Understanding the Business Case for Electric Vehicle Charging Infrastructure

What Drives the Costs and Profitability for Private Sector Involvement in Public Charging Infrastructure Deployment

January 2024

Table of Contents

This work was conducted for the International Zero Emission Vehicle Alliance.

Executive Summary

A substantial share of electric vehicle (EV) charging infrastructure deployed to date have benefited from public financial assistance, such as equipment and utility subsidies, carbon credits, discounted electricity costs, etc. In the meanwhile, private investments have also supplemented public funding gaps and will continue to play a critical role in establishing a reliable public infrastructure network. A promising business case for public charging infrastructure deployment is also emerging in some developed markets. To establish a positive business case, understanding key factors that impact costs and profitability for public charging infrastructure deployment is essential. In addition, a thorough market understanding will also help to identify necessary mitigation measures that government can implement to encourage leadership from private initiatives.

This study first reviewed and evaluated leading international approaches and policies that foster private sector involvement and maximize the benefits from public funds for public infrastructure deployment. In collaboration with the International ZEV Alliance (IZEVA), four markets – Canada, China, India, and the Netherlands – were selected to further survey charging infrastructure expenditure, revenue, and market sensitivity. These four markets span various geographic locations and characteristics, such as EV market maturity, population density, entry barriers, and public funding and policy schemes, providing a comprehensive overview of business case under distinct market conditions. In order to understand how the key factors such as capital costs, electricity prices, and utilization rates may affect charging profitability, the Charging Infrastructure Business Case Assessment Tool (CIBCAT) was designed. A total of eighteen scenarios have been generated using CIBCAT to demonstrate how business cases develop in the four markets under various conditions. For example, Figure 1 demonstrates how cumulative cashflow of a public charging station that hosts 20 charging ports with power ratings of 350 kilowatt (kW) can behave differently in four selected markets. Based on the comprehensive market research and case study results, the development of a positive charging business case is more plausible in markets with higher EV maturity such as the Netherlands, China, and Canada, while still feasible for India, especially with assistance from public funding and supportive regulatory environment.

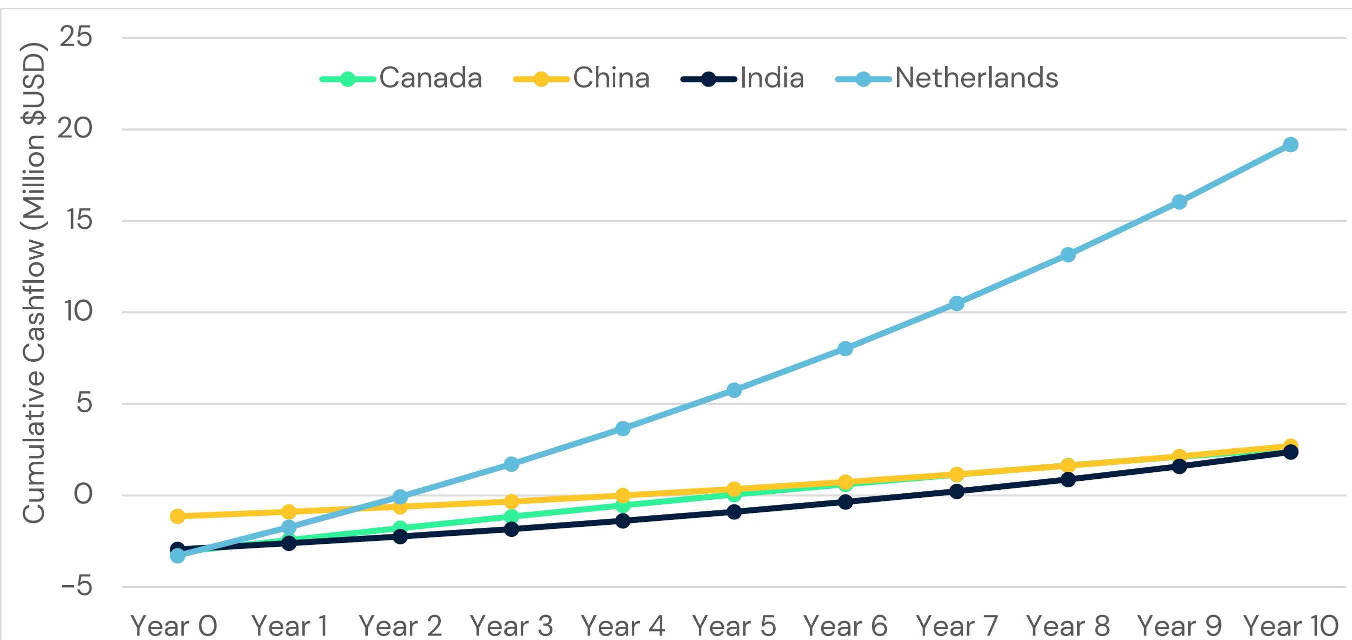

Figure 1. 10-year cumulative cash flow of a charging station with twenty (20) 350kW chargepoints in four surveyed markets. Station utilization is assumed to be 10%. On-site photovoltaics (PV) installation is included. Currency units have been converted from local currency to the United States dollar (USD) for comparison purpose.

Introduction and Background

As one of the major manifestations to battle climate change and reduce global energy-related emissions, the electric vehicle (EV) [1] market is experiencing unprecedented growth in recent years. According to the 2023 International Energy Agency's (IEA) Global EV Outlook, as illustrated in Figure 2, the global light-duty (LD) EV sales in 2022 exceeded 10 million and the share of EVs in total vehicle sales has more than tripled in the last three years, from 4% in 2020 to 15% in 2022 [1]. While the global EV sales are still predominated by the three major markets: China, Europe, and the U.S., there are promising signs for other emerging markets across the world as well. For instance, EV sales in India have escalated from 12,000 in 2021 to 48,000 in 2022, thanks to the recently formulated EV manufacturing legislations and incentive programs [2]. Although the current global transition to EV is mainly driven by LD vehicles, the medium- and heavy-duty (MDHD) sector has also seen growth in both EV sales and model availability in recent years. More than 120,000 MDHD trucks and buses were sold in 2022, representing 4.5% of all bus sales and 1.2% of truck sales worldwide. While China accounts for more than 80% of MD and 85% of HD EV sales, the MDHD EV market is projected to expand in other parts of the world as well due to recently adopted regulations and initiatives [1]. In light of global EV surge, the growing demand for publicly accessible charging stations is also outstanding. While early EV adopters have relied primarily on low-cost at home, workplace, or depot charging, as more EV owners without residential charging access and MDHD commercial fleets enter the market, the dependence on public charging is expected to increase rapidly in the future. By the end of 2022, as shown in Figure 2, there were 2.7 million public chargepoints worldwide, with more than 600,000 public alternating current (AC) charging points and 330,000 public direct current (DC) chargers[2] being installed in 2022 alone [1].

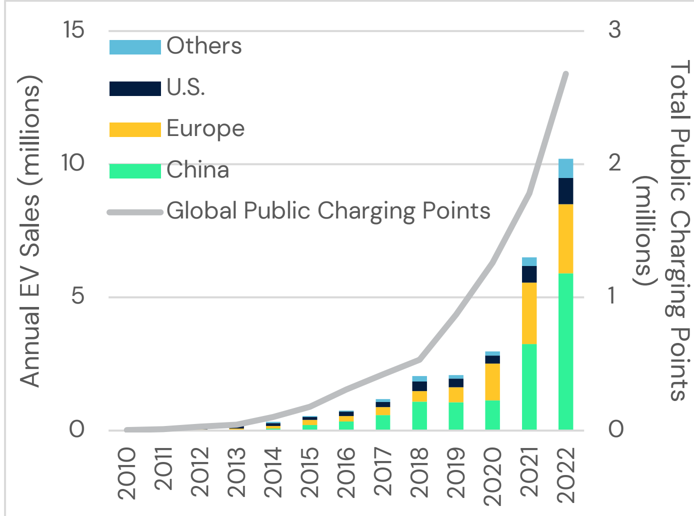

Figure 2. Global EV sales and total public EV charging points from 2010-2022.

A substantial share of public electric vehicle supply equipment (EVSE) deployed to date has benefited from government financial assistance and subsidies. The U.K. government legislated grant schemes for EVSE installation in 2016 and is currently funding up to 75% of the costs to buy and install EV charging ports through the EV Chargepoint and Infrastructure Grants for Landlords program [3]. In the U.S., as part of the 2022 Inflation Reduction Act (IRA), eligible commercial EVSE projects can receive up to 30% of the project cost in the form of tax credits [4]. Direct current fast charger (DCFC) stations can also receive credits from the California Low Carbon Fuel Standard (LCFS) program based on the amount of dispensed fuel and station capacity [5]. Similar clean fuel programs that offer carbon credits also serve as a reliable revenue stream for charging infrastructure operators in Canada, the Netherlands, and Germany [6, 7, 8]. Subsidized utility rates and EVSE installation incentives are also available across various provinces and municipalities in China, urged by the national 13th and

[1] Includes battery electric and plug-in hybrid electric vehicles.
[2] AC chargers have power ratings less than or equal to 22 kilowatt (kW) and DC chargers have power ratings more than 22 kW. Public AC chargers are mostly level 2 (L2) chargers, sometimes also referred to as slow chargers. DC chargers can also be referred to as fast/rapid chargers or direct current fast chargers (DCFC).

14th Five-Year Plan [9]. While public funding support is necessary to offset the high capital costs at the early market development stage and to catalyze private investment in EVSE deployment, it is also critical to enhance market competitiveness of charging service networks as government assistance gradually transitions away.

Private investments have supplemented public funding gaps and will continue to be critical in establishing a sustainable, accessible, and affordable infrastructure network globally. A promising financial business case for public charging infrastructure deployment is also emerging in some applications. For example, major charging network companies in North America have all seen growth in both revenue and gross margin since the economic activities started to recover from the COVID-19 pandemic in 2021 [10, 11, 12]. Privately-owned charging businesses in China have also seen an unprecedented 76% year-over-year (YOY) revenue growth in 2022 and a recent market evaluation has indicated that a positive return on investment (ROI) may be realized soon [13]. Real-world costs and revenue data in leading EV markets suggests that whether or when a positive business case develops, and thus when public funding is no longer needed, depend on various business elements, including level of local EV market maturity, location, vehicle class (LD vs. MDHD), charger type (AC vs. DC chargers), utility tariff, etc.

This study employed a holistic approach to evaluate policies, market conditions, and other key factors that affect public charging infrastructure profitability. The project team started by reviewing leading international approaches and policies that foster private sector involvement and maximize the benefits from public funds for public infrastructure deployment. In collaboration with the International ZEV Alliance (IZEVA), the team identified four markets of interest, including Canada, China, India, and the Netherlands, to further survey charging infrastructure costs, revenue, profitability, and market sensitivity. These four markets were chosen as they can provide a comprehensive overview of business case under various market conditions. This work further examined the dependence of the charging infrastructure profitability on key factors including, but not limited to, capital expenditure (CapEx), electricity costs, and utilization rates in the selected markets. The outcomes of this analysis served as the framework for the development of an interactive tool, the Charging Infrastructure Business Case Assessment Tool (CIBCAT), which assesses charging business cases for MDHD chargepoints (DC chargers with 50 kW+ power ratings). This report also demonstrated the applicability of CIBCAT by conducting comprehensive costs analysis of public MDHD chargers in all four markets. In addition, the study provided recommendations of government subsidies and incentives, as well as other policies or strategies that can better assist private sector to enter the infrastructure business given the various nature of local markets.

Policies to Foster Private Sector Leadership in EV Charging

Although the majority of public charging stations deployed to date have received public funding support, there are numerous on-going policies and approaches that encourage private sector actors to enter and lead public charging infrastructure development from different nations, jurisdictions, and intergovernmental alliances. These programs can be summarized into four major categories: establishing EV and infrastructure deployment targets, improving cost-competitiveness of EVSE components, accelerating charging station site development, and encouraging innovative business models. Detailed programs and policies are summarized below.

- Establishing national or regional EV penetration and adoption targets: Station utilization rate is clearly one of the determining factors of charging business profitability and an increase in on-road EV population is likely to improve public charger utilization. Therefore, setting EV adoption targets or sales requirements can help to relieve concerns from private initiatives and provide market certainty for both utility planners and charging developers. Many countries and jurisdictions have already established EV penetration and adoption targets for both LD and MDHD vehicles in the last decade, including China [14], the European Union (EU) [15], California

[16], the U.S. [17], Canada [18, 19], etc. Notably, as outlined in the ZEV Declaration, which was established during the 2021 United Nations Climate Change Conference (also known as COP26), more than 100 countries, businesses, and organizations are committed to working towards all sales of new cars and vans being zero-emission globally by 2040, and by no later than 2035 in leading markets [20]. The total number of signatories of the ZEV Declaration has expanded to more than 225 counties, jurisdictions, and automakers since COP26. In addition, twenty-seven countries have signed the Global Memorandum of Understanding (MOU) on Zero-Emission MDHD Vehicles, aiming for 30% new MHDVs being zero emissions by 2030, and 100% by 2040, as a strategy to achieve net-zero carbon emissions by 2050 [21]. This MOU has also been endorsed by representatives of sub-national governments, businesses, and other organizations with influence over the freight truck and bus industry and road transport.

