平日汽油費用較大，但如果轉用電動車，電費大約\$1.3一度電，成本省下不少，每個月不需要付油費。電動車很多時候有泊車優惠，例如領展商場消費可以有兩三小時的泊車優惠，泊車費也可以省下，很多人會覺得這是減低成本的方法，所以很多住村屋居民都會考慮轉用電

動車，亦可以成功轉用電動車，因為他們可以充電。

現在政府的定位就是公共充電器是輔助性質，他們希望車主在其住宅充電，你認為市場的真實情況是否反映到這項政策的願景？

不是，絕對不是，始終可以在個人住宅安裝到充電機的人真的很少。雖然我們大部份客人都是安裝個人充電機，但現在一萬多輛電動車，起碼五、六千輛都是用公共充電。有很多其他公司的充電機都經常需要排隊使用，你可以知道大部份人都是用公共網絡而不是私人充電機，所以絕對不是輔助的作用。

現時安裝私人充電機有什麼困難？你對行業的前景有甚麼看法？

以香港情況來看，很多屋苑很難可以協商好，而這不是私人公司可以處理的問題，而是政策上或行政上的問題。如果政府有某些設施或某些政策可以減輕屋苑的顧慮，會事半功倍。其實政府都在努力，但需要時間。電動車發展一定是一個趨勢，只是看香港何時可以追上外國的進度。以電動車充電機比率來看，香港不算是太差，不過使用率偏低。因為有時候被其他車霸佔而不能充電，另一個情況就是泊進去的電動車不是正在充電，所以也不能使用充電機，這個是車位不足的問題。

APPENDIX VII INTERVIEW TRANSCRIPT – CP PARKING

貴公司現時管理多少個可充電的停車場？當時是如何安排安裝？

建盈停車場在屯門悅湖山莊有兩個中速充電車位，公司亦管理數個具備充電設施的政府停車場。悅湖山莊的大業主向公司提出安裝要求，由公司搜集資料，取得報價，再代表停車場大業主提出要求。而實際安裝由業主立案法團根據管理公司提供的資料審批。而管理公司有參與安排車位的調配，充電機安裝公司也提出在停車場的最佳安裝位置以節省成本。所以是由業主立案法團、停車場管理公司及生產商三方商討最佳安裝方案。其他場地如政府停車場也有充電位，長沙灣政府合署停車場及灣仔政府大樓停車場也是公司負責管理，政府停車場所有的安裝由機電工程署及環保署負責，則按政府的政策去決定。

充電站的實際使用情況如何？對於管理公司而言，有否需要為安裝充電機付出成本開支？

悅湖山莊的充電站安裝後除了住戶，也開放給訪客使用，充電是按時收費。當時安裝是在數年前電動車尚未普及的時候，實際也沒有考慮利潤，只是大業主作宣傳性質，特別是當時在新界區電動車充電位不多。因為屋苑沒有電動車主，安裝後實際使用率不高，一個月大概只有一至二部車充電，故不會靠這個充電站收取額外利潤。由於充電機是較早期的型號，並沒有讀取數據的裝置，所以公司不掌握具體使用數據。充電機日常的保養第一年則由安裝公司免費提供。就悅湖山莊的個案，成本上要付出額外時間做資料搜集，抽調人手及時間上要作安排。有關安裝費用由法團承擔，日常的管理則由公司負責。安裝後營運成本沒有增加，兩個電動車位一般預留用作電動車叉電，也作為電動車出租車位使用，不會對營運有很大影響。出租車位需求較低時，一般都不會將充電位用作普通車位，除非在繁忙時間才有可能用作一般停車位。這有機會影響電動車的充電，但因為充電線可拉出在鄰近車位充電，故影響較低。公司工作純粹作控制車流，公司會防止汽油車輛在有其他車位時佔用電動車充電車位，車主一般都會合作，除非普通車位已泊滿。

政府對停車場管理公司有沒有就電動車充電服務方面的特別指引或支援？

在政府場地，主要是要求公司遵從電動車優先使用充電車位的政策，其他方面也沒有特別要求。作為停車場公司，都是按照慣常操作，因為即使電動車車主也未必每次泊車都一

定要充電，也可以只是正常泊車。也許政府停車場與私人停車場使用上會有分別，因為在政府停車場泊車，主要是辦公務（如續牌等），時間較短，而在其他停車場，客人泊車時間可能會較長（如看電影）。一般電動車主都會因應自己的泊車時間考慮是否安排充電，如果泊車時間短促，則不會在該時段充電，因此有否充電位不是首選。

政府現在提倡增加電動車充電位置，這對管理公司的生意有沒有影響？

其實安裝期間，對停車場運作是有影響的，但安裝後多了這方面的設施，對電動車主是有吸引的，因為會考慮有充電車位。

貴公司會否在其他場地加裝充電機？如果政府願意提供資助，你認為什麼方法最能鼓勵管理公司安裝充電器？

應該暫時不會，因為成本較高，不是一般人願意投資。安裝充電站的費用不算高，但拉線的費用大，因此如果沒有政府資助，一般私人停車場都未必會考慮。悅湖山莊的充電收益歸管理公司，但電費也由管理公司支付，但充電站實際帶來的收益很少。

APPENDIX VIII INTERVIEW TRANSCRIPT – CHARGED HONG KONG

What is the charging habit of Charged Hong Kong members?

