

**BARRIERS TOWARD ELECTRIC VEHICLE
ADOPTION IN THAILAND**



**A THEMATIC PAPER SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF MANAGEMENT
COLLEGE OF MANAGEMENT
MAHIDOL UNIVERSITY
2020**

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Thematic paper
entitled
**BARRIERS TOWARD ELECTRIC VEHICLE
ADOPTION IN THAILAND**

was submitted to the College of Management, Mahidol University
for the degree of Master of Management
on
December 20, 2020



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ACKNOWLEDGEMENTS

I would like to express my gratitude toward contribution and support of people involved in this research. Firstly to Assoc. Prof. Sooksan Kantabutra, Ph.D. for advising and giving a guidance in conducting this research from start till finish. His experience and expertise have highly contributed to the success of this research. Secondly, I would like to thank all participants who has sacrificed their times and willingly agreed to provide a beneficial data for me to use in this research. Thirdly to my family, friends and colleagues for a continuous support and encouragement to surpass obstacles and difficulty during research. Lastly thanks to Assoc. Prof. Winai Wongsurawat, Ph.D. and Asst. Prof. Pornkasem Kantamara, Ed.D. for a meaningful experience in thematic paper presentation session and useful comment on the topic.

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ABSTRACT

As a mean to counter a pollution problem, an electric vehicle has been seen as a solution to replace fuel vehicle. However due to a low adoption rate of electric vehicle in Thailand, this research aims to identify barriers toward electric vehicle in Thailand and propose countermeasures to reduce or eliminate barriers which would increase an adoption rate. The research is conducted through a qualitative research methodology with participants in Thailand to gain an insight information and reason behind barriers. Finding from a research has shown a strong indication of barriers in infrastructure, vehicle performance and financial which affects to decision to adopt electric vehicle.

KEY WORDS: Barrier/ Electric vehicle/ Electric vehicle adoption/ Thailand

64 pages

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CHAPTER I

INTRODUCTION

Nowadays, people have started to put more concern into environment and aim to reduce pollution. An internal combustion engine vehicle which uses fuel has been viewed as a cause of air pollution because in each combustion, it releases an emission as a byproduct into environment. Although there are regulations that has been announced to heighten control on level of emission in which it leads to an improvement of internal combustion engine to release less emission, however it can only slow down a release of emission and cannot fully stop the problem. Because of this, an electric vehicle has been introduced as an alternative solution to an internal combustion engine vehicle. As it uses electricity as a source of energy, there is no emission released from its process.

There are many countries that see this benefit and promote a usage of electric vehicle, however most of them still cannot make it into a mainstream vehicle including Thailand. Thailand is one of the countries that a majority of the population use an internal combustion engine vehicle and has a problem in pollution. This intrigues my interest to research on the barriers to adoption and set it as an objective for this research to identify on why consumers do not respond to this adoption and investigate the barriers in Thailand.

This research consists of 6 chapters in which from chapter 2, it is a study in literature review to gain more understanding on this topic from past research to set research questions and a research scope. Chapter 3 is about research methodology, data collection, data validity and data analysis in which research method is discussed on the appropriate method for this research to acquire a useful information. After this is chapter 4 which discuss on the finding from data collection to find a pattern and answer to research questions. Chapter 5 will suggest a recommendation from finding to create knowledges in eliminating barriers, a limitation, and a future research. Lastly chapter 6 is a conclusion of this research to reflect on achievement of this research.

CHAPTER II

LITERATURE REVIEWS

2.1 Statement

“Why does electric vehicle adoption in Thailand is low?”. This is the first question that I have when I start doing this research. Nowadays Thailand has faced with a poor air quality problem that shows in a form of PM 2.5 which leads to an action to restrict entry of some vehicles into Bangkok area to easing the situation. This poor air quality is partly a result of heavy usage of fuel vehicle in which it is one of the main transportation of Thai people. Nevertheless, it is unlikely for Thai people to suddenly stop using fuel vehicle, therefore it would be more possible to change to electric vehicle in which it can help this problem. I have heard many of my surrounding people talking about electric vehicle and benefit, but I rarely see anyone actually change into it. This becomes a question for me on why they do not want to change it now. There could be barriers in their perspective that prevent their final decision to change even if they want to and decide to postpone until the barriers are lifted. Because of this, I decide to study on this topic to get a better understanding.

To start on this research, conducting a literature review is important to understand on past research. It would be beneficial in formulating a concept for this research to focus on.

2.2 Electric vehicle

In 2010, it is reported that transport sector is a respondent to 23 percent of total carbon dioxide emissions therefore making it a driving force of climate change and a target for reduction. Electric vehicles or EV is seen as a cost-effective solution to counter climate change because of the concentration of emission that can be reduced from the energy source compared to gasoline (Broadbent et al., 2017).

Electric vehicles are vehicles that draw power source from electric grid and charge it inside vehicles for driving. It can be sorted into battery electric vehicles or BEVs which are vehicles that wholly propel with electricity and keep energy in battery inside vehicle which re-charge via plug-in. Another is plug-in electric vehicles (PHEVs) which are vehicles that run with energy from electrical grid together with an internal combustion engine to contribute to range and power (She et al., 2017).

In the past 3 decades, electric vehicles have significantly improved in various aspects such as cost, performance, efficiency, design, and option for customer. Electric vehicles have been elevated to an equal ground as internal combustion engine vehicles in many aspects. The transition is expected to be on the way as market share is increasing in many regions where incentive and charging station are in place together with government support for adoption. China is the country with the biggest single market with over half of world's electric vehicles sales in 2016 while United States is accounted for one fifth of total sales. Nonetheless, total electric vehicle is still only accounted for 1 percent of all vehicle sales around the world in 2016 (Sperling, 2018).

2.3 Barrier

Despite a widely recognition of electric vehicle adoption and benefit of electric vehicles, however electric vehicle adoption is still struggle and there are still have many factors involved (Kumar & Alok, 2020). Many research have been conducted to find barriers based on various assumption and approach. According to research from She et al., (2017) who specify an important issue to focus on barrier created from customer demand for electric vehicles adoption has sorted barriers into 3 scope which are financial barriers, vehicle performance barriers and infrastructure barriers.

2.3.1 Financial barriers

Financial barrier is defined as a barrier from a cost in electric vehicles adoption such as high purchase cost, high battery cost and maintenance cost. In comparison with internal combustion engine vehicles, the view on price of electric vehicles is premium (She et al., 2017). This barrier has been found to be an important barrier in many research such as a research from UK drivers has found that high purchasing price to be one of

the most essential barriers to electric vehicle adoption together with other significant financial barrier finding such as re-sale price and duration needed to reach break-even with a premium price paid are of high concern (Berkeley et al., 2018). People are willing to start considering on purchasing more electric vehicles when they see it as a beneficial investment (Egbue & Long, 2012).

In addition to this, an uncertainty with electric vehicles endurance, maintenance and service cost creates a doubt in people's thought on whether the purchase price can actually be offset by lower running cost (Graham-Rowe et al., 2012).

2.3.2 Vehicle performance barriers

This barrier refers to consumer perception on electric vehicles in factors such as reliability, driving range, charging time, etc. A research on consumer perspective in Tianjin, China has identified this barrier as main concern in electric vehicle adoption in which it implied that consumers do not have confidence with electric vehicle performance (She et al., 2017). Another research from early adopter of electric vehicle in Sweden has also reported a barrier from vehicle performance about range anxiety that it is considered to be a main barrier to mainstream adoption of electric vehicles (Vassileva and Campillo, 2017).

Electric vehicles have a disadvantage compared to internal combustion engine vehicle in its battery which is pricier, big and take time to charge which make electric vehicles to have shorter range and lower performance in refueling on the way. Moreover, due to range anxiety, user demand for a higher driving range than actual range from a fear that the vehicle cannot reach the destination (Egbue & Long, 2012). Range anxiety has long been considered a significant barrier to widespread electric vehicle adoption and cannot be ignored. It incorporates with human factor. It is a psychological barrier that come from user who become worrier on range than in conventional vehicle. (Franke et al., 2011).

Nonetheless, it is also mentioned that the driving range can be decreased if it were to compensate with fast charging (Egbue & Long, 2012). Lengthy charging time also posts a constraint in using electric car as it affects to user's plan on the journey that need to cope with charging time needed (Graham-Rowe et al., 2012).