- Identifying infrastructure deployment priorities and charging activity hotspots: One common conundrum that the private charging industry faces today is the competing priorities of charging infrastructure development, such as whether to install chargers that serve LD vehicles vs. MDHD trucks, to prioritize deployment of AC vs. DC charges, or to focus on the needs of corridor- vs. community-based charging. Therefore, public agencies should consider encouraging private investment to expand charging network in a cost-effective manner, where high utilization and ROI can be guaranteed. One example of such efforts is to identify priority corridors for charger deployment, such as the DCFC network along state highways in New Zealand [22], the EU TEN—T charging network [23], the Alternative Fuels Corridors and the National Electric Vehicle Infrastructure (NEVI) program in the U.S. [24], and the MDHD battery swapping corridor program along the Sichuan Expressway in China [25]. Establishing green or zero-emission zones is also quite common in many urban and metropolitan areas across the world, such as London, Amsterdam, Paris, Shenzhen, Kolkata, and Chennai [26, 27]. It is also noteworthy that while such demand-driven approaches can help to ensure profitable charger utilization, equitable access is also critical when planning for infrastructure deployment. Many European cities have seen promising outcomes to establish a balanced business case while synchronizing charger installation in both high-demand areas and places that are suitable to provide equitable charging access in the long run [28].
- Improving EVSE component cost-competitiveness: Substantial capital expenditure (CapEx) for charging infrastructure installation and site development remains one of the major market entry barriers that impede the development of a positive business case. Supporting the EVSE manufacturing and assembly industry could reduce equipment costs from EVSE suppliers and alleviate some financial burdens for charging service providers. This measure includes improving the market competitiveness of different EVSE parts and supporting upstream supply of distribution transformers, power supply cables, distribution boxes, circuit breakers, isolators, protection equipment, mounting units, etc. In addition, supporting research and development (R&D) that drives technology advancement will also help to reduce the manufacturing costs of EVSE. In China, for instance, the unit price for charging module (major component of a changepoint) has dropped from ¥1.2/W in 2016 to ¥0.13/W in 2022, while "actively supporting R&D of key charging techniques" was first named as a priority task in the China Electric Vehicle Charging Infrastructure Development Guidelines in 2015 [29, 30].
- Standardizing EV charger types and protocols: There are five major DCFC connector standards worldwide: the GB/T standard in China, the Combined Charging System (CCS) Type 1 in the U.S, the CCS2 in the EU, the CHAdeMO in Japan, and the North American Charging Standard (SAE J3400, similar to the Tesla charging standard) [31]. In addition, there are also various complementary communication protocols that certify seamless communication and data exchange between various entities in the EV realm, such as the Open Charge Point Protocol (OCPP), the Open Smart Charging Protocol (OSCP), the Open Charge Point Interface

(OCPI), and the ISO 15118 bi-directional protocol [32]. Different standards and protocols not only complicate the EV and EVSE trade between countries, but also cause confusion and frustration for charging station operators and EV drivers (for those who drive in countries or regions without a uniform standard). Recent data have also indicated that different standards of open public chargers may also result in more equipment failures and system downtime, which directly increases station operation and maintenance costs and reduces equipment utilization [33]. The EU Alternative Fuels Infrastructure Directive 2019/94/EU (AFID) has prescribed Type 2 connector for AC charging and CCS2 for DC charging, which demonstrates an ongoing collaborative governmental effort to improve this current situation [34]. While it may be implausible to have a uniform charging standard worldwide, government agencies may still encourage the standardization of new charging technologies. Such efforts include the development of the ultra-high-power megawatt (MW) ChaoJi Standard, led by China and Japan, and the Megawatt charging system (MCS) adoption by the U.S.-EU Trade and Technology Council [35, 36]. Initiatives to motivate the adoption of open systems to avoid lock-in effect may also be valuable [37]. The California Energy Commission, for instance, has recommended charging providers in California to pursue widespread deployment of ISO 15118-ready chargers [38].

- Streamlining site development administrative and permitting process: The development of charging stations may take anywhere between several months to years to complete, and this process can even be further slowed down due to poorly navigated administrative procedures. The extended development timeline is often poorly understood and may incur huge financial burdens to site owners and operators, especially for those who have to pay back their loans while waiting for the stations to be commissioned. A recent study has indicated that soft costs associated with these processes may explain why charger installation costs in the U.S. are three to five times the costs of the equipment itself, a much higher ratio than seen in Europe [39]. In order to support timely public charging infrastructure deployment and reduce soft costs due to site development and permitting delays, government agencies should consider minimizing administrative hiccups and streamlining the current site development process. Measures such as implementing a "one stop shop" for all permits needed [40], establishing national or regional guidelines for local authorities to align and standardize requirements [41], incorporating EV charging in zoning and land use code updates [42, 43], and land banking to set aside public land for future charging station development [44, 43] have all been implemented by public agencies in leading EV markets, encouraging more private initiatives in public charging infrastructure.

- Facilitating utility upgrades and site energizing: In addition to administrative processing and coordination with local officials, charging site energization [3], utility upgrades, and infrastructure make-ready also contribute significantly to site development costs. The costs and actual timeline of facility upgrade varies from site to site, depending on local utility policies, as well as grid, transmission, and substation capacity. Government agencies may consider establishing guidance of estimated timeline, costs, and other expectations for site developers when it comes to facility upgrades. For instance, California established an interim 125-business day average service energization timeline for projects taking service under the EV Infrastructure Rules [45]. Local authorities should also work with utilities to identify grid availability, incorporate transportation electrification in capacity planning, to enhance grid capacity in advance. Such effort is represented in the latest Hawaiian Electric Integrated Grid Plan [46]. Besides, it is also critical for government agencies to develop strategies and programs to support vehicle-grid integration and microgrid projects to improve grid resiliency and reliability [47].

[3] Steps taken from the utility-side for chargers to start receiving power.

- Promoting public-private partnership (P3) models: Public-private partnership (P3) models have been proven extremely effective to expand infrastructure deployment by bringing together the resources and expertise of both the public and private sectors. Examples include the Electric Island project in Oregon [48], the double-decker buses charging project in London [49]. P3 models can help to accelerate land acquisition process, speed up deployment, expand the network, diversify the business model, and ensure long-term sustainability of the charging service network. In the Netherlands, an organization called the National Charging Infrastructure Agenda (NAL)[4] has set an example where public and private actors collaborate on setting goals, determining actions, and making agreements, which leads to improved coordination and multi-stakeholder participation [50]. The City of San Diego in California has recently released a Request for Proposals (RFP) to select an exclusive group of EVSE provider to install, operate, and maintain networked EV chargers on all city-owned properties for public and workplace charging [51]. This P3 practice aims to accelerate the creation of a reliable and accessible regional charging network on large scale of public property while saving the time and costs for service providers to acquire land and permits. The European Bank has also established five contractual models between public authorities and private companies for deployment of charging infrastructure. Recommendations on how to select the optimal model are also provided, varying based on the public authority's objectives, market maturity, and the desired risk allocation [52]. Similarly, the Sustainable Transport Forum Handbook provides detailed guidance as well as instructive cases studies to public authorities for procuring, awarding concessions, licenses and/or granting support for electric charging infrastructure [53]. These P3 practices have shown success in building well-designed, strategically positioned, interoperable, future-proof, and user-friendly infrastructure. Public agencies should continue to explore and improve P3 models, revenue sharing structure, and public procurement processes, while encouraging innovative business models, such as EV charging service franchises, EV mobility hubs, etc.

Upon reviewing these international approaches and programs, in collaboration with the IZEVA and member jurisdictions, the project team selected four markets to survey the policy and funding schemes available in each of these jurisdictions, spanning various geographic locations and market characteristics, as shown in Table 1. The focus of this market survey is on high-powered DCFCs that serve MDHD vehicles, where a positive business case is yet to be fully understood and developed.

Table 1. Market selection criteria.

Market	Continent	IZEVA Member	Carbon Credits Offered	National MDHD EV Goal	Private Sector Representation in Current Market[5]	MDHD Market Maturity[6]
Canada	North America	Yes	Yes	Yes	Moderate	Moderate
China	Asia	No	No	Yes	High	High
India	Asia	No	No	No	Limited	Limited
Netherlands	Europe	Yes	Yes	Yes	Moderate	Moderate

[4] Nationale Agenda Laadinfrastructuur (NAL)
[5] The magnitude of private investment in the current market.
[6] A combination of policy support, funding programs, model availability, and infrastructure readiness.

Canada

Canada is one of the emerging EV markets in North America, that has already committed to 100% LD sales to be zero-emission vehicles (ZEVs) by 2035, and MDHD by 2040 (where feasible)[7] [54, 55]. As of August 2023, there are about 10,000 public charging stations deployed in Canada, with 24,000 total EVSE ports, as shown in Figure 3. The majority of these existing charging points are AC chargers, while around 4,400 ports are DCFCs.

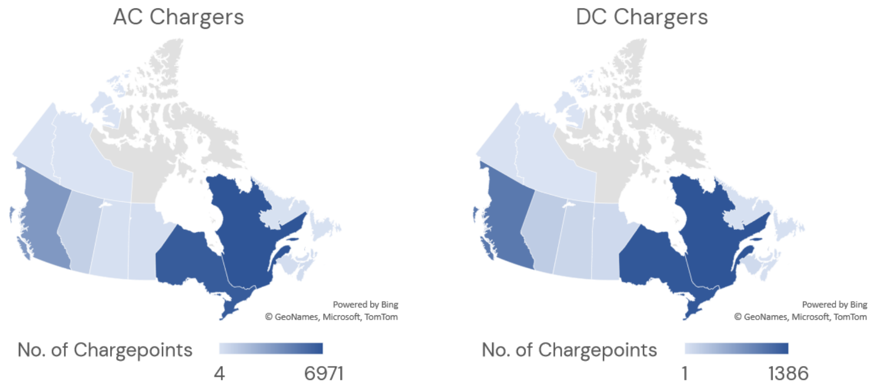

Figure 3. Number of public AC (left) and DC (right) chargers by provinces in Canada as of August 2023.

One notable governmental effort to install public DC chargers was to establish a national coast to coast DC charging network through the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI). The program was launched by the Natural Resources Canada (NRCan) from 2016 to 2021, which totaled $260 million investment distributed to different organizations and businesses to install 1,000 public EV DC chargers along core routes and highways [56]. Building upon the EVAFIDI efforts, the Government has also committed $280[8] million in 2019 to the Zero Emission Vehicle Infrastructure Program (ZEVIP) over 5 years to support the deployment of 33,500 electric vehicle chargers in public places, on-street, in multi-unit residential buildings and at workplaces. The program also provides support to strategic infrastructure projects for urban delivery and commercial fleet applications. The ZEVIP program contributes up to 50% of total project costs up to a maximum of $10 million per public charging project. The funding was recapitalized in 2022 with an additional $400 million, and extended the program to 2027.

The Canadian federal infrastructure investments have so far mostly focused on LD vehicles. Given the bigger energy requirements and diverse fleet duty cycles, multiple tailored approaches to support MDHD ZEV transition have been identified [57]. For instance, a targeted request for proposals for commercial fleets has been launched under ZEVIP. Fleets and organizations may receive up to $200,000 incentives for purchasing or leasing eligible vehicles [58]. Federal incentives are also complemented by $500 million Charging and Hydrogen Refueling Infrastructure Initiative (CHRI) that the Canada Infrastructure Bank will invest in large-scale EV charging infrastructure that is revenue generating and in the public interest [59]. The CHRI program aims to provide financing to the private sector structured to share in infrastructure utilization risk by aligning principal repayments with utilization levels [60].

EV charging station owners in Canada are also eligible to generate credits under the Clean Fuel Regulations (CFR). The credits will be evaluated based on the amount of carbon dioxide equivalent (CO_2e) emissions avoided through the delivery of electricity to electricity-powered vehicles as a transportation fuel [61]. The national CFR credits are also stackable with the Low Carbon Fuel Standard, or LCFS credits in British Columbia (BC) [62].

[7] Canada is a signatory of the Global MDHD ZEV MOU.
[8] Unless specified, the dollar sign ($) used for market studies represents the Canadian dollar, or CAD.

In Canada, most public EV charging infrastructure has received some public financial support to date. However, public funding was not the sole source. As a matter of fact, for every $1 that NRCan invested in the EVAFIDI program, $2 of outside funding was leveraged [56]. This program has demonstrated that public funding can help to build the business case for private sector to invest and to catalyze projects that would not otherwise have happened. As the MDHD EV market develops initially, public funding will still be necessary to incentivize both infrastructure installation and operation. Programs such as ZEVIP, CHRI, and CFR will certainly help to attract more investment and leadership from the private sector. Another public charger deployment gap that needs to be addressed in Canada, possibly through public funding and policy schemes, is the uneven geographic distribution of charger placement. As shown in Figure 3, charging access is very limited in some part of the country. Although the population density and overall vehicle ownership are lower in the North, installing chargers in remote areas and ensuring high equipment uptime in a cold climate will be critical as the country moves towards a zero-emission future.

China

China is by far the largest EV market and the biggest player in battery as well as EV and EVSE component trade in the world. As of the end of 2022, China accounted for more than 50% of all the electric cars operating on road globally, and also dominated the global MDHD bus and truck sales [1]. As of August 2023, there are a total of 1.3 million AC chargers and 963,000 DC chargers deployed across the country, with roughly 54,000 new public chargers installed every month in the last year [63]. The top 10 provinces with most public chargers are illustrated in Figure 4.

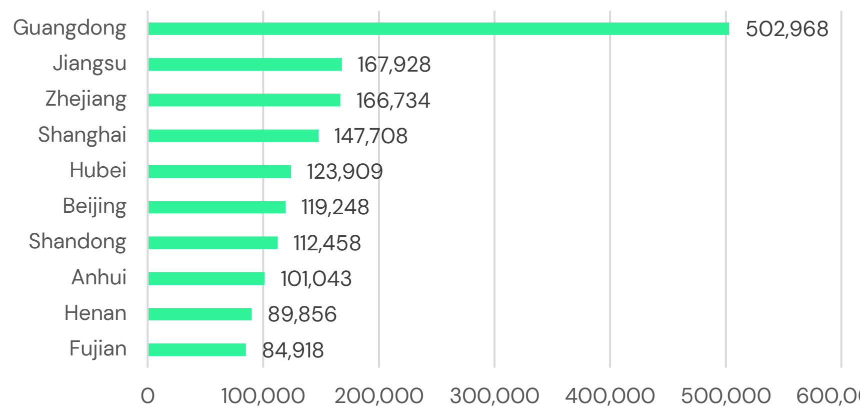

Figure 4. Top 10 provinces in China with most public chargepoints as of August 2023.

