P3

ASSESSING THAILAND'S READINESS FOR ELECTRIC MOBILITY

EVALUATING THE CHARGING EXPERIENCE OF
DIFFERENT CHARGE POINT OPERATORS AND
THEIR EV CHARGING SERVICES.

TABLE OF CONTENT

1. INTRODUCTION

As the rising global demand for electric vehicles (EVs)* is driving an increased need for charging infrastructure, the Thai government has set ambitious targets to address these charging infrastructure challenges posed by the significant increase of EVs on Thailand's roads - aiming for 2,200 publicly accessible fast charging stations by 2025 and more than five times as much in 2030.[1] Despite the government's efforts to prioritize the development of charging infrastructure in Thailand, the country still has a limited number of charging stations available.

In addition to the consistent development of the charging infrastructure, it is also necessary to consider the entire charging ecosystem to create attractive market conditions and low market entry barriers for electric mobility. Besides the charging infrastructure, this includes the availability and variety of electric vehicles offered, as well as the various EV charging services, which are the key user touchpoints.

This white paper aims to describe the current state of the charging infrastructure based on a user experience centred assessment of different charge point operators (CPOs). Furthermore, it includes a comprehensive overview of the current electric vehicle market in Thailand, key figures of the charging infrastructure, and a brief introduction of the major CPOs in the market.

1.1 EV-MARKET OVERVIEW THAILAND
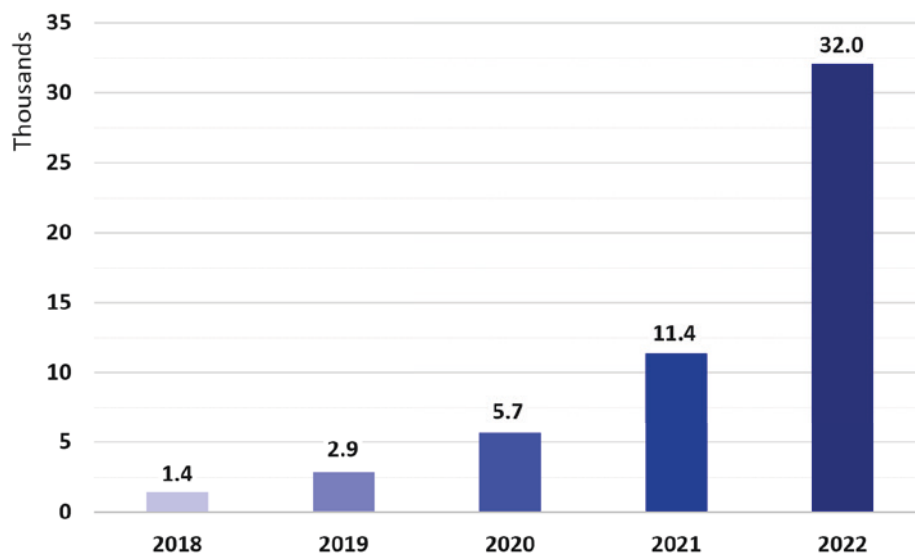
Graphic 1: Accumulated Battery Electric Vehicles (BEV) Registrations in Thailand [2]

According to the data provided by the Electric Vehicle Association of Thailand, battery electric vehicle registrations, including cars, motorbikes, buses, and trucks powered solely by electric batteries, have experienced significant growth in recent years. In 2018, slightly over 1,400 battery electric vehicles were registered in Thailand, which increased by about 1,500 to almost 2,900 BEVs on Thai roads in 2019, demonstrating a significant rise in adoption. This trend continued in following years, with close to 3,000 newly registered electric vehicles in 2020 and almost twice as many new registrations in 2021. 2022 saw even more significant growth, with more than threefold increase in the number of new registrations – leading to over 32,000 newly registered BEVs*. This tremendous growth is a clear indication of a rapidly growing interest in battery electric vehicles in the country, potentially resulting from government incentives introduced at the beginning of 2022 and the growing recognition of the advantages of electric vehicles.

---

*Note: In the further context of this text, the term "electric vehicle (EV) refers exclusively to passenger cars solely powered by electric batteries.

The electric vehicle incentives scheme includes exemption or reduction of import duty and excise tax, and conditional subsidies for imported EVs.[3] Furthermore, various automakers have introduced their new EV models in the Thai market in 2022 – making the EV market more attractive and accessible for new car buyers.