Our Charged Hong Kong members are early adopters obviously. About 50% have home or workplace charging, and the other 50% rely on public charging. For me I am lucky, my home is built on a garage and I have a home charger so it is easy for me to charge. Opportunistically, if I am there and the battery is low, I will take the advantage of free charging at public chargers. But 95% I charge at home.

What are the top concerns for users to install home chargers?

Regarding installing home chargers themselves, the biggest problem is that they do not get permission to install. **Some of them live in rental accommodations so they are not willing to spend their money** and there are hassles for you to install a charger if you are only going to live in there for a few years. **But the biggest issue by far that has been fed back to me is that they cannot get the permission from the building management to install a charger at their parking space.** In last several years, there has been very little change in ability to get permission. I think few years ago there was some impetus that there were so many EVs coming on the road. It seems to be something changing but that is definitely pulled back. It is very hard to get chargers installed.

Do you think the government has to split the EV policy in rural and urban areas?

The problem is being in particular private vehicles, but the government policy is taking public transports. There are lots of disincentives against owning a private car. But if you live in the New Territories, it is unfair because the people there do not have public transport. I think that regarding transportation in general, the government should have two policies, but regarding EVs, I think it is pretty much the same problem. It is obviously in the New Territories there are more village houses, and support to installing chargers in village houses is different to installing chargers in a private residential building with high-rise.

Would you say EV is more suitable for people living in rural area?

Not really, I think the problem is different. For instance, if you are dwelling in an urban situation with multi-level car parks, the problem there is using common areas, but in the New Territories with village house, very often the car is not parked at the house. It is like a village car park. So you have a problem there on how you are going to install the charger. It is just a different problem but they face the same situation. But obviously in places like my housing estate, we have 12 houses of private dwellings in the same estate, they all have garages and they all have the main power to go into garage. Half of the families have got EVs. I think the travel time maybe longer so people are driving more.

About the overall policy on EV chargers, the government is defining the public chargers as just a supplement to private charging. Is it the genuine picture in the EV community right now?

I think people would like public charging because they are parking their car somewhere anyway, but I think this is to a large part driven by free public charging. **I would not charge in public if I have to pay for it since I will be paying more than I charge at home.** I think the free service is a big thing. Hong Kong has a big problem with free charging at the moment is that people see free charging as an incentive to purchase EVs. It makes it cheaper to run but **the problem is that you cannot deploy public charging network commercially when your competition is strain.** **I think for the general health for the long term, it makes sense to move into a charged model.** Public and private (home/workplace) charging are two very different sorts of charging. Home/workplace charging tends to be long term charging (more than 10 hours), versus the public charging, which is much more opportunistic. While the utilisation of public chargers may be higher than home chargers, to be effective, public chargers are to be fast, at least medium chargers, and those are really expensive and require huge electrical subsystem to power them. Home chargers can get away with a 16A single phase. That is absolutely fine if you charger overnight with a 16A.

We had a meeting with EPD the other day and we are talking about policy in 5/10 years time, we are not talking about today. If you have a car park with 100 bays, you may only need 5 EV chargers today, but in 5/10 years time you may need 50 or 100. **So our general opinion is we**

would like low power charging in home/office, and then you can supplement it with public charging. Public charging is not the long term solution for Hong Kong.

What is your comment on the latest EV policy?

The 1/4 charger target is achievable figure. The government EV-enables new park spaces but there is no charger on the wall so it is a problem. But treating EV-enabling an existing building, the problem comes is which spaces are you choosing to enable with, which owners get the privilege of having chargers. The only solution is to get 100% enabled so it is fair. The 2 billion spending seems realistic. Another thing to bear in mind is the building age. If they get redeveloped, they can get EV-enabled. So in the very long term, 20-30 years, everything will get EV enabled. The government car parks are important supporters to EV charging particularly in the early stages. The government car parks are very often used by the EV communities. The problem comes as the government has not dedicated these spaces to EV. **In theory they prioritised EV but in reality it is just not workable so they have a very low utilisation.** The primary problem is when you drive to a government car park, **you cannot be guaranteed you can get a charging parking space.** I think if they can solve that problem, they can upgrade the chargers into medium chargers because a 13A for an hour just does not work, so at least a 32A single phase medium charger. Actually the management of government car parks is sub-contracted out and I think they can renew these contracts with EV friendly terms. I think these managements of car park see EV as a pain in the neck, because EVs show up and cannot charge and argue with the guard, and they block the driveway while waiting for charging. It causes friction and more workload to the management. If the contract includes EV proratisation, the management has to do it and can get reimbursed.