Under the direction of the most recent Five-Year-Plan, multiple levels of government and jurisdictions including the constituent departments, provinces, autonomous regions, and municipalities, have all established policies and programs to encourage EV adoption and public infrastructure deployment. For example, in Hainan, the southernmost province and largest island in China, qualified buyers of MD and HD ZEVs[9] may be eligible for a rebate up to ¥20,000 and ¥30,000 per vehicle, respectively [64]. In Shenzhen, a megacity and special economic zone located in the province with the most public chargers deployed as of 2023, Guangdong, every battery electric truck (BET) may receive up to ¥750 subsidy for every kWh of battery capacity [65]. On the infrastructure side, the Beijing Municipal Commission of Development and Reform has announced its plan to deploy a total of 700,000 public chargers by 2025, with an average station service radius of 3 km in the plain area and continue to identify appropriate use case applications for battery swapping stations [66]. Shenyang, the largest city in Northeast China, offers a one-time charger installation rebate of ¥300/kW for DC chargers, ¥100/kW for AC chargers, and ¥600/kW for battery swapping stations, as well as a ¥0.1/kWh subsidy for public charging station operation [67]. In addition, early in 2023, the Ministry of Industry and Information Technology, partnered with seven other constituent departments, established an ambitious goal to achieve an EV-to-port

[9] Often referred to as new energy vehicles (NEVs) in China.

ratio of 1:1 for every new EV deployed in China between 2023 and 2025 [68]. While urban centers and metropolitan areas are accelerating the deployment of public infrastructure network, there are also national and local initiatives to strengthen grid resilience and reliability in rural areas while EV adoption in these regions catches up. For example, the National Development and Reform Commission advised to futureproof infrastructure installation and to advocate the implementation of vehicle-to-grid technologies in the underdeveloped areas [69]. These policies and incentive programs focus on compensating the high CapEx for both fleet owners and infrastructure operators and establishing a healthy market that leads to a positive business case as the new technology market develops.

Although government subsidies and public fundings are still indispensable in the current public charging infrastructure deployment, private entities have already demonstrated strong leadership in China. For example, the State Grid Corporation of China (8.65% in market share) and the China Southern Power Grid (3.2% in market share) are the only state-owned corporations among the top 10 charging station operators across the country (top 10 totaling 86.2% in market share) [63]. The business model to charge users a service fee on top of their basic electricity rate is also quite established in China. The upper limit of charging station service fee is usually set by local government and station operators can adjust the actual fee as needed. In Beijing, service fee is set to be no more than 15% of unit gasoline[10] price in the city. Chongqing, on the other hand, sets the upper limit of service fee to be correlated with local electricity price instead, capping it at 50% of electricity rate. Most of other cities use a constant value as the ceiling service fee, for example, ¥1.6 in Shanghai, ¥1 in Shenzhen, and ¥0.8 in Sanya, Hainan [70]. The flexibility of service fees accounts for the differences in local EV adoption (and thus charger utilization) and offers a steady revenue stream for charger station operators. While service fees could add more burden to vehicle owners, the overall energy price to drive an EV is still much cheaper than a conventional fuel-burning vehicle. In Hainan, for example, the most expensive public charger costs about ¥2/kWh (service fee included) [71], which still saves roughly 45% on fuel costs as compared to driving a gasoline car[11].

It is noteworthy to mention that the conventional plug-in charging infrastructure for MDHD vehicles faces great competition from the emerging battery swapping technology in China. As of 2022, more than 49% of HD ZE trucks sold in China were battery swappable [72]. A recent market evaluation has estimated that the total CapEx required for a battery swapping station that serves HD vehicles is roughly ¥9 million - ¥23 million, and the ten-year internal rate of return can vary between -9% to 22% based on station utilization [73]. While battery swapping can greatly reduce vehicle down time required for charging, it still faces barriers such as lack of battery standardization, high CapEx compared to plug-in charging, and limited station access on fixed routes and selected locations. Therefore, at least in the near-term, plug-in charging will still play an important role in the MDHD EV recharging realm.

India

Electrification of mobility in India began more recently than in Europe, the U.S., and China, but is rapidly gaining traction. This is in part linked with the overall growth in vehicle usage, with the total car sales growing by nearly 15% in 2022. The EV market in India is particularly geared towards two- and three-wheel vehicles[12], where they have been popular for about a decade. Progress in electrifying this vehicle category has been rapid in India and,

[10] Per liter regular gasoline with octane rating of 92.
[11] As of November 2023, 92# gasoline in Hainan is ¥9.3/litter (L). Assuming fuel economy for a gasoline car is around 7 L/100 km and energy efficiency of an EV is 18 kWh/100 km, the total fuel cost to drive an EV vs. a gasoline car is 36:65.
[12] Often collectively referred to as powered light vehicles.

in 2022, over half of all three-wheelers registered in the year were electric. Their popularity has been attributed to both lower lifetime costs and supporting public policies. Deployment of public charging infrastructure remains at a nascent stage, primarily being installed since 2015 through the national level subsidy schemes: Faster Adoption and Manufacturing of Electric vehicles (FAME) and its extension [74].

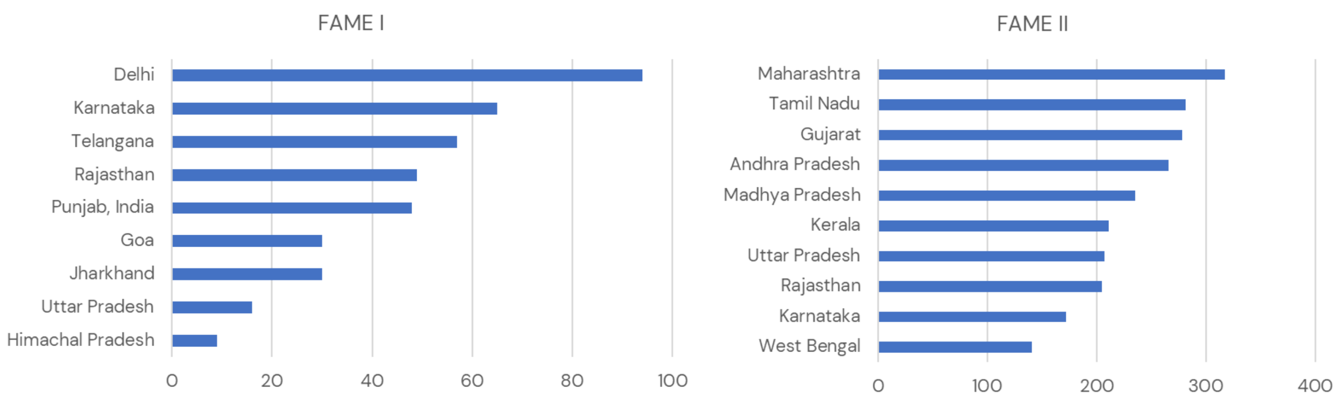

Figure 5 States with the highest number of electric vehicle charging infrastructure in India as part of the FAME schemes: FAME I (left) and FAME II (right).

Electrification of mobility in India gained traction in 2012 with the launch of the National Electric Mobility Mission Plan 2020 (NEMMP 2020), with the aim of encouraging the transition to electric and hybrid vehicles. It was followed at the national level by the Faster Adoption and Manufacturing of Electric vehicles (FAME I), which ran from 2015 to 2019, and the subsequent FAME II, as shown in Figure 5. These schemes provided subsidies for the purchase of vehicles and also involved deployment of charging infrastructure [75]. In parallel, as of 2022, 27 states in India had formulated electric vehicle policies, of which 15 states have already put these policies into active implementation [76]. These policies cover various vehicle classes and range from fiscal benefits to the establishment of green zones: urban areas where only zero emissions vehicles are permitted.

Two- and three-wheelers, passenger vehicles, and the public bus sector have all benefited from these policies, while the MDHD trucking sector has received much less attention both at the national and the state level. Some earlier policies supporting high speed charging infrastructure also facilitate charging infrastructure for the trucking sector. Interests in transitioning to BETs start growing as part of the wider reform of freight and logistics sector but it remains unaddressed at the policy level.

Though the FAME II scheme was expanded in 2023, BETs remained outside the scope of the framework. A few other measures which are targeted at the passenger vehicle segment are relevant to eventual operation of BETs. There is also a 70% subsidy on the purchase of EV chargers which are installed in public locations such as petrol stations, on-street, transport hubs [77]. Since 2023, upstream infrastructure including distribution transformers, distribution boxes and so on, which needed to be paid to DISCOMs[13] to secure an electricity connection, have been subsidised by 80%. The Ministry of Heavy Industries commissioned the installation of 7,432 DC chargers in 2023 to be deployed by 2024. These are to be installed at the retail outlets of the public sector Oil Marketing Companies (OMCs) – Indian Oil, Bharat Petroleum and Hindustan Petroleum [78].

Aside from public sector initiatives, there are also a few examples of leadership in the private sector in this space - mainly logistics companies running pilots with BETs for their operations. In 2021, Dalmia Cement (Bharat)

[13] DISCOMs or Distribution Companies are the private or public institutions responsible for the distribution grid in India.

Limited (DCBL), a large Indian cement manufacturer, deployed 2 BETs for the transportation of slag: a raw material used to produce cement. The trucks transport slag from the facility of the Steel Authority of India Limited at Rourkela, Odisha to DCBL's cement manufacturing unit in Rajgangpur, Odisha [79]. Also in 2021, Tata Steel, a large Indian steel multinational, contracted 27 BETs, each with a carrying capacity of 35 tons, for the transport of finished steel. The first BETs were put in operation between Tata Steel's Sahibabbad plant in Uttar Pradesh and the Pilkhuwa stockyard (38 km) [80].

The Netherlands

The Netherlands is widely considered to be a global frontrunner in the development of EV charging infrastructure. It has a highly mature domestic EV charging infrastructure market and a dense charging network that provides one the highest ratios of chargepoints to electric vehicles in any nation. The highest charger density as well as the highest EV ownership are found in the Randstad conurbation to the west of the nation, which includes the country's four largest cities: Amsterdam, Rotterdam, the Hague and Utrecht, as shown in Figure 6 [81].

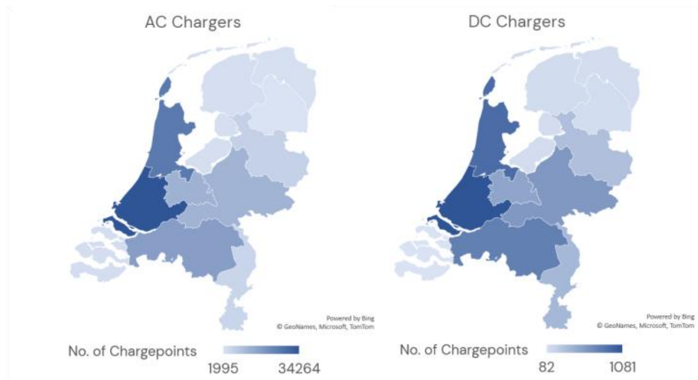

Figure 6. Distribution of slow (left) and fast (right) chargers in the Netherlands as of May 2023.

Charging infrastructure in the Netherlands was mainly developed after 2010 and was primarily driven by ambitious public policies. By end-2021, the Netherlands hosted about 30% of the public AC chargers and about 11% of DC chargers in the EU, with a total of 82,628 AC and 1,670 DC chargers, respectively [82]. The electrification of mobility has mainly affected the passenger vehicle and bus sectors, while the MDHD trucking sector has had comparatively very low production volumes [83]. As an initiator and signatory of the Global MDHD ZEV MOU as previous discussed, the Dutch government expresses the shared ambition to deploy ZE MDHD vehicles and related infrastructure with the objective of reaching 30% of MHDV sales by 2030, and 100% by 2040 in order to achieve net zero carbon emissions by 2050 [21].

To facilitate the transition of the trucking sector to zero-emission mobility, several policies have been enabled at the national level in the Netherlands. Beginning from the 1st of January 2025, Dutch cities will be permitted to designate certain areas as zero-emission zones for city logistics, where only zero-emission trucks and vans will be allowed to operate. 30 to 40 cities are expected to have these zones in total. As of June 2023, 29 cities have already declared a date when these restrictions will come into effect or are currently assessing the feasibility. The four largest cities, Amsterdam, Rotterdam, the Hague and Utrecht will all designate zero emission zones from 1st January 2025, with other cities opting for a later date [84].

The Dutch government offers the Aanschafsubsidie Zero-Emissie Trucks (AanZET), a subsidy for the purchase or lease of zero-emission trucks. In 2023, a budget of €57.4 million was allocated for the subsidy programme, an increase from the total of €25 million allocated in 2022. The day after the AanZET opened, it received applications amounting to €120 million, showing the widespread demand for BETs [85]. In the Netherlands, BETs are also exempt from paying Motor Vehicle Tax[14] [86]. Under the MIA/VAMIL[15] programmes, companies can apply for a deduction of up to 45% of costs when making "environmentally friendly" investments, meaning that investments made in electric truck charging infrastructure can be written-down against business profit and therefore reduce business taxes at a greater rate than average [87].

Several private sector fleet operators have already started working with BETs in their fleets with pilot programs, including supermarket logistics and waste transportation. As of 2023, Albert Heijn, one of the largest Dutch supermarket chains, uses BETs at their distribution centre in the City of Zaandam. The trucks are charged in about 20 to 25 minutes at 300 kW between routes which deliver goods to their supermarket outlets in urban areas [88]. Cure Afvalbeheer, a Dutch waste-management company, is responsible for the collection and transport of underground and overground waste containers in urban areas within their jurisdiction. As of 2023, BETs have been deployed for transporting waste as well as for lifting these waste containers with cranes as part of an ongoing demonstration project in and around the city of Eindhoven [89].

In 2023, the Dutch Ministry of Infrastructure and Water Management opened the Living Lab for Heavy Duty Charging Hubs[16] initiative, where heavy duty charging hubs (sometimes also called plazas) will be set up in 6 locations. These living labs, bringing together both public and private players, aim to share knowledge and experiences of heavy-duty charging in order to accelerate the electrification of the logistics sector.

Summary of Charging Station Costs and Subsidies

Charger hardware, installation, and site development costs, electricity prices, as well as available public subsidies for the four markets are summarized in Table 2. The values referenced in this report represent the best available public data at the time of writing. The actual figures are expected to vary across different markets, subject to local policies, regulations, and taxation, and change over time with market developments.

Information on Canada is based on quotes and estimates from local charging service providers such as FLO and Sun Country Highway [90]. While EVSE hardware and installation costs should be consistent across the country, electricity rates and public subsidies are different from province to province. To best account for the stackable BC LCFS program and the federal CFR credits, the project team focused the market case study on BC. Very limited information is available on costs for land acquisition and leasing as they are not eligible for NRCan incentives. However, it is quite common in Canada to seek affordable land leasing options through P3 models or business deals and thus land is not a major concern for most site operators.[17]

In China, as in Canada, there is not much geographic variation in cost data for charger hardware and installation based on recent market and stock evaluations [91, 92, 70]. However, public funding schemes and utility rates vary significantly across the country. The case study is therefore limited to Hainan Province, the first jurisdiction in the world to establish a detailed ZEV road map and one of the leading EV markets in China, which has well-

[14] Motorrijtuigenbelasting or MRB
[15] Milieu-investeringsaftrek (MIA) en de Willekeurige afschrijving milieu-investeringen (Vamil)
[16] Living Lab Heavy Duty Laadpleinen
[17] Via personal communication with NRCan staff.

established local policy and programs to support EV and EVSE market advancement as well as sufficient project cost data [91].