A closer look at the sales units per brand in 2022 shows an interesting development. The newly introduced brand Ora - a sub brand of the Chinese automaker Great Wall Motor - left all established EV brands behind and took the leading position of the total EV registrations in 2022, making their compact electric vehicle model Ora Good Cat the best-selling EV in Thailand with over 3,500 units sold and a market share of newly registered BEVs of more than two-fifths.[4] Following closely is MG with a market share of over 30%, demonstrating strong adoption rates as well. The Swedish brand Volvo follows at a larger distance with 7,6% market share, ahead of many other well-known brands like Tesla, BMW, Porsche and Mini, each of which can claim less than 5% market share in 2022.
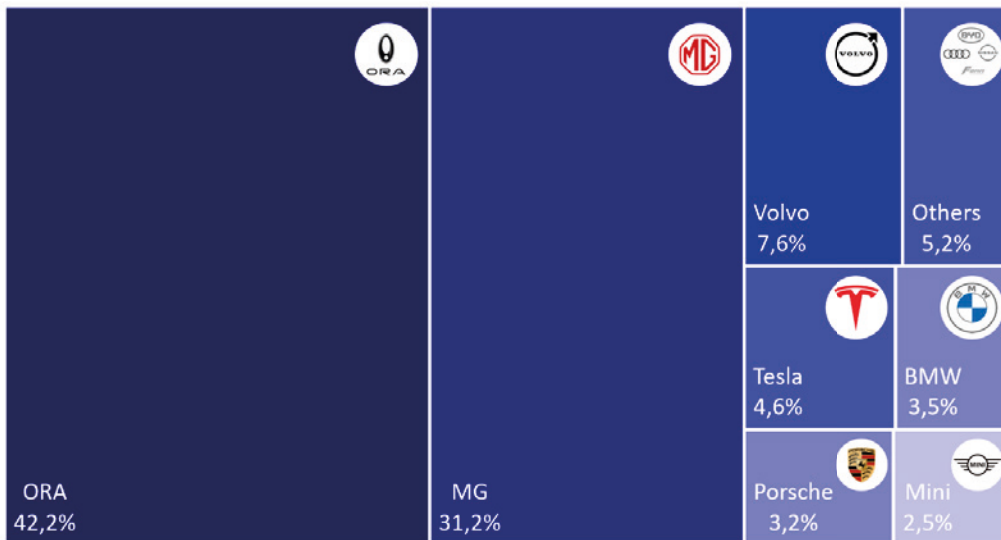
Graphic 2: Market share of sold vehicle units by brand in 2022 [5]
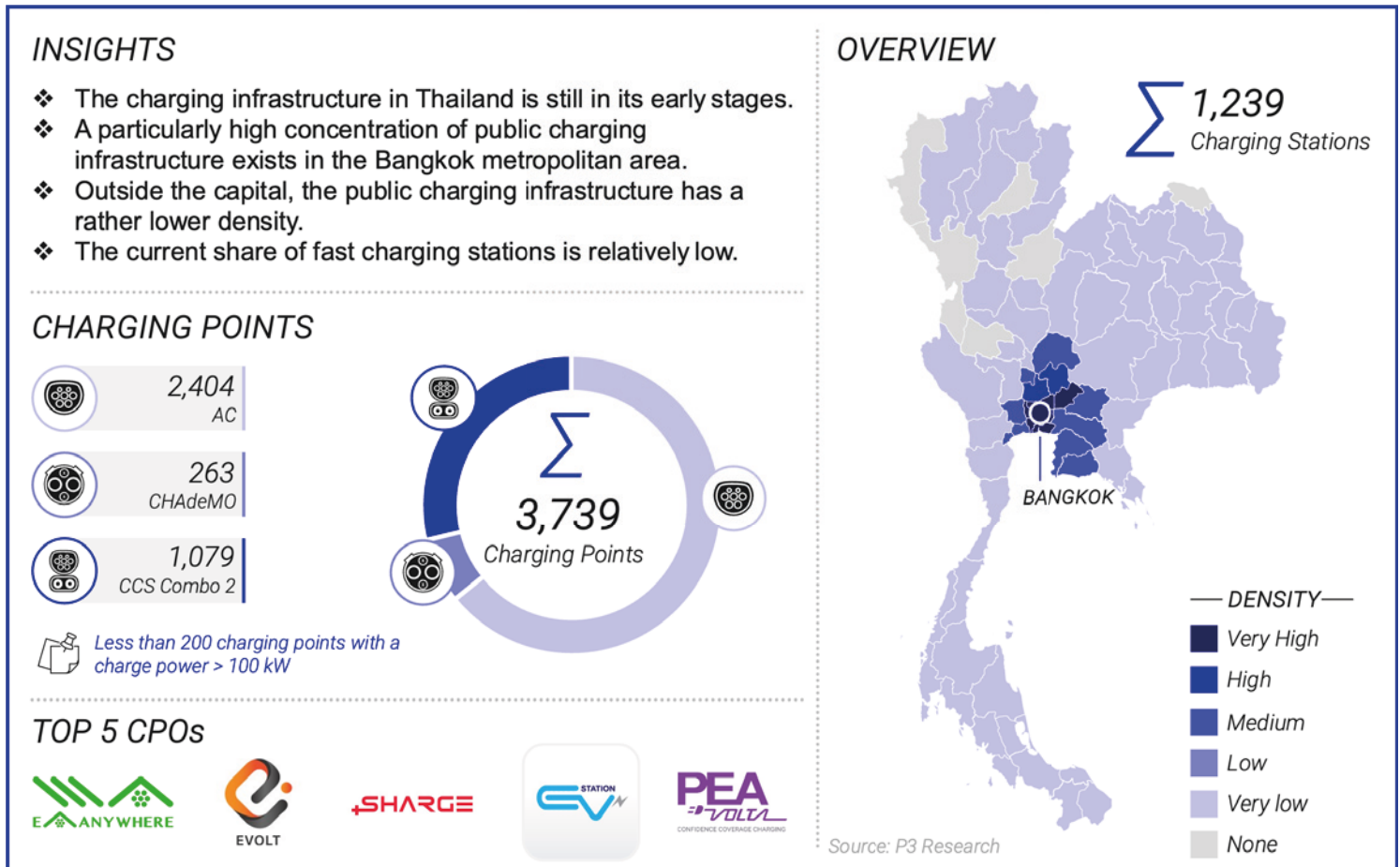
Graphic 3: Overview - Charging infrastructure in Thailand

