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The Impacts of the Transition to Electric Vehicles on Small and Medium Enterprises (SMEs) in Thailand's Automotive Parts Industry

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Abstract

At present, countries around the world are paying attention to energy and environmental issues, especially climate change and global warming, which are partly due to the accumulation of carbon dioxide released by internal combustion vehicles. One of the key approaches is increasing the use of electric vehicles (EVs), which has become a global trend in many countries. Thailand is also one of the important countries as the world's automotive production base with most Thai entrepreneurs in the group of automotive and automotive parts manufacturers and Tier 2 and Tier 3 parts manufacturers. The purpose of the article was to investigate the impacts of the transition to EVs leading to the determination of ways to alleviate such problems. Data were collected from 329 participants who were management representatives within small and medium enterprises (SMEs) in Thailand's automotive parts industry. The research revealed several related aspects, such as attitudes and readiness of manufacturers, and short- to long-term impacts. Therefore, EVs would inevitably affect entrepreneurs in the traditional automotive industry from these effects. Thus, this paper would summarise the impacts of such changes in the automotive industry on SMEs in Thailand and act as a guideline to sustainably prepare themselves for adapting to this change.

Keywords: *Climate Change; Global Warming; Sustainable Development; Electric Vehicles; Internal Combustion Vehicles*

1. Introduction

Since the Industrial Revolution, which created economic competition in many countries, productivity has brought increased cost advantages and accumulated wealth to expand cities' energy demand for goods, services, and facilities. The growth of the energy demand in the transportation activities that have taken place in various countries has been power-driven, which has mainly relied on energy from fossil primary energy sources (BP, 2010), in addition to the amount of the fuel in the

combustion process. This has resulted in the release of greenhouse gases (GHGs) to the atmosphere, resulting in global warming problems (Mar et al., 2022).

Awareness of this problem has resulted in negotiations on the world stage under the United Nations Framework Convention on Climate Change (UNFCCC) to address climate issues, which began in 1992 as the competitive industry and demand for fossil fuel energy continued. The impact of the release of GHGs has continuously accumulated. At the 21st Conference of Parties (COP-21) in 2015 in Paris, an agreement on reducing emissions was negotiated regarding carbon dioxide between the 196-member states, and the meeting adopted an agreement on combatting global warming by agreement of the COP-21 (COP, 2015). Measures were initiated in order to reduce pollution caused by transport. These measures include energy efficiency, alternative fuels, and reducing transportation activities although automakers have improved their internal combustion engine technology. On 1 October, 2015, Thailand submitted a proposal for the participation of the country in reducing GHGs and the activities on climate change after the year 2020 (intended nationally determined contribution (INDC)) to the Secretariat of the UNFCCC. The target of greenhouse gas (GHG) reduction in Thailand after 2020 would be 20-25% of the normal case member states of the COP-21 on 30 November, 2015, in Paris, France. The results of the meeting approved an agreement or the Paris Agreement, which became effective on 4 November, 2016, to meet the target of reducing GHGs by 20% by 2030 (Thailand-UNFCCC, 2021). The Office of Natural Resources and Environmental Policy and Planning (ONEP) serving as the secretary of the working group on national GHG reduction guidelines 2021-2030, plans to decrease GHGs in the field of energy and transportation, industrial processes and products use, and waste management. There has been a total of five working group meetings that concluded energy and transportation, industrial processes and products use, and waste management would be the fields where the agency's master plan would be ready and had the potential (ONEP, 2021).

The transportation sector is one of the most important emitters of GHGs into the atmosphere. Therefore, there have been efforts to develop transportation technology through various methods for the development of electric vehicles (EVs) to replace vehicles that use fossil fuels. Such changes would affect the automotive and parts industry around the world, including Thailand.

Thailand is one of the important countries as the world's automotive production base, so the emerging trend of EVs would inevitably affect entrepreneurs in the traditional automotive industry. These factors indicate that the future automotive industry would require fewer parts. The shift from internal combustion vehicles (ICVs) to EVs would affect traditional vehicle components. Furthermore, the target to reduce GHG emissions by 2030, which so far has totalled 115.6 million tonnes of carbon dioxide, by making its available action plan to reduce GHGs to achieve the set target by the relevant authorities. Therefore, there would be more investment in the development of EVs. Additionally, many countries automotive and transportation policies aim to promote EVs to replace the current ICVs (Prati et al., 2021). With regard to Thailand, most Thai automakers are Tier 2 and Tier 3 suppliers of small and medium enterprises (SMEs) that produce components and supporting equipment (Krongchan, 2020)7. Affecting traditional automakers, Thailand needs to realise the importance of developing the automotive industry from traditional electric cars to electric power and implement strategies and operational plans to prepare and adapt to these changes.

2. Literature Review

2.1 The Global EV Situation

Energy and environmental issues have caused agencies of various countries to promote measures to reduce carbon dioxide emissions, including the development of key parts of EVs and research, such as

batteries, motor drive, various control systems, etc., thus resulting in the price of parts (Jidi et al., 2021). Moreover, there has been the emergence of various types of electric vehicle (EV) manufacturers. These have included the United States, China, Japan, and India, hence causing the EV market group to expand continuously. In assessing that EVS would become more important in the global automotive industry and be a market that would have great growth potential in the future as EV sales around the world would tend to grow steadily, the Global EV Outlook 2019 found that globally, the cumulative volume of EVs was approximately 5.1 million in 2018, with a growth rate of 63% from the previous year (IEA, 2519). The cumulative number of EVs worldwide continues to increase as a result of measures taken by agencies of various countries (OSMEP, 2019).

2.2 Important Policies to Promote EVs

Relevant policies are an important part of the development and promotion of EVs. Most of them start with the development of the target groups and use of the vehicles. In defining the charging standards, EV promotion plans include purchasing items to boost demand for EVS. As such, each country or region has the following key policies:

2.2.1 The European Union has set many important policies, such as setting standards for fuel consumption for cars. Thes have included clean energy trucks and cars, purchasing electric public buses that requires new buildings to install charging stations, providing benefits to promote the use of EVS in many member countries of the European Union, etc. (IEA, 2021).

