Independent Final Report

Technological Competence Strategy for Electric Vehicles

- The Case of Volkswagen in China

by

WANG Wei

52121001

March 2023

Independent Final Report Presented to

Ritsumeikan Asia Pacific University

In Partial Fulfillment of the Requirements for the Degree of

Master of Business Administration

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AD	Autonomous Driving
ADAS	Advanced Driver Assistance System
AI	Artificial Intelligence
BEV	Battery Electric Vehicle
BMS	Battery Management System
CACP	China Passenger Car Association
CEVCIPA	China Electric Vehicle Charging Infrastructure Promotion Alliance
EV	Electric Vehicle
FAW	First Automobile Works
ICEV	Internal Combustion Engine Vehicle
IPC	International Patent Classification
M&A	Merger and Acquisition
PPE	Premium Platform Electric
QMS	Quality Management System
RMB	Renminbi
SAIC	Shanghai Automotive Industry Corporation
SoC	System on Chip
SSP	Scalable Systems Platform
USA	United States of America
VGC	Volkswagen Group China
VW	Volkswagen

CERTIFICATION

I, WANG Wei (Student ID 52121001) hereby declare that the contents of this Independent Final Report are original and true, and I have not submitted this report to any other university or educational institution for the award of degree or diploma. All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

WANG Wei

2023/01/12

ACKNOWLEDGEMENT

Writing up this Individual Final Report was like a journey; the process was full of challenges and surprises. My research topic is aligned with my interest, the automobile industry, because I have always been an avid car enthusiast and have loved everything about cars since an early age. However, the moment I started conducting the research, I immediately realized that academic research is not a thing easily accomplished. Fortunately, my supervisor Professor Kumiko Miyazaki has always helped me greatly and has given me patient guidance that allowed me to move forward step by step with her abundant knowledge and a positive academic attitude. My deep gratitude goes to her above all. Secondly, I want to thank Professor Beise-Zee and Professor Khan, they provided me many valuable insights during the WiPS which were extremely helpful for conducting this research.

Thirdly, I'd like to express my sincerest gratitude to APU and all of the faculty and staff for providing me with this precious study opportunity. Even though Covid-19 has brought many difficulties, everything was handled professionally and orderly during the past two years' study, which facilitated my own work.

Also, I would like to extend my thanks to the interviewees from Volkswagen Group China in this research. They have shared a lot of informative and sincere opinions that helped me study the research topic and answer the research questions. I admire their professional work attitude and their passion about the automobile industry.

Last but not least, I must also thank my family in China. Without their constant support, I would have never finished this journey.

ABSTRACT

Electric vehicles have been developing very quickly in recent years, this industrial trend has not only impacted the automotive industry, but has also provided academia with a precious opportunity for research. Thanks to the strong push from the government, China has developed into one of the world's leading markets for EVs. In the upcoming EV era, the ordinary capabilities cannot guarantee the incumbents' success in the future market, therefore they need to demonstrate strong dynamic capabilities. This research focuses on Volkswagen China and investigates how it has transformed itself for the future. The RQs include: 1. How have the technological competences in Volkswagen China changed in order to shift from traditional vehicles to EVs? 2. As an established automotive maker from a developed country, what has Volkswagen learned from China? 3. How does VW manage the EV common modular platform (MEB) strategically?

This research carried out in-depth interviews with 8 key staff members in VW China, and combined them with other qualitative methods. Patent analyses were also used. This research finds that top management strategy strongly impacted VW's organizational changes, strategic partnerships and outcomes. China is no longer simply a profitable market for VW, but also an important knowledge hub that is of great help with the shift. Furthermore, the findings reveal what VW has been learning much from China, for example, shortening the research-to-market time. VW China no longer plays a subordinate role, but a lead role, regarding EVs in the VW group.

Keywords: *EV, competence, technological strategy, automobile industry, Volkswagen, China*

Chapter 1. INTRODUCTION

1.1. Background of Research

Steam locomotives had been replaced by diesel locomotives; film cameras had been replaced by digital cameras. And conventional vehicles will be replaced by electric vehicles? In recent years, the entire automotive industry and the broader realms of individual and shared mobility have been rapidly transforming around electrification, connectivity and software, autonomous driving and (shared) mobility solutions. Already today we see that electric vehicles are increasingly prominent on the road globally, and the demand for future cars that address mobility pain points such as traffic congestion, charging, range anxiety and pollution is growing. Both the established automobile companies and industry disruptors must rapidly realize technological advancements to keep up with customers' changing expectations about mobility.

Facing such a rapidly changing environment, the ordinary capabilities such as engine technology, modular platform, engineering, high-volume manufacturing, distribution, cannot guarantee for the incumbents to succeed in the future market, therefore they need to demonstrate strong dynamic capabilities and utilize their integration skills to continue leading in the industry and get through the abovementioned transformation smoothly and effectively (Teece, 2019). The term EV has already become more than a buzz word, Volkswagen even named a newly debuted electric minivan "ID. Buzz" in order to revive its famous icon "T" series minivan in the form of an electric vehicle (Goods press, 2022). Electric car is indeed becoming a top priority for every car maker nowadays. Therefore, more and more competitions, innovations, investments, research and development activities, cooperations etc., have been witnessed in the automotive industry, as there has been an increase in the attention of media as well as academia for this industrial trend.

In this sense, the current automotive industry provides us a fertile field to study and research the related topics. This dissertation will mainly focus on technological competences shift from conventional vehicles to EVs by examining Volkswagen's Chinese operation, and based on existing theories, will try to find out how it has been undergoing transformation for the EV era.

1.2. Research Objectives and Research Questions

As the top player in the Chinese car market, Volkswagen's latest moves around EVs in China present a very good opportunity for study and research, particularly research about the upcoming electrified vehicle era, ways Volkswagen as an established automobile manufacturer tries to retain and enhance its core competences, as well as how it builds its new competences to maintain its competitive advantages to make itself thrive and stay competitive in the upcoming generation of the automobile industry.

This Independent Final Report focuses on the technological competences transition to the EV era of the automotive industry, aims to explore how the automotive industry incumbent has to manage the changing competences due to the transition to EVs, by analyzing Volkswagen China as a leading automobile company in the Chinese market, which is the largest automotive market globally. Furthermore, as a long-time follower in the automotive industry, China is well known for the eye-catching rapid progress in terms of both EV technology and market in recent years.

Against this backdrop, the Volkswagen China's case could be an interesting topic, because during the previous decades Volkswagen has always been the technology leader in China, however, along with the emergence of EVs, the situation seems to have changed somehow. Since the established car makers' strengths, such as engine and transmission technologies, carry less importance in producing EVs. Instead, battery technology and other EV related technologies become more and more important, in these fields, some Chinese indigenous companies are even stronger in terms of technological capability and market share. Therefore, another interesting research question arises. Is there a possibility that the long-time industry leader and teacher – Volkswagen, can learn something in China amid this EV wave?

To find these answers, the following three research questions are addressed in particular:

1) How have the technological competences in Volkswagen China changed in order to shift from traditional vehicles to electric vehicles?

2) As an established automotive maker from a developed country, what has Volkswagen learnt from the newly industrialized country - China?

3) How does VW manage the EV common modular platform (MEB) strategically?

1.3. Research Gap

This research is a response to the call from Borgstedt et al. (2017) which emphasized the need for deeper research in a specific country – China about the technological change around electric vehicles. Furthermore, Aaldering et al. (2019)

also called for further research on the developmental trajectories and the correlations between conventional drive train technology and electric drive-train technology. The EV industry is growing rapidly in recent years especially in China, but the previous literatures of EVs in China settings are not catching up to the speed of EV industry development, it is clear that this industrial trend could fundamentally change the entire workings of the automotive industry in the coming years. Hence, this research could contribute to the literature through empirical evidence collected in China by utilizing Volkswagen China's case.

1.4. Report Structure

Figure 1-1 outlines the structure of this report. It begins with the introduction, followed by Chapter 2 in which the background of EVs, EV industry in China and the Volkswagen Group in China are introduced, meanwhile the key components and technologies are discussed in detail for a better understanding of the research objective. In Chapter 3, literature review of important concepts is introduced as ground theories, including core competence, dynamic capabilities, competence-destroying and related concepts. Chapter 4 is about the methodology and approach that are chosen by the author to address the research questions. After that, the findings of the research are presented in Chapter 5. Finally, the conclusions and implications are covered in Chapter 6.

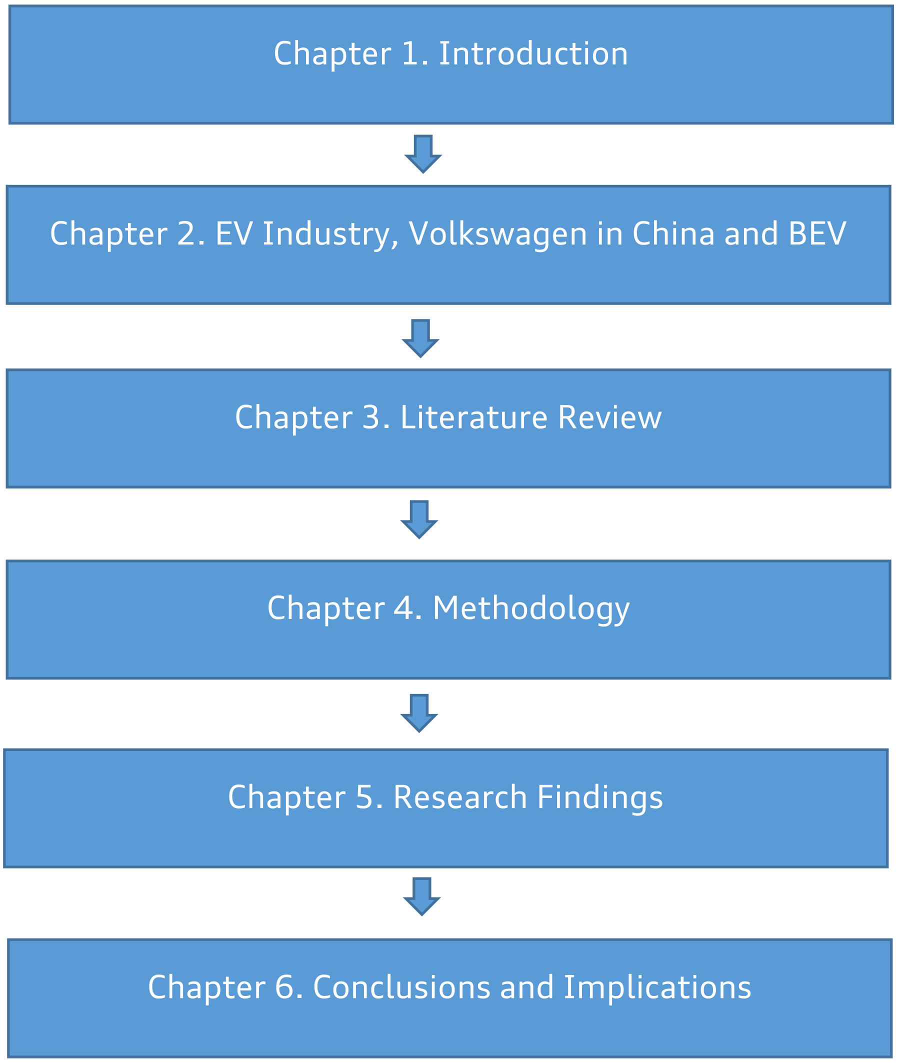

Figure 1-1: Independent Final Report Structure

Chapter 2. OVERVIEW OF EV INDUSTRY, VOLKSWAGEN IN CHINA AND BEV

2.1. EV Industry Overview in China

The EV industry is one that has been very interesting to researchers partly because it's an example of how government policy can potentially drive innovation in an industry. China is betting big on EVs for several reasons:

a) The country has always been a follower in the area of traditional vehicles, and they wanted to find a way to catch up technologically and not be dependent on Europe or Japan for drivetrain (engine, gearbox) technology.
b) Also, it has a significant air pollution problem, and they're the world's largest emitter of greenhouse gases (Günther et al., 2015).
c) It is one of the world's largest importers of oil (OPEC, 2021).

China has pledged to be carbon neutral by 2060 (Xinhua, 2021). In an effort to support the adoption of EVs, the Chinese government has played a massive role. Large amounts of finances, tens of billions of dollars, have been devoted in support of the sales of EVs electric vehicles. It is not secret that without regulation, rules, subsidies, EVs would never have gotten off the ground (Hsieh et al., 2020). Whether it's in China, Europe or in USA, it has been the government pushing the EV future. China has been the most aggressive in this regard.

China has subsidies and incentives that benefit automakers, suppliers and consumers (Wang et al., 2017). For example, in Shanghai, even before buying a gasoline powered vehicle, a potential buyer must first acquire a license plate which costs 100,000 yuan (c.a. 2,000,000 yen). However, for an EV buyer, the licensing fee is waived, which presents a great incentive towards purchasing EVs. There is a perception that China is winning the EV race because there are so many subsidies in place (Li et al., 2020). Thanks to strong support from Chinese government and other positive factors, in recent years, the sales of EV in China has been increasing significantly. China Passenger Car Association (CPCA) announced sales forecast of New Energy Passenger Vehicles (including BEV, PHEV, HEV) for 2022, expected to reach 6 million units in 2022, with the average monthly sales of new energy passenger vehicles expected to exceed 600,000 units from August to December 2022. From January to June 2022, the wholesale sales of new energy passenger vehicles in China reached 2.466 million units, up 122.8% year-on-year (CPCA, 2022).

2.2. Volkswagen in China

Volkswagen Group has a long and successful history in China, it was one of the first foreign automobile companies that invested and produced cars in China ahead of all of their Japanese counterparts (Kueh, 1992). As early as 1983, a car model named “Santana” became the Volkswagen’s first “made in China” product. Until 1986, around 10,000 units had been rolled off the production line and delivered to customers in China. From then, from this small beginning, Volkswagen helped develop both the Chinese domestic industry and market step by step. Now, with its three joint ventures, FAW-Volkswagen, SAIC Volkswagen and the Volkswagen Anhui (former name was JAC Volkswagen), the Volkswagen Group and its brands operate 40 production plants in the country as of the end of 2021 and are delivering over 3.3 million cars to Chinese customers, among them, 92,700 units are BEVs (battery electric vehicles) in 2021.

The Volkswagen Group kept its market leader position in China with a market share of 16%. Figure 2-1 plots the market share of five leading car companies in China, the data is from CPCA (China Passenger Car Association), compiled by the author. Globally, Volkswagen group sold 5.868 million vehicles in total during 2021 (Volkswagen, 2021, p.38), more than half of which came from China - this speaks volumes about the importance of the China market to the whole Volkswagen group.