2.3.3 Infrastructure barriers

This barrier is related to an availability of infrastructure such as charging station that is similarly to a gas station for internal combustion vehicle. It is essential to electric vehicle adoption (She et al., 2017). A comparison research between electric vehicles and conventional vehicles has pointed out that an improvement of infrastructure for charging is utmost important in stimulate people to use electric vehicle in long distance travel and fulfill driver needs in mobility (Haustein & Jensen, 2018). Even in UK where a landscape is in favor to electric vehicles to gain market share, an accessibility to public charging station is addressed among the most essential barrier to adoption (Berkeley et al., 2018). Beside public charging station, a difficulty in installing home charger for people who live in building or people who lack a space to install home charger also poses a problem in infrastructure (Wan et al., 2015).

An availability of maintenance and service place is another infrastructure barrier considered to affect user's confidence in using electric vehicles as user has a doubt on the durability of electric vehicles (Graham-Rowe et al., 2012).

2.3.4 Barriers in different regions

After conducting a literature review, many studies have been found to conduct in different regions around the world to identify barriers in each place in which the result from researches has showed a difference in a major barrier that has an effect in each country such as financial barrier ,which is a significant barrier for many countries, is not a barrier for electric vehicle adoption in Qatar which is a financially stable country or a range anxiety of electric vehicle that is not a major barrier in Doha, Qatar due to the geography of Qatar which is small and fill with many fueling station to transform to charging station (Khandakar et al., 2020).

This shows that a characteristic of each country can have an effect to the barrier toward electric car adoption, therefore it is important to understand consumer perception and reason behind barrier existence to consider on how to eliminate or reduce the barrier.

2.4 Conceptual framework

To understand and identify barriers from consumer perception that could affect adopting electric vehicle in Thailand, the barriers factors are divided into criteria in according to literature review, which are financial barriers, vehicle performance barriers and infrastructure barriers. These criteria are used as a guideline in exploring barriers in each criterion. These barriers are expected to exist and influence consumer perception in adopting electric vehicles.

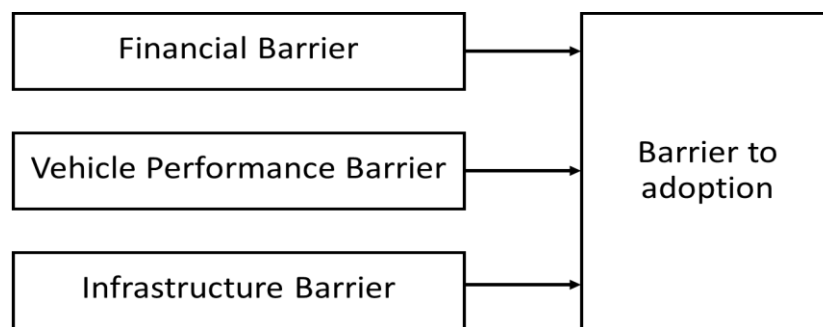


Figure 2.1 Conceptual framework

The propositions for the framework are

P1: Financial barriers prevent electric vehicle adoption in Thailand

P2: Vehicle performance barriers prevent electric vehicle adoption in Thailand

P3: Infrastructure barriers prevent electric vehicle adoption in Thailand

2.5 Research questions

1. Does and how financial barrier prevent electric vehicle adoption in Thailand?

2. Does and how vehicle performance barriers prevent electric vehicle adoption in Thailand?

3. Does and how infrastructure barriers prevent electric vehicle adoption in Thailand?

To answer these research questions, a research methodology and data correction method are discussed to select an appropriate method in chapter 3.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Data Collection Method

The objective of this research is to explore and understand barrier toward electric vehicles adoption in Thailand with a focus on exploring the perception of car users from 3 barrier criteria derived from literature review which are financial barriers, vehicle performance barriers and infrastructure barriers. In each criterion, factors from major barriers that have been identified from literature review have been used to explore perception in each topic. For financial barriers, purchasing price and maintenance cost. For vehicle performance barriers, driving range, charging time, and reliability. Lastly for infrastructure barriers, a number of public charging station and a number of maintenance/ service store.

A qualitative research method is chosen for this research as it is the most effective method in investigational studies to gain insight information (Sovacool et al., 2018). To collect qualitative data, an interview session with an open-ended and probing questions is used to understand each participant's perception toward barriers in electric vehicle adoption in Thailand. The interview is a one-on-one interview with a semi-structure. The interview starts with open-ended questions and follow by probing question in case an in-sight understanding, or concern need to be clarified. Interviews will take place in public places and over the phone depend on availability and concern on social distancing.

3.2 Data validity

During data collection, a set of question for semi-structured interview is prepared to ask participants. These questions are in an open-end question to allow participants to express opinion, feeling, experience and attitude freely. In this way, participants will have a freedom to choose an answer in their own style. Along with these predetermined questions, interviewer will ask probing question to acquire more in-depth

information from participant's answer or confirm on their intention in the answer. This will increase data validity for interviewer to correctly interpret participant's answer.

After data collection finish, interpretive validity is used to ensure on data validity. Interpretive validity ensure that participant's perceptions are precisely reflected into research and clearly understand by interviewer. This is conducted through participant feedback or member checking technique. Member checking technique aim to confirm interviewer's interpretation back to participants to assure that it is correctly transcribe as their intention and eliminate miscommunication (Johnson, 1997).

3.3 Research Participants

This research aims to understand major barriers that prevent consumer from adopting electric vehicles, therefore this research will conduct on conventional vehicle users to understand their perception and concern toward electric vehicles adoption. Although every participant might not fully aware of electric vehicles technology, however they can represent a mass-market perception toward electric vehicle that accounted for widespread adoption (Berkeley et al., 2018). Research interview will be conducted with 20 participants who currently drive a conventional internal combustion engine vehicle and use it as a mode of transportation. The participants will be divided into 2 groups of 10 participants consists of participants whose main usage is city driving and participants whose usage is for travel across province. This aims to cover a difference in perception that could be possibly existed from difference mobility needs.

3.4 Data analysis

In data analysis, the framework approach will be used to organized data from collection. Framework approach is a tool in analyzing qualitative data as it provides a systematic management of collected data and analysis. This allow researcher to be able to acquire an in-depth analysis while able to manage it effectively and keep it transparent (Smith & Firth, 2011). Data collected from the interview is transcribed and analyze to understand each participant's perception and thought toward barriers to electric vehicles adoption in Thailand. After transcribing, the data from the interview is inputted and

summarize in a systematic manner into analytical framework (Table 3.1) that is built from conceptual framework in Figure 1 to categorize and create a structure for data analysis. This structure will serve as both data storing and database for analysis. It helps guide in analysis and link a pattern of concern for each participant and the pattern that has been commonly expressed from all participants to be a barrier in adoption and the least expressed. From this analysis, a conclusion of barrier can be identified.

Table 3.1 A section of a working analytical framework

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Financial barriers	Purchasing price	If compare to fuel car, there is still a high import tax in which if I were to buy for usage, it would not provide a saving, so I continue to use fuel car	○
P2	Across province	Financial barriers	Purchasing price	From what I know, the price is higher than normal car. Maybe because it has not been widespread yet. Demand has not been high	○
P3	City driving	Financial barriers	Purchasing price	I think the price is still high compared to fuel car, so I still feel that it is a barrier	○

The finding from qualitative data collection and analysis is summarized and discussed in chapter 4

CHAPTER IV

RESEARCH FINDING

The interview was collected from 20 participants to understand how people perceived toward barriers to electric vehicle adoption in Thailand and understand concern through qualitative research.

4.1 Financial barriers

In this barrier, it is divided into 2 factors which are purchasing price and maintenance cost. These 2 factors are factors that are directly involve with car usage. Purchasing price is a financial cost that pay upfront in purchasing a car whereas maintenance cost is a financial cost to upkeep car in a good condition throughout its usage life.

From analyzing the interviews, 16 out of 20 participants have addressed that there are financial barriers in electric vehicle adoption in which 13 participants affected from both factors while 3 participants affected from either one of the factors. This result has indicated that financial barrier is affecting participants decision to electric vehicle adoption in Thailand which is consistent to conceptual framework.