2.2.2 China has imposed a policy to limit investment in ICVs factories to meet the average fuel consumption standards of automotives and provide benefits for vehicles based on the battery properties (e.g., zero-emission vehicles (ZEVs)) or new fuel vehicles (Gaoxiang et al., 2020).

2.2.3 Japan has established a collaborative approach among automotive industry stakeholders to reduce GHG emissions by domestic vehicles by 80% (reducing personal vehicles by 90%) and setting standards for emission reduction use energy efficiency for new trucks to release less pollution (OTP, 2019b).

2.2.4 Canada has a vision for future EV development. Some areas have challenged policies, such as Quebec City, which requires only ZEVs, and British Columbia, which has a set target of 30% of ZEV sales by 2030 and by 2040, 100% ZEV sales (Clean energy Canada, 2019). The Canadian policy is similar to the EV policy in 10 US states (e.g., California).

2.2.5 India announced the policy of Faster Adoption and Manufacturing of Electric Vehicles in India (FAME) Phase 2 by reducing the selling price of EVs (NRDC, 2019). This includes the promotion of EVs in public transport or vehicle sharing (buses, tricycles, and taxis) and electric motorcycles.

2.2.6 South Korea’s benefits for low-carbon emission cars have been increased from 32,000 to 57,000 vehicles, including setting policies to promote the use of EVs, such as government procurement policies, tax reduction and incentives for EVs, including measures to reduce toll fees and parking fees, etc. (OTP, 2019b)

2.3. Overview of the Development of Electric Vehicles by Country in ASEAN

The Thai Electric Vehicle Association organised the ASEAN EV Summit 2019 on 5 June, 2019, at the Bangkok International Exhibition and Convention Centre (BITEC) (EVAT, 2019) to present the promotion of EVS in the ASEAN region by inviting representatives from Myanmar, the Philippines, and Singapore. This can be summarized as follows:

2.3.1 Myanmar, at present, has a total of 1.3 million cars, of which no more than 500 are EVs with Nissan Leaf being the most popular electric car and an electric car from China investing in an assembly plant. For electric buses, there is a joint investment between Myanmar and EU countries to set up an assembly plant for domestic use and export abroad. However, in Myanmar, there is an unstable power problem. Consequently, the government of Myanmar must develop the electricity infrastructure to cover the whole country and plan to develop charging stations to support the increasing number of EVs in the future (OTP, 2019b).

2.3.2 The Philippines aims to promote the use of EVs, which is to reduce fuel consumption, create opportunities for the development of the automotive industry, and increase the quality of life and livelihood of the people. There are four policies to promote the increasing demand for EVs, EV price reduction, charging infrastructure development, and development of the EV industry (ITA, 2020).

2.3.3 The Singaporean government has a policy to promote the use of EVs under the Carbon Emission-Based Vehicle Scheme (CEVS). Hybrid electric vehicles (HEVs) have received the same tax rate discount as plug-in hybrid electric vehicles (PHEVs) and EVs resulting in EVs becoming more popular in 2018-2019. This tax discount has been modified to the vehicle emission scheme (VES) by cancelling the tax discount for HEVs, but maintaining the discount for PHEVs. This has been done to make people use this type of car more and increase the tax rate for diesel cars (OTP, 2019b).

2.4 Overview of Electric Vehicle Development in Thailand

The use of EVs in Thailand is likely to increase, which could be seen from the number of EVs registered with the Department of Land Transport in 2018. The number of HEVs and PHEVs are also expected to increase in the next five years (Jiacheng et al., 2022). There are now many brands of EVs available in Thailand and this number is increasing, so the price is likely to reduce in contrast with the increased efficiency. The increase in the number of registered EVs is a result of the government's policy to promote and support EVs, such as measures to promote the production of EVs by the Board of Investment (BOI). The related measures contributing to the development of technology investment in production and infrastructure, include electric charging stations that currently there are about 520 public electric charging stations across the country. In addition, the government aims for Thailand to be the centre of the ASEAN Economic Community in the EV industry. Therefore, for supporting and promoting EVs by issuing various policies and measures to stimulate cooperation from the private sector and related agencies, the government has set a target of 1.2 million vehicles in 2036, so to encourage the use of PHEVs and battery EVs (Wanna, 2020). Furthermore, government promotion measures have resulted in more use of EVs through registration in the past five years (2014-2018). This can be shown in Table 1 as follows:

Table 1 Number of new registered electric cars in 2014-2018.

Type of Vehicle	Type of Fuel	Number of New Registered Vehicles for the Year (Units)				
		2014	2015	2016	2017	2018
Personal motorcycle	EV	239	55	132	126	135
	HEV	-	-	-	1	287
	All EV	239	55	132	127	422
	Total	1,819,371	1,815,000	1,914,131	2,001,130	1,942,494
Private cars seating up to seven people	EV	245	14	2	27	57
	HEV	9,101	7,256	9,399	11,887	19,966
	All EV	9,346	7,270	9,401	11,914	20,023
	Total	603,843	526,764	552,947	638,030	698,743
Bus	EV	-	7	27	1	38
	HEV	-	-	-	-	1
	All EV	-	7	27	1	39
	Total	13,114	15,906	11,482	11,006	12,820

Table 2 Accumulative number of registered cars in 2014-2018.