The data for charger hardware and installation costs in India has been collected from both official as well as unofficial sources. Information on public subsidies and electricity costs for vehicle charging have been taken from recent official government documents issued among others by the Indian Department of Heavy Industry and the Indian Ministry of Power [77]. Since installation of EV charging is a de-licensed activity in India, there is a strong involvement of market players in the sector [93]. Permitting and site development costs, operation and maintenance costs and equipment costs, have all been sourced from market players who have made this data available online. As such, these figures should be taken as approximations rather than as exact values.

For the Netherlands, the project team has mainly leveraged reports published in 2022 and 2023, which were commissioned by the Nationale Agenda Laadinfrastructuur (NAL, the Dutch National Charging Infrastructure Agenda) [94, 95]. The costs information provided by the NAL is similar to those from the Alternative Fuels Infrastructure Regulation (AFIR) [96] [97]. Data on available subsidies and renewable energy units have been sourced directly from government websites [7, 94]. Land costs were not available at the time of the study and may vary depending on location.

Key Factors Driving Charging Profitability

The charging infrastructure business case often reacts differently to various market conditions, economies, business models, and regulatory environment. However, there are also several key factors that govern charging profitability across all markets, which includes utilization rates, energy costs, EVSE CapEx and operating costs (OpEx), ancillary revenue, and incentive and subsidy levels.

- Utilization rates: Charger utilization measures the average percent of time a vehicle is plugged into the charger and electricity is transmitted actively. High utilization rates are absolutely decisive for charging stations to generate revenue. Charging station utilization rates are often correlated to locations (e.g., population density, proximity to roadways with high traffic flow, nearby attractions, and amenities), regional EV penetration and adoption, and system uptime. Currently, as public charging is still nascent, the observed utilization remains low across the world. The average LD DCFC utilization in the U.S. is around 5 – 7.5% and utilization rates of stations located in office spaces, municipal buildings, parking lots or garages, and retail centers are two to three times as high as those in hotels [105, 106, 107]. In China, the average LD chargepoint utilization was roughly 8% pre-pandemic, dropped to below 5% in 2020, and slightly climbed back to 6% in 2021 [108, 91]. A recent study estimated that the average annual utilization time per LD charging point in Germany is 460 hours every year while urban centers such as Berlin, Munich, Stuttgart, and Dusseldorf are in the range of 800-1500 hours per year and rural areas are less than or equal to 100 hours per year [109]. Real-world data on MDHD chargepoint utilization is rather scarce. However, given the nature of MDHD fleet operation, the window for truck drivers to charge is often fixed and depends on duty cycles, and thus 20% is used as a maximum, “rule-of-thumb” value for high-power DCFC ports used for MDHD charging in this study [110, 106].

Table 2. Summary of costs and subsidies data collected from the four market studies.[18]

Itemized Category	Canada ($ Canadian Dollar, CAD)	China (¥ Chinese Yuan, RMB)	India (₹ Indian Rupee, INR)	Netherlands (€ Euro, EUR)
EVSE Installation Incentives	50% of total project costs[19] [59]	10% of total EVSE equipment costs [91]	50 to 70% purchase subsidy [77]	45% tax deduction [87]
Station Operation Subsidies	$0.4/kWh[20]	¥0.1/kWh [91]	₹12/kWh[21] [98]	€0.05-0.17/kWh [7]
Land Leasing or Acquisition	N/A	¥280,000/year[22] [91]	₹1/kWh[23] [98]	N/A
Electricity Sale Price	$0.06/kWh[24] [99]	¥0.3-¥1.2/kWh [100]	₹2.5-₹12/kWh [98]	€0.2/kWh [94]
Site Development and Construction	Included in installation	Included in installation	₹100,000 - ₹500,000 [101]	€7,000 (50kW) €21,000 (150 kW) €49,000 (350 kW) [94]
Equipment (50 kW and above)	$40,000 to $175,000 [102]	¥500 - ¥600/kW[25] [70]	₹1,700,000 (50kW) [103]	€17,500 (50kW) €52,500 (150 kW) €122,500 (350 kW) [94]
Installation & Make-Ready Infrastructure	$50,000 per port [90]	¥200 -260/kW [70]	₹100,000 - ₹350,000 [103]	€1,600 to €4,200 [94]
Network Connection & Utility Upgrades	$300,000 to $1,000,000 per project [104]	¥440/kW [70]	₹500,000 - ₹750,000 [103]	€45,000 - €85,000 per MW [95][26]

[18] As of December 2023, 1 CAD = 0.68 EUR, 1 RMB = 0.13 EUR, and 1 INR = 0.011 EUR.
[19] A maximum of $100,000 per charger; currently closed for application as of Fall 2023.
[20] Calculated based on the BC LCFS Requirements [62, 61, 149] and Rewatt Power estimates [151].
[21] Capped price of electricity for fast charging.
[22] Annual leasing cost for a charging station that hosts 38 chargepoints. As a reference, the project also has an overall construction and side development costs of ¥800,000.
[23] As part of a revenue sharing agreement over 10 years.
[24] Energy charge only; demand charge and basic charge are not included but separately accounted for in the assessment tool.
[25] Current cost estimates are based on EVSE component that uses insulated-gate bipolar transistors (IGBTs). For ultrafast high-power charging systems that use silicon carbide (SiC) instead, the price might be higher [152]. It is also estimated that the total charging project development costs, including site construction, equipment, make-ready, grid upgrade, is around ¥1.2 – ¥1.8/W in China [70].
[26] The utility upgrade costs do not increase linearly by capacity; costs may surge significantly above 2 MW.

- Energy costs: The costs of energy, including fuel prices and electricity rates, can also impact charger profitability in different ways. Although recent EV sales have been greatly impacted by the post-pandemic supply chain issues and the shortages of lithium-ion batteries and semiconductors, when fuel price increases, more drivers would still consider EV as a viable alternative [111], which can potentially drive both EV sales and the profitability of charging stations [112]. Likewise, when electricity rates increase, albeit not as prominent as the publicly displayed gasoline prices, may still change people's decision when driving an EV or using public charging stations [113, 112]. As an example, in the Netherlands, where electricity prices for commercial customers rose significantly in 2022, leading to BETs being more expensive to operate than diesel trucks [114]. Besides, time-of-use pricing and utility demand charges[27] can also alter the overall charging station profitability. A potential long-term cost-saving opportunity for operators is to integrate off-grid renewable energy sources such as solar into charging stations. Renewable energy sources can be harnessed independently, which allows charging stations to generate their own power while decreasing their dependence on centralized power grids and to save on utility bills. The CapEx of photovoltaics (PV) and battery electric storage system (BESS) can vary quite significantly by country. According to a study by the International Renewable Energy Agency, the utility-scale solar PV CapEx can range from a low of USD $590/kW in India and a high of USD $1,695/kW in Russia [115], which will impact the expected project return from PV installation.

- Chargepoint CapEx and OpEx: In addition to the costs that are illustrated in Table 2, typical CapEx and OpEx for chargepoint also includes permitting and administrative costs, insurance, warranty, network service connections, payment service subscription, and equipment maintenance (w/o warranty). Although these costs are not as significant as equipment purchase and installation, they could still impact charging profitability, especially considering some of these costs are not properly documented or well-understood, and thus may become an unpleasant surprise to station operators if not prepared. Besides, the profitability of a charging station is also dependent on the expected lifespan of EVSE. While 10 years have been commonly used as the average lifespan of a charge point, the actual time will also rely on the equipment operation and local climate. A much-shortened lifetime and more frequent equipment replacement schedule would be expected for EVSEs installed in places with high humidity, high temperature, high salinity, and prone to rain [91]. The length of land leasing or concession agreement will also impact the overall station profitability, It is also mentioning that the CapEx listed in Table 2 is mostly applicable to DCFC chargers at kW level. MCS, which is designed for a 6-fold higher current and up to 10-fold higher power compared to CCS [116], often incurs utility upgrade at substation and subtransmission level in addition to transformer level. A recent study on the U.S. Interstate 5 Corridor has estimated that the cost to install a dedicated customer substation and subtransmission interconnection to host 10 2MW MCS can be up to $10 million, which is four times as expensive as the average per kW upgrade costs to support kW-level CCS chargers [117].

- Ancillary revenues: Retails and advertising are the two most common ancillary revenue streams for charging stations. Although the convenience store – charging stations business model is not fully developed, lessons learnt from the conventional gas stations can be used as a reference [118]. In the U.S., data have shown that 44% of all fuel customers would walk in the store, almost 15% would purchase a snack or drink. While these items bring in only a third of the average gas station's revenue, their profit margins can be 50% or more than that of gasoline and account for nearly 70% of the overall profits [119, 120]. Similarly, truck stop upgrades have also gained interest among operators and investors. Pilot, a fuel provider and truck stop operator in the U.S.

[27] The highest level of electricity usage in one billing period

and Canada., has started a $1 billion initiative to remodel its facilities to multi-functional travel centers[28] that supports fast charging for customers [121]. As EV surges around the world, retailers and brands have also embraced the idea of displaying advertisements on charging ports. Since one charging event usually lasts more than 30 minutes, EV drivers are likely to be attracted to nearby activities, creating a win-win situation for both the charger operator and the retailer. In China, the annual revenue in 2020 from advertising displays is around ¥500 per port [122]. In the U.S., Volta's digital out-of-home (OOH) business model also may start gaining traction [123, 124]. The charging-advertising combination could likely expand in the future and attract more potential businesses and partnerships [125].

- Incentives and subsidies: As discussed earlier in this report, government incentives and subsidies will remain necessary for early markets to offset the costs of purchasing, installing, and operating charging stations and carbon credits are among the most significant revenue streams for charging service providers. According to a recent study, the California LCFS program was able to help cover up to 80% of the electricity cost during the pandemic [126]. It was estimated that in 2021, the annual revenue generated through LCFS credits from a station that charges 10 vehicles every day is roughly USD $15,400 [127]. Assuming reasonable future credit prices of $100 per metric ton, a total of $4 billion revenue can be generated through the LCFS program between 2017 and 2030 [128]. One thing to note, however, is that the price volatility of LCFS credits can significantly alter cost recovery. As the average credit price drops from $206 during the pandemic to $71 as of November 2023 [129], it may only compensate 20% of the electricity usage, 60% less than the maximum [126]. In The Netherlands, investments in truck charging infrastructure can be deducted from business profit at a higher rate (45%) than other investments, providing a more general tax incentive to invest in electric truck charging infrastructure [82]. Additionally, electricity used for truck charging which is sourced from renewable electricity are counted as Renewable Energy Units[29]. These units may be used to meet renewable obligations, and can either be traded or booked with the government to improve the business case of charging.

[28] Include amenities such as restrooms and showers, quick-serve kitchens, restaurants, and dog parks.
[29] Hernieuwbare Brandstofeenheden (HBE)

Cost Analysis for Public MDHD Chargers

To better understand how the forementioned key factors may affect charging profitability, a bespoke tool has been developed to provide assistance with assessing the business case for public charging infrastructure. The Charging Infrastructure Business Case Assessment Tool (CIBCAT) has been designed to be used in any market and has been made freely available. CIBCAT has been applied to the four markets selected in this report, with the detailed methodology, assumptions, and cost analysis results presented below.

Tool Methodology

CIBCAT is based on a discounted cashflow model, with the key result being expressed as a project Net Present Value (NPV). The user inputs to the tool are used to both calculate project initial set up costs (CapEx) and forecast annual operational costs. The numbers and types of chargepoints are selected by the user, as well as whether to include optional PV and BESS (with associated costs). The user can specify a PV array at the charging site, the energy from which is used to power the chargepoints while any excess will be exported back to the grid. A BESS may also be added, which will be used to store excess energy from the PV for nighttime usage by the charging site. Finally, electricity prices, forecasted annual utilization, and reliability[30] of the chargepoints are also required from users. The tool then simulates the charger usage, energy volumes, associated costs, and revenues for each year. These results are then used to populate a discounted cashflow model. An illustration of the calculation flow in the tool is provided in Figure 7.

The simulation of chargepoint usage in the tool is critical, firstly to produce a realistic maximum power capacity demand from the chargepoints (assuming there is no energy management), and secondly for scenarios that include PV, to produce realistic annual estimates of energy imported, consumed from PV, or exported to grid. The tool runs a Monte Carlo simulation of possible utilization of chargepoints based on an annual utilization target and a diurnal profile of when the chargepoint may be in use. The hourly usage of the chargepoint is simulated, drawing from a uniform distribution. This approach is used to determine realistic estimates of peak power demand, and the coincidence of charging energy demand and PV generation. From the Monte Carlo simulations, average energy is used to determine energy costs and revenues, whereas the maximum power is used to calculate import capacity, accounting for the fact that the chargepoints need sufficient power under all circumstances. For scenarios that include PV, simulations are performed for typical spring, summer, autumn, and winter days.

The energy provided from PV is determined through a complex relationship between the coordinate of the site, solar declination angle, and sunshine hours. A user-provided value for sky clearness, ranging from 0 to 1, is also included. Note that energy flows between PV, BESS, and chargepoints are not modelled stochastically, and rather a straightforward deterministic approach is developed. A fully accurate simulation of the energy is beyond the scope of this tool. Nevertheless, the approach taken should provide sufficient accuracy for a high-level business model assessment.

Assumptions

The following key assumptions have been made when creating the tool:

- The technology lifespan is 10 years, with net present value (NPV) calculated over the same duration.
- A single utilization profile is used and applies to all chargepoints.

[30] Charger reliability (0%-100%) quantifies the time that the charger is working as expected and not out of order. Any charging events that are simulated during periods of unreliability represent lost income.