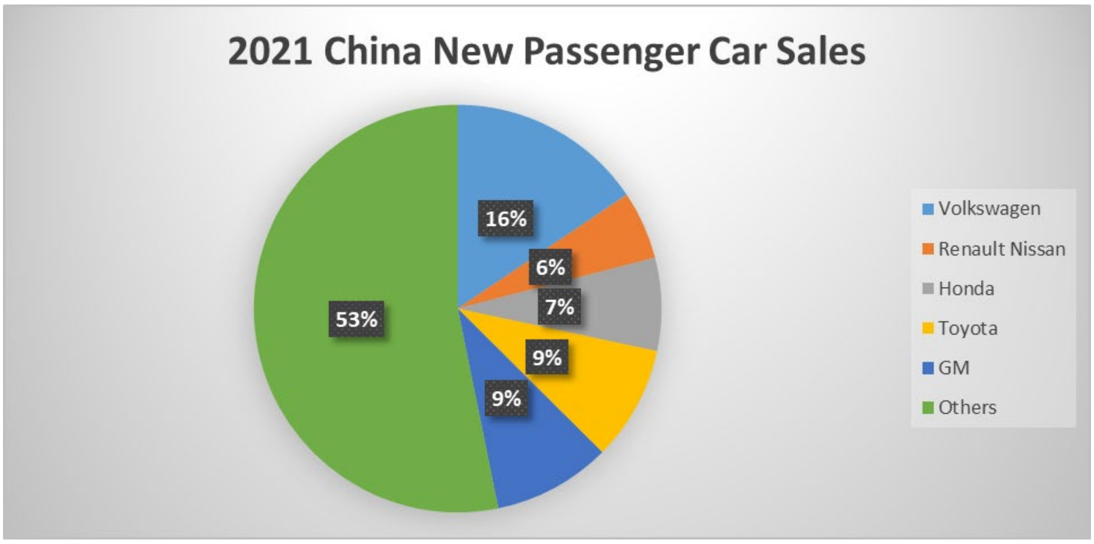

Figure 2-1: Top Five Automobile Companies' Market Share, Calendar Year 2021 *(Source: made by the author based on CPCA data)*

However, when it comes to BEV sales in China, Volkswagen's market share is quite lower than its overall market share, standing at 4%. The Figure 2-2 shows the Volkswagen's BEV market share in 2021 compared to other four BEV leading companies. In total, 2,446,740 new BEVs were sold in China. It should be noted that, being a market leader company does not necessarily mean it has more technological advantages than other companies. For example, GM's most popular EV model is

Hongguang Mini EV which is a low-end product with starting price 37,600 RMB (c.a. 750,000 Yen). 395,491 Hongguang MiniEVs were sold in 2021, and topped the list.

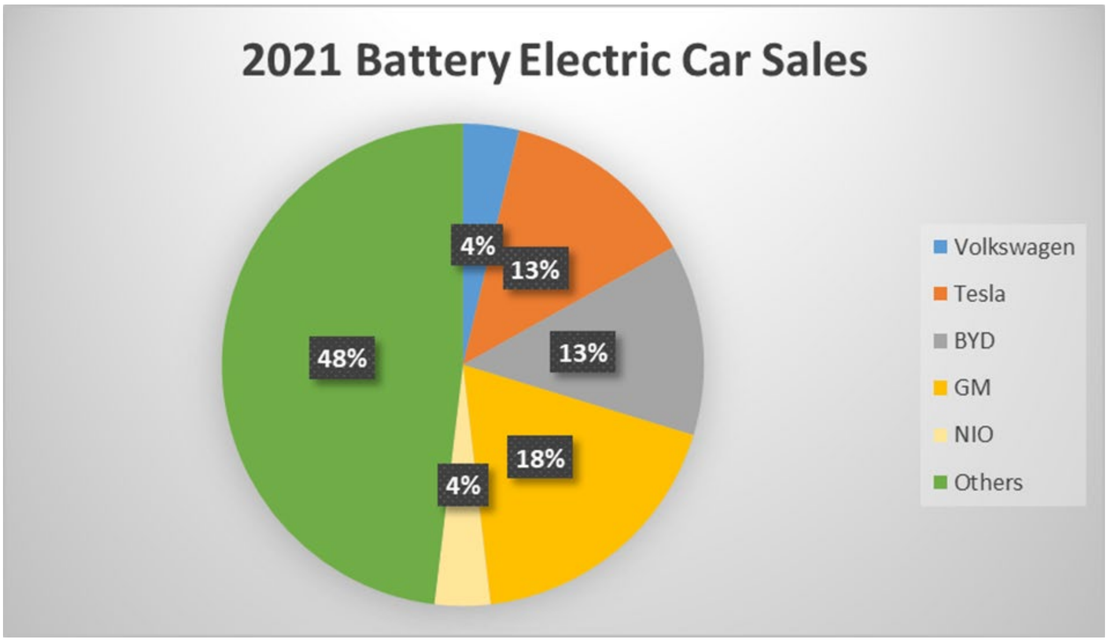

Figure 2-2: BEV Market Share for Volkswagen and Other Four Leading Automobile Manufacturers, Calendar Year 2021 *(Source: made by the author based on CPCA data)*

Meanwhile, China is also the biggest automotive production country in terms of production capacity followed by USA, Japan, India, South Korea, Germany and etc., in total 2,608,2220 vehicles (including both passenger cars and commercial vehicles) were produced in 2021(OICA,2022). Apparently, the Chinese market is huge in terms of both sales volume and production capacity, but it also implies there is fierce competition in this most profitable market.

To maintain the leadership in the Chinese market, which is Volkswagen Group's largest single market, on several occasions Volkswagen Group had claimed that their China operation would play an important role in the aforementioned transition and is moving wholeheartedly to embrace EVs, with an ambitious and expansive plan to become the top player in the EV market while adopting smart car technology as a fast follower on the market.

2.3. Overview of BEV and Key Components

2.3.1. BEV Introduction

Battery electric vehicle (BEV), also called all-electric vehicle, run entirely on battery and an electric drivetrain. The battery pack in an electric car is like the heart of the vehicle, it is also the most expensive part of an EV (Babin, et al., 2018). Electricity is stored in a large battery pack that is charged by plugging it into the power grid, the battery pack in turn provides power to the electric motor which runs the electric car. Judging whether a BEV is good or not, to a large extent, depends on its battery technology. And, it is clear that the potential of research and development in the battery and battery powered car field is much greater than internal combustion engine powered cars which had already reached an inflexion point (Zapata and Nieuwenhuis, 2010).

Compared to the conventional internal combustion engine vehicle (ICEV), the BEV is a relatively newfangled thing, even though the first electric car can be dated back to the early 19th century, but this kind of car was massively put into production and sold on the market only in recent years (Morimoto, 2015). An ICE car can have as many as 2000 moving parts but an electric car has far fewer moving parts. That's because of the absence of intricate mechanical parts that are necessary for a traditional car. EVs have an electric motor instead of a petrol or diesel-powered motor, in general, the drivetrain in an EV only has around 20 parts.

Figure 2-3 shows a comparison of the main components between an ICE car and BEV. Depending on the model, generally speaking, around 30,000 parts are required to run an ICE car as a whole, by contrast, only 12,000 parts are needed, on average, in an EV. The big difference indicates that the established car makers' advantages built on engine designs would be diminished or even erased (Teece, 2018). The core competence theory, dynamic capabilities and competence-destroying, will be discussed in this dissertation.

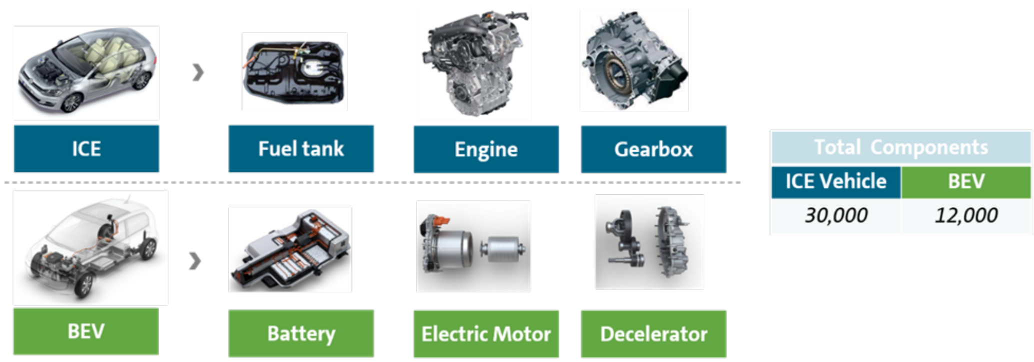

Figure 2-3: Main Components Comparison Between Internal Combustion Engine Cars and Battery Electric Cars *(Source: made by the author)*

Table 2-1 plots which changes and new technologies would be adopted due to the shift form ICE cars to electric cars, key components, changes and new requirements are also shown in the table. A patent trend analysis has been also conducted for the further research based on this ICE car vs. electric car comparison and shown in the Methodology section.

Though, established car makers have relatively less experience in producing the EV key components, to be specific - batteries, electric motors and electronic control systems, it does not necessarily mean the ICE-based car manufacturers are not capable of building the new capabilities that are needed for EVs. Many of them have sought support from external companies which could be outside their traditional supply and manufacturing environment (Pilkington et al., 2002).

Vehicle Key Component	EV Key Component	Transition requirements
Engine	Electric motor	Advanced Electric Motor technology
Fuel tank	Battery	Higher energy, higher power, lower cost
Refueling	Charging	Smart charging

Table 2-1: EV System Changes and Technology Adoption *(Source:* made by author)

2.3.2. Battery

As the name indicates, the battery electric vehicle uses energy stored in its battery which is rechargeable. In this sense, the battery is the "fuel tank" of a BEV as Figure 2-3 illustrated. But obviously battery technology is far more complicated than fuel tank technology, the battery pack is arguably the most expensive and important part of an EV electric vehicle, which was agreed by interviewees afterwards. For example, an interviewee said: “The development and production of battery systems is the most crucial step on the way to producing BEVs.” Battery production around the world is concentrated in Northeast Asia, namely Japan, Korea and China. Together, they account for about 95 percent of total battery production for vehicles, now within that percentage, China currently takes up more than 60%, so it’s clearly the leader in terms of battery production capabilities (Harrison and Ludwig, 2021).

In many cases, battery cell, module and pack are simply referred to as battery. For a better understanding of the further research, the differences between them are shown in Figure 2-4. A battery pack is a series of several battery modules as a complete system within an EV, and a battery module is comprised of several individual battery cells that are connected either in a parallel sense or in a series to achieve serviceability (Berjoza et al., 2019). Lithium-ion battery has been the most widely used electric car battery and has been considered to be the most promising for the near future, and no other battery technology has been studied as much as Lithium-ion battery (Sperling, 2018). Lithium is currently regarded as the most suitable chemical element when it comes to EV battery production, in the foreseeable future no other element can replace it (Volkswagen, 2019). And because of lithium-ion battery’s high energy density, relatively low cost and low self-discharging, the lithium-ion battery has been the preferred energy storage device for most EV makers including Volkswagen. According to the shape of the battery cell, it can be classified into prismatic type, cylindrical type and pouch type. And if we classify them based on the cathode material, there are four main types dominating the market: 1. Ternary lithium battery, 2. Lithium iron phosphate (LFP) battery, 3. Lithium manganese oxide (LMO) battery and 4. Lithium cobalt oxide (LCO) battery. Table 1-2 plots each battery type's features.

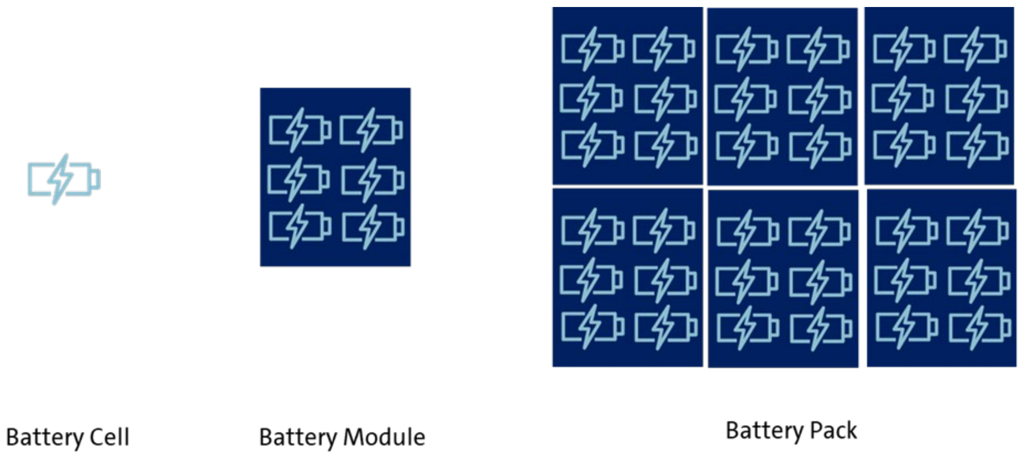

Figure 2-4: Battery cell, Module and Pack *(Source: made by author)*

Battery is the core and the driving source of new energy vehicles with a development trend of high capacity, high density, high stability and safety. Main performance indicators are specific energy (E), energy density (ED), specific power (P), cycle life (L) and cost (C), etc. (Scrosati and Garche, 2010). To a traditional car maker who is transforming to an EV maker, the battery is the new engine that moves it forward to the success of future business.

Indicators	Batteries made from ternary materials		Lithium iron phosphate (LFP)	Lithium manganese oxide (LMO)	Lithium cobalt oxide (LCO)
	Alnico (NCA)	Nickel manganese cobalt (NCM)			
Molecular formula	LiNixCoyAl1-x-yo2	LiNixCoyMn1-x-yo2	LiFePO4	LiMn2O4	LiCoO2
Specific energy at the present stage (Wh/kg)	>180	160-180	120-130	130-150	150-180
Cycle life	> 2000 times	> 2000 times	> 2000 times	500-800 times	> 1000 times
Comprehensive performance	Excellent	Excellent	Good	Poor	Good
Advantages	High-energy density	Electrochemical stability, good cycling performance	High safety level, long cycling time	Abundant manganese resources, low price, high safety	Stable charging and discharging, simple production process
Disadvantages	Poor safety	Use of some metal cobalt which is expensive	Poor low temperature performance, low discharge voltage	Low energy density, poor electrolyte compatibility	High price of cobalt, low cycle life

Table 2-2: Comparison of Different Batteries' Features *(Source: made by author)*

2.3.3. Battery Management System (BMS)

As mentioned in the last session, a battery system consists of several battery modules, in which there are many battery cells. Since the individual battery cell alone cannot provide enough power for a whole energy storage system, these cells need to be put together in series or parallels to create a module, and then many modules are connected together to become a pack. At pack level, lithium-ion battery performance becomes difficult to manage because the cell can get charged and discharged at varying rates and can be operated at different conditions due to their different operational state in terms of temperature, state of charge and state of condition.