As of December 2022, there have been 1,239 charging stations with 3,739 charging points in operations in Thailand.[6] In the last two years the charging infrastructure continuously developed, and since 2020, an average of around 200 charging stations per year were installed. The number of charging stations is projected to exceed 2,000 installed charging stations by the end of 2025.[7] The Thai government has announced an ambitious target of over 2,200 fast charging stations by 2025 and 12,000 by the year 2030.[1] However, as shown in graphic 3, the current number of charging stations in Thailand is still below these targets. In particular, the share of fast charging stations in Thailand is still significantly lower. Even though, there were no official numbers accessible on how many fast charging stations are in operation at the moment of this report, analysing the share of fast charging points and their connector types helps to roughly determine the number of fast charging stations. Currently, only 35% of the charging points are fast charging capable. In absolute numbers, only 1,079 charging points are equipped with a CCS 2 connector and 263 stations offer charging with the CHAdeMO connector. Under the assumption that a fast charging station has at least one or more fast charging points, the current number of fast charging stations in Thailand is likely to be less than 1,342 charging stations. Analysing the charging power, many fast charging stations allow a charging power between 50 kW and 100 kW. Fewer than 200 fast charging stations are capable of a charging power above 100 kW and can thus be classified as HPC (high power chargers). In light of the steadily increasing charging capabilities of new electric vehicles, it will be important that the charging infrastructure keeps pace with the evolving user needs and electric vehicle capabilities. As HPC stations allow for significant faster charging times, it is an important aspect of the overall charging user experience, especially for drivers that are charging their electric vehicles on the move. The further development of the charging infrastructure will require not only the construction of new stations with higher charging capacities, but also the enhancement of the existing stations. If we look at the distribution of the charging infrastructure across the various regions of Thailand, it is noticeable that a large part of the charging infrastructure is located in the Bangkok metropolitan area.

Outside the metropolitan area, the density of charging infrastructure decreases significantly. In the west of Thailand, the charging infrastructure is the least developed. However, this region is also the least populated region in Thailand.

When it comes to the operation of Thailand's charging infrastructure, the charging stations are primarily operated by 13 Charge Point Operators (CPO), each with their unique charging network and individual EV charging services. EA Anywhere is currently the market leader with more than 400 charging locations and over 1,100 charging points, offering more than twice as many charging points as the second largest CPO Evolt. By providing the largest charging network in Thailand, EA Anywhere holds a market share of more than 30%. The four largest following competitors Evolt, SHARGE, PEA Volta and EV Station Pluz each account for more than 10% of the charging locations in market. The following paragraph briefly characterises the seven largest CPOs.

EA Anywhere is a Thai-based CPO, a subsidiary of Energy Absolute (EA), and operates the largest network of charging stations across Thailand. The company offers both AC and DC charging stations, with charging stations located at various commercial buildings, shopping centres, hotels, and tourist destinations across the country. EA Anywhere has partnerships with several automakers and leasing companies. In addition to these partnerships, one of EA Anywhere's key partnerships is with Central Retail Corporation, a leading developer and operator of shopping centres in Thailand, to equip their locations with charging facilities.[8][9]

Evolt is a UK-based CPO that operates their network of charging stations primarily in Bangkok and its surrounding areas. The company offers both AC and DC charging stations and has partnerships with several commercial buildings and shopping centres. Evolt is known for its innovative charging solutions, including smart charging technology that enables remote monitoring and management of its charging stations. One of Evolt's key partnerships in Thailand is with Porsche, targeting at building a reliable nation-wide charging network in Bangkok centre and tourist cities. [10]

SHARGE is a Thai-based CPO that operates a network of charging stations across Thailand with focus on Bangkok and its surrounding areas. The company offers both AC and DC charging stations and has similar partnerships as Evolt with commercial buildings and shopping centres. In addition to these partnerships, SHARGE cooperates with PTT, one of the largest oil and gas companies in Thailand.[11]

EV Station Pluz is a subsidiary of PTT, one of the largest oil and gas companies in Thailand, offering EV charging solutions to both individuals and businesses. The company focuses on providing EV charging services at their own gas station (PTT) as well as shopping malls, hotels, and other public facilities. Their main partnerships are with LH Mall & Hotel Co., Ltd. and Siam Retail Development Co., Ltd., two developer leaders in the shopping centre industry in Thailand.[12]

PEA Volta is a subsidiary of the Provincial Electricity Authority (PEA) and was established in 2017. Their network is mostly to be found at Bangchak gas stations in Bangkok, which is also PEA's most prestigious partnership. The Bangchak Corporation is a petroleum and energy conglomerate in Thailand.[13]

1.2 CHARGING INFRASTRUCTURE IN THAILAND

EleX by EGAT

Elex is a Thai-based CPO operating several AC and DC charging stations across Thailand, focussing on commercial buildings, shopping malls and residential areas. EleX collaborates with various organizations and government agencies to raise awareness about the benefits of EVs and to support the development of EV-related infrastructure. EleX has also launched several initiatives to encourage the use of EVs, including a rewards program for EV drivers and a mobile app that provides information on its charging stations and EV-related news and events.[14]

mea ev

MEA EV is a Thai-based CPO that operates under the Metropolitan Electricity Authority (MEA), one of Thailand's major power providers. It offers AC and DC charging solutions to support the growing demand for electric vehicles and promote the use of clean energy in Thailand. The company has installed over 33 charging stations in various locations across Bangkok, including public areas, commercial buildings, and residential complexes.[15]

Following, this report evaluates the charging user experience at various locations offered by the above-mentioned CPOs. Complementary to the user experience testing, the charging station capabilities, surrounding amenities and further categories have been assessed - giving a comprehensive overview on the status quo of the charging infrastructure and corresponding EV charging services in Thailand. The next chapter introduces the chosen methodology and testing approach. Chapter 3.2 describes the findings and results of the research activities and user experience testing.

The results presented in this report are based on a two-step approach which includes first a charging site assessment with an analysis of the static charging location data and further charging station capabilities. In the second step, an user experience testing of relevant EV charging services has been performed, using P3's testing approach which includes the After-Scenario-Questionnaire (ASQ) framework. In order to be able to carry out the analysis and planned user tests with a realistic effort, a market-representative subset of charging stations and the associated EV charging services was selected.