- Utilization events within utilization profiles are from a uniform distribution.
- Charger OpEx applies to all chargepoints equally.
- Grid upgrade costs are applied on a per kW basis.
- Electricity prices are constant throughout each day and year. This was chosen partly to keep inputs simpler for the user, but also to exclude energy price volatility risk from the model. Such risk can be managed by a fixed price energy contract.
- Chargepoint utilization has no seasonal or within week variation.
- When calculating solar yield, only four typical days (one in each season) are simulated.
- The total power reduction due to a BESS is assumed to be evenly distributed across the hours where there is charging demand in a day. Also, the battery can only be fully charged and discharged one time in a day.

Case Studies

In order to better understand charging business cases in the four surveyed markets, the project team conducted a comprehensive cost analysis for public MDHD charging projects. In the analysis, the team evaluated how varying market characteristics, chargepoint utilization, inclusion of PV and BESS systems may impact the business case. Variables including the number of chargepoints (20), charger power output level (350 kW), project lifetime (10 years), PV rated capacity (250 kW), BESS storage capacity (200 kWh), BESS power (100 kW), inflation rate (5%), and NPV discount rate (6%) were held constant across all scenarios. Electricity price was assumed to increase 9% annually[31] while government subsidies and incentives remain the same as shown in Table 2. The results of eighteen case study scenarios are summarized in Table 3 and Figure 8.

In most cases, the inclusion of onsite PV may alleviate some operational burdens on station operators and thus improve the overall project profitability. The per kWh lifetime profit can increase roughly 5-15% in Netherlands, 10-40% in China, and 20-180% in India with onsite PV installation. The large profit margins observed in China and India are primarily linked to the low equipment and installation costs of PV observed in local markets, the recent growth in domestic polysilicon and PV manufacturing industry, and abundant sunlight exposure in the surveyed areas [115, 130, 131]. One exception to the cost-saving trends associated with PV is Canada. Using recent data published by the Canada Energy Regulator, the project team estimated the total CapEx of PV installation (with rated capacity of 250 kW) in Canada is roughly CAD $1,800 - $2,000/kW [132, 133], which can be almost three times as expensive as PV CapEx of similar scale in China or India [115, 134]. In addition, the feasibility and economic viability of solar power in Canada is also influenced by its climate and seasonal variance of solar irradiance. For instance, the daily insolation hours in winter months can be as modest as 1 – 2 hours in multiple regions across the country [135], which can substantially limit the overall energy production of an installed PV system. With the data use the cost of locally generated PV over the project lifetime was higher than the cost of grid imported electricity, hence for Canada PV detracts from the business case. As a point of reference, in the year of 2022, only 0.5% of total electricity generated in Canada was from solar energy [136], while this share is 4.7% in China [137], 5% in India [138], and 14% in the Netherlands [139, 140].

[31] Average energy inflation rates over last five years across G7 economies [153].

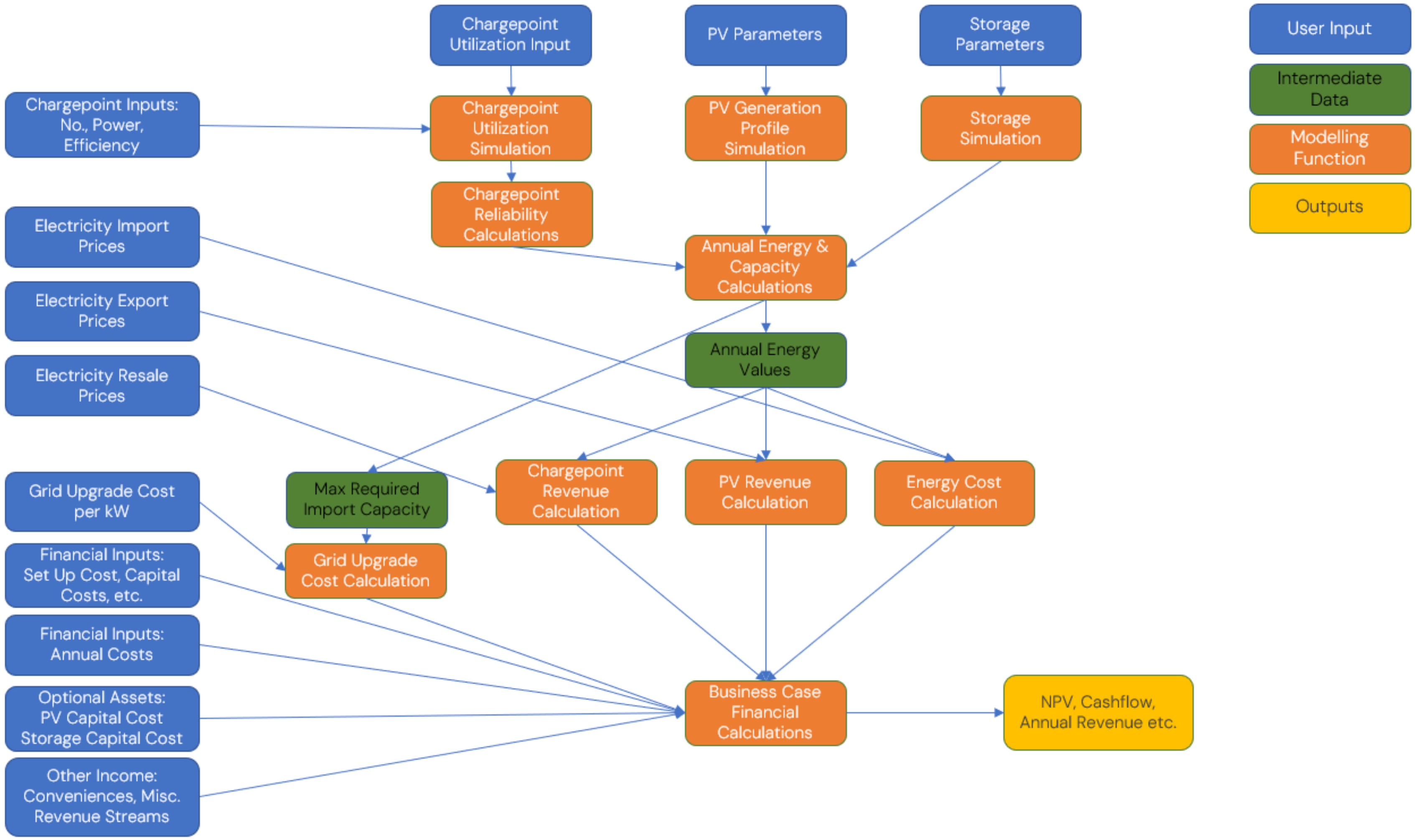

Figure 7: Charging Infrastructure Business Case Assessment Tool (CIBCAT) Diagram

As anticipated, higher utilization will lead to a better business case. As a matter of fact, the payback period, or the total time needed for the project to generate sufficient cash inflows to recover its initial costs, can be shortened by half when the average charging station utilization increases from 10% to 20%[32]. However, as discussed earlier, charger utilization for public MDHD stations may be limited by duty cycles and operating characteristics of MDHD fleets. Therefore, it is unreasonable to expect chargepoint utilization to be significantly highly than 20%, unless fleet operation undergoes drastic reform as the industry transitions to EV.

Due to limited data availability on BESS CapEx and OpEx, only two scenarios were considered in this analysis to show market sensitivity to BESS integration in China [141] and the Netherlands [142]. With the default battery storage and power capacity, the economic impact of incorporating BESS into charging station is not as consequential as other input variables. However, BESS may still offer great values for being able to relieve strains on the grid, to improve the overall grid resiliency, and to serve as a backup power source, ensuring that stations can continue to operate during power disruptions.

Table 3. Case study results for all four markets under various input conditions. All scenarios are assumed to have a project lifetime of 10 years, with a total of 20 high-power DCFC (350 kW) chargepoints.

Market	Input			Output				
	Utilization	PV	BESS	Project CapEx[33]	NPV	ROI	Lifetime Profit per kWh	Payback Period
Canada	10%	No	No	-$5.7 million	$1.2 million	15%	$0.07	Year 6
China	10%	No	No	¥-7.8 million	¥7.7 million	28%	¥0.44	Year 5
India	10%	No	No	₹ -241.5 million	₹ -7.8 million	7%	₹ 2.32	Year 9
Netherlands	10%	No	No	-€ 2.8 million	€ 10.2 million	95%	€ 0.53	Year 3
Canada	10%	Yes	No	-$6.2 million	$1.8 million	22%	$0.10	Year 5
China	10%	Yes	No	¥-8.6 million	¥11.6 million	44%	¥0.63	Year 5
India	10%	Yes	No	₹ -252.2 million	₹ 80.2 million	22%	₹ 6.61	Year 7
Netherlands	10%	Yes	No	-€ 3.1 million	€ 11.9 million	120%	€ 0.61	Year 3
Canada	20%	No	No	-$5.7 million	$8.7 million	58%	$0.18	Year 2
China	20%	No	No	¥-8.3 million	¥30.1 million	59%	¥0.74	Year 3
India	20%	No	No	₹ -252.7 million	₹ 328.8 million	35%	₹ 9.19	Year 5
Netherlands	20%	No	No	-€ 2.9 million	€ 23.4 million	117%	€ 0.58	Year 2
Canada	20%	Yes	No	-$6.2 million	$8.7 million	57%	$0.19	Year 3
China	20%	Yes	No	¥-9.1 million	¥33.4 million	70%	¥0.82	Year 3
India	20%	Yes	No	₹ -261.9 million	₹ 415.6 million	46%	₹ 11.30	Year 4
Netherlands	20%	Yes	No	-€ 3.1 million	€ 24.9 million	131%	€ 0.62	Year 2
China	20%	Yes	Yes	-$9.5 million	¥33.1 million	69%	¥0.81	Year 3
Netherlands	20%	Yes	Yes	¥-3.3 million	€ 24.7 million	130%	€ 0.62	Year 2

Broadly speaking, the likelihood to establish a positive MDHD charging business case in the Netherlands, China and Canada is higher than that in India. One aspect that contributes to such difference is, as discussed earlier,

[32] Note that increases in project CapEx for 20% utilization are due to increase to the grid connection cost to accommodate higher peak demand.
[33] Considers the grid upgrade costs that accounts for the actual peak import power in the scenario (includes offsetting by PV, BESS, and impact of utilization).

the overall market maturity in these counties is, to some extent, well-established and capable of attracting private businesses to start investing in EV infrastructure. On the other hand, as the private MDHD charging infrastructure business is still in its fledgling stage, India will potentially confront additional hurdles until a positive business case can be fully developed. In addition, not all the input data were available at the time of analysis, especially in India and Canada, while the project team has formulated a series of educated projections to fill in the gaps, the outcomes may still vary once additional and more comprehensive data becomes available.

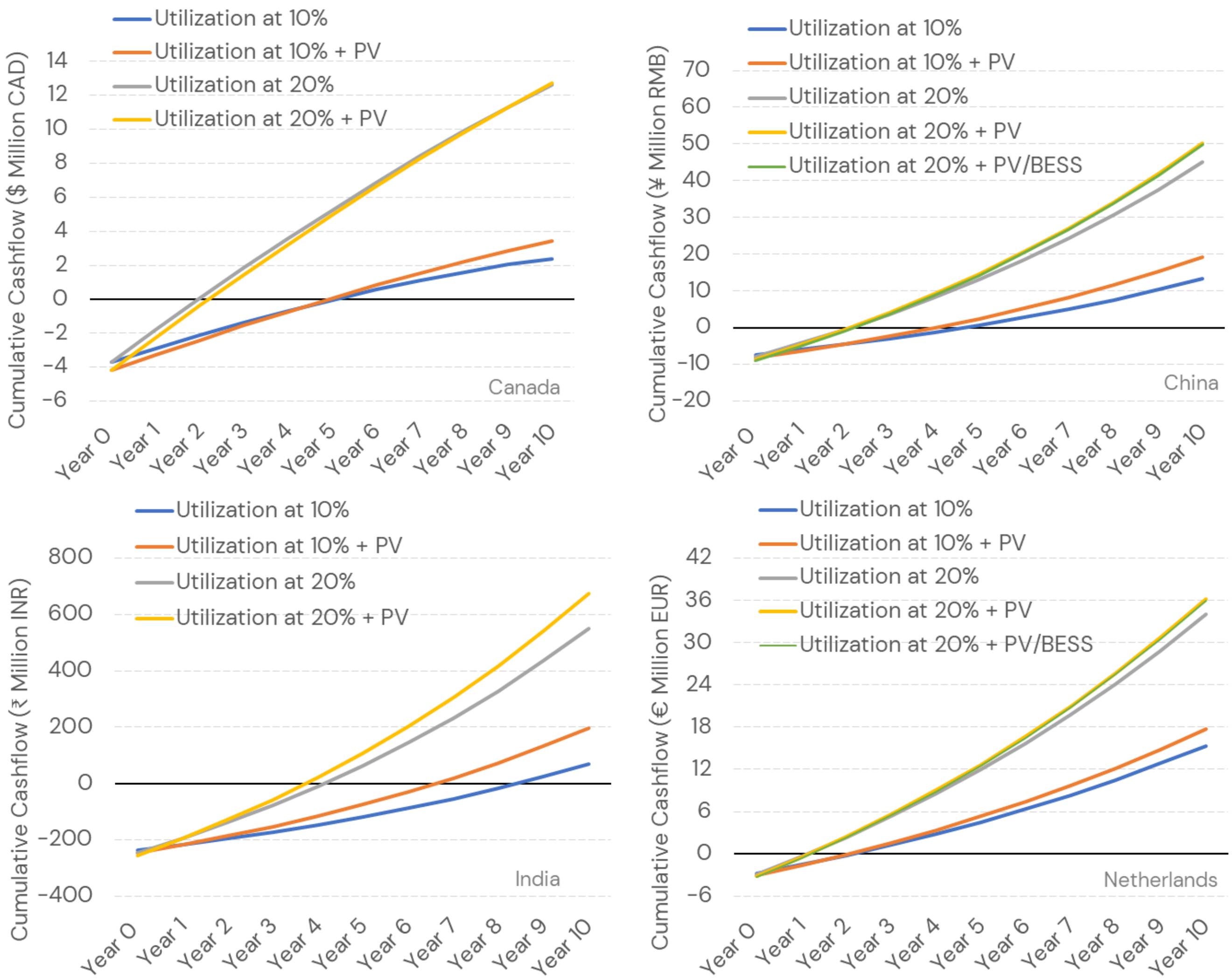

Figure 8. Ten-year cumulative cashflow to operate a MDHD charging station in Canada (top left), China (top right), India (bottom left), and the Netherlands (bottom right) under various business scenarios.