Type of Vehicle	**Type of Fuel**	**Accumulative Number of Registered Vehicles (Units)**				
		2014	**2015**	**2016**	**2017**	**2018**
Personal motorcycle	EV	2,405	1,720	1,356	1,223	1,110
	HEV	64	61	54	49	326
	All EV	2,469	1,781	1,410	1,272	1,436
	Total	20,141,213	20,308,201	20,276,806	20,501,439	20,887,785
Private cars seating up to seven people	EV	36	50	54	82	138
	HEV	62,629	69,816	79,711	101,527	121,465
	All EV	62,665	69,866	79,765	101,609	121,603
	Total	7,284,259	7,742,434	8,197,012	8,740,890	9,362,259
Bus	EV	29	34	61	61	65
	HEV	-	-	-	-	1
	All EV	29	34	61	61	66
	Total	144,773	152,857	157,015	159,189	162,975

According to the EV registration statistics, it was found that after the government's measures to promote the use of electric cars, the excise tax reduction measures that were announced in 2017 resulted in EV registrations increasing by almost 50% in 2018 (Figure 1).

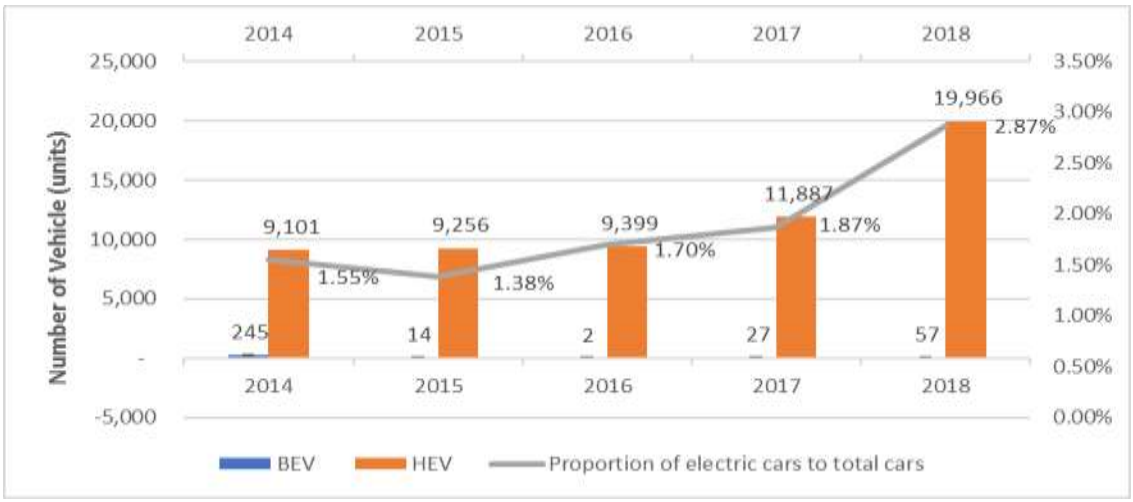

Figure 1 Number of new EV registrations 2014-2018

2.5 Thailand's Policies Related to Electric Vehicles

In the past, the government became aware of the importance of the changes in the automotive industry. To maintain an advantage in the production of vehicles and automotive parts, various related plans and measures were formulated for developing EVs more concretely. This included research and development, production, investment, as well as restoring the environment conducive to the creation of EV value chains in the country. As a consequence, many agencies have developed plans and measures that have corresponded to the promotion of EVs in the country by the government's important measures. These include:

2.5.1 Measures to support the production of EVs in Thailand in 2017 (BOI, 2020): The government has approved measures to support the production of EVs in Thailand through the Ministry of Industry to promote the use of PHEVs and BEVs totalling 1.2 million vehicles by 2036 according to the 2036 Energy Conservation Plan 2015-2036. There are six important measures, namely:

1) Measures to promote investment to create supply in 2017: The government aimed to make EVs one of the national strategic industries. By wanting to push for EVs to become the third product champion in Thailand after pickup trucks and eco-cars, there are measures to promote the production of EVs. These consist of a policy to promote investment in the production of EVs and EV parts. Moreover, there is a policy to promote investment in electric charging stations, special rate of excise tax, and imposing import duty on BEVs under the ASEAN-China Free Trade Agreement (ACFTA).

2) Measures to stimulate the domestic market: This consists of issuing policies for government agencies and state enterprises to purchase BEVs, planning to use PHEVs and BEVs as airport service vehicles (limousines), and conducting feasibility studies on the use of EVs. BEVs would also serve as a taxi and electric bus in the area of a large historical park (OSMEP, 2020).

3) Preparation of infrastructure: This would consist of studying the plans to install electric charging stations in the targeted areas and establishing a national vehicle and tire testing center.

4) Preparation of electric vehicle standards: This would contain a battery standardisation charging system, electromagnetic compatibility, and distribution of DC meters.

5) Management of used batteries: This would consist of a plan for the management and disposal of car batteries and the specification of EV batteries in the statute, as well as the management of waste electrical and electronic products and other end-of-life products.

6) Other measures, such as organizing a project to increase productivity by emphasising the development of a personnel competency certification system for five consecutive years would be initiated. Therefore, it could be seen that these six main measures would cover the value chain of EVs. This would create both the demand and supply for EVs in the country. The readiness of the infrastructure as well as the preparation of EV standards would also include plans to manage used batteries as well.