What can we do to rule out the occupation problem?

Public charging is just a short or medium term measure to support the adoption rate. We think the government can adopt shared charging. At the moment when they have got 20 spaces they put 20 chargers, but petrol cars will park. The better solution is if you have three spaces you put the charger in the middle, and that now can reach the three spaces. So now you

get 60 spaces to gain access to chargers, which is much more available. I think one of the pioneers who did this was Ocean Terminal in Tsim Sha Tsui. They put 13A sockets at both side of the pillars so they can cover 72 spaces with just a dozen or two of sockets. That is a good approach and it works well. As long as you can park reasonably close, you can just stretch the cable to reach.

Do you worry that the current provision of public charger would spoil the EV owners that they are not trained to use home/workplace charging?

The general feedback from people using public charging is that they are always complaining about public charging. In essence the car is a tool, if you have to go out and wait to charge, hang around or fight people over charging and queue for charging, it becomes a disincentive to buy an EV. So I think the satisfaction among the home/workplace chargers is higher than people who use public charging.

Are the phone applications commonly used by EV owners? Are they helpful?

In general no (helpful). **One of the things we have wanted to do is to come up with a unified platform for Hong Kong, where every people can exchange information about chargers and charger availability.** The charging providers and vehicle companies can provide information. Currently there is really no single place you can go to search for a charger.

How does the change in FRT policy affect the EV community?

It has been horrendous. The problem is you do not know what the policy would be next year. Would I buy an EV now when the policy may change in 3/4 month's time? The thing you purchase yesterday is different from the thing you purchase today. When they cancel the FRT exemption, the price of your car may double. It has caused a huge amount of problem to the industry, not just from the amount of the FRT, but also from the uncertainty. They announced the policy for three years, but in the next year they relax it. This indecisiveness is not good. The other problem is the FRT is blatantly unfair. The purpose of the FRT wavier is to incentivise the

purchase of EV, and somehow to offset the price of EV. But EVs are more expensive so they incur higher FRT, comparing to an equivalent petrol car. It turns out to be a disincentive to buy EV. I think the policy should be based on pricing comparison. Basically the vehicles are the same. The only difference is the battery is costing a lot more than the petrol tank. In my view, the battery should be taxed separately.

Do you suggest a shift of responsibility on charger provision from the government to private sector?

For public charging, yes, but it only happens when charging is charged because **the commercial market cannot do it when they compete to free government charging.** But then it becomes a disincentive to buy EV. But for private charging, no. The biggest issue is encouraging or forcing buildings to install EV charging facilities. The big thing is getting permission, and really the only person that could do that is the government. It takes years to persuade the building to pick up EV charging.

Some companies offer monthly subscription plans in housing estates, do owners prefer that?

We prefer each owner having their own charger. The problem with monthly subscription plan is, at the moment they are expensive, and typically more expensive than petrol, or at least getting close to the price of petrol. If you look at the core cost of electricity, it will take \$1 per kWh. The equivalent to petrol car is \$3-4. Part of it due to vehicle efficiency and part of it due to the tax on petrol. The monthly scheme works out for \$3-4 kWh, which becomes equivalent to buying a petrol car.

Are users educated on regular charging habit?

I think they know, but if it is a hassle to charge, you want to get as much as you can at a short time as possible. So it is easy to queue up half an hour at superchargers and supercharge to full. They do not have to go three or four times in a week to top up or find a medium charger and leave it for 6 hours.

So if user gets home charging, everything can be solved?

Yes. I do a lot of education tours to show EVs to kids and the number one question asked is how long does it take to charge. And interestingly my answer is about 30 seconds – I get home, walk to the back of the car, open the charging board and plug in, that is about 30 seconds. I do not know how long it takes to charge because by next morning it is charged. It is just like your mobile phone. Unless you are commercial driver, then you do not need to charge more than once a day. There is a huge opportunity for light commercial vehicle in Hong Kong which has been missed out. There are lots of vans and minibuses. These lighter vehicles are easier to charge. The government is emphasising on commercial vehicles because they are producing the majority of air pollution. But **the charging infrastructure for light commercial is the same for private cars.** I really think the government could do more with the light commercials. Part of the problem with public transport is the licensing. Maybe you could release EV-only licences for tour buses, so the licence is restricting to use EVs only. So if you issue 200 EV-only licences and then you will be able to get 200 EV school buses on the street, which would be wonderful.