Conclusions

This report first features a thorough review of existing policies and approaches that encourage private sector leadership in public charging infrastructure from different nations and jurisdictions. Based on the outcomes of the policy review, the project team identified four different markets, Canada, China, India, and the Netherlands, to evaluate the development of charging business case. In addition to policies, markets characteristics, and charging station expenditure, information was also gathered on key factors that affect charging infrastructure profitability. The results were then used to develop an interactive business case evaluation tool, CIBCAT. Eighteen case study scenarios spanning all four markets were examined and intercompared to understand how varying market characteristics, charger utilization, and inclusion of PV and BESS systems may impact the MDHD charging business case. Synthesizing the lessons learnt from literature review and the CIBCAT case studies, the following SWOT (strengths, weaknesses, opportunities, and threats) analysis has summarized advantages and barriers of each market and provided case-by-case recommendations of government support opportunities that can better assist private sector to enter the public MDHD infrastructure business.

Canada

- Strengths: The Canadian federal and provincial governments have established a series of initiatives and regulations in both the transportation and energy sectors to promote a smooth ZEV transition. In addition, similar MDHD EV policies and programs are also emerging in the U.S., especially in major bordering states such as Washington, Minnesota, New York, Maine, and Vermont. A synchronized binational EV transition schedule can improve the commercial EV model availability and corridor charging access [143], benefiting both sides of the border.
- Weaknesses: The current charging network development is limited geographically due to the climate, weather conditions, and population density in Canada, which could pose challenges to the operation of interregional long-haul commercial fleets. In addition, the application of PV and BESS may also be limited due to insufficient sunlight exposure. The current upfront expenditure, including equipment and site development costs, is also on the high end in Canada compared to other markets.
- Opportunities: Government initiatives to further reduce equipment costs and promote MDHD charging station deployment in rural and remote areas will certainly help to address the current infrastructure gaps. Public agencies may consider examples of balanced business case in Europe to build out charging stations in places with high-utilization and low-utilization simultaneously [28]. For regions where PV may not be viable, the government may explore other off-grid renewable energy generation options to enhance power system reliability while reducing the dependence of high-power EV charging station on local grid.
- Threats: Given the limited performance of battery electric technology in cold climates, it may also be challenged by the hydrogen industry.

China

- Strengths: The market in China bears strong prior knowledge from LD EV adoption and a comprehensive and supportive regulatory environment to facilitate MDHD EV transition has already been established at all levels of government. Being a global leader in EV, EVSE, and PV manufacturing allows China to continue developing innovative vehicle, battery, and charging technologies that are also affordable and cost-effective. The existing sizeable charging network can also provide a strong foundation for any future expansion.
- Weaknesses: The geographic imbalance of EV adoption and infrastructure deployment remains a significant barrier of charger deployment in China. The reasons that lead to such discrepancy are also quite complex, including economic disparities, levels of urbanization, and climate. In addition, the current business case is highly dependent on public subsidies and government initiatives, making it vulnerable to regulatory changes. The current grid capacity, especially in rural areas, also limits the expansion of MDHD charging network.
- Opportunities: Government support will be needed to further improve grid resiliency and power system reliability in rural areas. The public and private sectors should also collaborate to explore innovative business models and P3 models that can expand the current ancillary revenue streams of EV charging. It is also critical for China to continue leading and promoting the development of the ChaoJi standard.
- Threats: Strong domestic competition from battery swapping technology may limit the business case of MDHD public charging. In addition, there are already a large number of private businesses and players in the current EV charging market, which can potentially lead to market saturation and low charging profitability in

the future. Customs duties imposed by other countries could also reduce the cost-competitiveness of hardware and equipment exported out of China, and adversely affect the domestic manufacturing industry.

India

- Strengths: India has a large and rapidly growing trucking sector with long term anticipated growth in demand, creating a competitive market for the MDHD EV transition. The country has a well-developed electric bus sector, the experience and manufacturing capacity from which can be easily reapplied. In addition, India also has one of the strongest domestic manufacturing capabilities for both EVSE and PV hardware.
- Weaknesses: Low amount of existing charging infrastructure in place adds complexity to MDHD EV charging expansion. Besides, as the current charging market in India is highly price-sensitive, the case for profitability is relatively low, causing less favorable market entry for the private sector.
- Opportunities: As a late mover, India has many advantages over other early markets, such as being able to learn from mistakes, install at lower costs, and benefit from technology standardization. India can therefore apply learnings from the historical EV market interventions of other nations to implement government support schemes that will achieve targeted market outcomes, maximize net-benefit, and minimize market disruption. Cost-competitive hardware can also be developed for export markets in addition to domestic ones.
- Threats: Later adoption of MDHD EV technology can lead to loss of market share to faster movers in the sector. In addition, India has limited access to critical resources such as minerals for battery manufacturing, which may restrain its pace and scale of EV transition.

The Netherlands

- Strengths: The Netherlands has vigorous electrification experience in passenger vehicle sector and established associated policies to support MDHD EV adoption. The high-density existing charging network also may expedite broader infrastructure deployment. Besides, there are strong interests among local commercial fleet operators and vehicle manufacturers to electrify the MDHD sector as well.
- Weaknesses: The Netherlands has one of the most developed EV charging infrastructure networks in the world, but this network was developed around the needs of LD vehicles. This introduces a challenge to change and evolve the current EV charging network, particularly in locations where MDHD infrastructure should or must be co-located with LD infrastructure (e.g., major road services). To enable LD and MDHD charging colocation – particularly for MCS – substantial utility network upgrades are likely to be required. The structural grid congestion and limited land availability for dedicated new infrastructure remain major challenges in the Netherlands.
- Opportunities: The government shall continue to develop EV and EVSE expertise for both local deployment and export and to lead the establishment of technique standardization at EU level.
- Threats: Limited grid capacity may limit future infrastructure rollout. In addition, the existing public infrastructure may experience low usage in case of incompatible standards.

References

[1] International Energy Agency (IEA), "Global EV Outlook 2023: Catching up with climate ambitions," April 2023. [Online]. Available: https://www.iea.org/reports/global-ev-outlook-2023.

[2] India Ministry of Heavy Industries, "Production Linked Incentive (PLI) Scheme for Automobile and Auto Components," 23 September 2021. [Online]. Available: https://heavyindustries.gov.in/UserView?mid=2482.

[3] Government of the United Kingdom, "Electric vehicle chargepoint and infrastructure grants for landlords," 27 September 2022. [Online]. Available: https://www.gov.uk/electric-vehicle-chargepoint-grant-landlords.

[4] Internal Revenue Service, "Alternative Fuel Vehicle Refueling Property Credit," 23 June 2023. [Online]. Available: https://www.irs.gov/credits-deductions/alternative-fuel-vehicle-refueling-property-credit.

[5] California Air Resources Board, "LCFS ZEV Infrastructure Crediting," 19 August 2021. [Online]. Available: https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting.

[6] Government of Canada, "Clean Fuel Regulations," 17 February 2023. [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations.html.

[7] Dutch Emission Authority, "Renewable energy units," [Online]. Available: https://www.emissionsauthority.nl/topics/general---energy-for-transport/renewable-energy-units. [Accessed 23 September 2023].

[8] "Achtunddreißigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes 1, 2," 12 November 2021. [Online]. Available: https://www.gesetze-im-internet.de/bimschv_38_2017/__5.html.

[9] The State Council of the People's Republic of China, "China to further boost electric vehicle charging services," 10 January 2022. [Online]. Available: https://www.gov.cn/zhengce/zhengceku/2022-01/21/content_5669780.htm.

[10] Blink Charging, "BLINK CHARGING ANNOUNCES RECORD SECOND QUARTER WITH 186% REVENUE GROWTH AND 528% INCREASE IN GROSS PROFIT," 8 August 2023. [Online]. Available: https://ir.blinkcharging.com/news-events/press-releases/detail/2464/blink-charging-announces-record-second-quarter-with-186.

[11] ChargePoint, "ChargePoint Reports Second Quarter Fiscal Year 2024 Financial Results," 6 September 2023. [Online]. Available: https://investors.chargepoint.com/news/news-details/2023/ChargePoint-Reports-Second-Quarter-Fiscal-Year-2024-Financial-Results/default.aspx.

[12] EVgo, "EVgo Inc. Reports Record Second Quarter 2023 Results," 2 August 2023. [Online]. Available: https://investors.evgo.com/news/news-details/2023/EVgo-Inc.-Reports-Record-Second-Quarter-2023-Results/default.aspx.

[13] Hwabao Securities, "边际盈利改善，充电桩运营商有望迎来黎明前的曙光," 2 June 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H301_AP202306061590452901_1.pdf.

[14] Ministry of Transport of the People's Republic of China, "交通运输部关于印发《绿色交通“十四五”发展规划》的通知," 29 October 2021. [Online]. Available: https://www.gov.cn/zhengce/zhengceku/2022-01/21/content_5669662.htm.

[15] European Commissioin, "Zero emission vehicles: first ‘Fit for 55' deal will end the sale of new CO2 emitting cars in Europe by 2035," 28 October 2022. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_6462.

[16] EXECUTIVE DEPARTMENT STATE OF CALIFORNIA, "EXECUTIVE ORDER N-79-20," 23 September 2020. [Online]. Available: https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.

[17] The White House, "FACT SHEET: Biden-Harris Administration Announces New Private and Public Sector Investments for Affordable Electric Vehicles," 17 April 2023. [Online]. Available: https://www.whitehouse.gov/briefing-room/statements-releases/2023/04/17/fact-sheet-biden-harris-administration-announces-new-private-and-public-sector-investments-for-affordable-electric-vehicles/.

[18] Government of Canada, "Canada's Zero-Emission Vehicle (ZEV) sales targets," 22 November 2022. [Online]. Available: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/canada-s-zero-emission-vehicle-zev-sales-targets.

[19] Government of Canada, "2030 Emissions Reduction Plan: Clean Air, Strong Economy," 7 December 2023. [Online]. Available: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html.

[20] Accelerating to Zero Coalition , "The Zero Emission Vehicles Declaration," 2021. [Online]. Available: https://acceleratingtozero.org/the-declaration/. [Accessed November 2023].

[21] Global Commercial Vehicle Drive to Zero, "GLOBAL MEMORANDUM OF UNDERSTANDING ON ZERO-EMISSION MEDIUM- AND HEAVY-DUTY VEHICLES," 27 October 2021. [Online]. Available: https://globaldrivetozero.org/mou-nations/.

[22] Waka Kotahi, "Enabling a nationwide network of public EV charging infrastructure," April 2017. [Online]. Available: https://nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/enabling-a-nationwide-network-of-public-charging-infrastructure/.

[23] European Parliament, "Fit for 55: deal on charging and fuelling stations for alternative fuels," 28 March 2023. [Online]. Available: https://www.europarl.europa.eu/news/en/press-room/20230327IPR78504/fit-for-55-deal-on-charging-and-fuelling-stations-for-alternative-fuels.

[24] U.S. Deparment of Transportation, "Types of Charging Infrastructure Planning," 29 June 2023. [Online]. Available: https://www.transportation.gov/urban-e-mobility-toolkit/e-mobility-infrastructure-planning/charging-planning-types.

[25] Chengdu Hi-tech Industrial Development Zone , "成渝电走廊充换电重卡项目在蓉首发," 10 February 2023. [Online]. Available: https://www.cdht.gov.cn/cdht/c139820/2023-02/10/content_28e410a33e68490ea0b6bacecad7f78b.shtml.

[26] H. Cui, P. Gode and S. Wappelhorst, "A global overview of zero-emission zones in cities and their development progress," August 2021. [Online]. Available: https://theicct.org/sites/default/files/publications/global-cities-zez-dev-EN-aug21.pdf.

[27] S. Anup and Z. Yang, "Comparative evaluation of non-fiscal incentives to promote electric vehicles across Indian states and union territories," June 2023. [Online]. Available: https://theicct.org/publication/evs-non-fiscal-incentives-indian-states-jun23/.

[28] M. R. Bernard and D. Hall, "Efficient planning and implementation of public chargers: Lessons learned from European cities," 2 February 2021. [Online]. Available: https://theicct.org/publication/efficient-planning-and-implementation-of-public-chargers-lessons-learned-from-european-cities/.

[29] Nanjing Securities, "乘着时代的风，继续高飞！——充电桩行业深度报告," 7 September 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202309071598011358_1.pdf?1694102729000.pdf.

[30] National Development and Reform Commission, People's Republic of China, "Electric vehicle charging infrastructure development guidelines (2015-2020)," 9 October 2015. [Online]. Available: https://www.nea.gov.cn/134828653_14478160183541n.pdf.

[31] EVEXPERT, "Connector types for EV charging around the world," [Online]. Available: https://www.evexpert.eu/eshop1/knowledge-center/connector-types-for-ev-charging-around-the-world. [Accessed 24 September 2023].

[32] Greenflux, "Open protocols," [Online]. Available: https://www.greenflux.com/spotlights/open-protocols/#:~:text=OCPP%20(Open%20Charge%20Point%20Protocol,EVs%20and%20the%20electricity%20grid.. [Accessed 24 September 2023].

[33] Rempel, David; Cullen, Carleen; Bryan, Mary Matteson; Cezar, Gustavo Vianna, "Reliability of Open Public Electric Vehicle Direct Current Fast Chargers," 7 April 2022. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4077554.

[34] European Commission, "European Alternative Fuels Observatory - Recharging systems," [Online]. Available: https://alternative-fuels-observatory.ec.europa.eu/general-information/recharging-systems. [Accessed November 2023].

[35] Y. D. Liu and M. D. Yoshida, "ChaoJi Standard: Faster, Safer, and Compatible to All," June 2020. [Online]. Available: www.chademo.com/wp2016/wp-content/uploads/ChaoJi202006/ChaoJi_Presenataion_EN.pdf.

[36] THe White House, "U.S.-EU Joint Statement of the Trade and Technology Council," 31 May 2023. [Online]. Available: https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/31/u-s-eu-joint-statement-of-the-trade-and-technology-council-2/.

[37] Greenlots, "Open Standards –Based Networks White Papers," September 2018. [Online]. Available: https://greenlots.com/wp-content/uploads/2018/09/Open-Standards-White-Paper.pdf.