2.5.2 The BOI has issued a stimulus policy to promote investment in the production of EVs and automotive parts in the country to entrepreneurs who are interested in investing in EV production. Such industries have applied for investment privileges. Currently, the BOI has approved nine automakers to set up EV factories with a total investment value of THB 51.55 billion. All EV manufacturers promoted by the BOI must use EV parts that are produced in the country. Four of the important parts are the battery, motor, drive control unit, and battery management system (ISIT, 2019). In the case of other operators, it was found that there were 10 projects of battery manufacturers for EVs that have been promoted with value of more than THB 6.8 billion. There are also plans and measures related to EVs in Thailand, such as roadmaps for promoting EVs, energy mission driving plans to promote the use of EVs, electric infrastructure development plans to support EVs, etc. Moreover, there is the Electric Vehicle Research and Development Centre of the National Science and Technology Development Agency (NSTDA) (Panisa, 2018), as well as the National Metal and Materials Technology Centre, (MTEC), and National Electronics and Computer Technology Centre (NECTEC) for promoting the modern automobile industry as well. Furthermore, there are relevant educational institutions and associations that are sources of knowledge and support the growth of the EV market in the country, such as the Electric Vehicle Association of Thailand (EVAT), etc. As such, it can be seen that the EV market in Thailand is still in its early stages and is gradually growing related to the Thai automotive and parts industry. It was also found that Thailand was the recipient of technology from foreign carmakers, thus causing it to take time to learn the technology, build infrastructure, and develop more EV supply chains in the country (Wanna, 2020). In addition, there is still less foreign investment since many countries aim to attract foreign investment in the industry as well. The demand for EVs in the country is also still small, so it is expected that the development of the EV industry could take up to 10 years by using HEVs as a carrier. This is reflected from the direction of the investment of Japanese carmakers with large production bases in the country, together with many challenges in the EV market, such as unstable technology, high selling prices, inadequate infrastructure concerns over battery performance that have limited the production, and use of other types of EVs, including PHEVs and BEVs (GSB Research Centre, 2018). However, even though the development of EVs in the country could still take some time, from the current situation, it could be seen that Thailand has started to have a clearer policy to promote the country as a fully EV production base of carmakers that have a clearer plan for producing EVs. For example, Japanese carmakers have continuously researched and developed modern automotive technology with plans to launch new car models. This would ensure the technology of EVs and other clean energy vehicles, which is a trend in the global automotive industry. Consequently, the Thai automotive and parts market would also follow the direction of the global electric vehicle market, as it would become an important production base for foreign car manufacturers, and this transition in the automotive industry would inevitably affect the automotive parts industry (Wasita, 2013). Therefore, entrepreneurs should not be complacent and should quickly adjust to keeping up with the technological changes to maintain their competitiveness and not allow foreign parts manufacturers to compete for the market share.

2.6 Analysis of the Potential of the Electric Vehicle Industry

According to forecasts, the Thai electric vehicle industry supply chain consists of two main groups, which are:

2.6.1 Core activities are car assembly and auto parts manufacturers, which can be classified according to the hierarchy of the production structure (NSTDA, 2017) as follows:

1) Assembler consists of passenger car assemblers and motorcycle assemblers who assemble automotive parts into finished vehicles, most of which are foreign companies and joint ventures with foreigners. This is considered an important group in determining the role and direction in the production of all Thai auto parts manufacturers.

2) OEM Tier 1 is a supplier or manufacturer of equipment parts that are delivered directly to the car assembly plant, which must have the technology or standards as specified by the car assemblers, as well as must have the ability to certify the quality of the parts. In general, this group of parts manufacturers produces parts in the form of modules, which are divided into five main groups; namely, the powertrain group, suspension group, electrical system group, body group, and other parts group. For operators in this group, most of them are large companies comprising foreign companies, Thai companies, and joint ventures

3) Group of automotive spare parts manufacturers Tier 2 and Tier 3, where the Tier 2 auto parts manufacturers act as suppliers or manufacturers of subparts for delivery (Peerachat, 2015). Tier 1 manufacturers' parts, such as mechanical and metal products, plastics, rubber, steel, electronics, glass, mirrors, etc., receive technology transfer from Tier 1 and Tier 3 manufacturers' parts acting as suppliers or manufacturers. Subcomponents are delivered to raw material suppliers in the Tier 1 and Tier 3 order, which Tier 2 and Tier 3 parts manufacturers can be classified according to the production process depending on the type of the raw materials for the entrepreneurs in the group. This is mostly for Thai entrepreneurs.

2.6.2 Support activities consist of upstream industries that include the support industry group, service industry group, and policy and support groups. The details are as follows:

1) The upstream support industry is a group of manufacturers of raw materials, such as steel, glass, leather, plastic, etc., which are produced according to the needs of the parts manufacturers in terms of quantity and quality (Tartat, 2009).

2) The support industry is a group of machinery manufacturers and services, including machine, mould, jig and fixture, and tooling.

3) The service industry is a group of transportation service providers that offer sales and after-sales services, such as distribution service providers, financial services inspection, testing services, etc.

4) The policy and support group is a group responsible for planning and formulating technical and marketing policies, such as the Ministry of Industry, Ministry of Commerce, Ministry of Science and Technology, Thailand Automobile Institute, Electric Vehicle Association of Thailand, Thai Automotive Industry Association, Thai Auto Parts Manufacturers Association, and various research institutes responsible for developing personnel and adding specific skills to the industry (OSMEP, 2020).

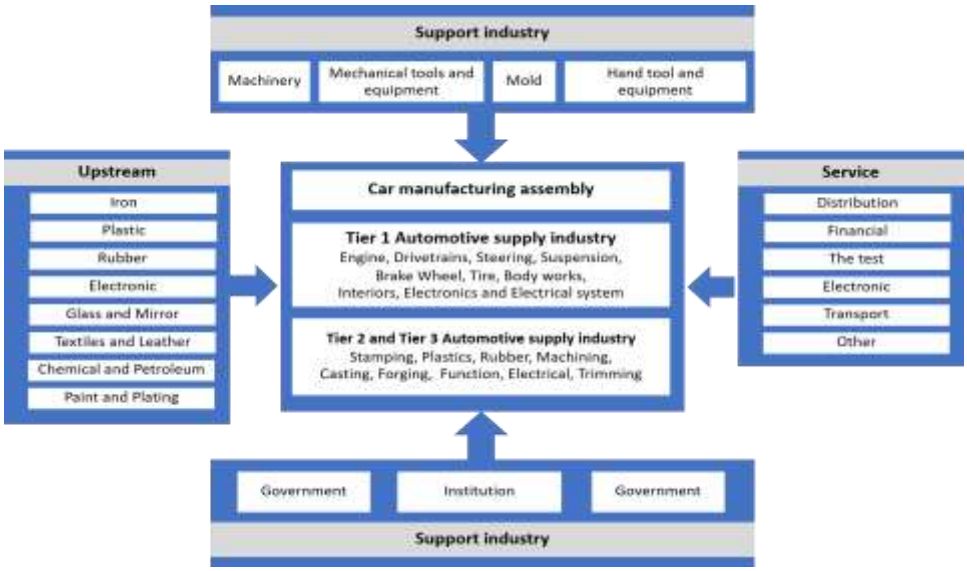

Figure 2. Thai automotive industry supply chain.