A complex electronics control system known as the Battery Management System (BMS), is required to monitor the charge rate across the whole pack down to the cell level to ensure peak performance and prolong battery life. BMS has two key functions which are thermal management and charging balancing (Panwar et al., 2021).

For an individual EV user or owner, BMS is invisible and nameless, but it is truly an important part of an electric car due to its abovementioned functions. To a large extent, BMS can determine an EV performance in terms of battery reliability and robustness, safety, driving experience etc., therefore the BMS technology can be regarded as a key indicator of the quality of any given EV (Ashok, et al., 2022). Hence, along with the rapid growing sales of EVs in China, the BMS production and development have been growing fast (PR Newswire, 2022). Table 2-3 plots the top five BMS providers' installed capacity in China in year 2021, and Figure 2-5 shows each provider's market share.

Manufacturer	**BMS Installed Capacity in 2021**(Unit)
BYD (China)	544,368
CATL (China)	476,908
Tesla (USA)	311,620
Sinoev (China)	227,830
Ligoo (China)	146,770
Others	528,751
Total	2,236,247

Table 2-3: Battery Management System Installed Capacity in China 2021 *(Source: made by author, according to www.modiauto.com.cn)*

It is important to note, that the EV makers - BYD and Tesla are both in the Top 5 list, the former is No.1 and the latter is third place. That is to say, both companies have this key component technology's R&D in house. As Figure 2-5 showed, BYD and Tesla are also the No.2 and No.3 EV manufacturers in China, respectively. This preliminary finding is consistent with the point of view of Miyazaki (1995) that a firm should develop key components in-house so that they can move to a further level in building system-wide.

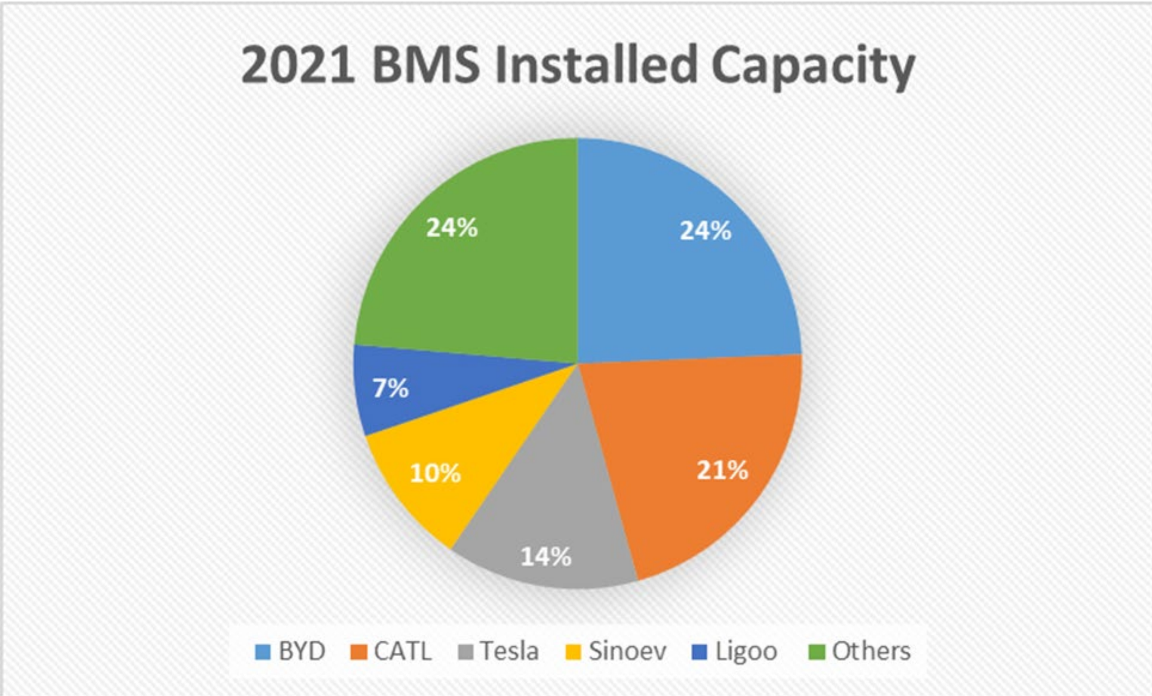

Figure 2-5: Battery Management System Installed Capacity in China 2021 (Source: made by author according to Modiauto)

2.3.4. Electric Motor

In an EV, the electric motor and battery are complementary, the motor serves as another key component which realizes mutual conversion between electric energy and mechanical energy. Figure 2-6 illustrates the function of a motor. For most electric vehicles, mechanical energy is converted into electric energy in the state of braking. The battery is charged through a generator (Pesiridis, 2017).

The motor is composed of a rotor, stator winding, speed sensor and housing, cooling parts, etc. The most widely used motors can be categorized into Direct Current motor (DCM), Permanent Magnet motor (PMM) and Induction motor (IM) (de Santiago, et al., 2012). Table 2-4 explains the characteristics of the three types of electric motors. Comparatively speaking, permanent magnet motors are the most widely used motors in new energy vehicles because they're outstanding in every aspect.

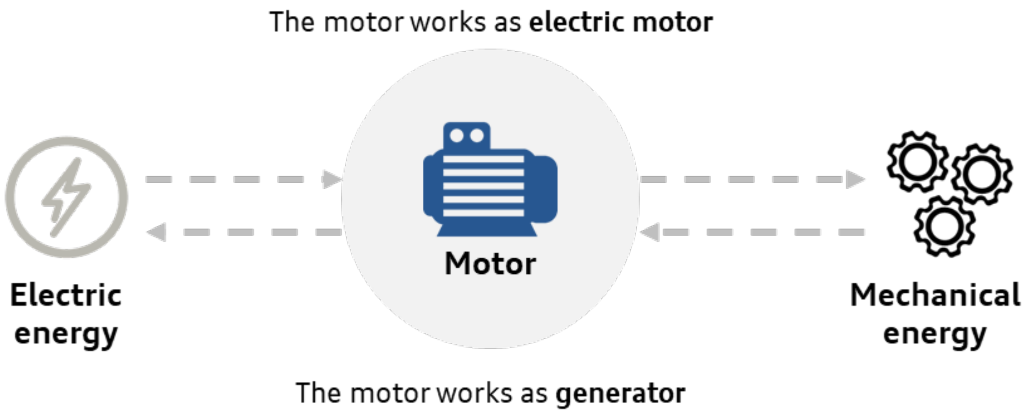

Figure 2-6: Electric Motor's Function *(Source: made by author)*

Classification	DCM	PMM	IM
Specific power	Low	High	Medium
Peak efficiency (%)	85-89	95-97	94-95
Load efficiency (%)	80-87	85-97	90-92
Rotational speed range	4000-6000	4000-10000	12000-15000
Reliability	Fair	Excellent	OK
Dimension	Big	Small	Medium
Representative model	Small EVs	Volkswagen ID. 6 BYD Tang	Tesla Model S
Cost	Low	High	Low
Degree of difficulty to control	Low	Fair	High

Table 2-4: Comparison of DCM, PMM and IM *(Source: made by author)*

In the electric motor industry, Japanese, north American and European companies are very strong in terms of market share and technology achievement. One electric motor supplier to VW's Electric powertrain for MEB platform is Magna, a Canadian company (Magna, 2022).

2.3.5. Charging

For most consumers, the biggest difference between a BEV and a gasoline powered car is how the car's "tank" is filled up. The so called "range anxiety" has been a profound concern when potential consumers make the decision to purchase an EV. Lack of infrastructure charging is one of bottlenecks for developing the

EV industry. Therefore, the charging technology and development of charging infrastructure are among the car companies' top priorities.

At the national level, the governments tend to lead and participate in developing the charging infrastructure (Cârstea, 2022). In China, the central government also made charging a national priority and has been installing an extensive network throughout the country. According to CEVCIPA (China Electric Vehicle Charging Infrastructure Promotion Alliance), China added 48,000 public charging piles in August 2022, representing a year-on-year increase of 64.8%. The country now has 1.623 million public charging piles in operation; the pile-to-car ratio reached 1:2.3 (meaning every 2.3 EVs have 1 charging pile on average) in terms of increment from January to August 2022, meaning that EVs' daily charging demand can be satisfied. However, the needs for centralized charging along expressways during holidays still puts huge pressure on charging facilities. From January to August 2022, 1.698 million charging facilities were added in the country, with the number of public and private charging piles up 232.9% and 540.5% year-on-year respectively. As of August 2022, China had built 4.315 million charging facilities, an increase of 105.0% year-on-year (CAN, 2022). These charging facilities are funded by both government and companies.

By classification of charging method, there are constant current (CC) charging and constant voltage (CV) charging (Gong et al., 2018). By the type of charging pile, it can be divided into DC charging and AC charging. Also, they can be divided into public charging piles and private charging piles based on the ownership. Table 2-5, plots the aforementioned different types of charging methods with respective characteristic.

Categorization		Features	Disadvantages
Charging method	Constant current charging	A charging method which keeps the strength of charging current unchanged. Simple control method	The battery's capacity to accept current gradually decreases with the charging process
	Constant-voltage charging	The voltage of charging power supply maintains a constant value during the entire charging process. With gradual increase of battery voltage, the current gradually decreases.	-
Categorization of charging piles	DC charging piles	DC electric vehicle charging station, commonly known as "fast charging"	-
	AC charging piles	AC electric vehicle charging piles, commonly known as "slow charging"	Since the power of on-board charger is not high, fast charging cannot be realized
Private and public charging piles	Private charging piles	Provided with fixed parking spaces Admitted by the property party The community meets the requirements for construction of 220 V and 2KW slow charging pile	Installation is not possible if the 3 conditions cannot be met simultaneously
	Public charging piles	The maximum power of public charging pile is about 40 Kw	Long charging time and waiting time

Table 2-5: Different Types of Charging *(Source: made by author)*

There is another way to "fuel up" EVs - battery swapping – meaning, rather than charging their cars at charging piles, owners can also drive them to a battery swapping station to have a new battery pack installed in minutes. However, some companies didn't succeed in this "battery-swapping" business, for example, an Israeli company named "Battery Place" failed in 2003 (Reuters, 2003). And in China, only one company – Nio, takes this approach, as it remains unclear if this kind of charging method can be successful in the future.

2.3.6. Volkswagen's Modular Platform (MQB and MEB)

Modular design can be seen in many industries, and modularity is an important source of entrepreneurial activity (Hatch, 2001). By utilizing a modular strategy and platform sharing, car companies can effectively reduce the cost and complexity of production of many different car models at a large scale, because many aspects are standardized, and numerous components and technologies are interchangeable. With that said, this widely used strategy allows car companies to provide large external product variants with minimal internal variances. One of the great examples could be Volkswagen's Modularer Querbaukasten (MQB), meaning modular transverse toolkit in English (Lampón , et al., 2019). In order to have a better understanding, a comparison is made below. Table 2-6 shows two VW cars – Golf GTI and Teramont, though both of them are MQB-based vehicles, their body sizes are quite different, the former is a compact segment hatchback, while the latter is a large SUV.

Photo / Item		
Car Model	Golf GTI	Teramont
Length (mm)	4296	5022
Width (mm)	1788	1989
Height (mm)	1471	1773
Wheel base (mm)	2631	2980

Table 2-6: Comparison of Golf GTI and Teramont *(Source: made by author according to dongchedi.com)*

In this case, the car maker is able to adapt dimensions like length, height and width to accommodate a small or a larger body while still using the same modular platform, however, inside the vehicle, they can still use the same parts such as transmission, engine, steering, axle suspension and so on. Figure 2-7 shows two MQB platform pictures, the left one is a platform with VW's engine, right one shows the width and length are adjustable. Because of the bundling of core technologies (engine, transmission etc.) within the platform, the manufacturing process becomes very efficient as there are fewer differences between vehicles. Within this core competence, Volkswagen is in its element in mass production (Frank et al., 2022).

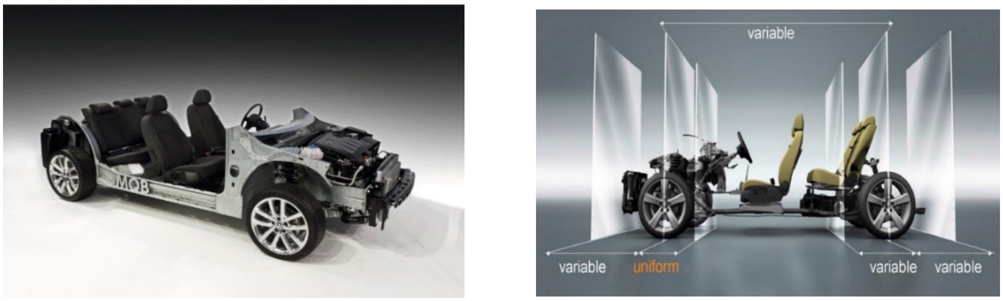

Figure 2-7: Volkswagen’s MQB Platform *(Source: Volkswagen AG)*

Likewise, MEB is also a versatile modular platform, but it is designed exclusively for the all-electric vehicle models. It can be seen as the electrification version of MQB platform from the Volkswagen Group, which provides the technical basis for the latest BEVs. The MEB allows all the aforementioned key components to be installed based on it, while electric motors and lithium-ion batteries can be offered in different sizes and capacities (MacKenzie, 2022). The battery systems, electric motors and axle designs form a stringent technology toolkit. Figure 2-8 shows a real MEB based chassis with battery pack. To figure out the research question 3, it is better to focus on the way VW uses MEB strategically, because utilizing an existing technological platform has been considered a very important strategy to generate new businesses (Lichtenthaler, 2006).

Figure 2-8: VW's MEB Based Chassis with Battery Pack *(Source: shot by author)*

Chapter 3. LITERATURE REVIEW

3.1. Core Competence and Competence-building

What can be learned, when we look back, is that history tells us that the core competence is an essential ingredient for a growing and prosperous corporation. There are many big companies that failed to build the core competences which they had the potential for, mostly because top management was not able to conceive of the company as anything but a collection of discrete businesses (Prahalad & Hamel, 2003). Competence building is a process that consists of technological opportunities, research & development, uncertainties, management strategy etc. The process of building competence requires time and dedication. There are some key factors affecting the outcome of this process, such as previous core business, top management strategy, key components and component generic technologies and so on (Miyazaki, 1995).