As the analysis and tests for this report have been conducted at the end of 2022, the most recent charging station data available at that time was the July 2022 EVAT report, which stated that the number of charging stations in Thailand was 855.[6] Taking into account the market shares of the different CPOs, introduced in the previous chapter, and setting the overall testing target of evaluating at least 10% of the national charging infrastructure, a test set of 109 charging stations, summarised in graphic 4, had been compiled. Besides taking into account the different market shares of the respective CPOs, the general distribution of charging locations at points of interest, such as gas stations, shopping malls or public facilities, was also considered proportionally in the composition of the test group.

This resulted in a distribution of 35 charging station of the test group at shopping malls, 21 at gas stations and the remaining charging stations out of 109 are spread across different locations such as Electricity Authority offices, residential and commercial complexes, public facilities as well as car dealerships and garages.

EA Anywhere	Evolt	SHARGE	EV Station Pluz	PEA VOLTA	EleX	MEA EV	Others	Total no. of charging stations
48 Stations	11 Stations	11 Stations	10 Stations	7 Stations	12 Stations	8 Stations	2 Stations	109 Stations

Graphic 4: Charging station test set

To perform the on-site assessment and evaluation of the user experience, the P3 team downloaded and set up the different EV charging apps provided by the CPOs. As part of the charging site assessment the location of each charging station within the test set was analysed and detailed charging station information such as opening hours, accessibility, charging connectors, charging instructions and safety protection as well as the overall availability were part of the analysis. Furthermore, the surrounding amenities e.g., small shops or restaurants to buy a coffee or a snack, were evaluated. As test vehicle the Ora Good Cat had been selected as it represents the most-sold EV in the Thai market in 2022 as detailed in chapter 1.1.

Charging User Journey			Tasks per Phase	
1	Pre-Use	1.1	Step of registration/sign up until account creation is completed
		1.2	Step of finding charging stations in the respective app
		1.3	Step of route planning via application
2	Use	2.1	Step of authentication/initiation of the charging session
		2.2	Step of monitoring the charging progress
		2.3	Step of terminating/stopping the charging process
3	Post-Use	3.1	Successful payment of the charging session
		3.2	Adding or updating payment and billing information
		3.3	Review transactions based on received charging detailed record
4	Customer Support	4.1	Customer support

DIMENSIONS

- Ease of Use
- Time to perform the task
- Support given to perform the task

POINT SCALE

STRONGLY DISAGREE ←→ STRONGLY AGREE

1 2 3 4 5 6 7

Graphic 5: ASQ Questionnaire

The second part of the P3 charging station tests focussed on the user experience along the charging user journey. For better comparability and evaluation of the different EV charging services, a standardized questionnaire was designed based on the ASQ framework. The actual tests were then carried out by a diverse P3 team which included various levels of experience in the field of electric mobility, so that different challenges and questions along the charging user journey could be identified.

The after-scenario questionnaire is a framework used to gather feedback and insights from users about their experience using a particular service. It typically includes questions related to ease of use, satisfaction, and suggestions for improvement. In evaluating different EV charging services along the charging user journey consisting of the phases "pre-use", "use", "post-use" and "customer service", the after-scenario questionnaire can be used to assess each phase.
For example, in the pre-use phase, questions focus on the ease of finding charging stations and how easy it was to set up an account. During the use phase, the questionnaire focuses on the charging station's ease of use and the monitoring of the charging progress. In the post-use phase, questions are tailored to assess the ease of paying for the service and the final payment confirmation and transaction overview. Finally, the customer service phase is being assessed by evaluating the responsiveness and helpfulness of customer support.

By utilizing the after-scenario questionnaire to evaluate EV charging services throughout each phase of the charging user journey, the P3 team was able to identify areas of strength and weakness and deriving suggestions for improving the overall charging user experience. Graphic 5 summarises the used ASQ questionnaire along the introduced charging user journey phases "Pre-Use", "Use", "Post-Use" as well as "Customer Support".

The evaluation of user satisfaction was conducted in the dimensions "Easy of use", "Time needed to perform the tasks" as well as "Support given by the service to perform the task". The respective degree of user satisfaction was evaluated along the point scale 1 = strongly disagree to 7= strongly agree. The average overall result across all users and EV charging services was then calculated with the weighting 20% of phase "Pre-Use", 50% of phase "Use" and 20% of phase "Post-Use" and 10% of phase "Customer Support".