For purchasing price, the finding has showed that participants view current electric vehicle price in the market to be high in which it becomes a barrier to change from fuel vehicle to electric vehicle. By comparing with a fuel vehicle price in the market, they see a big difference in price and because of this difference, it makes electric vehicle to be less desirable to change now which can be seen from a comment as follow

“At present, electric car price is considerably higher than fuel car at almost double to triple the price, so if to compare with car in same segment, the price is quite a leap. This is one of factors that I consider to not change now”. (P5)

“This is a barrier. The price is equal C-segment top model or maybe even D-segment. Therefore, I view that it is difficult for normal people to reach and definitely a barrier.” (P16)

These comments have shown perceptions toward a purchasing price that it has effect to participants decision on changing to electric vehicle. A comparison on price of electric vehicle with a fuel vehicle shows a big difference on price in the same tier of vehicle which has lessen interest in adopting an electric vehicle. With this difference, it becomes challenging to convince people to change to electric vehicle. Moreover, normally for a new technology like electric vehicle, there could be people who adopt new technology because of other benefit or value that it can provide, however from the interview finding, it showed that as the price difference is big, it also overshadows other benefit in adopting electric vehicle such as saving from energy cost. Due to the difference between energy used by electric vehicle and fuel vehicle in which a price between 2 energy differ, people often expect a value from saving. However, in the interview, a participant has expressed a perception as follow

“A higher price of electric car still cannot offset by the cost that we can save from fuel price”. (P14)

This comment has shown that participants view the current price is too high to be compensated with a saving from energy cost, therefore there is no value from saving in using electric vehicle.

For a maintenance cost, a finding has shown that most participants do not have an exact information on this factor. This could be because electric is relatively new to Thailand with only few people who start to use it, so information on this topic is not widely known yet. In addition to this, to clearly clarify this cost, electric vehicle would have to be used for a certain distance and time because vehicle has a long usage year in which many costs comes after a certain period or usage life. Nonetheless participants have expressed their opinions regarding to this factor. This is an important information because it shows how participants perceive how the cost in the future will be. It is a future cost that cannot precisely predict, so a perception affects to determination in adoption.

Finding from a perception on maintenance cost indicates that participants think that maintenance cost is higher than fuel car in which it would be a barrier to electric vehicle adoption. There are several reasons given on perception why maintenance cost

is expected to be higher such as a higher price of spare part, a shorter usage life and limitation to use only brand service center. Some of different aspect on perception are stated as followed.

“At present, I think it is a barrier because a major brand like Toyota and such have not officially produced yet, so I think that there is no brand service center yet. Therefore, there is only private service store which has a risk, so I think that it is a barrier. I think that only minority is using it right now, so spare part needs to be imported which has a high expense” (P1)

“I think that the electronic parts have a shorter usage life or a specific usage time. Moreover, if frequently use for a long-distance drive like driving across province and use for a long period of time, I think it will affect in a higher depreciation cost than a conventional car”. (P5)

4.2 Vehicle performance barriers

This barrier is divided into 3 factors which are driving range, charging time and reliability. These 3 factors are unique functions that characterize electric vehicles to be different from conventional fuel vehicle. Driving range is the distance that electric vehicle can commute with a full charge of battery. Charging time is a duration needed for electric vehicle to be charged and lastly reliability which is related to user confidence on usage of electric vehicle.

For this barrier type, 17 out of 20 participants have expressed that there is a barrier from vehicle performance of electric vehicle in which result varies between participants of city driving group and across province group. City driving group has shown to be less affected by this barrier as only 1 out of 10 participants has addressed all three factors as a barrier to electric vehicle adoption while most of participants address only 1 factor to be a barrier and 3 participants has addressed none of them to be a barrier at all. On the contrary, for across province group, 8 out of 10 participants has agreed that all 3 factors are barriers to electric vehicle adoption, and none has addressed that there is no barrier from these factors. This shows that vehicle performance barrier has an influence on electric vehicle adoption especially on people who use a vehicle in long-distance drive in which electric vehicle cannot fully compete with fuel vehicle.

From interview, Participants who addressed driving range as a barrier have expressed that this is relate to a long-distance drive. Participants feel that this factor create a limitation in long-distance drive that complicate their usage. The finding shows that this factor is related to other factor such as charging time and charging station. In a normal usage of fuel vehicle, driving range is not highly affected in usage because an average range is far enough to cover a range needed to reach gas stations which are widely distributed and high in quantity. Moreover, the amount of time used to refuel also considerably quick. However, for electric vehicle in which these components are still inferior to fuel vehicle, therefore driving range become a barrier. It restricts usage from a concern on sufficiency of energy to reach the destination or next charging station in which for charging station, it also has another concern from charging time. This relation creates a complicate usage condition for electric vehicle user in which it become a barrier that user must consider before changing to electric vehicle. This can be seen from a statement below

“As I mention earlier, when drive to a far location, it is one of an important factor that does not think of changing to electric car now because for one charge of battery, current electric car in Thailand market can probably drive 300-400 km. Definitely not over 500 km per charge. This is a factor that you cannot plan ahead or go off-route in upcountry drive because you do not know where to recharge or have to leave the car in which it needs a time to charge” (P5)

Moreover, some participants have firmly specified that this factor is a barrier due to driving range is insufficient to support their usage which make them unable to change to electric vehicle. A participant has expressed as followed

“This is definitely a barrier. Nowadays I drive in a very long distance in which from what I saw from electric car in the market, its range is around 400 km. It cannot satisfy my usage.” (P17)

From these comments, they show that the current electric vehicle’s performance cannot fully serve a usage of customer who use a vehicle for an extensive range.

In case of factor from charging time, the finding from interview has shown that participants concern on this factor in term of an inconvenience caused by a longer charging time compared to refueling in fuel vehicle. Participants have expressed that

they feel that it is a waste of their time to wait for vehicle to be recharge. It obstructs with their routine and plan as stated below

“It is a barrier like I said in last question that if I have an appointment that is far and I have to plan that currently my car can drive this far, but it still only halfway, so I have waste time to charge. It is unacceptable, so wouldn't it be better to drive fuel car.” (P20)

Moreover, due to a lengthy time required for charging, it affects to driver's convenience that they must plan ahead to constantly evaluate their vehicle and reserve a time slot for charging. It creates a difficulty in usage as it cannot be used spontaneously especially when there is an incident occurred. This make electric vehicle to be less flexible and create an inconvenience to user which become a barrier to adoption. This has been expressed by participants such as P10 and P16

“I feel that it is burdensome to constantly charging and checking how much is left and how long do I have to leave it to charge. It makes life more complicated.” (P10)

“It certainly has an effect in case we have to suddenly use a car such as we have just arrived at home and spontaneously a close people of us need to go to hospital or need an emergency help, but our car is not ready yet, it definitely affected because it needs to charge first and waste hours of time.” (P16)

In term of reliability, the finding shows that it is a barrier from a lack of knowledge on electric vehicle performance. Due to electric vehicle is still new in the market especially in Thailand, people do not know about it as much as they have in fuel car that has been used for a long time. It becomes a doubt for fuel vehicle user on whether electric vehicle has same level of performance with fuel vehicle or not. They feel that it could be inferior to fuel vehicle and could have more problem during usage or whether it is suitable for Thailand's condition or not.

“I think I do not have that much confidence because I have never used before or know someone who use electric vehicle. I think there might be an electrical malfunction or something.” (P2)

“If to ask whether I trust it 100%, then I do not have that much confidence because it is not fully accepted in Thailand and I do not have that much knowledge about electric vehicle in same level as fuel vehicle. I have more reliability in fuel car. I knew that it is safe, but I do not know where it can be risky.” (P11)

These uncertainty and lack of knowledge for referencing are a barrier to adoption because it creates a concern for user that they have to take risk in using it in which it might be beneficial for them to do so.

4.3 Infrastructure barriers

This barrier is a barrier from an infrastructure or an ecosystem in society that support to usage and adoption. Especially for an electric vehicle, it requires a different infrastructure from conventional fuel vehicle such as a charging station instead of gas station, thus if the infrastructure does not support enough, it can become a restriction that prevent adoption due to its difficulty in adapting to user's life. This has been divided into 2 factors which are a number of public charging station and a number of maintenance store. A number of public charging station is a barrier that relate to usage of electric vehicle as it represents a gas station for conventional fuel vehicle. Without enough public charging stations, it will limit a range of usage of electric vehicle and become a difficulty in electric vehicle adoption. For a number of maintenance store, it is a barrier that relate to an accessibility to receive service or repair when vehicle breakdown. It is one of an essential infrastructure that ensure users in maintaining the product at its usable condition and access to help in case of emergency situation occur.

For infrastructure barriers, every participant has agreed that these are barriers in electric vehicle adoption. The barriers are caused from an insufficiency in which it creates a problem for user. As all participants has indicated same response, it could imply that this barrier group is widely concerned by users and affect their decision to adopt electric vehicle.