Back in the 1980s, the concept of "core competence" came out as a burgeoning strategic management approach. So, what is "core competence"? Most of the previous literatures tend to relate the concept to the know-how and other kinds of intangible resource and several other types of ability of a company. According to Miyazaki (1995), the competences can be divided into financial competence, marketing competence, production competence and technological competence. Among them, technological competence is the most important area of competences for a knowledge-intensive industry. In the case of Volkswagen, based on Table 2-1, the powertrain (engine and transmission) technology can be seen as their core competence and core business which they had spent many years to develop and build.

As a company, regardless of all the new opportunities and possibilities that are opening up, it must not neglect its existing technologies and core competences. Because unlike other forms of assets, core competence as an intelligent asset is not going to depreciate over time, by contrast, the competence can be promoted and sharpened if it keeps being used and shared properly (Prahalad and Hamel, 1990). Furthermore, Hamel and Prahalad (1994) emphasized the importance for companies to find the most effective path between current and future business. And an established company that has already built up core competences and continues to pursue opportunities is very difficult to be taken over. Because a firm with strong core-technology competence is supposed to have far more commercial opportunities for development that derives from technological diversification than those with weak technological competence (Kim et al., 2016). In the context of the automobile industry, that is to say, even though the future is electric, existing technologies and core businesses still play, and will continue to play a key role together with the new technical competences in the foreseeable future, since products and technologies are much more diversified than they used to be.

3.2. Dynamic Capability and Competence-destroying

Dynamic capabilities have been considered as a firm-specific ability that can build, redeploy and integrate internal and external competences in order to keep or gain competitive advantages in a changing environment (Teece et al., 1997). Pisano (2017), developed a framework to assist firms to identify and choose the “correct” existing and new capabilities wisely, and then invest, build and develop the selected capabilities to ensure the firm's good position on the market. He also pointed out there are two dimensions of dynamic capabilities by using Honda's case, one is deepening, the other is broadening. In deepening, some "new capabilities" are argued to be more related to a firm's "old capabilities", and the firms can "deepen" the old capabilities by continuing to exploit their old capabilities (existing capabilities). But to broaden the capabilities, the firms need to invest in new capabilities in the form of R&D, acquisition and so on. And based on this, the importance of vertical integration, mergers and acquisition, cooperative ventures, open innovation etc. should also be discussed (Kay, 2018; Bogers et al, 2019).

The answer to the first question in the beginning of this report is actually getting clearer as more and more car companies are setting deadlines for selling conventional vehicles. The term competence-destroying explains the fact that due to core technology shift, the previously set up knowledge base or skills are no longer important and useful (Tushman & Anderson, 1986). As a case study conducted by Ahsan et al. (2010), the result shows, for an incumbent, forming alliances, partnership and collaboration with emerging technology firms can be extremely important in adapting to competence-destroying technology change.

The new electric powertrain system, as an alternative system of cars, can be seen as a kind of "competence-destroying" technology for the established traditional car makers (Aaldering et al., 2019), therefore as a technology-based firm, organizational learning is critically important for maintaining competitiveness (Leonard-Barton, 1992). Firms should continuously establish and develop their investments, production, and linkage capabilities in order to improve their knowledge accumulation and absorptive capabilities (Qiu et al., 2022). In this sense, R&D is extremely important to a firm, not only because R&D creates innovations but also helps firms develop their absorptive capacity (Cohen and Levinthal, 1989). Miyazaki and Giraldo (2016) focused on the innovation strategy and technological competence building for new generation networks and services in the telecommunication industry by conducting a case study of NTT Japan. Collecting information from publications, analyzing publication data, observing technological changes and conducting interviews, they found that the collaboration with other partners like universities, academic societies, subsidiary companies play important roles in building competences and to overcome technological shifts.

3.3. Technology Strategy

Miyazaki and Kijima (2000) analyzed five major Japanese car companies, and emphasized the importance of the technology strategy regardless of the level, company or national, especially for the decision-makers when dealing with complexities and uncertainties. The emergence of EVs is accelerating the complexities and uncertainties for auto makers, therefore companies should succeed in making effective technology strategies (e.g. form strategic alliances) which are necessary for building technological competences in order to stay competitive in the changing environment. Cabigiosu (2022) analyzed the strategies of 13 incumbent automotive manufacturers over a 26-year timeframe, and argues that established companies tended to utilize open innovation strategy, which entails cooperation with external partners, shared knowledge base with suppliers and competitors to form a win-win situation in face of the high technological uncertainties brought by the emerging competence-destroying technology - EV technology.

To cope with the uncertainties, utilizing technological platforms is considered a common method by multinationals to enter a new market or generate new businesses. For companies to stay successful in future business, they can diversify more smoothly with the complementary assets and synergies in place (Lichtenthaler, 2006). Also, a holistic product variant management is regarded as a core competence of a firm (Forza and Salvador, 2008). Therefore, the importance of developing modular platforms is noticeable, it can give an automotive manufacturer competitiveness in the long-run. Van Biesebroeck (2007) collected data from U.S. Bureau of the Census, and after analysis, he suggested the flexible technology (modular platform) and bringing previously outsourced activities in-house are two effective ways to enhance competitiveness, because they can decrease the cost of producing varieties of products.

3.4. Conceptual Framework

The previous existing literatures have been well prepared for the research on examining the changes of competences in the context of EV transformation, which is the Research Question 1: *How have the technological competences in Volkswagen China changed in order to shift from traditional vehicles to electric vehicles?* Since during the preliminary research, it was found that Volkswagen's technology strategy, such as forming alliances or M&A activities, are all based around Chinese companies, especially in the field of new technologies. Hence there is a possibility that China has already become a technology hub rather than only being a profit market, which is related to Question 2: *As an established automotive maker from a developed country, what has Volkswagen learned from the newly industrialized country - China?* Therefore, we wished to explore what VW could be learning from China. Modular platform as an existing competence, that acts as a mediator affected by the top management strategy, is related to Research Question 3: How does VW manage the EV common modular platform (MEB) strategically? A conceptual frame work is presented as below.

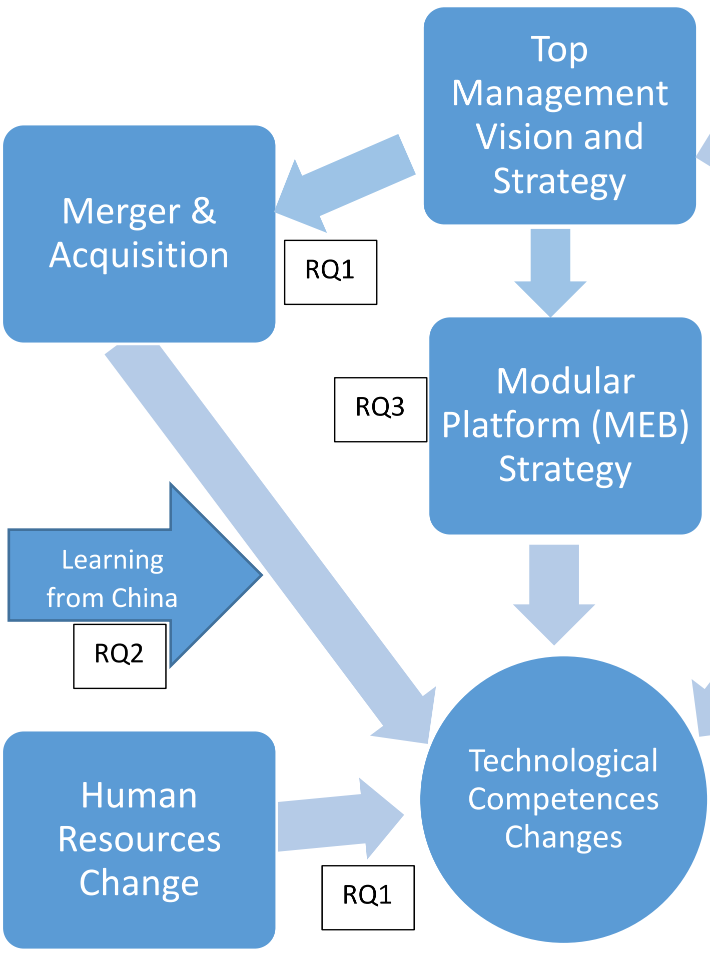

Figure 3-1. Conceptual Framework

Chapter 4. METHODOLOGY

4.1. The Main Procedure

In order to investigate the research questions, a qualitative methodology based on Yin (2014)'s case study approach was chosen. Firstly, to gain a deeper understanding of EV and EV industry, the author obtained the information and the overall picture about EV industry news, technologies, trends from related websites, journals, press releases. Secondly, the author reviewed Volkswagen's EV related news focusing on recent VW development and major activities especially in China as well as data including patents, written documentation in the form of reports, company presentations, which he then combined with VW's historic organizational changes in order to analyze the entirety of this information and get preliminary findings and ideas. Then, to get a better understanding of the changes inside Volkswagen Group China that impacted the technological competences relating to the shift to EVs, conducted interviews with 8 key employees of Volkswagen Group China. All of the interviews had been recorded and transcribed, the author utilized these three sources of evidence so that misinformation could be reduced as much as possible, and to validate the research outcome (Riley et al., 2007). The process follows the steps shown below:

Figure 4-1. Research Process

4.2. Patent Analysis

As mentioned above, tech mining of VW patent data, by using PatBase Express, has been incorporated for triangulation. Since patent analysis has been considered an effective tool and is widely used in technology and innovation related research as a reliable source of knowledge and information (Yuan & Miyazaki, 2017; Seo, 2022). The author firstly searched the patents of key EV components to get a rough idea of Volkswagen's technological trend by using PatBase Express, then compared it with a competitor of Volkswagen Group China – BYD which is a Chinese EV market leader.

There are a few reasons for the choice of PatBase Express as the patent analysis tool: First, PatBase Express is developed and maintained by Minesoft, which is teamed up with patent issuing authorities around the world. It has one of the most comprehensive patent datasets, in which 150 million patents from 107 jurisdictions can be found (Minesoft, 2022). Second, PatBase Express organized millions of patents into patent families. One patent family is a collection of all single patent applications filed in different countries which protect the same invention (EPO, 2022). This feature makes PatBase Express very suitable for analyses as it can effectively reduce overlaps and duplications, because the data needs to be collected from different patent offices. Third, PatBase Express also provides a machine translation function that even allows non-English text translation, for example, from Chinese into English and German or vice-versa is available when searching for patent information, e.g. claim, description and so on.

As mentioned earlier, to gain a comprehensive view of the current EV industry, a Chinese leading EV manufacturer – BYD was also chosen for the analysis. And to ensure the data collected is as appropriate as possible, the search applied different strategies for different situations, for example, the author used exclusive keyword combinations in titles, abstracts and claims of the patents when searching for the patents about battery technology (used “BATTERY not FUEL CELL not SOLAR not PHOTOVOLTAIC” instead of simply using “Battery” to avoid misinformation). But when searching for charging technology patents, to get as many results as possible, also as precise as possible, the author used the Boolean search with keywords combined with International Patent Classification (IPC) at its subclass level or with IPC symbols directly, including: B60K1/04 or B60S5/06 or B60L50 or B60L53 or B60L58 or B60W20/13 or G01R31 or G01T1/142 or H02J7 (WIPO, 2022). Table 4-1 explains what these IPC symbols stand for.

Code	**Item**
B60K1/04	Electric storage means for propulsion
B60S5/06	Supplying batteries to, or removing batteries from vehicles
B60L50	Electric propulsion with power supplied within the vehicle
B60L53	Methods of charging batteries, specially adapted for electric vehicles; Charging stations or on-board charging equipment therefor; Exchange of energy storage elements in electric vehicles
B60L58	Methods or circuit arrangements for monitoring or controlling batteries
B60W20/13	Prevent overcharging or battery depletion
G01R31	Arrangements for testing electric properties; Arrangements for locating electric faults; Arrangements for electrical testing characterized by what is being tested not provided for elsewhere

G01T1/142	Charging devices; Read-out devices
H02J7	Circuit arrangements for charging or depolarizing batteries or for supplying loads from batteries

Table 4-1: Charging Technology International Patent Classification (IPC) *(Source: made by author, according to WIPO)*

4.3. Interviews

The interview is a tried-and-true method of qualitative research, and it is widely used in research and study as an important source of information (Yin, 2009). Interviewees with comprehensive and complex information or knowledge towards a certain research question or topic can be extremely helpful, as well as their opinions. The author contacted eight employees from Volkswagen Group China from several divisions in order to get a bigger picture of the VW's case, the interviewees were not only selected from R&D division, but also from other divisions like Human Resource, Marketing and Product. To gain objective and reliable evidence, the author interviewed veteran employees that have been working at Volkswagen a minimum of 7 years, meaning they have witnessed the electrification process and the technological shift in the previous years. The interviewee list is as below:

No.	Name	Division	Job Title	Dept./Function	Date	Duration (minutes)
1	Gu Gongyao Dr.	R&D	Director	Innovation Center Asia	2022/10/17	55
2	Shao Cheng	Product	Product manager	NEV Product Development	2022/10/19	60
3	Li Hualong	R&D	Team leader	Engine Development (EA211)	2022/10/20	60
4	Xu Xiaoxiao	Marketing	Manager	Brand Marketing Intelligence	2022/10/21	55
5	Zhang Yu	VW Academy	Master trainer	Product & Sales Training	2022/10/25	55
6	Xie Ying	HR	Manager	DSSO	2022/10/26	45
7	Sun Jie	CARIAD	Team leader	Vehicle Archi Concept	2022/10/26	45
8	Stueckler Tobias Dr.	R&D	Team leader	Technical Project Lead MEB Drive	2022/10/28	55

Table 4-2: Interviewee List

Based on the information previously collected and literature review, a set of common questions was made (Appendix 1). In order to obtain thorough answers, the question list had been sent to the interviewees beforehand. And due to interviewees being from different departments and specializing in different areas, customized questions were also made for each of the interviewees, and all of the interviewees were informed clearly about the research purpose, as well as were asked for permission to record and take notes for analyzing the interview transcripts.

4.4. Secondary Data

To investigate the research questions, the author also looked for secondary data sources that facilitate the rough reconstruction of partnerships, major top decisions, strategies, important events etc. about Volkswagen EVs from the last decade (2013 to 2022) roughly, while paying more focus on China related ones. According to the conceptual framework, the data selection was based on the following patterns: Merger

& Acquisition, strategic alliance, organizational change, supplier relationship, top management vision and strategy, human resource change, joint ventures. Some data was excluded, for example battery recycling and disposal related topics, because they are not coherent with the research objective and questions. Table 4-3 reports in chronological order.