3. Methods

This paper was qualitative research; the researcher used in-depth interviews (Carolyn et al., 2006) as a tool for the data collection. Semi-structured interviews (Cohen et al., 2006) were conducted among the sample groups, in which the question topics were planned step by step. The interview style was structured with wider questions, so that the samples could freely and thoroughly express their opinions on the subject. The desired issue, including the question format, was flexible, so the questions could be modified to suit the samples.

3.1 Scope of the Study Areas

3.1.1 The scope of the study areas was parts manufacturers located in Thailand. They were selected on the grounds of the manufacturer of the automotive parts organisations that were SMEs around each location in Thailand.

3.1.2 The population for the study comprised those management representatives of the automotive parts organizations that were SMEs.

3.1.3 The study was carried out during May 2019 to April 2023.

3.2 Scope of the Population and Sampling

The population in this study consisted of the following:

3.2.1 The population was management representatives of over 1,657 SMEs that were in the automotive industry supply chain as shown in the data reports of the Thai Automotive Institute (DIP, 2018).

3.2.2 The population of this study's questionnaire survey comprised 310 (+10%) participants, who were management representatives within SMEs in Thailand's automotive parts industry, such as power transmission systems, suspension systems, electrical systems, distributors, etc. The reason why entrepreneurs in the automotive industry were considered the population of the study was because the entrepreneurs in the aforementioned group were important and directly related to parts entrepreneurs who set policies and directions for automotive production. This affected the automotive parts industry for the sample group in this study (Krejcie & Morgan, 1970).

3.2.3 The population of this study for the in-depth Interviews was as follows (Purposive Sampling):

1) Ten management representatives of the automotive parts organizations that were SMEs.

3.2.4 The population of this study for the focus group discussion was as follows:

1) Twenty management representatives of the automotive parts organizations that were SMEs.

2) Three Tier 1 management representatives of automotive parts organizations.

3) Three Tier 2 management representatives of the automotive parts organizations that were SMEs.

4) Officials or academics from related agencies, such as the Thailand Automobile Institute.

5) Government agencies, such as the Office of Industrial Economics etc.

6) Agency automotive brand owners

3.3 Scope of the Contents

3.3.1 Questionnaire survey and in-depth interviews for entrepreneurs in the automotive parts industry comprised the following:

1) Part 1 General Information Questionnaire of the Respondents;

2) Part 2 Questionnaire about the Establishment's Information;

3) Part 3 Questionnaire on attitudes and readiness of Thai Automotive Parts Entrepreneurs.

4) Part 4 Other Comments.

3.3.2 Focus group discussion was as follows:

1) The situation of the automotive part's industry at present and the trend of the industry in the future.

2) Impacts of EV technology on the automotive parts business.

3) Adaptation of the automotive parts business towards the entry of EV technology.

4) Readiness of the auto parts business to the technological changes in the industry.

5) The role of the government in helping to adjust the automotive parts business.

3.4 Research Instruments

3.4.1 The method for designing the instruments

1) The related documents, theories, and research based on a conceptual framework design were investigated.

2) The specified scope of the questionnaire relating to the conceptual framework was set and presented to the principal advisor for approval.

3.4.2 Validity and reliability of the instruments

1) Validity of the instruments, the advisor who specialized in social science analysed the instruments for the content validity (index of item objective congruence (IOC)), which a value of >0.5 was accepted. Then, the researcher revised the instruments based on the advisor's suggestions (Surapong, 2008).

2) Reliability of the contents, after revising the instrument, the researcher tested the questionnaire with 30 subjects that were similar to the real sampling group of the investigation to do reliability testing. Then, the 30 pilot samples were verified and analysed in terms of statistics by using the SPSS program for the reliability coefficients measurement. Moreover, the questionnaire had reliability coefficients according to Cronbach's alpha coefficient equal to or above 0.75. This was considered reliable to be used for collecting the data (Ngamsantiwong, 1995).

3) Reliability of the contents for the in-depth interviews, using triangulation techniques (Denzin,1978 and Patton, 1999) to verify the accuracy of the data using in-depth interviews, this examined the sources of the information from many different sources, including information from interviews with entrepreneurs in the automotive parts industry. Data from interviews with officials or scholars from organisations related to the automotive and auto parts industries were also used. Moreover, information about the production and export of automotive parts was obtained from secondary sources and was used to verify the accuracy of the data before analysing the key themes obtained from the interviews. Then, the main issues were separated into sub-themes and categories, which resulted in an analysis from the overview to the analysis of the sub-issues. Then, the research results were presented by using a descriptive method.

3.5 Data Collection

For the research and development of the framework, it was necessary to define a level descriptor system, and this study focused on the impacts of the current situation on SMEs in Thailand's automotive parts industry, which was based on the conceptualization of sustainability development. The mixed process was undertaken for three years and seven months and consisted of three stages:

3.5.1 Preliminary stage

1) The researcher studied the current situation of climate change, as it is a major issue. The Paris Agreement is a new international agreement on climate change. As a result of the 21st UNFCCC, the UK hosted the COP26 in Glasgow on 31 October–13 November 2021.