3 RESULTS

3.1 CHARGING SITE ANALYSIS

In this chapter, the results of the charging station assessment as well as the user experience testing are presented.
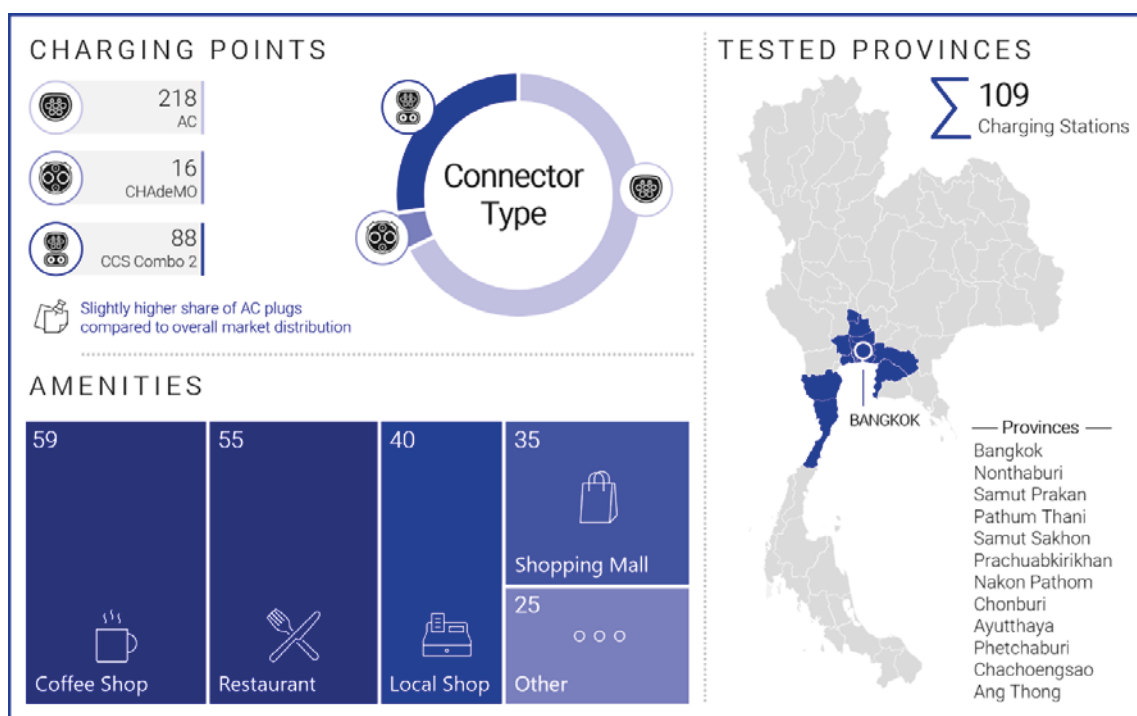
Graphic 6: Characteristics and geographical distribution of charging station test group

If one first looks at the locations of the charging stations and their distribution across the regions of Thailand, it is noticeable that all CPOs tested currently have their focus on the Bangkok metropolitan area. However, this seems not surprising as more than a fifth of the Thai population lives in this area. In addition to the charging stations in the Bangkok metropolitan area, the P3 team analysed charging stations in 12 provinces. Graphic 6 shows the geographical distribution of the tested charging stations among the provinces.

In addition to the macro analysis of the charging locations, the P3 team also assessed the availability of surrounding amenities. The results show that more than half of the stations analysed offer the possibility to buy a coffee or spend time in a restaurant while charging. At about two fifth of the stations, local shops were nearby in addition to the various restaurant options. If one includes the large shopping malls, more than three quarters of the charging stations offer the possibility to make purchases, buy a coffee or order food during the charging process.

Looking at technical capabilities of the tested charging stations, one third is fast-charging capable. Within the group of fast charging stations, almost 85% are equipped with CCS2 Combo connectors, only 15% are equipped with CHAdeMO connectors. As many of the tested charging stations are located at or close by larger shopping malls or office complexes, it does not surprise that two third of the tested chargers are slower AC chargers as these chargers are more commonly found at locations with longer dwell time, meaning that drivers can leave their cars to charge for a longer period while they for example shop or work.

Additionally, AC charging stations are less expensive to install and maintain than fast charging stations, making them a more cost-effective option for e.g., shopping malls, that usually offer multiple charging stations per parking lot. In addition to this characteristic, the high number of slower AC charging stations corresponds to the overall market distribution outlined in chapter 1.2.
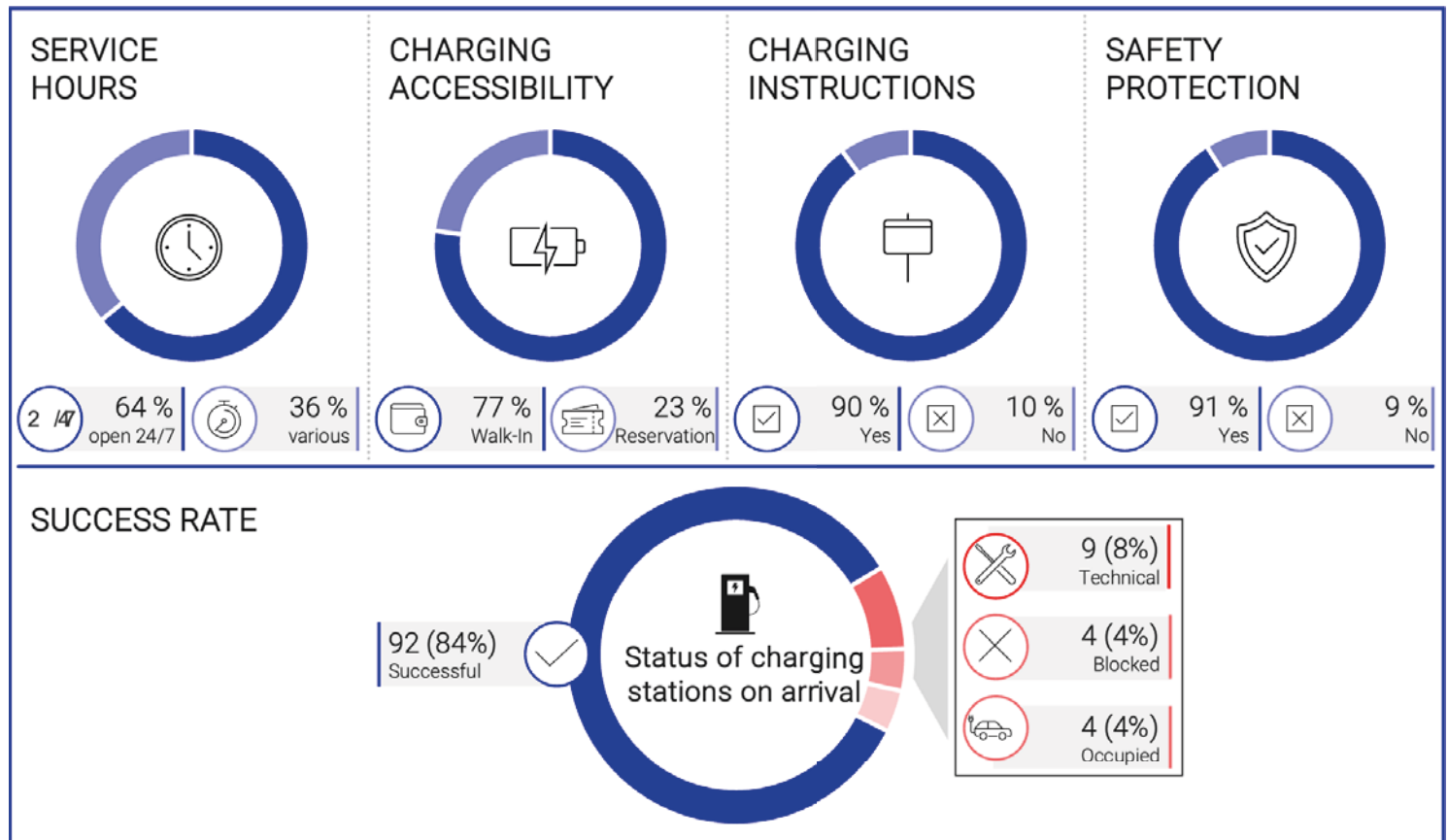
Graphic 7: Results of charging site assessment