Entity	Event Type	Description	Year	Source
Volkswagen AG	Top management vision and strategy	Outlined Volkswagen's vision of new energy vehicles and a sustainable mobility future "TOGETHER – Strategy 2025"	2016	Corporate Presentation https://www.volkswagenag.com/presence/investorrelation/publications/presentations/2016/11-november/1122_Transform2025_PK_EN_03_V12%20translation%20review_final.pdf
Volkswagen China	Partnership	VW and JAC established a new Joint Venture for battery electric vehicles, the R&D center, established through joint efforts, develop connectivity and autonomous driving technologies specifically tailored to the Chinese market.	2017	Press release, https://portal.vgc.com.cn/vcic/pr/en/volkswagen-group-china-jac-and-seat-sign-new-deal-driving-forward-e-mobility-in-china

Volkswagen AG	New subsidiary	Innovation Center Asia built in Beijing, one of just three Volkswagen Group Innovation Centers worldwide, focused on digitalization and autonomous driving	2018	Internet news, https://www.sohu.com/a/218767622_120702
Volkswagen AG	Strategic Alliance	Volkswagen AG and Ford signed a MoU to explore strategic alliance to extend capabilities, strengthen Competitiveness	2018	Company document
Volkswagen AG	Supplier relationship	Volkswagen nominated further battery cell supplier: SK Innovation, LG Chem, Samsung and CATL	2018	Press release, https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-nominates-further-battery-cell-supplier-4374
Volkswagen China	Top management vision and strategy	VGC set up “goTOzero” initiative and strive to be fully net carbon neutral by 2050	2019	Corporate document
Volkswagen China	M&A	Acquired 26% of Gotion High-Tech, becoming the largest shareholder with the total investment of around €2 billion	2020	Corporate presentation
Volkswagen China	Partnership	Announces Strategic Alliance with Suning Motor: Partnership to	2020	Internet news, https://t.cj.sina.com.cn/articles/vi

		drive Innovation in intelligent retailing for EV		ew/1233914290/498c09b200100ql3h?cre=tianyi&mod=pcpager_fintoutiao&loc=19&r=9&rfunc=34&tj=none&tr=9
Volkswagen China	M&A	VW increased stake in JAC Volkswagen joint venture to 75% and acquires 50% of parent company JAG, and renamed to Volkswagen Anhui	2020	Company presentation
Volkswagen China	Milestone	SVW began to produce pure electric models, ID. X, on the new MEB platform in Anting plant. FAW-VW began to produce ID. CROZZ models in Foshan MEB plant.	2020	Corporate document
Volkswagen China	New subsidiary	Start of construction of All-new electric car plant at Volkswagen Anhui	2021	Press release, https://www.volkswagen-newsroom.com/en/press-releases/start-of-construction-of-new-electric-car-plant-in-china-7069
Volkswagen AG	Top management vision and strategy	Presented “NEW AUTO strategy 2030”, aims to transform itself into a software-driven mobility company and become a global market	2021	Press release, https://www.volkswagen-newsroom.com/en/press-releases/new-

		leader in electric vehicles		auto-volkswagen-group-set-to-unleash-value-in-battery-electric-autonomous-mobility-world-7313
Volkswagen China	New subsidiary	VGC builds battery system factory in Anhui to strengthen BEV value chain, its initial annual capacity is 150,000 to 180,000 high-voltage battery systems for Volkswagen Anhui's all-electric vehicles based on the Modular Electric Drive Toolkit (MEB platform)	2021	Pres release, https://portal.vgc.com.cn/vcic/pr/en/volkswagen-group-china-builds-battery-system-factory-in-anhui-to-strengthen-bev-value-chain
Volkswagen AG	Partnership	VW and Ford expanded collaboration on MEB electric platform, Ford to build another electric model based on the MEB platform	2022	Press release, https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-and-ford-expand-collaboration-on-meb-electric-platform-7808
Volkswagen China	New subsidiary	CARIAD (VW's software company)'s China subsidiary debuted, with a focus on building green and safe	2022	Internet news, https://auto.sina.com.cn/news/2022-04-28/detail-imcwipii6970802.shtml

		mobility services with software-defined cars.	
Volkswagen China	Partnership	VW invested, via CARIAD, €2.4 billion to create a joint venture with Horizon Robotics, a China-based global leader in edge artificial intelligence (AI) computing platforms for intelligent vehicles	Press release, https://www.volkswagen-newsroom.com/en/volkswagen-group-news-3492

Table 4-3. Volkswagen Major Decisions Summary (*Source:* made by author according to Volkswagen Official Website)

There is also a summary (Appendix 2) about VGC's critical events, it shows how the organization evolved and the other agents which affected VW's competence building in EVs in a chronological order.

Chapter 5. RESEARCH FINDINGS

5.1. Technological Competence Changes

According to the previous literature reviews, the battery is said to be the most important component of an EV, which is consistent with the opinions of all the interviewees. When presented with the question "Which component or subsystem is the most important for an electric car?" all of the interviewees responded that the battery is the most, or one of the most important components and key emerging technologies for EVs. For instance, Li Hualong, one of the interviewees who is a team leader responsible for powertrain development in the Volkswagen China R&D division, shared his opinion regarding this question:

> *"First of all, it is the battery, which is the crucial core component for an EV. There are a lot of things that need improvement, for example, energy density needs to be higher, as well as safety, and an increase in capacity and stability are all important for a good battery system. But there are few traditional car companies specialized in these fields, most of them purchase the batteries from suppliers. Because it is a totally new area of technology for the traditional car companies, therefore much time and energy would be needed to develop it."*

The response from Li Hualong, actually indicates two facts: first, without doubt, battery is the most essential component for EVs. Second, most traditional car makers are not capable of producing battery cells, meaning this is a competence-destroying technology for Volkswagen as well. Furthermore, Figure 5-1 and Figure 5-2 show the patent analysis on battery and BMS (Battery Management System) respectively, compared with BYD which is a Chinese leading EV maker, Volkswagen's number of patents is much lower than BYD. BYD was founded in 1995, it started with rechargeable batteries and photovoltaic business, then entered the automotive business in 2003 with passenger vehicles (PV), followed by pure electrified commercial vehicles, starting in 2008. Hence, battery technology is not a competence-destroying technology for BYD, in fact, the batteries produced by BYD are not only used in BYD's EVs, but are also used to enhance the vertical integration of its NEV business, they became a major battery supplier to other OEMs (BYD, 2021).

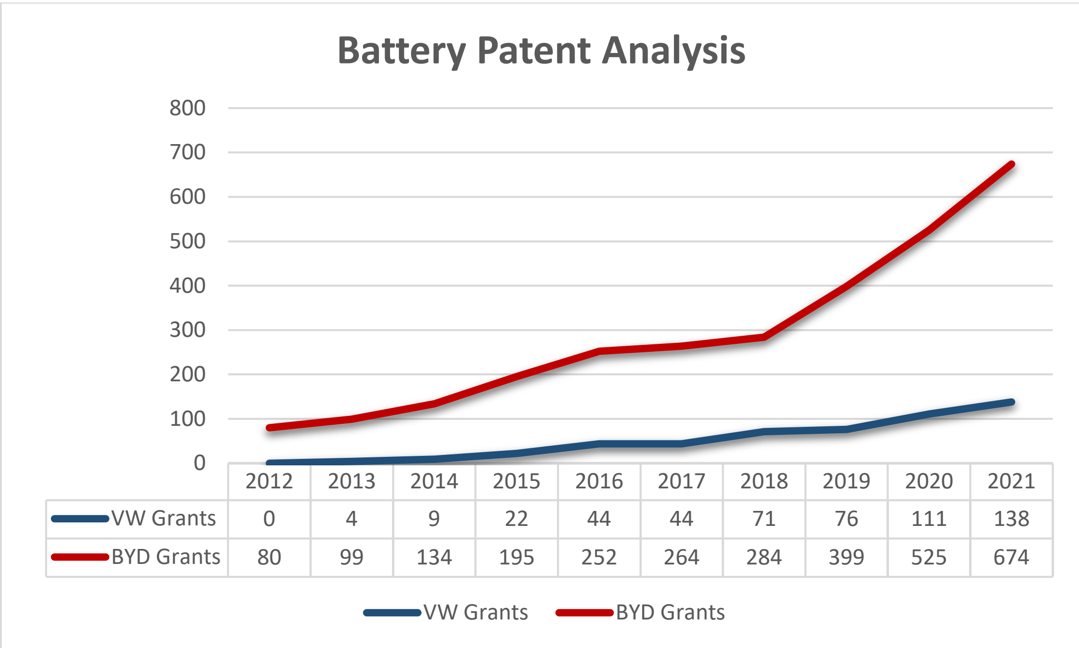

Figure 5-1: Battery Patent Analysis *(Source: made by author)*

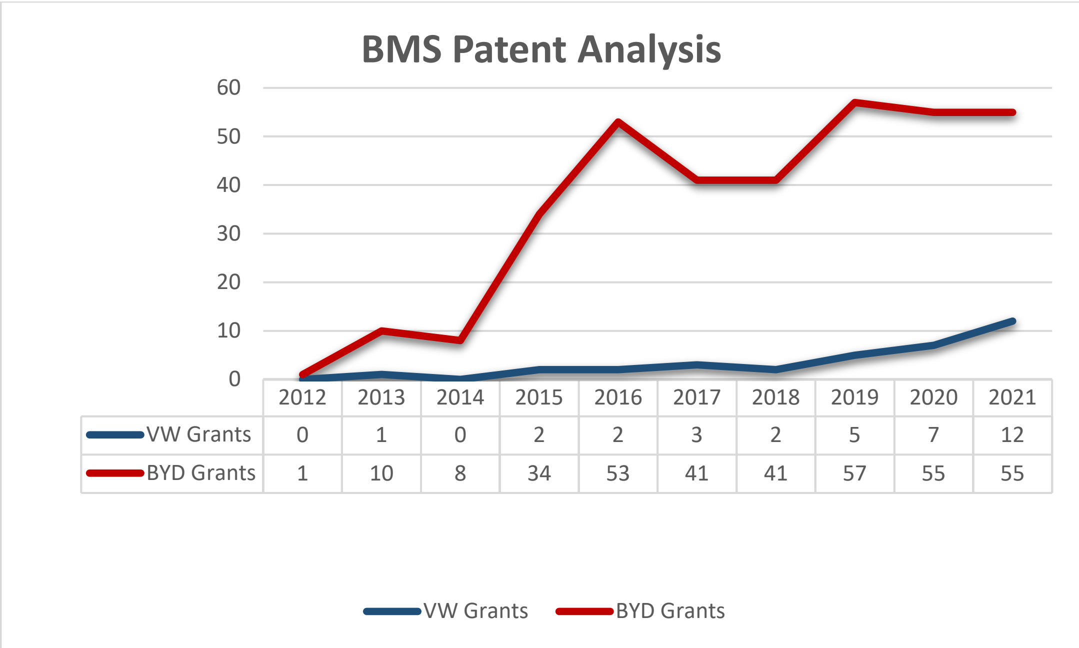

Figure 5-2: Battery Management System Patent Analysis *(Source: made by author)*

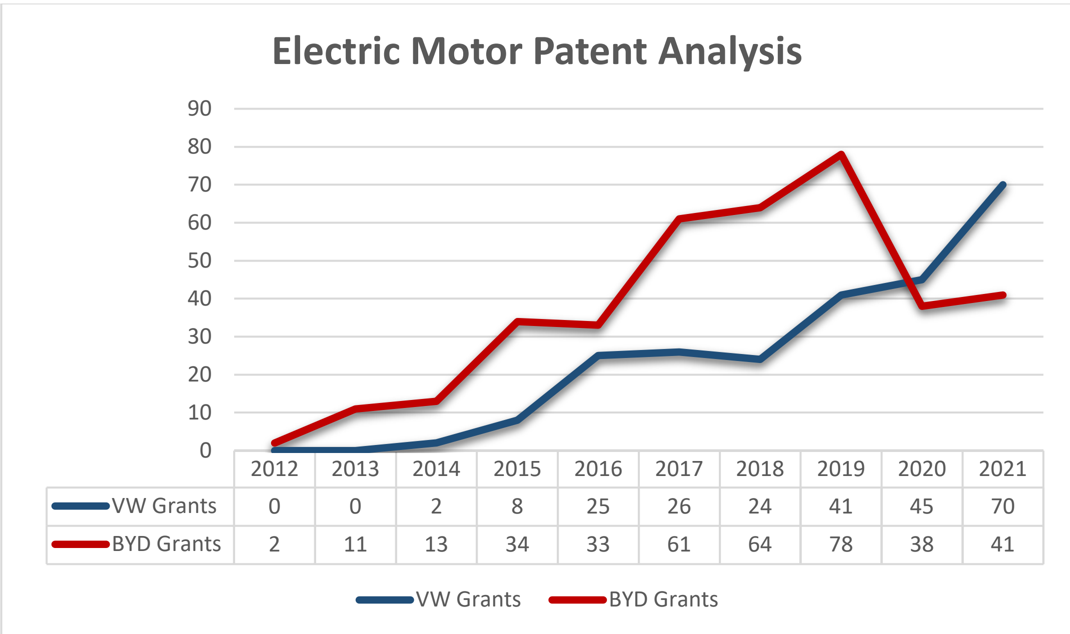

Figure 5-3: Electric Motor Patent Analysis *(Source: made by author)*

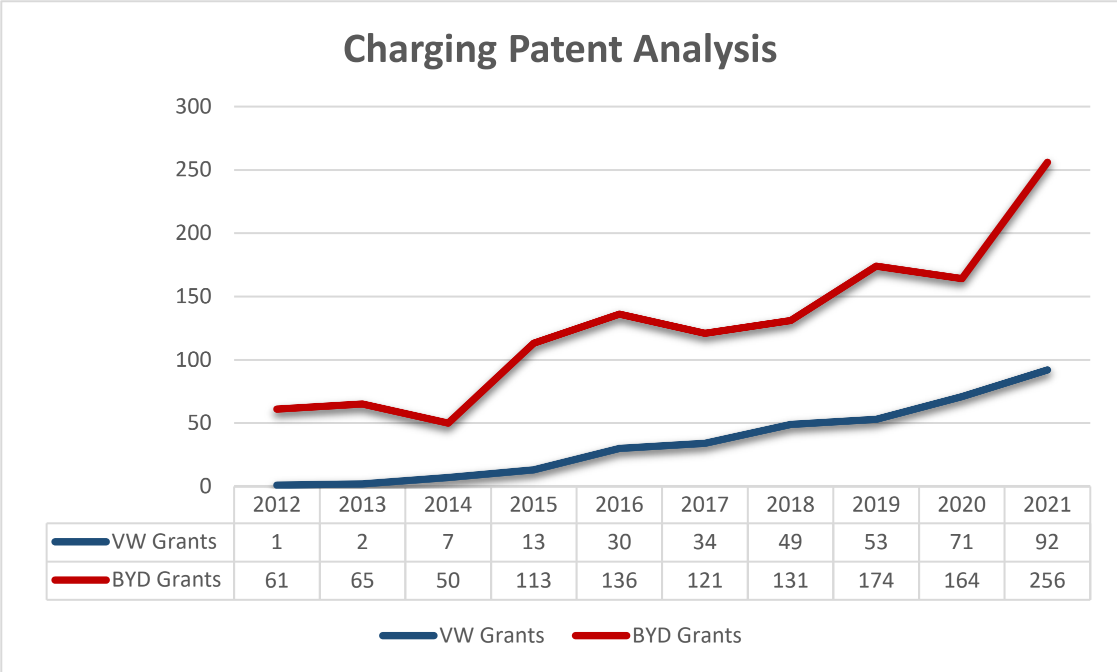

Figure 5-4: Charging Patent Analysis *(Source: made by author)*

However, Volkswagen unfortunately has no experience in producing the batteries which are the key components for building electric vehicles. To gain this new core technological competence, Volkswagen has adopted many approaches in recent years.