2) Global policy trends have been announced as targets to phase out ICVs. Countries and major economies around the world began with the announcement of a policy to stop the use of vehicles or ICVs with the goal of making new or all vehicles zero-emission vehicles (ZEVs).

3) Gap analysis of the positive and negative impacts of the technology change from ICVs to EVs was conducted.

3.5.2 Initially the current situation was studied of the SMEs in Thailand's automotive parts industry by using a questionnaire survey. The following factors were included: Management representatives of organisations in different places and levels, the size and manufacturing type of firms of different business types, power transmission systems, suspension system, electrical systems, and supporting industries, including the necessary aim, the perception attitudes, and readiness of entrepreneurs when transitioning to EVs.

3.5.3 The second stage of the work involved the analysis by in-depth interviews with management representatives of SMEs in Thailand's automotive parts industry regarding the situation of the automotive parts industry at present and the trend of the industry in the future, impact of EV technology on the value chain of the automotive parts industry, and the organisation's role in promoting EVs in the country.

3.5.4 The last stage involved the focus group discussion by inviting participants, such as management representatives of automobile manufacturers with production bases in Thailand, officials or academics from related agencies, such as the automotive brand owners, automobile institutes, and government agencies, such as the Office of Industrial Economics, to make conclusions on the impact of the transition on the SMEs in Thailand's automotive parts industry.

3.6 Data Analysis

This study used a questionnaire, in-depth structured interviews, and focus groups to collect the data. Questionnaire responses were received from a total of 329 participants who were management representatives within SMEs, and whose work covered the areas under examination to answer the research objectives in this study. The statistical analysis applied a number of measures, including percentages, frequencies, and standard deviation.

3.6.1 This study investigated the current situation and the potential impact of the transition on the SMEs in Thailand's automotive parts industry.

3.6.2 This study investigated on attitudes and readiness of Thai Automotive Parts Entrepreneurs.

3.6.3 The aim was to summarise the guidelines for the development of SMEs in Thailand's automotive parts industry and the impact of the transition to EVs.

4. Results and Discussion

This paper was an analysis of various related data that considered the effects of EV technology on Thailand. This included investigating the situation that could occur, and the situation that could be expected to occur with the automotive parts industry in Thailand when affected by EV technology. This was based on basic data collection, such as production information, exports and government policies, including information about EVs in Thailand, as well as information from in-depth interviews with entrepreneurs in the automotive parts industry and the related agencies.

4.1 Impact on SMEs Automotive Entrepreneurs in Thailand

According to the Thai Auto Parts Manufacturing Association, about 1,657 companies would be affected, of which 816 were auto parts manufacturers and 183 were related to supporting industries. This was as follows:

4.1.1 Five hundred and ninety-eight power transmission systems, which could be divided into five groups:

1) Engine systems, such as air filters, carburetors, gaskets 334 manufacturers.

2) Transmission system, such as rear gear 97 manufacturers.

3) Fuel systems 58 manufacturers.

4) Exhaust control systems, such as exhaust pipes and exhaust systems 65 manufacturers.

5) Cooling systems, such as radiators and water pumps 44 manufacturers.