Based on a finding in a factor of a number of public charging station, comment on this factor has identified that at present, a public charging station is unable to support electric vehicle adoption. Some participants have said that even though there are chargers available, but most of them are located in the city whereas other province is lacking on charging locations in which it creates a difficulty in usage of electric vehicle as stated below

“I think that it is a barrier because from my observation of current status in Thailand, charging station cannot satisfy electric car user's condition. It is mostly in

main city, however if we have to travel upcountry, the area that support charging is not enough” (P5)

Beside this, a limitation of charging station in term of distribution and charging capacity is also expressed. Due to many chargers that participants have seen are located in malls, so it limits a usage to malls visit only. In case they go to other places, they might not be able to find a charger and would become a problem. In addition to this, participants have also expressed a doubt that with current number of chargers, they do not believe that it can support a mainstream adoption of electric vehicle in the future. It will still be insufficient especially from a long charging time that is a problem. This is stated in below finding.

“If there are chargers in almost every place such as in malls and such, it would be nice, but at present in Thailand, there are already chargers in most malls in Bangkok. However Thai people do not go to mall all the time. For me, I might drive to buy food from a shop on the side of the road and there would not have a charger available in which it would be a barrier. If I were to drive in Bangkok or upcountry, it would be a bit difficult.” (P11)

“It is a barrier. Nowadays, there is none. There are some in a mall that I used to see, but there is a limit. It does not have that many. In the future, if electric cars become mainstream, there should be more in malls, charging stations and other places. It should be better organized because if we have to wait or struggle to use, using gasoline would be better as it has more. There is not enough facility now.” (P12)

These comments have clearly indicated that insufficiency and limitation are existed in participant’s perception and they become a barrier for participants in deciding on electric vehicle adoption.

For a number of maintenance store, an analysis of finding has found that participants, who have expressed that this is a barrier, have a concern on this factor in term of limitation in usage area and location. They view that because electric vehicle is still new in Thailand, therefore an available service centers might still be few and could be limited to only brand service center who know how to operate electric vehicle. In this case, this is a limitation for them to travel a long-distance to reach the service center including when a car has a problem in which an assistance might use considerably long time to reach due to their location is far away.

“It is a barrier and could be second or third place because in car usage, we must go to routine checking at certain range, but if the store is far away from us, we feel that it will take long time and consume a lot of time for that day.” (P2)

“If consider that buying an electric car for a long term, then it is. If one day, I drive upcountry, and it has a problem and there is no service center for electric car in that province. I will have to wait for them to drive up from Bangkok. It would be inconvenience for me. It is unlike fuel car that anyone can fix it.” (P11)

4.4 Finding summary

In conclusion, the finding on an interview with participants on a topic of barriers toward electric vehicle adoption in Thailand has answered research questions that all 3 barriers which are financial barriers, vehicle performance barriers and infrastructure barriers prevent electric vehicle adoption in Thailand in which the barriers that have the highest response to electric vehicle adoption is infrastructure barriers, follow by vehicle performance barriers and financial barriers respectively. For infrastructure barriers, participants have addressed that an infrastructure is insufficient or ready to support an adoption of an electric vehicle yet and there is a limitation on usage area and location. For vehicle performance barriers, a finding has indicated that this is a barrier in electric vehicle adoption due to a limitation in driving range, an inconvenience from a long charging time and a lack of knowledge on electric vehicle for user to have a reliability in electric vehicle. They have a concern that these limitations in electric vehicle that is still lacking behind fuel vehicle and cannot replace it entirely. For financial barriers, participants have expressed that current purchasing price is higher than fuel vehicle which make it less competitive and they expect that electric vehicle is going to have a higher maintenance cost. A higher spending in adoption hinders to an adoption of electric vehicle. They showed no interest in paying extra to adopt an electric vehicle or see any value to pay premium for it.

Overall, all barriers have prevented electric vehicle adoption in Thailand in which in next chapter, a recommendation is discussed to handle barriers

CHAPTER V

RECOMMENDATIONS

5.1 Recommendation

From the finding, barriers are existed in every barrier type, therefore several recommendations are suggested to reduce barriers in each aspect. The recommendations are arranged in according to the effect to electric vehicle adoption. The recommendations are as followed in figure 5.1.

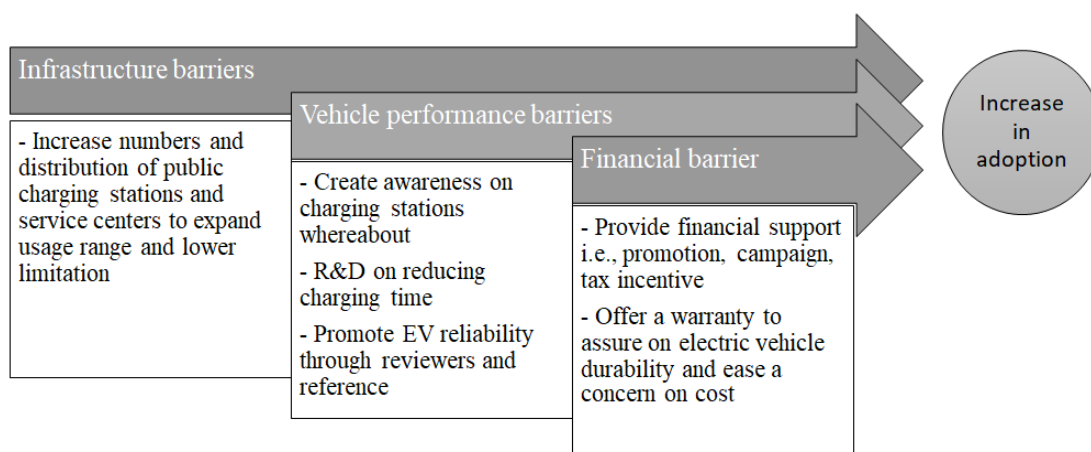


Figure 5.1 Recommendation to electric vehicle adoption barriers

Firstly, in infrastructure barriers which is the most affected barriers from every participant. The barriers in this criterion comes from an insufficient of public charging station and service center which restrict usage of electric vehicle and create a limitation on usage area and location, therefore the recommendation for this barrier is to increase numbers and distribution of public charging stations and service centers to expand usage range and lower limitation. It is inevitable for an electric vehicle to develop its own ecosystem as it cannot fully use same infrastructure as fuel vehicle. Not only the numbers, but also the distribution must be carefully considered to choose a strategic location which can provide service to surrounding area and does not concentrate too much in same area or locate only in a specific infrastructure which would only create a

further limitation. It should be widely distributed to support different usage of users. This recommendation should be the first priority as it is the most affected and require times to develop

Secondly, for vehicle performance barriers, there are several issues in this barrier type starting from driving range in which participants have expressed that there is a limitation in long distance drive as electric vehicle has limited range. This problem is correlated with charging time and a number of public charging station because if there is enough charging station to support recharge along the route, people would have lower concern on range. Relatively to the recommendation in infrastructure barriers, I recommend in creating an awareness of public charging station whereabouts to user so that they can have less concern on range. For charging time, this is a barrier that create an inconvenience for electric vehicle user from a lengthy time for recharge to complete. This barrier requires an improvement in charging technology to solve this barrier. Lastly for reliability that participants expressed their lack of knowledge which led to a barrier. This would be lessened by promote of electric vehicle reliability through reviewers and referencing from people who has used it.

Thirdly, financial barriers, this barrier type comes from a higher purchasing price of electric vehicle compared to fuel vehicle, so a financial support is needed to close the gap and increase competitiveness of electric vehicle. A financial support can be in a form of promotion, campaign or tax incentive which reduce the cost of ownership. Another cause of barrier is an expectation for a higher maintenance cost. For this cause, an electric vehicle manufacturer should consider on providing a warranty to assure to public on electric vehicle durability that it will not break down easily. This would ease a concern for consumer that afraid of cost from its durability.

By combining and proceed with the recommendations, it would improve current condition and reduce a barrier that prevent electric vehicle in Thailand which then lead to an increase in electric vehicle adoption.