5.1.1. Merger and Acquisition

In 2021, Volkswagen has found an important partner to match future demand for batteries in China. By signing binding agreements, Volkswagen (China) Investment Co. Ltd. became the largest shareholder in Gotion High-Tech Co., Ltd., with 26% of shares, which is a major battery supplier in China. This partnership is considered a unique opportunity for VW to obtain deeper know-how in the future strategic area of batteries and begin to insource battery cell production instead of outsourcing. Gotion is in the process of becoming a certified Volkswagen Group battery supplier in China, including supplies for local MEB vehicles. Mr. Shao Cheng, a product manager at Volkswagen China, said in the interview:

> *"Currently we still have to purchase the battery cells from the suppliers, we don't have the capability to produce battery cells or battery systems, but we are cooperating with suppliers like CATL and Gotion in order to get batteries and develop the technology. CATL is our main battery supplier; and we are working with Gotion to build a battery system factory. In the future we can buy battery cells and then assemble them into battery packs on our own and supply these battery packs to our Joint Venture (VW Anhui) for producing the EVs."*

His information has been confirmed in a press release from Volkswagen AG, according to it, Volkswagen Group China has already begun construction in Hefei, Anhui Province of the first battery system production plant to be wholly owned by VW which will provide battery systems for EVs produced at Volkswagen Anhui (Volkswagen, 2021). Mr. Zhang Yu, who is a product master trainer in Volkswagen Academy disclosed during the interview:

> *"Battery technology is our weakness as a core technology for EVs. We are still using other companies' batteries, such as CATL, LG. We'd better have this technology in house and produce them ourselves. That's why VW is building the battery system factory, by doing that, firstly, we can reduce cost, secondly, we can integrate the whole industry eco-system."*

Actually, "bring the new core technology in-house" is a comment often heard in the interviews conducted with the employees of Volkswagen China.

5.1.2. Organizational Changes

Apart from integrating external competences to prepare VW for a rapidly changing environment as illustrated in the last paragraph, internally there are also many changes. Dr. Gu Gongyao is a director in charge of Volkswagen's Innovation Center Asia, when interviewed by the author, he introduced the Innovation Center Asia as well as the changes in his daily work and organization since VW started accelerating the electrification:

"My department is very simple to describe, we are responsible for R&D's 'R' part. We conduct research on many different technologies, including batteries, autonomous driving technologies, materials etc. Since we don't belong to 'D', we don't actually develop the products for mass production, we mainly focus on technology research and the technological knowledge base for the whole group.

From our department's view, before 2017 or 2018, the battery related topics were more likely to be in the research phase, so our department had been involved or responsible for many of these types of projects. In the meantime, to accelerate the transition towards EVs, within the group, many new organizations have been founded, even a new battery company has been built in Germany - PowerCo. Many projects that we did before have been handed over or transferred to "D". For a quicker shift to EVs, recently many "D" departments have been founded. So, from my standpoint, there are fewer and fewer battery related projects for my department. But this is a good sign, because it means our company's battery related technology has already gone from 'R' to 'D', making it closer to mass production."

Furthermore, under each brand (VW, Audi, Porsche, Skoda, SEAT etc.) there is a newly created department for electrification. For example, in Beijing, C-EN department has been newly created and dedicated to EVs, and covers technologies ranging from battery cell level to whole vehicle level. Meanwhile, in Volkswagen AG headquarters (Wolfsburg), the group created CoE (Center of Excellence), that does research and development of battery technologies from cell level to system level. According to the latest news, a battery company called “PowerCo” has been created (above mentioned). The company is bundling all of the battery activities including development, planning, production management and cell manufacturing (Volkswagen, 2022). In the future, battery products will not only be used in VW’s cars, but also will be sold to other OEMs. We can see these are all organizational changes meant to form a strategic competitive advantage, step by step.

The analyses (Figure 5-1 to Figure 5-4) show that EV related key technologies’ patent number has increased exponentially from 2017, this is consistent with the timeline given by Dr. Gu. The research efforts focused on EV technologies and organizational changes seem to pay off in terms of patent quantity.

5.1.3. Human Resource Changes

People are at the core of shaping the future of a company and an industry, in accordance with the technological focus change towards EVs, Volkswagen China’s recruiting positions have been more and more related to the EV business. Its recruiting team has been fueling their capacity in hiring a talented and digitally minded workforce that can help VW in reaching the company’s transformation targets. By examining the current recruiting positions (572 positions) posted by Volkswagen in China, the author found that there is a significantly low number of positions for conventional vehicle technology, instead, most of the open positions include EV technology-related skills like battery and software engineer positions. Figure 5-5 shows a comparison between the number of EV technology-related positions and ICE technology-related positions. After examining the 572 hiring positions, the non-technologic jobs e.g., HR, Legal, Administration etc. are excluded since they are not the focus of the research topic. Figure 5-6 shows an example of VW's recruitment

page.

EV technical-related position	**ICE technical-related position**
503	32

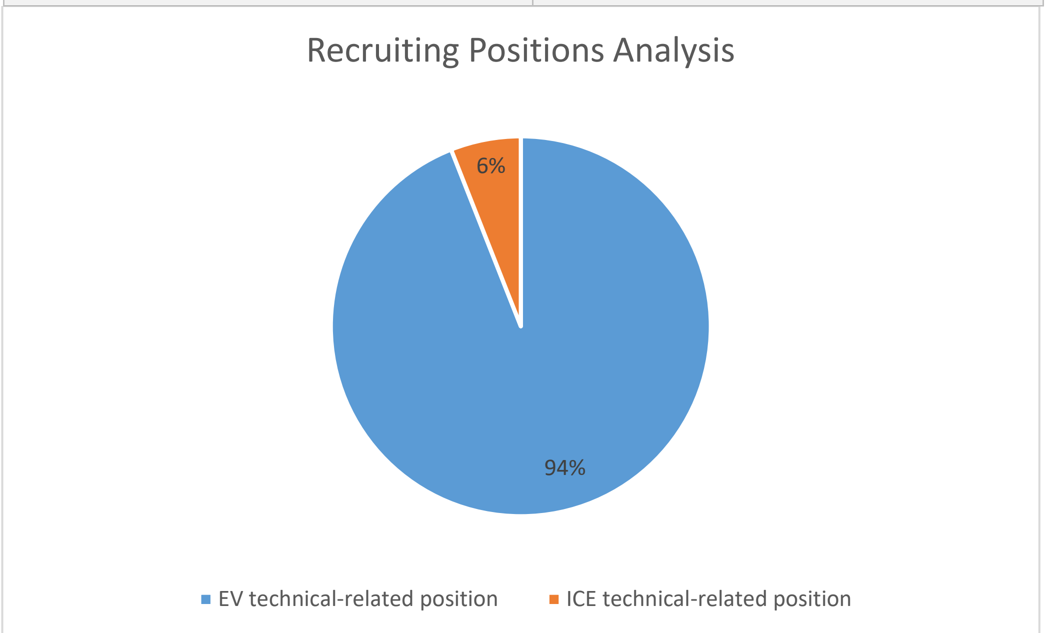

Figure 5-5: Job Openings Comparison *(Source: made by author)*

Results **191 – 200** of **572**   « 16 17 18 19 20 21 22 23 24 25 »

Title	Job Function	City
Project Lead PPE Drive (MVK)	R&D	Beijing
Battery Development Software	R&D	Beijing
Engineer Battery Cell Module	R&D	Beijing
Navigation Development Engineer	R&D	Beijing
Shanghai - ADAP Computation Software (43001756)	R&D	Shanghai
CI/CD Operations and Cloud Security Management	IT	Beijing
Medical support	Administrative/Secretary	Beijing
Technical Calibration MEB	R&D	Hefei
Beijing _ Purchasing SSP Platform Sourcing Interio _ 43003620	Purchasing	Beijing
Beijing - Automated Parking Systems (43001794)	R&D	Beijing

Figure 5-6. Open Positions Information Example *(Source: Volkswagen China recruiting center internal system)*

Interview has been indeed is a superb and appropriate method of investigation to gain insight for this research. Mr. Xie Ying is an HR manager at Volkswagen China, he responded to a request asking for the past 5 years hiring data in order to obtain a more detailed comparison:

"The data cannot be disclosed by me. Because firstly, I had not been directly responsible for recruiting before I came to Hefei, so I'm not in possession of such data; secondly, I believe this kind of data is of the sensitive nature, thus I am not sure if anyone would be able to share it for your research purpose. But what I can share with you is what I have been experiencing and doing in the recent months, I have been responsible for recruiting since I came here. I have a very busy schedule because I need to meet candidates every day, and many of them have

been working for established Chinese tech companies such as Alibaba, Tencent, Baidu and so on. The digitalization is one of the most important future directions for Volkswagen, consequently, local software talents are the key to enhancing the R&D strength of Volkswagen China and even the entire group."

As with the battery, software, a crucial technology of an EV, can also be classified as competence-destroying change. Volkswagen China is also devoted to proactively developing workforce competencies to meet rapidly changing technological demands. The digital and electric transformation of the automobile industry requires them to strengthen competencies related to information technology, battery and software which had not been ordinary capabilities before. Using internal and external sources, "Strategic Competence Management" is of the utmost importance to Volkswagen. Mr. Xie continued the interview with:

"I believe through discovering and cultivating qualified talents, and the good foundation laid out so far, we are able to establish a more solid ground for our strategy by further strengthening the competence and know-how of our talents in this area, which will definitely bring more innovations in the future."

5.2. What Volkswagen has been learning from China

2022 remarks the 50th anniversary of diplomatic relations between China and Germany, in the past 50 years the two countries have cooperated in economy, science and technology bringing mutual benefits to people in both countries. The longstanding cooperation in the automotive industry is particularly emblematic of this relationship, this dissertation took the chance to review the German car company's investment in

China to understand the value generated by the half-century of cooperation. As mentioned earlier, Volkswagen was the first German car company that started operating in China back in the 1980s', since then Volkswagen has always been deemed as a technology leader and a "teacher" in the Chinese automobile industry. VW's first product sold in China was Santana, it was a car model that had almost been obsolete in Germany at the time. However, this car model was very successful in China because it had big technological advantages over its competitors and the model remains present in the Chinese market until now, albeit in an advanced form. Mr. Li Hualong, an engineer leading a team that develops engines from VW's R&D division talked about the importance of Volkswagen to the Chinese automobile industry:

> *"In China, the automobile industry has already been developing for more than 30 years. With the help of Volkswagen, many Chinese local component suppliers have already developed very well. In this regard, Volkswagen indeed helped and taught a lot to the Chinese automotive industry. Volkswagen China not only has partnerships with many established European and German component manufacturers in China, e.g. Bosch, Continental and Schaeffler, but also has partnerships with many Chinese local manufactures, especially in Zhejiang, Jiangsu and the Shanghai area. Even though most of them are tier two suppliers and have a very low profit margin from being VW's suppliers, they are still very happy and proud about it since they can enjoy many benefits by staying within VW's supplier base."*

5.2.1 Learning battery technology

Undoubtedly, Volkswagen has a comprehensive technological advantage over Chinese car makers in the traditional business, and their core competences including engine technology, transmission technology and mechanic technology etc. assured their considerable profit margins in the market. However, when it comes to EVs, the aforementioned core competences no longer guarantee the leading technology company position. As shown in Figure 2-2, VW's EV sales fall behind Chinese car makers like BYD. In the interviews, the author showed the patent trend analyses and also asked questions about interviewees' opinions toward BYD. The question asked was "By analyzing the number of patents involving EV key components filed by VW and BYD, I found that the patents filed by BYD are much more numerous than VW's. Do you think it means VW falls behind BYD in terms of EV technologies?" Here are some answers I got from the interviewees below:

a) *"Yes, I have to admit your patent analysis is correct, we do fall behind BYD when it comes to battery technology, especially high-voltage components and material. From battery cells to battery modules and battery systems, we are behind in almost every aspect."*
b) *"Yes, BYD was founded in the 90s, starting with a rechargeable battery business, and entered the EV business a very long time ago, so EV business has been their principal business for a long time. BYD's development has been very fast, especially in recent years. Their monthly EV sales as of September (2022) has already surpassed FAW-VW's total sales. It is a very historic moment."*

c) *"BYD is indeed selling like hot cakes in the Chinese market, their EV sales only have already surpassed many other brands' traditional car sales. The sales result is very impartial and unbiased. More customers choosing BYD shows their products are good. The company has been researching and developing battery technology for quite a long time, I admit they have made huge progress in terms of EV technology. But I cannot say BYD surpasses VW thoroughly, every manufacturer has its own advantages. What I want to say is, in order to judge a car as good or bad, there are many dimensions including safety, driving, human-machine interaction and so on. BYD has several advantages over VW, therefore we need to learn from them. But VW has even more advantages over them, for example, safety, driving experience and others. And many advantages are not able to be learned or imitated by these Chinese competitors in a short time."*

d) *"As mentioned earlier, our profit margin for EVs is very low. One of the reasons is that many key components that are used in VW EVs are purchased from external suppliers with comparatively high costs. For example, the battery is the most expensive part, so if we don't have this technology in-house, the cost cannot be decreased. Consequently, we reduced other parts' costs, and then a problem occurred: many ID. series (VW's EV product line) customers complained our interior materials are of low quality.*

One other weakness is software, as EVs are getting increasingly smart, strong software ability is needed urgently. As compared to the new Chinese EV makers and startups, we are behind them. BYD focused on EVs much earlier than us, so they have more advantages over us in this respect."