[38] California Energy Commission, "CEC Recommendation for Deployment of ISO 15118-Ready," 24 February 2022. [Online]. Available: https://www.energy.ca.gov/event/workshop/2021-11/iso-15118-charger-communications-and-interoperability-workshop.

[39] C. Nelder and E. Rogers, "Reducing EV Charging Infrastructure Costs," 2019. [Online]. Available: https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/.

[40] California Governor's Office of Business and Economic Development (GO-Biz), "Permitting Electric Vehicle Charging Stations: Best Practices," [Online]. Available: https://business.ca.gov/industries/zero-emission-vehicles/plug-in-readiness/permitting-electric-vehicle-charging-stations-best-practices/. [Accessed 12 December 2023].

[41] New York State Energy Research and Development Authority, "EV Charging Station Permitting Resources," [Online]. Available: https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Siting-Resources/EV-Charging-Station-Permitting-Resources. [Accessed 12 December 2023].

[42] Guangdong Province Department of Housing and Urban Rural Development , "关于印发广东省贯彻落实《国家发展改革委等部门关于进一步提升电动汽车充电基础设施服务保障能力的实施意见》重点任务分工方案的通知," 15 September 2022. [Online]. Available: http://zfcxjst.gd.gov.cn/xxgk/wjtz/content/post_4018859.html.

[43] Z. Tang, J. Chen, X. Mo and X. Fei, "规范建设运营充电桩，你需要知道的二三事儿," 9 February 2023. [Online]. Available: https://www.lexology.com/library/detail.aspx?g=368b3688-c458-4735-8ce9-c90489549a0d.

[44] R. McLane and Q. Liu, "A look inside China’s timely charging infrastructure plan," 21 July 2020. [Online]. Available: https://www.greenbiz.com/article/look-inside-chinas-timely-charging-infrastructure-plan.

[45] California Public Utility Commission, "Distribution Infrastructure and Planning to Support EV Charging," December 2022. [Online]. Available: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/distribution-infrastructure-and-planning.

[46] Hawaiian Electric, "Integrated Grid Plan," 2023 12 May. [Online]. Available: https://hawaiipowered.com/igpreport/.

[47] Eastmoney Securities, "大储的拐点：增长加速，成本转降," 19 January 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202301191582154621_1.pdf?1674135877000.pdf.

[48] Black & Veatch, "Electric Island: Providing the Pathway to Carbon-Free Trucking," April 2021. [Online]. Available: https://www.bv.com/projects/electric-island-providing-pathway-carbon-free-trucking.

[49] SIEMENS, "Siemens powers zero-emission double decker buses in London," 26 November 2020. [Online]. Available: https://press.siemens.com/global/en/pressrelease/siemens-powers-zero-emission-double-decker-buses-london.

[50] Eurocities, "Better alternatives for city authorities: EUROCITIES policy paper on the revision of the alternative fuels infrastructure directive," EuroCities, Brussels, Belgium, 2020.

[51] City of San Diego, "As-Needed Electric Vehicle Supply Equipment (EVSE) Contractor," 21 March 2023. [Online]. Available: https://pbsystem.planetbids.com/portal/17950/bo/bo-detail/103675.

[52] European Investment Bank, "Electric vehicle charging concessions: A contract guide for public authorities," European Investment Bank, Luxembourg, 2022.

[53] Sustainable Transport Forum, "Summary Handbook," Sustainable Transport Forum, Brussels, 2020.

[54] Environment and Climate Change Canada, "2030 emissions reduction plan : Canada's next steps to clean air and a strong economy," 2 June 2022. [Online]. Available: https://publications.gc.ca/site/eng/9.909338/publication.html.

[55] Government of Canada, "Building a green economy: Government of Canada to require 100% of car and passenger truck sales be zero-emission by 2035 in Canada," 29 June 2021. [Online]. Available: https://www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html.

[56] Natural Resources Canada, "Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative," 1 March 2023. [Online]. Available: https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/electric-and-alternative-fuel-infrastructure/electric-vehicle-alternative-fuels-infrastructure-deployment-initiative/18352.

[57] Government of Canada, "Canada’s Action Plan for Clean On-Road Transportation," December 2022. [Online]. Available: https://tc.canada.ca/en/road-transportation/publications/canada-s-action-plan-clean-road-transportation#_Toc117001124.

[58] Government of Canada, "Medium and heavy-duty zero-emission vehicles," 30 August 2022. [Online]. Available: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles.

[59] Natural Resources Canada, "Zero Emission Vehicle Infrastructure Program," 9 May 2023. [Online]. Available: https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876.

[60] Canada Infrastructure Bank, "Charging and Hydrogen Refuelling Infrastructure Initiative," July 2023. [Online]. Available: https://cib-bic.ca/en/projects/green-infrastructure/charging-and-hydrogen-refuelling-infrastructure-initiative/.

[61] Government of Canada, "Clean Fuel Regulations (SOR/2022-140)," 13 September 2023. [Online]. Available: https://laws-lois.justice.gc.ca/eng/regulations/SOR-2022-140/page-12.html.

[62] Government of British Columbia, "Credit Market," August 2023. [Online]. Available: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels/credits-market.

[63] China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA), "2023 年 8 月全国电动汽车充换电基础设施运行情况," 10 September 2023. [Online]. Available: https://mp.weixin.qq.com/s/BWzkWyhQT06UktHGrxgMuA.

[64] Hainan Industry and Information Department, "海南省 2022 年鼓励使用新能源汽车若干措施," 29 March 2022. [Online].

[65] Transport Buearu of Shenzhen Municipality, "深圳市现代物流业发展专项资金管理办法," 15 August 2018. [Online]. Available: http://jtys.sz.gov.cn/attachment/0/773/773335/8727800.pdf.

[66] Beijing Municipal Commission of Development and Reform, "北京市"十四五"时期能源发展规划," 27 May 2022. [Online]. Available: http://fgw.beijing.gov.cn/fgwzwgk/zcgk/ghjhwb/wnjh/202204/P020220426362073075921.pdf.

[67] Shenyang Municipal Government, "沈阳市人民政府关于印发沈阳市贯彻落实国务院和辽宁省扎实稳住经济一揽子政策措施若干举措的通知," 5 June 2022. [Online]. Available: https://www.shenyang.gov.cn/zwgk/zcwj/zfwj/szfwj/202206/t20220605_3064397.html.

[68] The State Council of the People's Republic of China, "工业和信息化部等八部门关于组织开展公共领域车辆全面电动化先行区试点工作的通知," 30 January 2023. [Online]. Available: https://www.gov.cn/zhengce/zhengceku/2023-02/03/content_5739955.htm.

[69] National Development and Reform Commission of the People's Republic of China, "国家发展改革委 国家能源局关于加快推进充电基础设施建设 更好支持新能源汽车下乡和乡村振兴的实施意见," 14 May 2023. [Online]. Available: https://www.ndrc.gov.cn/xxgk/zcfb/tz/202305/t20230517_1355814.html.

[70] Guosheng Securities, "电气设备 充电桩：新基建，新周期," 12 March 2020. [Online]. Available: http://pdf.dfcfw.com/pdf/H3_AP202003121376196593_1.pdf.

[71] 无敌电动网, "海南充电桩收费标准及分布," [Online]. Available: https://www.modiauto.com.cn/cdz/c31.html. [Accessed November 2023].

[72] China Post Securities, "换电站系列专题：如何看待重卡换电站的市场空间？," 6 March 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202303061584079050_1.pdf.

[73] Cinda Securities, "换电站系列专题（一）--换电站成本拆分及运营收益的敏感性分析," 24 July 2022. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202207241576497196_1.pdf?1658680797000.pdf.

[74] CBRE, "Electric Vehicles in India - The New Wheels on the Roads," 31 May 2023. [Online]. Available: https://www.cbre.co.in/insights/reports/electric-vehicles-in-india-the-new-wheels-on-the-roads.

[75] India Ministry of Heavy Industries and Public Enterprises, "National Electric Mobility Mission Plan 2020," August 2012. [Online]. Available: https://heavyindustries.gov.in/writereaddata/Content/NEMMP2020.pdf.

[76] Government of India, Ministry of Power, Bureau of Energy Efficiency, 2023. [Online]. Available: https://evyatra.beeindia.gov.in/state-ev-policies/. [Accessed 2023].

[77] India Ministry of Heavy Industries and Public Enterprises, "Expression of Interest inviting proposals for availing incentives under FAME India Scheme Phase II for deployment of EV charging infrastructure within cities," September 2019. [Online]. Available: https://heavyindustries.gov.in/writereaddata/fame/famedepository/15-E__didm_WriteReadData_userfiles_Revised-%20Expression%20of%20Interest%20for%20charging%20station.pdf.

[78] India Press Information Bureau, "Centre sanctions Rs. 800 crores under FAME Scheme Phase II for 7432 public fast charging stations," March 2023. [Online]. Available: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1911394.

[79] Dalmia Cemen, "Dalmia Cement Bharat Leads Sustainability Efforts with the Launch of India’s First e-Trucks Initiative," 28 December 2021. [Online]. Available: https://www.dalmiacement.com/pressrelease/dalmia-cement-bharat-leads-sustainability-efforts-with-the-launch-of-indias-first-e-trucks-initiative/ .

[80] Tata Steel, "Tata Steel pioneers the deployment of Electric Vehicles for transportation of finished steel in the country," 30 July 2021. [Online]. Available: https://www.tatasteel.com/media/newsroom/press-releases/india/2021/tata-steel-pioneers-the-deployment-of-electric-vehicles-for-transportation-of-finished-steel-in-the-country/.

[81] Netherlands Enterprise Agency, "Electric Vehicles Statistics in the Netherlands Up to and including April 2023," April 2023. [Online]. Available: https://www.rvo.nl/sites/default/files/2023-05/Statistics-Electric-Vehicles-and-Charging-in-The-Netherlands-up-to-and-including-April-2023.pdf .

[82] Netherlands Enterprise Agency and Revnext, "Trendrapport Nederlandse markt personenauto's: Overzicht van trends en ontwikkelingen," July 2022. [Online]. Available: https://open.overheid.nl/documenten/ronl-bcdd5d1b47d6e448bdf78e5b143ccedd4e258935/pdf .

[83] TNO, "Techno-economic uptake potential of zero-emission trucks in Europe," October 2022. [Online]. Available: https://www.transportenvironment.org/wp-content/uploads/2022/10/202210_TNO_-techno_economic_uptake_potential_of_zero_emission_trucks_in_Europe.pdf.

[84] Zero Emissie Stadslogistiek, "WAAROM ZERO-EMISSIEZONES?," [Online]. Available: https://www.opwegnaarzes.nl/over-zes/doel. [Accessed 24 September 2023].

[85] Netherlands Enterprise Agency, "Aanschafsubsidie Zero-Emissie Trucks (AanZET)," 25 April 2022. [Online]. Available: https://www.rvo.nl/subsidies-financiering/aanzet.

[86] Netherlands Tax Administration, "Personenauto," [Online]. Available: https://www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/prive/auto_en_vervoer/belastingen_op_auto_en_motor/motorrijtuigenbelasting/soort_motorrijtuig/personenauto. [Accessed July 2023].

[87] Netherlands Enterprise Agency, "Milieu-investeringsaftrek (MIA) en de Willekeurige afschrijving milieu-investeringen (Vamil)," 23 August 2017. [Online]. Available: https://www.rvo.nl/subsidies-financiering/mia-vamil/ondernemers .

[88] Heliox Energy, "Getting Albert Heijn's E-Trucks Charged and Back on the Road: Netherlands," [Online]. Available: https://www.heliox-energy.com/case-studies/getting-albert-heijns-e-trucks-charged-and-back-on-the-road. [Accessed July 2023].

[89] Heliox Energy, "Electrifying waste truck routes with CURE," [Online]. Available: https://www.heliox-energy.com/case-studies/electrifying-waste-truck-routes-with-cure. [Accessed July 2023].

[90] Goderich Published Meeting, "Electric Vehicle Chargers – Cost Estimates from FLO & Sun Country Highway," [Online]. Available: https://pub-goderich.escribemeetings.com/filestream.ashx?DocumentId=11079. [Accessed 8 June 2023].

[91] China Automotive Technology and Research Center, "Research & Policy Measures Suggestions on Road Map of Infrastructure Construction Such as Charging to Support Hainan 2030 New Energy Vehicle Development Goal," 10 August 2020. [Online]. Available: https://www.efchina.org/Attachments/Report/report-ctp-20201103-2/支持海南 2030 年新能源汽车发展目标措施建议.pdf.

[92] Zhongtai Securities, "充电桩行业报告- 海外市场空间空前显著，看好出海布局及直流快充渗透率提升," 7 December 2022. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202212091580948799_1.pdf?1670578510000.pdf.

[93] B. Tyagi and S. Das, "DISSECTING INDIA'S ELECTRICITY TARIFF LANDSCAPE FOR EV: A Special Review," January 2020. [Online]. Available: https://aeee.in/wp-content/uploads/2020/07/2020-Dissecting-India's-Electricity-Tariff-Landscape-For-EV-1.pdf.

[94] Nationale Agenda Laadinfrastructuur , "Kosten laadinfrastructuur logistiek laden op privaat terrein," 2 December 2022. [Online]. Available: https://agendalaadinfrastructuur.nl/ondersteuning+gemeenten/documenten+en+links/bibliotheek+-+logistiek/bibliotheek+logistiek/handlerdownloadfiles.ashx?idnv=2404030.

[95] Nationale Agenda Laadinfrastructuur , "Laden voor logistiek bij beperkte netcapaciteit," [Online]. Available: https://www.agendalaadinfrastructuur.nl/ondersteuning+gemeenten/documenten+en+links/documenten+in+bibliotheek/handlerdownloadfiles.ashx?idnv=2301859. [Accessed July 2023].

[96] Stratelligence, "Financiële implicaties Alternative Fuels Infrastructure Regulation (AFIR)," Rijkswaterstaat Water, Verkeer en Leefomgeving, Leiden, 2023.

[97] TNO, "Indication of the number of electric trucks required per (semi-)public charging point for cost-effective operation for the Living Lab Heavy Duty Charging Hubs (hereafter “Living Lab”), a Rijkswaterstaat project.," TNO Mobility & Built Environment, The Hague, 2023.