5.2 Limitation

In this research, there is 2 limitations founded during data collection which are a small number of participants. Due to a limited time, there is a limit on the number of participants to gather data from in which it might not cover all the demographic yet. Another limitation is that many comments are based on perception toward electric vehicle because electric vehicle is in an early stage and new to Thai market, so many participants only aware that there is an electric vehicle, but they do not have a direct experience with it yet. This influence the result to be based on perception in which it can be changed in the future when an awareness is widely spread. Nonetheless perception is also important as it dictates people in decision making, however it also limits in identifying the true root of barrier in adoption.

5.3 Future research

An interesting future research is a quantitative research of barriers toward electric vehicle adoption in Thailand. This can expand and measure a barrier in a wider demographic. It could strengthen an evidence on which barriers are the most affected for electric vehicle adoption in Thailand and provide a statistic information on each barrier. Another future research is a research on barriers toward electric vehicle adoption in Thailand from a perspective of drivers who have experiences. This can provide a rich information on actual barriers that they found from usage. This data can be used to improve a usage condition for current users and prepare a better environment to attract new users.

In next chapter, a conclusion from this research is discussed and summarized each step throughout this research.

CHAPTER VI

CONCLUSION

With a growing concern on environment, a solution is needed to reduce a release of pollution. An electric vehicle is one of a promising solution on this problem as it can replace an internal combustion engine vehicle which produce pollution through burning of fuel. Even though with its benefit, a mainstream adoption is still considerably low. This indicates that there are barriers that restrict people from adoption.

A review on past study of barriers has identified that there are 3 common barriers that affect in electric vehicle adoption which are financial barriers, vehicle performance barriers and infrastructure barriers. Due to an existence of these barriers in consumer perception, it affects consumer to neglect or postpone electric vehicle adoption as they do not feel comfortable to change. Although these barriers have been identified in many studies, each study reported a different barrier to be a major concern. This is an effect from a different in many aspects such as geography, policy and more. This leads to a study on barriers in Thailand market where electric vehicle is still new and low in adoption. A conceptual framework is drawn based on a review that financial barriers, vehicle performance barriers and infrastructure barriers are barriers in adoption with an aim in identifying which barriers are existed in Thailand and understand on perception that led them to be barriers for consumer. The research is conducted through a qualitative study to get an insightful information from participants. Factors in each barrier are specified to acquire a detail information. The factors in financial barriers are purchasing price and maintenance cost. The factors in vehicle performance barriers are driving range, charging time and reliability and the factors in infrastructure barriers are a number of public charging station and a number of maintenance store. These factors are used to ask participants in a semi-structure interview to observe their opinions and perceptions.

A finding has shown that there are barriers from all 3 barriers in Thailand which rank infrastructure barriers at the highest and follow with vehicle performance barriers and financial barriers. Infrastructure barriers are caused by an insufficient of public charging station and service center and a limitation on usage area and location. Vehicle performance barriers are caused by a range limitation in long-distance drive, an inconvenience from long charging time and a lack of reliability due to lack of knowledge. Financial barriers are caused by a higher purchasing price than fuel vehicle and an expectation of a higher maintenance cost.

As barriers are existed in Thailand, it would restrict electric vehicle adoption. Therefore, to increase adoption, a countermeasure must be implemented in these barriers. Infrastructure barriers should be reduced or eliminated by an increase in number and distribution of public charging station and service center to expand usage range and lower limitation. Vehicle performance barriers should be handled with an awareness creation on charging station to reduce concern on range, an effort in R&D to reduce charging time and promote on electric vehicle reliability via reviewers and referencing. Lastly, for financial barriers, they should be lessened with a financial support via a promotion, a campaign, or a tax incentive to lower spending per car to be able to compete with fuel car and a warranty to assure on electric vehicle durability and ease consumer concern on cost.

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APPENDICES

Appendix A: Working analytical framework of financial barriers (Purchasing price)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Financial barriers	Purchasing price	If compare to fuel car, there is still a high import tax in which if I were to buy for usage, it would not provide a saving, so I continue to use fuel car	<input type="radio"/>
P2	Across province	Financial barriers	Purchasing price	From what I know, the price is higher than normal car. Maybe because it has not been widespread yet. Demand is not high	<input type="radio"/>
P3	City driving	Financial barriers	Purchasing price	I think the price is still high compared to fuel car, so I still feel that it is a barrier	<input type="radio"/>
P4	Across province	Financial barriers	Purchasing price	if it is higher than fuel car, then I will not buy it	<input type="radio"/>
P5	Across province	Financial barriers	Purchasing price	At present, electric car price is considerably higher than fuel car at almost double to triple the price, so if to compare with car in same segment, the price is quite a leap. This is one of factors that I consider to not change now	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P6	City driving	Financial barriers	Purchasing price	As I see like Tesla, the price is higher than conventional fuel car. I think that the price is still high. If it can be replaced, the price should be in the same market price such as Vios that I use, the top model is around 800K, so electric car should be in same price range.	○
P7	Across province	Financial barriers	Purchasing price	Price is not a barrier. I think price is not as much concern as a charging station. The price is higher, but electricity is cheaper than gasoline. It is a saving in long-term	×
P8	Across province	Financial barriers	Purchasing price	The price is highly affected, it is the first thing that come to mind. If speak about electric car, the brand that come to mind is Tesla in which the price is high. Although there are other brands, but I am interested in them.	○
P9	City driving	Financial barriers	Purchasing price	It is a barrier. I view that price is still high, and I have not used car that much, so I feel that it is not worthy now	○
P10	City driving	Financial barriers	Purchasing price	I think that price is not a barrier. I think electric car's price is still affordable. There should not be a problem	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P11	City driving	Financial barriers	Purchasing price	Purchasing price is not a barrier because it is in the same range as fuel car, not that different.	×
P12	City driving	Financial barriers	Purchasing price	It is a barrier because if electric car is expensive than fuel car, I would not consider buying it. I feel that it is more complicate to use in having to frequently charge. If it were expensive and complicate, then I must think about it	○
P13	City driving	Financial barriers	Purchasing price	I view that price is not a barrier. I think it is not much different from fuel car	×
P14	Across province	Financial barriers	Purchasing price	A higher price of electric car still cannot offset by the cost that we can save from fuel price	○
P15	Across province	Financial barriers	Purchasing price	It is not a barrier. I am more concern on shape and appearance based on my personal preference. Electric or fuel car is not my factor in deciding.	×
P16	Across province	Financial barriers	Purchasing price	This is a barrier. The price is equal C-segment top model or maybe even D-segment. Therefore, I view that it is difficult for normal people to reach and definitely a barrier.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P17	Across province	Financial barriers	Purchasing price	It definitely is a barrier. In my opinion, if compare price, personally I would save more by using fuel car	○
P18	City driving	Financial barriers	Purchasing price	It is not a barrier. Lately there is a launch from several brand that the price is not so high such as MG which the price is reachable	×
P19	City driving	Financial barriers	Purchasing price	I think that it is a barrier. The price is still high. If compare between price in Thailand and oversea such as USA, I think the price in Thailand is very high.	○
P20	Across province	Financial barriers	Purchasing price	It is a barrier for me because if we take a current electric car in this size to compare with fuel car in same size and calculate in long term, we still find that fuel car is still have higher value which lead me to view that current electric car is over expensive to change into	○