Shifting the focus from the locations and technical charging capabilities to the charging stations and their accessibility and the on-site provided charging information, one can highlight that roughly two thirds (64%) of the evaluated charging stations offer access at any time - 7 days a week. The service hours of the other third vary across the different charging sites, depending on the surrounding points of interests and their opening hours e.g., local offices or car dealerships.

Apart from the offered service hours, the P3 team also evaluated the success of the charging attempt and categorized the reasons if they could not charge the car. In 84% of cases the charging was successful. In 16% of the cases the team was not able to charge the car for different reasons. 9 charging stations (8%) out of the 109 tested charging stations had a technical defect in which the charging station was either down (3 stations or 3%) or the charging session could not be initiated (6 stations or 5%). In 8 cases the team could not access the charging station, because it was blocked by another charging EV (4 stations or 4%) or blocked by other reasons (4 stations or 4%). In one case the charging station could not be used, because a local beer fest was set up in front of the charging station – our testers noted it with a smile and looked for an alternative charging station nearby.

Considering the current low density of charging stations, this can lead to significant problems when driving an electric vehicle with low state of charge (SoC) and the nearest alternative charging station can no longer be reached – increasing the so-called "range anxiety" and thus significantly affects the overall charging experience. It should be noted that particularly in the Bangkok region, the time and electricity required for secondary systems, such as air conditioning, may be more critical than the actual distance travelled.

3.1 CHARGING SITE ANALYSIS

As charging station utilization numbers steadily increase with the number of electric vehicles, the possibility of reserving a charging point before arriving at the charging station is drawing the focus of EV drivers as well as of charge point operators. Out of the 109 tested charging stations, only slightly over 20% offered a reservation through their app. When using the reservation feature, the user has for example 15 minutes to arrive at the location and initialize the charging session before the reservation expires and cannot be renewed. Besides the time restrictions, the reservation at all tested charging stations is subject to a charge and the reservation fee varies between 2.5 THB and 100 THB.

The needed steps to start a charging session and the provided instructions either in-app or on-site differ significantly between charge point operators and charging locations, even from the same CPO. On a positive note, 90% of the charging stations offer some kind of charging instructions to help EV drivers start their charging session easily. The means of providing these charging instructions range from detailed process descriptions on the charging station screen, over additional information stands or signs as to links to the FAQ section on the respective CPO website.

As a last criterion within the charging site assessment, the P3 team checked the emergency and safety protections and whether an emergency button to stop the charging session was available. Regardless of the individual conditions of the charger itself, over 90% of the tested charging stations have an emergency button. However, it needs to be highlighted that the overall condition of some charging stations and safety protections seemed questionable.

Graphic 8: Examples of different charging station conditions and blocked charging stations

3.2 USER EXPERIENCE TESTING OF EV CHARGING SERVICES

As outlined in the previous chapter, the accessibility, availability as well as the surrounding amenities at the tested charging stations are generally well developed.

In the second part of their test, the P3 experts wanted to analyse and evaluate the charging experience from a user's point of view. For this purpose, a standardised test procedure based on the ASQ framework was followed, as introduced in chapter 2. This chapter describes the aggregated average results across all evaluated CPOs.

	Tasks per Phase	Ease of use Score 1 - 7	Time Score 1 - 7	Support Score 1 - 7	Score Score max. 21
Pre-Use 1.1	Step of registration/sign up until account creation is completed	4	4	4	12
Pre-Use 1.2	Step of finding charging stations in the respective app	6	6	6	18
Pre-Use 1.3	Step of route planning via application	4	4	4	12

Graphic 9: Results "Pre-USE"-phase

In the "Pre-Use" phase, it's all about preparation and getting familiar with a new EV charging service. Usually, each CPO offers their own EV charging service and app, so users need to download the app and create an account before being able to start a charging process. So-called "ad hoc" or "anonymous" charging events were not part of the assessment. After the app setup, users start to search for charging stations around their current location or destination. Detailed charging station information and various filter options help the users to speed up the search and find the right charging station easily. As last preparation step, users need to plan their trip to the charging station.

Looking at the tested apps from the defined test group, the overall score of the "pre-use" phase is satisfying, but there is still room for improvement. On a high note, the individual app support for searching and finding the right charging station can be rated as good across all tested apps but based on the user feedback, some apps still lack fully functional filters or provide only rudimental charging station information.