[98] India Ministry of Power, "Amendments in the revised consolidated Guidelines & Standards regarding Charging Infrastructure for Electric Vehicle (EV)," 27 April 2023. [Online]. Available: https://beeindia.gov.in/sites/default/files/inline-images/Amendments_in_Charging_Infrastructure_for_Electric_Vehicles_27.04.23-1.pdf.

[99] BR Hydro, [Online]. Available: https://app.bchydro.com/accounts-billing/rates-energy-use/electricity-rates.html. [Accessed July 2023].

[100] Hainan Provincial Development and Reform Commission, "海南省电动汽车充换电设施用电峰谷分时电价表," 21 December 2021. [Online]. Available: http://plan.hainan.gov.cn/sfgw/050301/201905/5ec828576721454fa19b07519b972b11/files/bc62ac25032e4f31905e6b6938ae4961.xls.

[101] A. Gautam, "How to set up an EV Charging Station Business in India in 2023?," 24 July 2023. [Online]. Available: https://ecogears.in/how-to-open-electric-vehicle-charging-station-in-india-startup/.

[102] Kijiji Autos, "Costs of Installing an Electric Car (EV) Charging Station in Canada," 29 May 2023. [Online]. Available: https://www.kijijiautos.ca/advice/content/electric-car-charging-station-installation-costs-canada/.

[103] R. Jha, "What is the Cost of Setting Up an Electric Car Charging Station in India?," 25 July 2023. [Online]. Available: https://www.cars24.com/blog/cost-electric-car-charging-station-india/.

[104] BC Hydro, "Options for upgrading your equipment," [Online]. Available: https://app.bchydro.com/accounts-billing/electrical-connections/multi-residential-commercial-connections/voltage-conversion/options.html. [Accessed October 2023].

[105] P. Frode, M. Lee and S. Sahdev, "Can public EV fast-charging stations be profitable in the United States?," 5 October 2023. [Online]. Available: https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/can-public-ev-fast-charging-stations-be-profitable-in-the-united-states.

[106] R. Telang, A. Singh, H. Le and A. Higashi, "Electric vehicles and the charging infrastructure: a new mindset?," [Online]. Available: https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-charging-infrastructure.html. [Accessed May 2023].

[107] B. Borlaug, F. Yang, E. Pritchard, E. Wood and J. Gonder, "Public electric vehicle charging station utilization in the United States," *Transportation Research Part D,* 2023.

[108] Z. Tong, "发挥充电基础设施投资带动作用助力高质量发展," 9 February 2023. [Online]. Available: https://cdo.develpress.com/?p=13887.

[109] B. J. Mortimer, A. D. Bach, C. Hecht, D. U. Sauer and R. W. De Doncker, "Public Charging Infrastructure in Germany– A Utilization and Profitability Analysis," *JOURNAL OF MODERN POWER SYSTEMS AND CLEAN ENERGY,* vol. 10, no. 6, pp. 1750-1760, 2022.

[110] J. Bennett, P. Mishra, E. Miller, B. Borlaug, A. Meintz and A. Birky, "Estimating the Breakeven Cost of Delivered Electricity To Charge Class 8 Electric Tractors," December 2022. [Online]. Available: https://www.nrel.gov/docs/fy23osti/82092.pdf.

[111] N. Popli, "High Gas Prices Are Pushing Electric Car Sales to a Tipping Point," 3 May 2022. [Online]. Available: https://time.com/6173178/high-gas-prices-electric-vehicles/.

[112] J. B. Bushnell, E. Muehlegger and D. S. Rapson, "Energy Prices and Electric Vehicle Adoption," *National Burean of Economic Research Working Paper Series,* no. 29842, 2022.

[113] X. Peiyu, "新能源汽车充电涨价影响几何," 27 September 2023. [Online]. Available: http://paper.people.com.cn/rmrbhwb/html/2023-09/27/content_26019571.htm.

[114] Mobilyze, "Factsheet Energieprijzen elektrische vrachwagens," Nationaal Kennis Platform Laadinfrastructuur, Utrecht, 2023.

[115] International Renewable Energy Agency, "Renewable Power Generation Costs in 2021," 2022. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Power_Generation_Costs_2021.pdf?rev=34c22a4b244d434da0accde7de7c73d8%20Fig.%203.5.

[116] CHARIN, "Recommendations and requirements for MCS related standards bodies and solution suppliers," 24 November 2022. [Online]. Available: https://www.charin.global/media/pages/technology/knowledge-base/c708ba3361-1670238823/whitepaper_megawatt_charging_system_1.0.pdf.

[117] West Coast Clean Transit Corridor Initiative, "Interstate 5 Corridor California, Oregon, Washington FINAL REPORT," June 2020. [Online]. Available: https://www.westcoastcleantransit.com/.

[118] P. Fröde, M. Lee and S. Sahdev, "Can public EV fast-charging stations be profitable in the United States?," 5 October 2023. [Online]. Available: https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/can-public-ev-fast-charging-stations-be-profitable-in-the-united-states.

[119] National Association of Convenience Stores, "Consumer Behavior at the Pump," March 2019. [Online]. Available: https://www.convenience.org/topics/fuels/documents/how-consumers-react-to-gas-prices.pdf.

[120] J. Bowerman, "The Truth Behind C-Store Revenues," 14 October 2021. [Online]. Available: https://offers.p3reps.com/blog/the-truth-behind-c-store-revenues.

[121] J. Gose, "Truck Stops Upgrade to Recharge Electric Vehicles (and Their Drivers)," 26 September 2023. [Online]. Available: https://www.nytimes.com/2023/09/26/business/truck-stops-electric-vehicles.html#:~:text=Square%20Feet-,Truck%20Stops%20Upgrade%20to%20Recharge%20Electric%20Vehicles%20(and%20Their%20Drivers,time%20of%20electric%20vehicle%20owners..

[122] W. Lingzhi, "2020 年中国新能源汽车充电桩行业概览," April 2020. [Online]. Available: https://www.leadleo.com/report/details?id=5e22b4d1e0f75151588d862a.

[123] Volta, "Digital OOH evolved.," [Online]. Available: https://voltacharging.com/advertisers#about-volta-media. [Accessed November 2023].

[124] S. Descant, "Ad Revenue Might Be the Secret to Lowering EV Charging Barriers," 1 August 2022. [Online]. Available: https://www.govtech.com/fs/ad-revenue-might-be-the-secret-to-lowering-ev-charging-barriers.

[125] R. Cote, "A perfect pair: EV charging station and in-store display advertising," 13 February 2023. [Online]. Available: https://www.retaildive.com/spons/a-perfect-pair-ev-charging-station-and-in-store-display-advertising/641974/.

[126] S. Mohanty and M. McNamara, "Understanding California’s Low Carbon Fuel Standards Regulation," 4 October 2023. [Online]. Available: https://rmi.org/understanding-californias-low-carbon-fuel-standards-regulation/.

[127] Freewire, "Low Carbon Fuel Standard (LCFS) Credits Explained," 15 March 2021. [Online]. Available: https://freewiretech.com/lcfs-credits-explained/.

[128] Union of Concerned Scientists, "California’s Clean Fuel Standard Boosts the Electric Vehicle Market," January 2018. [Online]. Available: https://www.ucsusa.org/sites/default/files/attach/2018/01/cv-fact-sheet-lcfs.pdf.

[129] California Air Resources Board, "Weekly LCFS Credit Transfer Activity Reports," 12 November 2023. [Online]. Available: https://ww2.arb.ca.gov/resources/documents/weekly-lcfs-credit-transfer-activity-reports.

[130] Economic Times, "Has the sun finally started shining on India's solar industry?," 15 September 2023. [Online]. Available: https://economictimes.indiatimes.com/industry/renewables/has-the-sun-finally-started-shining-on-indias-solar-industry/articleshow/103686223.cms.

[131] C. Lo, "Solar power: India lets the sunshine in," 20 December 2011. [Online]. Available: https://www.power-technology.com/features/featuresolar-power-india-lets-the-sunshine-in/.

[132] Canada Energy Regulator, "Market Snapshot: The cost to install wind and solar power in Canada is projected to significantly fall over the long term," 8 July 2022. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2018/market-snapshot-cost-install-wind-solar-power-in-canada-is-projected-significantly-fall-over-long-term.html.

[133] Canada Energy Regulator, "Economics of Solar Power in Canada – Appendix A: Methods," 60 June 2022. [Online]. Available: https://www.rec-cer.gc.ca/en/data-analysis/energy-commodities/electricity/report/archive/solar-power-economics/economics-solar-power-in-canada-appendix-methods.html.

[134] Southwest Securities, "BIPV 风头正盛，谁将异军突起？," 14 July 2022. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202207141576136777_1.pdf.

[135] N.A.P.S Solar Store, "Sun Insolation Hours per Day in Canadian Cities," [Online]. Available: https://www.solar-store.com/Insolation%20Chart.pdf. [Accessed November 2023].

[136] International Trade Administration, "Canada - Country Commercial Guide," 3 November 2023. [Online]. Available: https://www.trade.gov/country-commercial-guides/canada-energy#:~:text=Canada%20is%20among%20the%20world's,%2C%20and%20solar%20(0.5%25)..

[137] L. Fernandez, "Solar energy in China - Statistics & Facts," 13 June 2023. [Online]. Available: https://www.statista.com/topics/11028/solar-energy-in-china/#editorsPicks.

[138] Rodrigues, Neshwin; Lolla, Aditya, "Solar adoption in India entering “accelerating growth” phase," 3 October 2023. [Online]. Available: https://ember-climate.org/insights/research/india-solar-uptake/.

[139] K. Taylor and S. S. Leeson, "The Netherlands ‘unquestionable solar energy leader’ of 2022: study," 30 January 2023. [Online]. Available: https://www.euractiv.com/section/politics/news/the-netherlands-unquestionable-solar-energy-leader-of-2022-study/.

[140] International Trade Administration, "Netherlands - Country Commercial Guide," 9 September 2022. [Online]. Available: https://www.trade.gov/country-commercial-guides/netherlands-energy#:~:text=The%20top%20five%20energy%20sources,plant%20and%20one%20LNG%20terminal..

[141] Eastmoney Securities, "大储的拐点：增长加速，成本转降," 19 January 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202301191582154621_1.pdf?1674135877000.pdf.

[142] Energy Transition Expertise Centre (ENTEC), "Study on Energy Storage Annex 2.1 Energy Storage Database and Use Case Matrix," 14 November 2022. [Online]. Available: https://energy.ec.europa.eu/publications/entec-storage-report-annexes_en.

[143] Prime Minister of Canada Justin Trudeau, "Prime Minister Trudeau and President Biden Joint Statement," 24 March 2023. [Online]. Available: https://www.pm.gc.ca/en/news/statements/2023/03/24/prime-minister-trudeau-and-president-biden-joint-statement.

[144] India Ministry of Heavy Industries, "Centre sanctions Rs. 800 crores under FAME Scheme Phase II for 7432 public fast charging stations," 28 March 2023. [Online]. Available: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1911394.

[145] THe People's Republic of China National Development and Reform Commission, "国家发展改革委等部门关于进一步提升电动汽车充电基础设施服务保障能力的实施意见," 10 January 2022. [Online]. Available: https://www.ndrc.gov.cn/xxgk/zcfb/ghxwj/202201/t20220121_1312634.html.

[146] California Governor's Office of Business and Economic Development (GO-Biz), "Plug-in Electric Vehicle Charging Station Readiness," [Online]. Available: https://business.ca.gov/industries/zero-emission-vehicles/plug-in-readiness/. [Accessed 24 September 2023].

[147] Government of India NITI Aayog, "STATE LEVEL POLICIES," [Online]. Available: https://e-amrit.niti.gov.in/state-level-policies. [Accessed July 2023].

[148] Government of India NITI Aayog, "NATIONAL LEVEL POLICY," [Online]. Available: https://e-amrit.niti.gov.in/national-level-policy. [Accessed July 2023].

[149] B.C. Reg. 394/2008, "Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act," 1 January 2023. [Online]. Available: https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/394_2008.

[150] [SBC 2008] CHAPTER 16, "GREENHOUSE GAS REDUCTION (RENEWABLE AND LOW CARBON FUEL REQUIREMENTS) ACT," 1 May 2008. [Online]. Available: https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/08016_01.

[151] Rewatt Power, "Credits to ignite explosion of public EV chargers across Canada," 17 February 2023. [Online]. Available: https://rewattpower.com/intro-to-canada-clean-fuel-credits-ev-chargers/.

[152] Yidu Data, "2022 年中国 SiC 碳化硅器件行业深度研究报告," 2 February 2023. [Online]. Available: https://pdf.dfcfw.com/pdf/H3_AP202302021582658137_1.pdf?1675418414000.pdf.

[153] United Kingdom Office for National Statistics, "Food and energy price inflation, UK: 2023," 23 May 2023. [Online]. Available: https://www.ons.gov.uk/economy/inflationandpriceindices/articles/foodandenergypriceinflationuk/2023.

icf.com

twitter.com/ICF

linkedin.com/company/icf-international

facebook.com/ThisIsICF

#thisisicf

About ICF

ICF (NASDAQ:ICFI) is a global consulting and digital services company with over 7,000 full- and part-time employees, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future. Learn more at icf.com.

Lowering your emissions through innovation in transport and energy infrastructure

Cenex was established as the UK's first Centre of Excellence for Low Carbon and Fuel Cell technologies in 2005.
Today, Cenex focuses on low emission transport & associated energy infrastructure and operates as an independent, not-for-profit research technology organisation (RTO) and consultancy, specialising in the project delivery, innovation support and market development.
We also organise Cenex-Expo, the UK's premier low carbon vehicle event, to showcase the latest technology and innovation in the industry.
Our independence ensures impartial, trustworthy advice, and, as a not-for-profit, we are driven by the outcomes that are right for you, your industry and your environment, not by the work which pays the most or favours one technology.
Finally, as trusted advisors with expert knowledge, we are the go-to source of guidance and support for public and private sector organisations along their transition to a zero-carbon future and will always provide you with the insights and solutions that reduce pollution, increase efficiency and lower costs.
To find out more about us and the work that we do, visit our website: www.cenex.co.uk

Tel: +44 (0)1509 642 500
Email: info@cenex.co.uk
Website: www.cenex.co.uk
Twitter: @CenexLCFC
LinkedIn: Cenex