Appendix B: Working analytical framework of financial barriers (Maintenance cost)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Financial barriers	Maintenance cost	At present, I think it is a barrier because a major brand like Toyota and such have not officially produced yet, so I think that there is no brand service center yet. Therefore, there is only private service store which has a risk, so I think that it is a barrier. I think that only minority is using it right now, so spare part needs to be imported which has a high expense	<input type="radio"/>
P2	Across province	Financial barriers	Maintenance cost	In fact, I do not know whether the maintenance cost is high or not, but if it is higher than fuel car, then it is one of factor in making decision	<input type="radio"/>
P3	City driving	Financial barriers	Maintenance cost	I think it is a barrier. I think maintenance cost will be higher than fuel car from an electric system	<input type="radio"/>
P4	Across province	Financial barriers	Maintenance cost	I think it is a barrier because maintenance cost is likely to be higher than fuel car.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P5	Across province	Financial barriers	Maintenance cost	I think that the electronic parts have a shorter usage life than normal car or a specific usage time. Moreover, if frequently use for a long-distance drive like driving across province and use for a long period of time, I think it will affect in a higher depreciation cost than a conventional car	<input type="radio"/>
P6	City driving	Financial barriers	Maintenance cost	I am not sure that the battery will be expensive or not. I think that maintenance cost might not different and is not a barrier. However, if it were more expensive, but can use longer than fuel car, then it is not a barrier. Nonetheless if it is just more expensive, then it will be barrier	<input type="radio"/>
P7	Across province	Financial barriers	Maintenance cost	I do not know how picky the maintenance of electric vehicle will be. I do not that it is much different, so it is not a problem	×
P8	Across province	Financial barriers	Maintenance cost	Frankly, I do not know what the difference in maintenance cost of fuel car and electric car is, but if it is equal, it is okay and acceptable to change if the price is drop. If the maintenance cost is higher 10-20%, I still would not mind, but if it is 50% increased, then it is not okay.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P9	City driving	Financial barriers	Maintenance cost	I think that it is a barrier now. If it were a normal car, it does not need to go to brand service store. There is a private store with affordable price, but for electric car, if a problem occurs, it is most likely that it needs to use brand store in which price is high.	○
P10	City driving	Financial barriers	Maintenance cost	I think about it. I do not know about the cost before, but personally I think that maintenance cost is likely to be high and I do not know that after use, will it break down often or not, will it frequently be having a problem or not because it is about electricity.	○
P11	City driving	Financial barriers	Maintenance cost	Yes, it is a barrier because from what I heard; it is more expensive than fuel car	○
P12	City driving	Financial barriers	Maintenance cost	I think that it will be equal to fuel car. However, I must consider about it when I buy a car on how much it cost. If it were more expensive, then I will not buy it yet	○
P13	City driving	Financial barriers	Maintenance cost	It is not a barrier because if price is equal with fuel car, then maintenance would not be much different.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P14	Across province	Financial barriers	Maintenance cost	I do not think that it is a barrier because I think that it is not much different	×
P15	Across province	Financial barriers	Maintenance cost	It is not a barrier because I think that it is not much different.	×
P16	Across province	Financial barriers	Maintenance cost	It is also a barrier because the car is not mainstream yet. Spare part and maintenance cost in case we must claim, it will definitely be expensive	○
P17	Across province	Financial barriers	Maintenance cost	It definitely is a barrier because I look at a big component like battery that is bigger and more expensive including an electric system that is costly to fix	○
P18	City driving	Financial barriers	Maintenance cost	I cannot say for sure because I have not studied about labor and spare part cost of EV yet, so I cannot tell you on this information. However, if I compare to Altis new model which is hybrid, at first, I thought that cost will be high like Alphard that I ever used, but when I saw the ads of Altis, I admit that they have done a great job. It makes me feel that it is not different from fuel car, so I believe that they can make it so that consumer feel that it is not a burden. I feel that they can manage it	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P19	City driving	Financial barriers	Maintenance cost	I think that for a money that has to pay for electric car service cost, I think it would be better to buy a diesel car that has a good saving rate.	<input type="radio"/>
P20	Across province	Financial barriers	Maintenance cost	I think that it is a barrier because from my knowledge, for example like battery changing, electric car would be higher than fuel car in which it is a factor that affect my decision whether to change or not	<input type="radio"/>

Appendix C: Working analytical framework of vehicle performance barriers (Driving range)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Vehicle performance barriers	Driving range	For me, I use in Bangkok and nearby area, so I don't think that it is a barrier because electric car can cover daily usage	×
P2	Across province	Vehicle performance barriers	Driving range	I think it is a barrier because in Thailand, you can drive anywhere, but unlike other country that use electric vehicle like China where you can only drive in your province in which it is appropriate to use it because you cannot cross province. However, in Thailand, our car can drive anywhere in which range is a barrier because you would want to go north, south, east or west in which if there is no charging station, it would be an obstacle	○
P3	City driving	Vehicle performance barriers	Driving range	I normally use my car for a short distance in city, so I do not feel that range will be a problem.	×
P4	Across province	Vehicle performance barriers	Driving range	I think it is a barrier for long distance drive, but in short distance, it might not be. However personally I must travel to other province, so it is a barrier to usage.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P5	Across province	Vehicle performance barriers	Driving range	As I mention earlier, when drive to a far location, it is one of an important factor that does not think of changing to electric car now because for one charge of battery, current electric car in Thailand market can probably drive 300-400 km. Definitely not over 500 km per charge. This is a factor that you cannot plan ahead or go off-route in upcountry drive because you do not know where to recharge or have to leave the car in which it needs a time to charge	○
P6	City driving	Vehicle performance barriers	Driving range	At present, I do not often go upcountry, so it is not a barrier	×
P7	Across province	Vehicle performance barriers	Driving range	I think electric car can drive in shorter distance than fuel car and normally I drive upcountry, so I need to consider on range	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P8	Across province	Vehicle performance barriers	Driving range	It affects because if 1 charge can drive for 300 km, then I would not interest in it. However, if it is liked my previous car that can drive 600-700 km per tank and electric car can do the same, I would interest.	○
P9	City driving	Vehicle performance barriers	Driving range	There is an effect, but only a little because I drive in short distance	×
P10	City driving	Vehicle performance barriers	Driving range	Normally I drive in city. I think that I do not use it in long distance drive, so I am not likely to have problem like charging this much and can drive a short trip or cannot reach destination.	×
P11	City driving	Vehicle performance barriers	Driving range	If it can drive far enough, then it does not matter that much. For example, for me, I only drive in Bangkok. I do not go anywhere much. The most is going to nearby mall and come back. If it can drive this range, I am okay.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P12	City driving	Vehicle performance barriers	Driving range	It has an effect because if it charges and can drive only in a short distance, then it affects. It should at least be able to drive for 200km. Because if I were to go anywhere or stuck in traffic, it cannot easily find a charger.	○
P13	City driving	Vehicle performance barriers	Driving range	I think that in the future, it would not be a concern. Battery should be able to make a long charge and drive in an equal distance as fuel car. However, at present, it will be a barrier. If I were to drive in a long distance, I do not feel confidence that it will be sufficient for me or not	○
P14	Across province	Vehicle performance barriers	Driving range	It is highly affected because my usage is in upcountry drive in which driving range of electric vehicle is unlikely to be enough for daily usage	○
P15	Across province	Vehicle performance barriers	Driving range	It is not a barrier because I normally do not drive that far.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P16	Across province	Vehicle performance barriers	Driving range	For someone who a drive across province, it certainly has an effect due to a long distance like drive to Kanchanaburi then Nakhon pathom with a distance at least 300 km, the battery might be depleted. However, for city drive, it might be more appropriated than drive across country. For me, I drive across country, so I still feel that it is not suitable for this kind.	○
P17	Across province	Vehicle performance barriers	Driving range	This is definitely a barrier. Nowadays I drive in a very long distance in which from what I saw from electric car in the market, its range is around 400 km. It cannot satisfy my usage	○
P18	City driving	Vehicle performance barriers	Driving range	Not a barrier at all because many models that I check like Nissan leaf can drive for 400-500 km per full charge. I think that for normal car can run 600-700 km for a big 65L tank, so this is acceptable.	×
P19	City driving	Vehicle performance barriers	Driving range	I think it is not a barrier if it can drive for 300-400 km per charge for a drive in Bangkok. I can drive for a week	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P20	Across province	Vehicle performance barriers	Driving range	Because I focus on long distance drive such as across province, so I think that a current driving range of electric vehicle is still low in which if we have to waste time to charge en-route, it would be a waste of time	○