As learned from these sincere answers by the interviewees, we can see that Volkswagen already realized there is a technological gap between itself and BYD. And furthermore, all of the interviewees agreed that VW should learn from China. Dr. Stueckler Tobias is a team leader in the R&D division, responsible for developing E-Drive system for MEB platform products, said in the interview:

> *"I think what we learned is that the market in China is growing rapidly. As you said VW has been the market leader, there is an old saying in Germany: 'It is not easy to reach the top, but it is more difficult to stay at the top'. Since the competition in China is very strong, we need to learn from other OEMs. We need to learn from the market, learn about how to speed up the development, about the innovation of new products. What is also needed is to learn the battery, software and e-drive technologies as well as the infotainment system development. They are what we are learning and have learned."*

Here is another evidence to prove China is no longer a technological follower but also a strong technological hub for Volkswagen's EV offensive. In the past, the VW's R&D division in China carried less responsibilities and authority compared to their German counterpart. However, this kind of relationship is changing rapidly, and new corporate pattern is forming. Below is a conversation during the interview between Dr. Gu and the author as below.

The author: "I want to know what the role is for R&D in Germany and in China respectively? Is it that Germany assigns tasks and projects, and the R&D in China follows and does what is assigned from Germany and performs the localization?"

Dr. Gu: "In the past, we mostly followed this pattern. But now it is different, gradually shifting from "Germany leading" to "In China, for China" meaning technologies like battery, from cell level to system level, are all developed in China (localization). The old pattern was that Germany first launches a project or an idea, then China attempts to implement it according to its settings. Now the R&D is far more independent than before. Our C-EN department is getting bigger and bigger by the day."

The author: "Is this C-EN located in Beijing or Hefei (the capital city in Anhui Province, VW is building the battery system factory there)?"

Dr. Gu: "Good point, at first C-EN was located in Beijing wholly, now it is relocated to Hefei. And C-EN also has a branch in Gotion high-tech, and C-EN will continue expanding there. It is important to be noted, there is a plan to send German employees (from white-collar to blue-collar) to Hefei to study battery technology. Times have changed, Chinese engineers *don’t go to Germany to study advanced technologies anymore, but German engineers and workers come to China to learn.”*

Dr. Gu’s remarks show that VW has already started to learn core component techniques from its Chinese partners. And by looking into the company press release, it is found that with the help of Gotion High-tech, Volkswagen began to develop unified battery cells for its EVs. The unified cell concept refers to a prismatic cell format adaptable to available mixtures and compatible to all major upcoming innovations in both product and production technology. Furthermore, Gotion High-tech has been supporting VW in building a battery plant in Germany (Volkswagen, 2021).

5.2.2 Learning Software Technology

Apart from battery, software is another weakness for VW’s EV development, according to the previous interview. Though VW had founded a standalone software company called “CARIAD”, they still have struggled to develop its own new core technologies such as operating system for its electric vehicles and automated driving system etc. According to Mr. Xu Xiaoxiao who is a manager responsible for Marketing Intelligence at Volkswagen Group China “*VW cannot even realize OTA (over-the-air) system updates for now, this is a very big disadvantage in the current market situation*”. The reason why Mr. Xu said this, is that China has already developed into one of the world’s leading markets for intelligent vehicle technologies. In no other country is the level of innovation and implementation of Advanced Driver Assistance System (ADAS) / Autonomous

Driving (AD) solutions as advanced as in China. This is also why Volkswagen AG has announced it is strengthening its development competence and competitiveness 'in China, for China' as part of NEW AUTO strategy (See Table 4-3). In addition to building up its own development capacities, Volkswagen pursued local partnerships in China, via CARIAD, invested €2.4 billion in a collaboration with Horizon Robotics, a China-based global leader in edge artificial intelligence (AI) computing platforms for intelligent vehicles.

Mr. Sun Jie is one of the interviewees who works at CARIAD China as a vehicle system architect, he shared his opinion on the collaboration with Horizon Robotic:

> *"Horizon is a champion in the field of autonomous driving and advanced computer chips. The collaboration is a valuable chance to enhance our know-how while exploring new fields. I've been working on the CARAID-Horizon partnership as a system architect responsible for the technical evaluation of Horizon's technology and integration in the E3 architectures. I appreciate their courage in implementing new technologies, their sincerity and openness. Many discussions we had about autonomous driving were unfathomed fields and we fortunately had the opportunity to blaze the trails for others. I am confident that CARIAD China and Horizon will present the best Autonomous Driving and Parking function in China for China."*

The collaboration with Horizon is not just about investing and expanding the business scope, but also a method of learning new technologies and building new core competences. According to the interviews and corporate documents, a key goal for the Joint Venture is to create a high-tech semiconductor for China, a so-called System on a Chip (SoC), to drive forward the integration of numerous functions on a single chip (see Table 5-1 for further details).

Who is Horizon Robotics? ➢ Founded in 2015 in Beijing, Horizon Robotics has become a leading company in automotive-grade edge AI computing platforms for intelligent vehicles. ➢ Horizon Robotics employs circa 1,700 people, over 80% of whom work in engineering and R&D and, in 2021, it has shipped over one million chips. ➢ Local partnerships play a decisive role in building new capabilities and the Joint Venture with CARIAD will drive the development of VW's ADAS and AD technologies in China.
Why is 'System on a Chip' (SoC) technology so important for VW China business? ➢ Smart, intelligent driving enabled by advanced AI-based ADAS and AD systems is the key technology of future mobility and an area with high potential for market growth in China, especially through mass adoption after 2030, in which the speed of development is paramount. ➢ Through the partnership with Horizon Robotics, the creation of SoC technology for China will drive forward the integration of numerous functions on one chip, increasing the stability of the system, saving costs, and reducing energy consumption.

➢ SoC technology integrates numerous functions into a single integrated circuit and increases the stability of automated systems. ➢ Fully integrated software and hardware technology will offer differentiation and provide scalable as well as cost efficient ADAS/AD solutions for VW's BEV models in China.

Table 5-1: Detailed Information about Horizon Robotics *(Source: VW's cooperate presentation)*

5.2.3 Diversified Market and Development Cycle Speed

Market knowledge and speed of product development circle are mentioned many times in the interviews. Mr. Zhang Yu, the product master trainer said in the interview:

> *"The number of customers in China is huge, hence the car application scenarios are very diversified, based on this diversified user database, the algorithms have been well developed, and already became the most advanced in the world. So, odds are that most advanced artificial intelligence technology will be developed in China. VW should take advantage of this good opportunity and study from the Chinese market as well as from the local high-tech companies."*

There are some differences between the Chinese market and the German market, first of all, the customers' average age in China is lower than in Germany. Therefore, they have different preferences towards cars and EVs. For example, VW's software disadvantage in the German market is not that obvious compared to China. The German customers' needs for functions like driving automation system, HMI (human machine interface) are not as strong as in China. Actually, European EV market development is slower than China and the U.S which are the world leading markets in terms of EVs. The competition in Europe is not very intensive, but China is very different.

Secondly, Chinese market itself is also very different than before. 20 years ago, Germany was much more advanced than China, German cars and vehicle functions were very advanced, so the cars quickly gathered adoration from Chinese customers. But now it is totally different, the Chinese younger generation (generation Z) have lived in a much better environment, they have experienced new things and technologies no later than their European contemporaries. Through the interviews, the author found all of the interviewees noticed and emphasized this. This is a good sign, because it means VW already started to review itself and the Chinese market, as well change their mindset.

Another finding is, VW is now reviewing its product development speed, because compared to Chinese competitors, the product development cycle seems too long. Almost every interviewee mentioned this point. Mr. Li Hualong told the author:

> *"Our product development cycle is too long. For traditional vehicles, we set a 5-year cycle, nowadays the technologies develop very fast, 5 years is obviously too long for EV standards. We need to change this, shorten the product development cycle. Compared to the new Chinese competitors, we are too conservative, and always want to play safe. Volkswagen is a huge company; the decision procedure is slow and few radical decisions can be made. This is partly due to the culture of the company; it will take time to*

change it. When you look at the new Chinese competitors, they are more daring and are more likely to take risks. This is our largest disadvantage in my opinion."

For reference, normally Chinese EV makers can develop a new product within 2.5 to 3 years. This is because within the electrification process, most Chinese EV start-ups stem from the internet age, but the established makers like Volkswagen and Toyota, they stem from the traditional industrial age. The new EV makers are leading the traditional car makers, in terms of them being from a more advanced age – the internet age, so they are able to launch top-down attacks at the established car makers. The product development cycle is really short in the internet industry, the EV startups use the internet thinking when producing cars, while the established car companies still tend to use stereotypes towards EVs. Sometimes it is very hard to say which way of thinking is better, we could say it reflects different attitudes to EVs. Dr. Stueckler shared his opinion:

"We need to shorten the R&D cycle, but not at the price of lowering our quality standards. The quality standard for EVs remains the same, even higher. I think the shortening of the research cycle should come from the research system itself. And we are studying how to do that."

Dr. Stueckler's words showed a very important fact, that as an established car company, VW already has complete internal processes and a very good QMS (Quality Management System) are core competences and a big advantage over the new players in the market. In summary, VW needs to learn something new from the Chinese market, but should not give up its own strengths.

5.3. Modular Platform MEB and Its Future

In early 2022, Volkswagen Anhui announced the completion of a body shop at its new MEB plant, which was a milestone in developing Volkswagen Anhui into one of Volkswagen global centers for e-mobility. In the finalization ceremony, Dr. Erwin Gabardi, CEO, Volkswagen Anhui, said, *"Volkswagen Anhui is crucial to the Group's success in a pure-electric and fully-connected future of mobility both in China and globally. We are well on track to build our MEB plant, strengthen R&D capabilities, grow the value chain and fill the talent pool*." According to internal news, the full-scale e-model factory will have a production capacity of about 350,000 vehicles per year, all of them will be based on the MEB platform.

All of the interviewees agreed that the modular platform has been one of Volkswagen's most important competitive advantages. The company is making use of group-wide synergies and relies on the modular platform in both development and production. As the MEB platform is designed to be highly versatile and scalable, by using it, VW Group can attract more customers. Since it is designed exclusively for electric drives, the MEB allows customers to experience all the advantages that compact electric motors and lithium-ion batteries in different sizes and capacities offer. The battery systems, electric motors and axle designs form a stringent technology toolkit.

Some may argue that since all EVs come from one common platform, there must be a lack of diversity. Mr. Zhang Yu explained:

> *"Regarding the diversity of the modular platform, by using it, the R&D cost will reduce, the common parts will be around 60% to 80% of the final product. So,*

customers may ask if the increase in common parts means lower diversity and customization. But I would say these two things are not contradictory, and even can help each other. Because when your common part rate is higher, then you have more energy and resources to put your focus on customers' other needs like customization and diversities, and improve the product."

Indeed, MEB can massively reduce the cost all the while providing sufficient diversity to different targeted customers. As currently all of VW's EVs come from MEB, its importance is clear to Volkswagen Group. In 2022, Ford signed an agreement with Volkswagen, in which Ford plans to use MEB electric vehicle architecture to design and produce 600,000 vehicles, and Volkswagen will supply MEB parts and components to Ford (Volkswagen, 2022). This is obvious evidence that the modular platform strategy is very successful and it is a competitive advantage of VW. To maintain this modular strategy, VW is still making efforts on the modular platform strategy. Mr. Shao Cheng, the product manager of Volkswagen disclosed in the interview：

"Now all EVs of VW and Audi are using the MEB platform, in 2025 Audi will use the PPE platform. In the long run, VW will use the SSP platform. The SSP is like the MEB, it can produce a wide range from small cars to large cars. But SSP's big advantage over MEB is the level of electrification, the electronic architecture is a large upgrade from MEB. Only when the electronic architecture is upgraded, many other advanced, fancy functions and technologies can be realized, such as Autonomous driving. In MEB platform, the ability of electrification is limited, it cannot fully meet these needs."

PPE stands for Premium Platform Electric, which is jointly developed by Audi and Porsche. SSP (Scalable Systems Platform), represents the next generation of all-electric, fully-digital and highly-scalable mechatronics platform after MEB and PPE. The SSP initiative is one of the crucial technological initiatives in Volkswagen's strategy. With this, VW can control most of the BEV value chain in China via a multi-brand business model ensured by technological competitiveness with increased local development scopes, cost competitiveness via reduction of complexity and value capturing by tapping into new profit tools. This can be found in Volkswagen Group's New Auto Strategy, which acts as a roadmap and top management vision in guiding the company.

Figure 5-7 shows the current factories operated by Volkswagen in China, from it, we can learn that most of them are already transformed into EV business or in transformation. Some plants are still producing engines and gearboxes which are still the core business of VW.

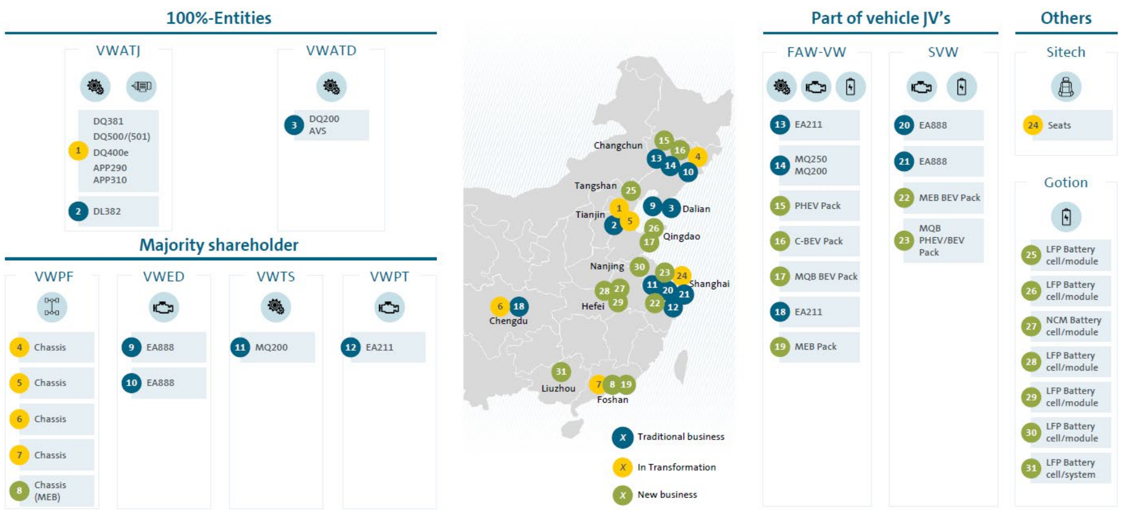

Figure 5-7. Information about plants and their Transformation towards EVs. *(Source: VW corporate presentation)*

Chapter 6. CONCLUSIONS & IMPLICATIONS

This research aims to investigate how the technological competences of an established car company – Volkswagen have been changing and how Volkswagen has been preparing itself for the shift from conventional vehicle era to the electric vehicle era, specifically within China, since there are a great deal of industry disruptors and competitions that drive the electrification process very quickly compared to other regions. According to Prahalad and Hamel (1990)'s core competence theory, competence-destroying change concept and Miyazaki (1995)'s competence-building concept and research findings, the conceptual framework was built for investigating the three research questions: 1. How have the technological competences in Volkswagen China changed in order to shift from traditional vehicles to electric vehicles? 2. As an established automotive maker from a developed country, what has Volkswagen learned from the newly industrialized country – China? 3. How does VW manage the EV common modular platform (MEB) strategically? Based on the conceptual framework, a top management strategy can affect a company's future direction by making critical decisions e.g., M&A and organizational changes, and it is perceived as a strong source of a push in a company's competence change and building. And as stated earlier, since the strategic partners are from China, and China's EV industry has been growing fast, there are many talents and resources that can help VW develop EV technologies, hence there should be a possibility that VW can learn something from this developing country. Utilizing a qualitative methodology, the author conducted interviews with eight experienced employees of Volkswagen Group China who are all participating in this transformation and they gave a lot of insightful information as insiders. The data from the interviews was also triangulated with other sources of evidence from patent analysis, corporate presentation, published articles, books and so on. The findings have responded to the three research questions appropriately.