Contrary to the positive results, only a mediocre score could be awarded for the steps "Registration" and "Sign-Up", as some test users found problems particularly in the account verification step. The same applies to the last sub-category in this phase - "Plan & Drive". Only one app in the test field offers a dedicated route planning with the user's electric vehicle. The majority of apps transfers the user to 3rd party navigation apps like Google Maps. However, in some cases the testers encountered technical difficulties during testing. The app usage via Android Auto and Apple CarPlay is currently not supported by any of the tested apps. From the user's point of view, incorporating Apple CarPlay and Android Auto applications would be highly beneficial as it would allow for fast searching and availability checks of the nearby charging stations through the vehicle's HMI while driving.

3.2.2 USE PHASE

	Tasks per Phase	Ease of use Score 1 - 7	Time Score 1 - 7	Support Score 1 - 7	Score Score max. 21
Use 2.1	Step of authentication/initiation of the charging session	6	6	6	18
Use 2.2	Step of monitoring the charging progress	6	6	6	18
Use 2.3	Step of terminating/stopping the charging process	6	6	6	18

Graphic 10: Results "USE"-phase

Moving on to the next phase along the charging user journey, the P3 experts were very satisfied with the test results within the "Use"-phase. It is particularly positive that 90% of the charging processes could be started completely digitally and via the app. In most cases, the QR scan functionality of the app proved to be very efficient and helpful. Only in a few cases was it necessary to manually enter a code to start the charging process. Interestingly, the provision and use of RFID cards are primarily for the exclusive charging networks provided by the OEMs which have been excluded from the charging station test group as there are often not open to all electric vehicle drivers. When looking at the step of monitoring the charging process, it can be highlighted that most apps provide the needed functionality of monitoring an ongoing charging session. Only in some cases, the testers were not able to monitor the charging process through the app as the app either crashed or could not communicate with the charging station. Shifting the view from the app to the charging station, the testers highlighted the partly poor conditions of the charging stations. Especially the screens of the charging stations have been documented as a negative point as they were sometimes difficult to read or even damaged, so that the use of the charging station would have not been possible without the app.

This said, in one single case, the poor condition of a charging point resulted in a situation that the charging cable was not released after a completed charging process and the P3 test team struggled for several hours to resolve the issue with the help of two local officers. Apart from this exception, the overall user experience in the sub-category "stop of a charging process" can also be stated as good.

Graphic 11: Examples of the different charging stations

3.2.3 POST-USE PHASE

		Tasks per Phase	Ease of use Score 1 - 7	Time Score 1 - 7	Support Score 1 - 7	Score Score max. 21
Post-Use	3.1	Successful payment of the charging session	6	5	5	16
	3.2	Adding or updating payment and billing information	4	4	4	12
	3.3	Review transactions based on received charging detailed record	6	6	6	18

Graphic 12: Results "Post-USE"-phase

After completing more than hundred charging sessions, the P3 experts evaluated the user experience in the phase "Post-Use" which includes the payment of the charging session, adding or updating billing information as well as receiving a detailed transaction overview based on the issued charging detailed record (CDR). Across the different aspects of the "post-use" phase, the P3 testers awarded overall a mediocre score as they noticed some time-consuming obstacles along the charging user journey. The main point of criticism in relation to the payment process is the choice of payment methods available. For over two third of the performed charging session the only payment option offered was a credit card. In addition to the limited choice of payment means, the P3 testers pointed out that during the pre-authorization of a charging session, in almost all cases they were prompted to enter the security code and an additional one-time-password (OTP) to authorize the charging session. Depending on the network connection e.g., in a parking garage or shopping mall, these additional steps can increase the time between arriving at the charging station and the start of the charging session significantly. Another time-consuming task, which was nevertheless mostly completed successfully, was the retrospective change or update of the billing information. In most cases, a simple e-mail was sufficient to update the billing information and update the previously issued invoices. However, in some cases the billing information were never updated, even though the P3 test team contacted the customer support via different communication channels. Which leads to the last evaluated aspect of the user experience testing - the "customer support".

3.2.4 CUSTOMER SUPPORT

		Tasks per Phase	Ease of use Score 1 - 7	Time Score 1 - 7	Support Score 1 - 7	Score Score max. 21
-	4	Customer Support	4	4	4	12

Graphic 13: Results "Customer Support"-phase

As described in the section above, the customer support along the charging user journey can vary heavily, depending on the CPO as well as the problem to be solved. All in all, the customer support across all CPOs can be rated as satisfactory. Nevertheless, considering that users contacting the customer support are usually seeking help solving a problem around their charging session, any lack of assistance along the charging user journey has a significant impact on the user experience. In many cases the CPO support hotlines and further self-service features, such as a FAQ section, can either be found within the app or on the related CPO website. However, depending on the quality of implementation, the mobile use of a FAQ section on the CPO website was documented as challenging by the test team. In a few cases, the P3 team could not find any support hotline helpful information in case of charging problems or an emergency. Evaluating the various support hotlines, one can point out that long waiting times and a multi-level support process with many redirects to different agents can cause frustration and dissatisfaction.

Based on the results of our report, it is evident that the charging infrastructure for electric vehicles in Thailand is still in its early stages. Our tests of 109 charging stations across several provinces revealed various areas of improvement related to the charging infrastructure and the overall charging user experience when using the various EV charging services provided by the charge point operators. We can summarise that the overall charging user experience at public charging stations in Thailand is not yet a seamless process, particularly when considering areas beyond the Bangkok metropolitan area.