Appendix D: Working analytical framework of Vehicle performance barriers (Charging time)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Vehicle performance barriers	Charging time	Personally, there is no problem because I do not drive in a long distance. For charging, I will do it at home and do not need to charge during the day	×
P2	Across province	Vehicle performance barriers	Charging time	because from what I knew, it takes quite a long time to charge as I have used an electric bike and it take a long time, so car should even longer than that, therefore it is a barrier because if it takes a long time and I want to use it immediately, but I have to wait. It will not convenience for me. Unlike fuel car that took only few minutes to refuel.	○
P3	City driving	Vehicle performance barriers	Charging time	Charging time is not a problem for me because I do not drive far, so I think I can charge overnight at home.	×
P4	Across province	Vehicle performance barriers	Charging time	I think it take quite a long time per charge. In my opinion I think that it can be used for a certain time in 1 week and if it needs to charge, it will take a considerably long time in which we cannot go anywhere to wait for car to charge	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P5	Across province	Vehicle performance barriers	Charging time	It is a barrier because as I mention that when drive back and forth to upcountry. In work route, I cannot stay overnight, so it will be a day round trip. If you have to waste time to recharge in driving upcountry, it does not fulfill my usage in waste 1-2 hour to charge.	○
P6	City driving	Vehicle performance barriers	Charging time	Not a barrier. I think that when I go to work and come back, I can charge overnight when I do not use a car	×
P7	Across province	Vehicle performance barriers	Charging time	If it takes a long time to charge, but can drive a long distance, then it is okay. However, it is taking an hour to charge, but can drive only half of fuel car, then it is not okay.	○
P8	Across province	Vehicle performance barriers	Charging time	It definitely affects because even if it can drive for 700 km, but need to charge for 1-2 hours, then it is not okay. It is very inconvenience for example if I were to drive upcountry and battery deplete in which I have to wait for 2 hours instead of refueling and can go immediately.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P9	City driving	Vehicle performance barriers	Charging time	I think that it can be charged overnight, so there is not much effect.	×
P10	City driving	Vehicle performance barriers	Charging time	I feel that it is burdensome to constantly charging and checking how much is left and how long do I have to leave it to charge. It makes life more complicated.	○
P11	City driving	Vehicle performance barriers	Charging time	If it can drive for 300 km, then it is not a barrier.	○
P12	City driving	Vehicle performance barriers	Charging time	If said that It can drive for 300-400 km then it is not a problem, but if it can drive in short distance and need to charge, then it is.	○
P13	City driving	Vehicle performance barriers	Charging time	If we talk about present, I think that it is a barrier because I think that charging time is considerably longer than refueling. It is a barrier in wasting time without having any merit.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P14	Across province	Vehicle performance barriers	Charging time	It is highly affected to my work. My work emphasizes on time usage in which I cannot wait for a 4-8-hour charging	<input type="radio"/>
P15	Across province	Vehicle performance barriers	Charging time	I think that it is because electric car is likely to have a longer charging time than a fuel car in refueling. It is inconvenience	<input type="radio"/>
P16	Across province	Vehicle performance barriers	Charging time	It certainly has an effect in case we must suddenly use a car such as we have just arrived at home and spontaneously a close people of us need to go to hospital or need an emergency help, but our car is not ready yet, it definitely affected because it needs to charge first and waste hours of time.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P17	Across province	Vehicle performance barriers	Charging time	It certainly is a barrier because from my observance, most of them take 1-2 hours to charge. For me, after I reach destination, I must immediately make time, so when I drive upcountry, the most I do is make a short stop for refueling then continue the trip. 1-2 hours is too long for me.	<input type="radio"/>
P18	City driving	Vehicle performance barriers	Charging time	I used to consider about it. It is important. I think that from a brand that has launched, they are doing okay. There is no worry but let say that we are in a hurry like come in for 5 min charge then have to leave. It will have an effect that we must manage everything well to use this type of car	<input type="radio"/>
P19	City driving	Vehicle performance barriers	Charging time	I do not think there is a barrier on this because for my home, I can charge it overnight, so it would not be much of a barrier except when I have to drive upcountry and need to find a charging station, then it would be a barrier.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P20	Across province	Vehicle performance barriers	Charging time	It is a barrier like I said in last question that if I have an appointment that is far and I have to plan that currently my car can drive this far, but it still only halfway, so I have waste time to charge. It is unacceptable, so would not it be better to drive fuel car.	○

Appendix E: Working analytical framework of Vehicle performance barriers (Reliability)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Vehicle performance barriers	Reliability	Overall performance is enough. I think that acceleration is better than fuel car, no sound and pollution. I think that if drive in a short distance, the performance is even better than fuel car	×
P2	Across province	Vehicle performance barriers	Reliability	I think I do not have that much confidence because I have never used before or know someone who use electric vehicle. I think there might be an electrical malfunction or something.	○
P3	City driving	Vehicle performance barriers	Reliability	I think that it is not a barrier because in my opinion, if I buy from a well-known brand, it should have guaranteed its quality	×
P4	Across province	Vehicle performance barriers	Reliability	I do not think it is reliable enough. It might be in short distance, but personally I have to travel to other province in which long distance drive is not reliable. I think that it is a barrier to long distance drive	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P5	Across province	Vehicle performance barriers	Reliability	Personally, I do not have an experience in driving electric car, so I cannot compare this, but in my perception, it is a barrier because I think that fuel car can deliver more power than electric car	○
P6	City driving	Vehicle performance barriers	Reliability	I am not sure if it is a full electric car, the drivetrain system is stable or not.	○
P7	Across province	Vehicle performance barriers	Reliability	I think that electric car is not stable enough to change to.	○
P8	Across province	Vehicle performance barriers	Reliability	Not reliable enough because the first thing is price, and second thing is driving range that a lot lower than fuel car and also charging time and everything. I view that if it cannot equally compete with fuel car, then it cannot respond to needs.	×
P9	City driving	Vehicle performance barriers	Reliability	It is not affected because if I were to look at electric car, it will be Tesla. At present, Tesla is likely trustworthy to a certain level.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P10	City driving	Vehicle performance barriers	Reliability	Depend on the car brand too because it builds trust in its own. If it is a new brand launching an EV, I might not have trust in that brand. However, if it is a big brand, it is already a prove that with an image of this brand, they already have a reliability.	×
P11	City driving	Vehicle performance barriers	Reliability	If to ask whether I trust it 100%, then I do not have that much confidence because it is not fully accepted in Thailand and I do not have that much knowledge about electric vehicle in same level as fuel vehicle. I have more reliability in fuel car. I knew that it is safe, but I do not know where it can be risky.	○
P12	City driving	Vehicle performance barriers	Reliability	I have a friend who use it and also, I drive a hybrid and it seems to not have any problem. It is like a normal car.	×
P13	City driving	Vehicle performance barriers	Reliability	For reliability, I think that it still cannot compete with fuel car because we use fuel car for many decades, so we have a familiarity with it, but electric car is still new. If does not try, I might feel that it is still a barrier.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P14	Across province	Vehicle performance barriers	Reliability	Now in Thailand, it does not answer to my condition because there is no big brand to compete in market such as Tesla.	○
P15	Across province	Vehicle performance barriers	Reliability	I think that it is not a barrier because I view that electric car has already been widely used all over the world. There is enough reliability to use.	×
P16	Across province	Vehicle performance barriers	Reliability	For this, because I have never test drive, so I cannot say that there is a reliability or a problem from actual drive because if never test-drive, I cannot say that it is reliable or not.	○
P17	Across province	Vehicle performance barriers	Reliability	Personally, I think that Thailand condition is not quite suitable, and I do not have quite confidence because Thailand have a flood in which it feels opposed to electric vehicle. I do not trust in this.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P18	City driving	Vehicle performance barriers	Reliability	I think that reliability is the same as normal car because they use an existing model for example MG that use same model, but install new full electric engine system, so suspension and other is the same. Moreover, in my opinion, someone who change to EV does not want a high-speed drive. Changing to this concept means that you expect saving.	×
P19	City driving	Vehicle performance barriers	Reliability	I do not think that it is a barrier because I have ever test drive Tesla and I like the speed, acceleration, and performance.	×
P20	Across province	Vehicle performance barriers	Reliability	I think that it is a barrier because currently I still have never test-drive an 100% electric car and my close people also have not too, so it affects my feeling that I cannot trust it yet.	○