4.1.2 Suspension system, such as brake delivery system and steering systems 158 manufacturers.

4.1.3 Electrical systems, such as fuel gauges 10 manufacturers.

4.1.4 Fifty distributors.

4.1.5 Supporting industries, such as 183 moulds and die lathes.

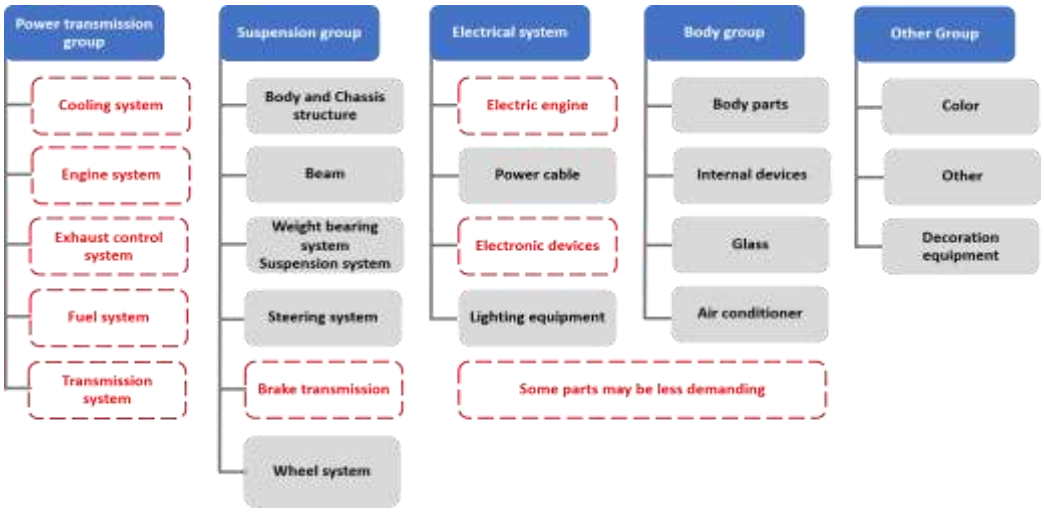

Figure 3 Thai auto parts affected by EVs

As for the Thai SMEs, most of them were Tier 2 and Tier 3 automotive parts manufacturers, accounting for 60% of the country's total automotive parts manufacturers with 75% of the SMEs not in the parts product line (Sikhon, 2018). These SMEs would be directly affected, such as the engine group, but would be in the production line of other decorative parts, including body structure, type parts that would be considerably affected. The other 25% would be auto parts manufacturers that there would be a risk of being affected by this change. Therefore, the other 25% would comprise engine parts manufacturers who would be at risk due to the production of parts in the group that would no longer be used. The first phase would be expected to not be affected much. Because the market demand is still gradually growing, service centres and auto repair shops would be indirectly affected, while frame and body manufacturers, undercarriage, lighting, and interior equipment would not be affected. However, it is expected that the development and production of EV batteries would still take at least 10 years before the number and market share would be sufficient and in a gradual manner, thus allowing enough time to adjust moderately. In addition, it is predicted that in 2037, there would be electric cars in the proportion of only 20%, hence causing the car market to still need parts in the production line of conventional cars that use internal combustion engines. Moreover, the investment in the production of HEVs and PHEVs would not have much impact on the original group of auto parts manufacturers. In this transition period, operators would need to adapt by producing more electronic components, while the traditional mechanical control components would be in less demand (Kasikorn Research Centre, 2017)37. Materials used in production to suit new models of vehicles would require more lightweight. In the view of the Thai Auto Parts Manufacturers Association, looking at the short-term impact if considering the orders during 2018-2021, parts for ICVs would still be needed. Additionally, because one engine model used to produce the car would take about 10-15 years, so, during this period, there would not be much change for auto parts

manufacturers. Manufacturers should also reduce costs and increase production efficiency by bringing in automation to be used more.

4.2 Results of the Present Status of Attitudes and Readiness Questionnaire Survey

4.2.1 The questionnaire respondents provided the following demographic data. The sample comprised males (78.12%) and females (21.88%), with the greatest age group being 36-40 years (44.38%). The largest educational group had a Bachelor's degree (66.57%), while the most frequently reported working status was that of manager (75.38%). The mean work experience was between 10 and 15 years (51.70%).

4.2.2 The questionnaire feedback was arranged in terms of the size of the organisations the respondents represented. Small organisations were those with fewer than 50 employees and capital of less than THB 50 million (80.24%). Medium-sized organisations were those with 50-200 employees and capital of THB 50-200 million (19.76%).

4.2.3 The questionnaire feedback was arranged in terms of the entrepreneurs' experience, which most frequently reported small organisations had between five and 10 years (56.06%). Medium organisations had between 10 and 15 years (43.08%).

4.2.4 The questionnaire feedback was arranged in terms of the entrepreneurs' type of business, such as power transmission systems (23.71%), suspension systems, such as brake (26.14%), electrical systems (3.65%), distributors (1.82%), and supporting industries, such as mould and die lathes (44.68%).

4.2.5 The questionnaire feedback was arranged in terms of the study attitudes and readiness of manufacturers

1) The results of the study attitudes of manufacturers

Table 3. The results of the study attitudes of manufacturers

Attitudes	Result	Full score	Levels
Attitudes cooperation between the government and the industrial sector	4.29	5	Very High
Attitudes support and promotion from the government to the industrial sector	4.35	5	Very High
Attitudes R&D and development	4.65	5	Very High
Attitudes personnel development	4.63	5	Very High
Attitudes technology support	4.10	5	High
Attitudes access to sources of funding	4.64	5	Very High

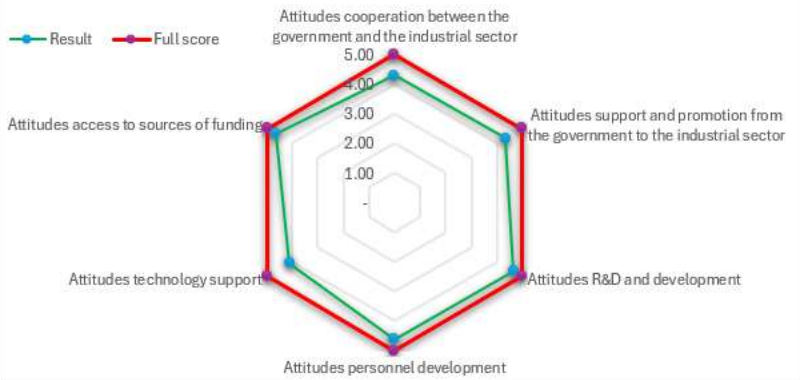

Figure 4. The results of the evaluation of the attitudes of Thai automotive parts manufacturers

The table summarizes the attitudes of Thai automotive parts manufacturers, revealing that the majority of respondents rated each item at the highest evaluation level. The item that garnered the strongest agreement was government support for research and development, especially given that Thailand has only recently begun testing electric vehicles. Consequently, the technology for research, development, and production is not yet fully established. Access to capital is essential, necessitating cooperation between Thai automotive parts manufacturers and financial institutions to unlock the country's potential and position it as a center for electric vehicle production in alignment with government policy. Lastly, it is essential to develop human resources with specialized knowledge and skills related to electric vehicles, enabling personnel in Thailand's automotive parts manufacturing industry to effectively apply these competencies in the future. In conclusion, all three of these factors are crucial for Thailand as it begins transitioning the current automotive industry toward a future centered on electric vehicles.

Table 4. The results of the study readiness of manufacturers

Readiness	Result	Full score	Levels
Management System	3.36	5	Moderate
Finance and investment	2.45	5	Moderate
Employees competency	2.72	5	Moderate
Product technology	2.79	5	Moderate
Production process ability for electric vehicle parts	2.86	5	Moderate
Research and development of electric vehicle parts products	3.06	5	Moderate

From the table on the readiness of Thai automotive parts manufacturers, it can be concluded that most respondents feel most prepared in terms of management systems, as they have extensive experience with standard production systems. The next most significant factor is the research and development of electric vehicle components, given that Thailand is in the early stages of electric vehicle testing, supported by government initiatives. Consequently, it is essential for Thai automotive parts manufacturers to first develop readiness in this area to produce components suitable for electric vehicles.