While the number of electric vehicles in Thailand is expected to double in the next three years, the charging infrastructure is not yet keeping up with the increasing demand. Given that the majority of charging stations are concentrated in the Bangkok metropolitan area, it is crucial not to overlook the significant regional disparity in the development of the charging infrastructure. Especially for electric vehicle drivers leaving the Bangkok metropolitan area, the regional differences bring further challenges. Looking at the current low share of faster DC chargers as well as the limited number of high-power chargers with charging powers above 100 kW, one can state that long-distance travel with an electric vehicle, in addition to the low density of charging infrastructure, significantly increases the travel time compared to a vehicle with an internal combustion engine. As a result, electric vehicle drivers need to carefully plan ahead and map out their charging stops along their route to counter these problems. This situation will even intensify during peak travel time as for example Songkran period. Unfortunately, among the CPO applications tested, only one offers a trip planning feature. Overall, the applications provided by various CPOs still have room for improvement, with each having their strengths and weaknesses. While most CPOs offer comprehensive functionalities for the charging process itself, the transaction history and an easy-to-use customer support, some apps still struggle with the app initialization and sign-up process, inaccurate real-time data and incorrect charging site information. Reservation features for charging stations are also only available for a small portion of the charging infrastructure. Incorporating Apple CarPlay and Android Auto applications would allow for a fast and easy search for nearby charging stations while on the move. Looking at the supported payment methods and billing information, CPOs should consider offering additional payment methods and improve their ability to issue full tax invoices to corporate customers. Foreign users relying on English language will encounter additional problems, as for example not all apps support the English language during the sign-up and registration process.

In conclusion, with the expected increase in the number of electric vehicles on Thai roads in the next three to five years, CPOs need to improve their network coverage across Thailand significantly, upgrade their charging stations to more reliable and faster hardware as well as improve the mobile charging applications to create an excellent and attractive charging experience. Coupled with the government's goal to expand the charging station network to 12,000 charging stations by 2030, positive developments and strategic decisions can be seen, but the objectives that have been set must be implemented consistently and rapidly in the upcoming years. P3 is thrilled to be part of this development and to continue shaping the expansion of electromobility in Thailand.

5 OUTLOOK

This UX focused study of the charging infrastructure of Thailand was the first step of a multiple phase approach of the near and middle future. P3 plans to continue the UX testing but also roll out a technical focused testing in which the charging process and its parameter will be analysed and evaluated. We are looking forward to not only evaluate and rate the performance of charging stations but also have a look at compatibility of car brands and different CPOs and their hardware.

ABOUT P3

P3 is a technology, process and organizational performance consulting company with a focus on new technologies and innovation. P3 understands the change towards electromobility as a holistic requirement, which demands a completely changed eco system. In addition to the technical transformation of drive systems, the provision of suitable charging infrastructure as well as the development of adequate application scenarios and business models are important components of this comprehensive change process. P3 is an E E partner to their customers from consulting to operationalization.

1. **The Nation Thailand (2022) - Plugging into the future with EV mobility**
   Plugging into the future with EV mobility (nationthailand.com)
2. **Electric Vehicle Association Thailand (2022) – Thailand Electric Vehicle Current Status**
   (Version 31/12/22)
3. **Global Compliance News (2023) - Thailand: EV landscape - how it looks now and what's on the horizon**
   https://www.globalcompliancenews.com/2022/10/22/thailand-ev-landscape-how-it-looks-now-and-whats-on-the-horizon_10222022/
4. **The Nation Thailand (2023) - Great Wall Motor Reveals 2022 Achievement**
   Great Wall Motor Reveals 2022 Achievement with 11,616 Car Sales (nationthailand.com)
5. **AUTOLIFE THAILAND.TV (2023) – Electric vehicle sales per model**
6. **Electric Vehicle Association Thailand (2023) - Number of Electric Vehicle Charging Stations**
   (Version 31/12/22 & 30/06/22) Current Status (evat.or.th)
7. **Statista (2023) - Mobility Market Insights - Electric Vehicles Thailand**
8. **AEITF THAI (2023)**
   EA จับมือ 4 พันธมิตรใหญ่ "คาลเท็กซ์ – ซีพี ออลล์ – บริดจสโตน เอ.ซี.ที – โรบินสัน" ผุดสถานีชาร์จรถยนต์ไฟฟ้าทั่วไทย – มูลนิธิสถาบันพลังงานทางเลือกแห่งประเทศไทย (aeitfthai.org)
9. **EA ANYWHERE (2022)**
   EA ANYWHERE - ELECTRIC FOR ANY CARS
10. **EVOLT - 'Porsche' partners with 'Evolt' to pave a path for public charging stations**
    'Porsche' partners with 'Evolt' to pave a path for public charging stations in Bangkok center and tourist cities, aiming to launch EV charging station nation-wide. - Evolt
11. **BITEC (2020) - Ptt Joins Charging Partners To Launch The First Ev Charging Station Business At Bitec Bangna**
    PTT joins charging partners to launch the first EV Charging Station business at BITEC Bangna - Bangkok International Trade & Exhibition Centre
12. **OR (2022) - 'OR' Expands Accessibility to Electric Car Charging Services**
    'OR' Expands Accessibility to Electric Car Charging Services, EV Station PluZ, Adding 24 (pttor.com)
13. **Bangchak – PEA Volta Charging Station**
    บางจากกรีนเอส (bangchakmarketplace.com)
14. **EGAT Today (2022) - EGAT in collaboration with Future Park Shopping Center EleX by EGAT electric vehicle charging stations**
    "ชอปพร้อมชาร์จ" กฟผ.-ฟิวเจอร์พาร์ค หนุนผู้ใช้ EV เปิดสถานี EleX by EGAT ใหม่ พร้อมมอบสิทธิพิเศษถึงสิ้นเดือนพฤษภาคมนี้
15. **Metropolitan Electricity Authority - MEA joins hands with Bangkok to open EV Charging Station at Benjakiti Park**
    MEA จับมือ กทม. เปิดให้บริการสถานีอัดประจุไฟฟ้า EV Charging Station ที่ สวนเบญจกิติ