Appendix F: Working analytical framework of infrastructure barriers (Number of charging station)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Infrastructure barriers	Number of charging station	Personally, I use in city, so I can charge in a mall that has EV charger and big gas station. For my current usage, it is not a barrier. I do not drive upcountry only in Bangkok and nearby area, so there is no problem.	×
P2	Across province	Infrastructure barriers	Number of charging station	It is a barrier, and it is one of the top barrier because if there is no charging station and the car stop somewhere, it can inflict more cost to call mechanic or towing truck to help	○
P3	City driving	Infrastructure barriers	Number of charging station	I think that the charging station is insufficient for use in which it creates limitation and hinder usage	○
P4	Across province	Infrastructure barriers	Number of charging station	It is a barrier. I think that there is no charging station for EV. It is a big barrier in changing to electric vehicle	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P5	Across province	Infrastructure barriers	Number of charging station	It is a certainly a barrier because as I mention earlier in case that I drive in a long distance which is how I use for my sales work. When drive out to other province, a limitation of usage is up to charging station because most of the charging stations that we see nowadays are for an EV that is a city car for city drive. Therefore, when you go out of city, you will definitely face with a difficulty in finding a charging station. This could have one of the important barrier in motivate people to change to an electric car in which it is not responded very well at the moment	○
P6	City driving	Infrastructure barriers	Number of charging station	It is complicated. If inside Bangkok, it does not need to have a lot because if it can drive for 300 km, then drive in Bangkok is not a problem because can go back to charge at home, but if to go upcountry, it needs to have a charging station in other province. I must consider on this. Although I normally use in Bangkok, but sometimes I drive upcountry. I am a bit worry that if I go to a far place and cannot find a charging spot, there will be a problem with using the car. However, it is only a little bit, but need to consider	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P7	Across province	Infrastructure barriers	Number of charging station	This is a main reason I consider. Personally, I go upcountry and I think that public charging station in other province is fewer than Bangkok	<input type="radio"/>
P8	Across province	Infrastructure barriers	Number of charging station	It is a barrier because it certainly has a limitation. For gas station, the smallest one has 4 hoses or at maximum 8 hoses to serve 8 cars at the same time. On the other hand, for public charger, how many hundreds of chargers do it need to have to support cars that charge 1-2 hour.	<input type="radio"/>
P9	City driving	Infrastructure barriers	Number of charging station	I think that it is a barrier. For electric car, we cannot 100% sure on when electricity will run out, so at least there should have as a spare to charge as an option. However now there is few to none.	<input type="radio"/>
P10	City driving	Infrastructure barriers	Number of charging station	I consider a little bit. At big malls, there are charging stations, but in the future when people start using more, the charger will be enough or not or if I do not go to malls and I want to charge, where can I go to charge. It points back to prior question that it relates to difficulty in planning	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P11	City driving	Infrastructure barriers	Number of charging station	If there are chargers in almost every place such as in malls and such, it would be nice, but at present in Thailand, there are already chargers in most malls in Bangkok. However Thai people do not go to mall all the time. For me, I might drive to buy food from a shop on the side of the road and there would not have a charger available in which it would be a barrier. If I were to drive in Bangkok or upcountry, it would be a bit difficult.	<input type="radio"/>
P12	City driving	Infrastructure barriers	Number of charging station	It is a barrier. Nowadays, there is none. There are some in a mall that I used to see, but there is a limit. It does not have that many. In the future, if electric cars become mainstream, there should be more in malls, charging stations and other places. It should be better organized because if we have to wait or struggle to use, using gasoline would be better as it has more. There is not enough facility now.	<input type="radio"/>
P13	City driving	Infrastructure barriers	Number of charging station	I think that it has an effect if charging station is insufficient in case that we want to travel in longer distance.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P14	Across province	Infrastructure barriers	Number of charging station	Mainly in Thailand, it is definitely a barrier. if it does not have many charging stations like a gas station that fuel the car.	<input type="radio"/>
P15	Across province	Infrastructure barriers	Number of charging station	I think that it is a barrier because the charger is insufficient	<input type="radio"/>
P16	Across province	Infrastructure barriers	Number of charging station	I think that it is a barrier in case I drive upcountry and need to go to different route from a route that has a charging station. I might have to go off-route to charge and return to another route to reach destination.	<input type="radio"/>
P17	Across province	Infrastructure barriers	Number of charging station	It is a barrier because it definitely is not enough.	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P18	City driving	Infrastructure barriers	Number of charging station	I think this is a barrier for Thailand because it needs to see on how much response from consumer and at each key location or landmark, it can sufficiently support or not and also in the future too. This is important. For example, if it is already promoted or doing a marketing and consumer respond with interest to more usage, but you cannot support, in the end EV can only be a concept and never fully adopt in Thailand.	○
P19	City driving	Infrastructure barriers	Number of charging station	For me, I do not think it is a barrier as my house is located in Laphao area and I used to see many chargers in my neighborhood area such as CDC, The mall Bangkok. I see many charging stations that are near to my house. In fact, there are also in the city, but it depends on that moment whether how many people have changed to electric vehicle. If many people change, it might not be sufficient	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P20	Across province	Infrastructure barriers	Number of charging station	I think that it is a barrier because from my observation of current status in Thailand, charging station cannot satisfy electric car user's condition. It is mostly in main city, however if we have to travel upcountry, the area that support charging is not enough.	○

Appendix G: Working analytical framework of Infrastructure barriers (Number of maintenance store)

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P1	City driving	Infrastructure barriers	Number of Maintenance store	I think that it is a barrier. At present it does not cover like fuel car, so there could be an additional cost.	<input type="radio"/>
P2	Across province	Infrastructure barriers	Number of Maintenance store	It is a barrier and could be second or third place because in car usage, we must go to routine checking at certain range, but if the store is far away from us, we feel that it will take long time and consume a lot of time for that day.	<input type="radio"/>
P3	City driving	Infrastructure barriers	Number of Maintenance store	I think that it is barrier because it is still new and need to use only brand service center in which it might not be everywhere that can fix electric car. It would be inconvenience in using it.	<input type="radio"/>
P4	Across province	Infrastructure barriers	Number of Maintenance store	I think it is a barrier because currently there is not many electric vehicles, so store and spare part might not ready. I think that there are few stores and might not be enough to find easily like when car has a problem somewhere or to change spare part, I think that store is insufficient.	<input type="radio"/>
P5	Across province	Infrastructure barriers	Number of Maintenance store	I think it is a barrier because from my experience, I have never seen any garage that fix electric car, so if the car has a problem, it would be difficult to find a store to fix it	<input type="radio"/>

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P6	City driving	Infrastructure barriers	Number of Maintenance store	I consider on this. If there were few stores and there are many electric car users, when I go to the store, it could take quite a long time. People will crowd and not evenly distribute, so it will waste time each visit.	○
P7	Across province	Infrastructure barriers	Number of Maintenance store	I consider on this. Normally when car has a problem, we have to go to a service store. Then if the store is not well distributed, when the car has a problem and it has to fix at only certain place, then it is troublesome.	○
P8	Across province	Infrastructure barriers	Number of Maintenance store	I do not think it is a barrier because if for example Toyota make it, then it would not be a problem as it can service anywhere.	×
P9	City driving	Infrastructure barriers	Number of Maintenance store	I think that it is a barrier. As I mention before, there are very few choices. There is no option to choose	○
P10	City driving	Infrastructure barriers	Number of Maintenance store	Depend on brand that they have their own stores similar to normal car.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P11	City driving	Infrastructure barriers	Number of Maintenance store	If consider that buying an electric car for a long term, then it is. If one day, I drive upcountry, and it has a problem and there is no service center for electric car in that province. I will have to wait for them to drive up from Bangkok. It would be inconvenience for me. It is unlike fuel car that anyone can fix it	○
P12	City driving	Infrastructure barriers	Number of Maintenance store	I think that it affects, but if it were the same store for normal car like Toyota for both normal and electric can visit same place. It would not be a problem. It depends on whether it open as many or not or private stores if it is certified.	×
P13	City driving	Infrastructure barriers	Number of Maintenance store	I view it that at present, service center is still few, so it is a barrier because it is still new. We have to depend on brand service center when it has a problem.	○
P14	Across province	Infrastructure barriers	Number of Maintenance store	I think it is a barrier because a number of dealers is still low which mean that service center is still a problem. It is a problem with maintenance when I go to a place that does not have.	○

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P15	Across province	Infrastructure barriers	Number of Maintenance store	I think that it is not a barrier. I think that it can use a normal service center.	×
P16	Across province	Infrastructure barriers	Number of Maintenance store	This is definitely a barrier because it is still new and not widespread yet, so there might have only few places and could be far from our home in which we must drive to that store instead of nearby store like usual	○
P17	Across province	Infrastructure barriers	Number of Maintenance store	It is a barrier because I drive quite heavily in which if maintenance for 1-2 hours, I can still spare time for it on some occasions and adjust it. However, I view that there are few maintenance stores for electric car and I do not want to leave my car and do not have time for it	○
P18	City driving	Infrastructure barriers	Number of Maintenance store	I do not worry for big brand, only small brand is worrisome.	×

Participant	Group	Barriers type	Factor	Data	Barrier to electric vehicle adoption
P19	City driving	Infrastructure barriers	Number of Maintenance store	I think it is a barrier. For Nissan, it is okay and there is no problem because we can use any service center. However, we don't know that how much knowledge their staffs have because it is quite new in Thailand. Also, for Tesla	<input type="radio"/>
P20	Across province	Infrastructure barriers	Number of Maintenance store	I think this is a barrier because if we live in one province and the nearest service center is across another province in which I feel that it is not acceptable to drive across province to buy a car or go to service.	<input type="radio"/>