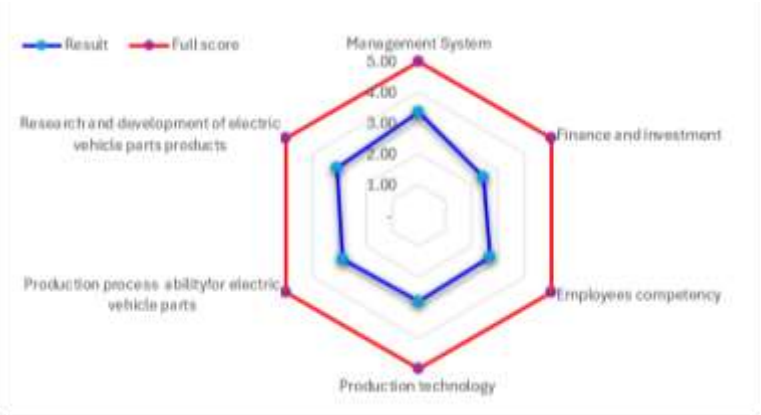

Figure 5. The results of the evaluation of the readiness of Thai automotive parts manufacturers

Based on Table 4 and Figure 5, which assess the readiness of Thai automotive parts manufacturers, it can be concluded that most respondents feel most prepared in terms of management systems, due to their extensive experience with standardized production processes. The second most significant area of readiness is research and development for electric vehicle components, as Thailand is still in the early stages of electric vehicle testing, with government support playing a crucial role. Therefore, it is essential for Thai automotive parts manufacturers to prioritize developing readiness in this

area to produce components compatible with electric vehicles. In other areas, respondents noted a lack of clarity in government policies related to electric vehicles, which has hindered concrete planning for electric vehicle component production. Currently, manufacturers are focused primarily on studying and researching prototype electric vehicle components. Given the limited size of the electric vehicle market in Thailand, manufacturers are cautious about taking risks on significant electric vehicle component development, resulting in similar readiness levels across this aspect.

4.3 Guidelines for the Development of Entrepreneurs

4.3.1 Follow the information closely as well as study innovations for using to improve the product to be appropriate and respond to modern EVs, such as the use of electronics to make the work more efficient and energy-saving, or the design of the parts to be smaller and lightweight (DEDE, 2007). This would be very much needed in an EV to compensate for the size and weight of the battery that would be installed, as well as to use the battery energy for the most dismissal.

4.3.2 Seek a joint venture in product development by collaborating with entrepreneurs in Tier1, both at home and abroad, to develop products (NESDC, 2017). Alternatively, invest with foreign investors to invest in Thailand, which would also help to transfer new technology and create opportunities to expand the customer base in another way. Additionally, cooperate with government research units in product development, which would also receive tax rights (Tewika, 2017).

4.3.3 Develop products to reduce the risk of manufacturing the same parts only by using the original expertise to receive the benefits. Initially, the products could be developed for use in other types of vehicles, or develop products to be flexible and able to meet the needs of many customers (Chonlatis, 2013).

4.3.4 Manage costs to be able to compete with both the cost of the products and other risky, costs such as exchange rates (Thanawut, 2012).

4.3.5 Develop the production process to be effective. In particular, the automatic systems to use in the production process and bring more technological machinery to be used in the production process to reduce costs and increase production quality.

4.3.6 For developing personnel, entrepreneurs would need to lay the foundation for the development of personnel, research, and product development to understand the EV technology, so to be able to develop products to be appropriate and in line with the needs. Furthermore, develop production staff to have more skills and be more flexible to support any changes that may occur.

5. Conclusion and Recommendations

This paper analyzed that during the next two-four years, the manufacturers of automotive parts in Thailand would not be overly affected by the entry of EVs (GSB Research, 2018). This would be because most car manufacturers would still have investment plans, HEVs and PHEVs, which would mainly use the same components. For the production of BEVs, there would still be very few proportions, including car manufacturers with large production bases in the country. Nevertheless, so far, no such automotive production in Thailand has been announced. However, although the proportion of EVs and electric batteries is still small, most car manufacturers would still think that the direction of the future automotive vehicle would be an EV, and the battery could be used. In the beginning, the manufacturers would use HEVs and PHEVs transmitted with more than 20 motor vehicle manufacturers to invest in EVs in Thailand (TDRI, 2017). It is expected that the production of EVs in Thailand would likely increase in the

future, which would benefit automotive parts manufacturers in the country. Therefore, from the analysis of the effects of EVs and batteries on the manufacturers of Thai automotive parts, the impact would more or less depend on the type of automotive parts produced. As for the production of EVs, this would directly affect parts manufacturers as the number of parts needed to assemble would be reduced by about half from the ICV parts, thus causing many operators to close the production line of such products or cause the manufacturers of those parts to compete for the production of parts that would still be in demand. Additionally, Thailand can already produce EV parts from the expertise in manufacturing parts that have been around for a long time. In addition, the characteristics of EV parts are not much different from traditional cars. Powertrain components would be the group most affected by technology, as the changes came into effect for parts operators. Every step would have to be accelerated to adapt. Entrepreneurs would also need to understand the nature of their business and the global trends that could affect their business. As such, entrepreneurs would need to constantly improve and develop, including improving the production process, using automation in production, product development, and maintaining standards for personnel development to be able to compete. For the survival of SMEs, it may be possible to do joint ventures with foreigners to rely on know-how in the production of parts for EVs. Regarding the limitations on the basis of the findings presented in this study, and to improve environmental development sustainability practices in the field of the industry, the researcher devised the following: i) For the number of SMEs, the researcher could only access data by the Thailand Automotive Institute, and ii) the number of the sampling size may not cover all of the SMEs in Thailand's automotive parts industry.

6. Research Imitations

This research is based on a sample group that voluntarily participated in the questionnaire or interview.

7. Recommendations

Based on the findings presented in this study, and in order to improve educational practices in the field of industrial sustainability, the researchers offer the following suggestions.

1. Some industry organizations have not yet prepared for the impending impact of technological changes. It is therefore essential that these organizations become prepared and respond accordingly.

2. It would be beneficial to expand the implementation of learning guidelines aimed at developing entrepreneurs' preparedness and planning for conducting business in the context of technological changes in electric vehicle production.

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