6.1 Main Findings

6.1.1 Battery and Software Related Technologies Are the Most Important New Technological Competences for Volkswagen

Volkswagen set a strategic target to reach the market leader position in EVs. Battery technology and software are the most crucial technologies to achieve the goal, which are considered competence-destroying technologies for Volkswagen, meaning their previous core competences hardly helped them obtain and develop these two crucial core technologies immediately. To combat the difficulties caused by the industrial transformation, in China, VW adopted a set of approaches and manages to cultivate the new core competences strategically.

The company started with purchasing batteries from external suppliers, including CATL which is the world's largest battery supplier. Considering the importance of batteries, VW has no intention to keep them outsourced endlessly. Volkswagen's R&D started researching battery related technologies several years ago, thanks to those previous efforts, many projects had already transformed from "R" (refers to Researching) department to "D" (refers to Development) department. We could see evidence of the change from the interviews and the increase in patent numbers analyzed by the author. Furthermore, Volkswagen searched for a strategic partner to help them develop battery technology. The Chinese battery manufacturer Gotion

High-tech became VW's first important strategic partner for developing battery technology. By acquiring a 26% stake of Gotion High-tech, VW now is the largest stakeholder of the company, the new investment can intensify VW's already ongoing electrification strategy. And with the partnership, Volkswagen is able to achieve deeper Know-How in the future strategic field of batteries as well as insource battery cell production.

Apart from battery, software has proven to be another crucial technology for future business of VW after conducting the research. Because in the EV era, EV is not simply considered as a vehicle with a new type of power source – electricity other than gasoline. Instead, with the development of the internet and information technology, the auto industry is also undergoing a period of rapid transformation toward intelligence and digitalization, adding advanced functions to EVs. This is why within the NEW AUTO STRATEGY, Volkswagen aims to transform itself from a traditional manufacturer to a software-driven mobility tech company. This point was also talked about by the interviewees. But likewise with the situation in battery technology, VW also didn't have an existing capability of developing software. VW has made the best possible use of resources, thus a new software company – CARIAD has been founded within Volkswagen Group. In the middle of 2022, Volkswagen Group invested in a Chinese autonomous driving technology company – Horizon Robotics via CARIAD's China subsidiary in order to make the best possible use of this innovation dynamic - and thus also to strengthen its competitiveness. The partnership aims to accelerate the software product development for Chinese local consumers, including ADAS and automated driving, next-generation connectivity functions, intelligent cockpit and body design, big data and software operating systems. These above-mentioned elements had already been discussed in the previous interviews, some of them are weaknesses that need to be improved by Volkswagen, and others are the very core technologies that can be game-changers in the future automobile industry.

6.1.2 **Top Management Strategy and Vision**

The idea of all these initiatives can be traced back to VW's top management strategy and vision. The Volkswagen Group has rolled out its "NEW AUTO 2030 strategy" (reference to Table 4-3) as the blueprint to transform itself from a traditional vehicle manufacturer into a leading software-driven mobility-tech company. For China, with concrete strategic initiatives. Its local adaption of this strategic framework puts Volkswagen on track to actively shape a market driven by electric vehicles, autonomous driving and smart car capabilities.

Furthermore, China region plays an increasingly important role for the whole VW Group. We can see that VW is strengthening tech capabilities and competitiveness by focusing more consistently on the development in China for China concept, this is a reflect of VW's top management strategy.

6.1.3 **Lessons Learned from China**

This research found that Volkswagen, as an established car company, no longer has a thorough technological competitiveness and advantage over the Chinese car companies in the field of EVs. This is related to the second research question, RQ2:

As an established automotive maker from a developed country, what has Volkswagen learned from the newly industrialized country-China?

After conducting the research, two aspects can be identified: First, technological learning. Second, market knowledge learning. Within the first aspect, the key technologies, battery and software for EVs, are just the capabilities that Volkswagen has been in need of or has been learning from China. These aspects are evident from examining the organizational changes and partnerships with Chinese companies, as well as from the interviews conducted. Furthermore, shortening the product development cycle is another takeaway from the Chinese market environment. Regarding the market knowledge aspect, it can be concluded that China automobile industry and market have developed very rapidly especially in the area of EVs in recent years. China is no longer simply a follower or student to car companies from developed countries, instead, China is becoming a pioneer for EVs. From the interviews, almost all the interviewees mentioned that Volkswagen needs to change its mindset towards China market. Established car companies need to look past the stereotype, because EV competition is very strong in China, which drives the market and the industry development at an extremely fast rate. We could see it from the market analysis at the beginning of this report, and the interviews also reflect this change.

6.1.4 MEB and Its Future

MEB as a modular form of producing electric vehicles of Volkswagen, it is extremely important at the moment and for the future. Currently, all of Volkswagen's and its premium brand's, Audi, EV models are built on this modular platform. This platform will be further developed and upgraded, as a modular platform called SSP (Scalable System Platform), a platform that stems from MEB, however a more advanced one in terms of the level of mechatronics, is currently under research. By adopting this new modular platform, VW can significantly enhance competitiveness while reducing costs, because it can consolidate all of the existing various platforms into one architecture for its entire future production.

If battery and software related technologies are the competence-destroying technologies for Volkswagen, then the modular platform is the core competence of Volkswagen that needs to be enhanced continuously. Because of the importance of this modular platform, within the top management strategy, namely NEW AUTO 2030 strategy, the concept of SSP has been introduced. The strategy acts as a blueprint which serves to transform Volkswagen from a traditional vehicle manufacturer into a so called "software-driven mobility-tech company". In China, it has complemented the strategy with concrete strategic initiatives. The local adaption of this strategic framework puts Volkswagen on track.

6.2 Implications

This research focuses on the current state of the automobile industry, in which the environment has been rapidly and vastly changing in EVs. By shedding light on an established car company – Volkswagen, especially within the context of the setting in China, this research aims to provide a fresh and contemporary insight into how EV transformation affects the car company and how it prepares itself for the upcoming

EV era through the case study. The research is based on theoretical concepts of core competence, competence-building, competence-destroying technologies. Hence this report contributes to the literature by showing first hand evidence and a real case, as well as by deepening the understanding of related concepts and theories.

Also, this study confirmed Miyazaki (1995)'s finding – developing core competences in-house is a necessity for a company. Volkswagen's actions such as the founding of a battery company and building battery system factories are all evidence that support the abovementioned finding. In VW's case, battery technology is not only a nice-to-have new core technology, but a must-have, which is the reason why they are putting so much effort to have it in-house.

Furthermore, this research also uncovered that Volkswagen has been learning from China. Consequently, the relationship between Volkswagen Headquarters in Germany and Volkswagen China has changed, it has not been completely following a top-down model, as VW China has been carrying more and more responsibilities and authority.

Last but not least, this research has managerial implications for stakeholders in the automobile industry. Comparing with BYD's pattern, VW manages to gain the new competences through a lot of active and passive actions, and some good outcomes have been seen, though it is still early to say whether VW can surpass BYD at the current stage. The EV is the prospective direction of the future of the automobile industry, and China acts as a pioneer with a faster pace than other countries, therefore a case study from China can be a high-quality reference to many industry stakeholders.

6.3 Limitations and Future Research

There are two limitations in this research. First, the research only focuses on one car company, meaning the strategies that Volkswagen adopted may not be universal. Second, since the electrification process is still on-going and rapidly developing, there are still many uncertainties in the automobile industry, therefore we cannot get a solid conclusion if VW's approaches are successful or not. We can only present its electrification process in an unbiased way.

Future research could be widened to include further research targets such as other car companies within China or different companies in different countries. Since not all established companies have the same opinion or mindset towards EVs, the future research could be focused on another company. For example, the CEO of Toyota, Aoki Toyoda explained his opinions of EVs on several occasions. As indicated by Mr. Toyoda, his company may not adopt the same approach and may in fact follow a completely different one for the future of the automobile industry.

References

Aaldering, L. J., Leker, J., & Song, C. H. (2019). Competition or collaboration? Analysis of technological knowledge ecosystem within the field of alternative powertrain systems: A patent-based approach. Journal of Cleaner Production, 212, 362–371. https://doi.org/10.1016/j.jclepro.2018.12.047

Ahsan, M., Ozer, M., & Alakent, E. (2010). Incumbents Adaptation to Competence-Destroying Change: Role of Prior Experience and Knowledge Sourcing. *Journal of Managerial Issues*, 22(4), 456–475.

Ashok, B., Kannan, C., Mason, B., Ashok, S. D., Indragandhi, V., Patel, D., Wagh, A. S., Jain, A., & Kavitha, C. (2022). Towards Safer and Smarter Design for Lithium-Ion-Battery-Powered Electric Vehicles: A Comprehensive Review on Control Strategy Architecture of Battery Management System. *Energies (19961073)*, 15(12), 4227. https://doi.org/10.3390/en15124227

Babin A, Rizoug N, Mesbahi T, Boscher D, Hamdoun Z, Larouci C. Total Cost of Ownership Improvement of Commercial Electric Vehicles Using Battery Sizing and Intelligent Charge Method. *IEEE Transactions on Industry Applications*. 2018;54(2):1691-1700. doi:10.1109/TIA.2017.2784351

Berjoza, D., Pirs, V., & Jurgena, I. (2019). Possibilities to identify defective electric automobile batteries. *Agronomy Research*, 17((S1)), 935–944. https://doi.org/10.15159/AR.19.078

Bogers, M., Chesbrough, H., Heaton, S., & Teece, D. J. (2019). Strategic Management of Open Innovation: A Dynamic Capabilities Perspective. *California Management Review*, 62(1), 77–94. https://doi.org/10.1177/0008125619885150

Borgstedt, P., Neyer, B., & Schewe, G. (2017). Paving the road to electric vehicles – A patent analysis of the automotive supply industry. *Journal of Cleaner Production*, 167, 75–87. https://doi.org/10.1016/j.jclepro.2017.08.161

BYD (2021). Annual report. https://www.bydglobal.com/sitesresources

Cabigiosu, A. (2022). Sustainable development and incumbents' open innovation strategies for a greener competence-destroying technology: The case of electric vehicles. (2022). *Business Strategy & the Environment*, 31(5), 2315–2336. https://doi.org/10.1002/bse.3023

Cârstea, V. (2022). Are the Electric Vehicles the Solution for Sustainable Transportation? *Romanian Economic & Business Review*, 17(2), 7–15.

China Automotive News. (2022). Retrieved from http://www.cnautonews.com/houshichang/2022/09/13/detail_20220913352818.html [Access on 21.09.22]

China Passenger Car Association (2022). Retrieved from https://www.jiemian.com/article/7881089.html [Access on 21.09.22]

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and Learning: The Two Faces of R & D. *Economic Journal*, 99(397), 569–596. https://doi.org/10.2307/2233763

Delucchi, M. A., Yang, C., Burke, A. F., Ogden, J. M., Kurani, K., Kessler, J., & Sperling, D. (2014). An Assessment of Electric Vehicles: Technology, Infrastructure Requirements, Greenhouse-gas Emissions, Petroleum Use, Material Use, Lifetime Cost, Consumer Acceptance and Policy Initiatives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical & Engineering Sciences*, 372(2006), 1–27. https://doi.org/10.1098/rsta.2012.0325

de Santiago, J., Bernhoff, H., Ekerg, rd, B., Eriksson, S., Ferhatovic, S., Waters, R., & Leijon, M. (2012). Electrical Motor Drivelines in Commercial All-Electric Vehicles: A Review. *IEEE Transactions on Vehicular Technology,* 61(2), 475–484. https://doi.org/10.1109/TVT.2011.2177873

EPO. (2022). Retrieved from https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families.html [Access on 17.09.22]

Frank, C., Holsten, L., Şahin, T., Vietor, T., (2022). How to manage vehicle platform variants? A method to assess platform variance through competitive analysis. *Procedia CIRP*, 19, *598-693. https://doi.org/10.1016/j.procir.2022.05.300*.

Gong, L., Xiao, C., Cao, B., & Zhou, Y. (2018). Adaptive Smart Control Method for Electric Vehicle Wireless Charging System. Energies, 11(10), 2685. https://doi.org/10.3390/en11102685

Goodpress (2022, September 23). 日本導入が待ち遠しい！ VW のピュア EV ミニバン「ID.BUZZ」に「VW タイプ 2」のワクワク感を見た. https://www.goodspress.jp/reports/478205/

Günther, H.-O., Kannegiesser, M., & Autenrieb, N. (2015). The role of electric vehicles for supply chain sustainability in the automotive industry. *Journal of Cleaner Production*, 90, 220–233. https://doi.org/10.1016/j.jclepro.2014.11.058

Harrison, D., Ludwig, C. (2021). . Electric vehicle battery supply chain analysis 2021: How lithium-ion battery demand and production are reshaping the automotive industry. https://www.automotivemanufacturingsolutions.com/ev-battery-production/electric-vehicle-battery-supply-chain-analysis-2021-how-lithium-ion-battery-demand-and-production-are-reshaping-the-automotive-industry/41938.article [Access on 21.09.22]

Hamel, G., & Prahalad, C. K. (1994). Competing to Shape the Future. In Competing for the Future (pp. 177–196)

Hatch, N. W. (2001). Design Rules, Volume 1: The Power of Modularity. *Academy of Management Review*, 26(1), 130–134. https://doi.org/10.5465/AMR.2001.4011995

Hsieh, I.-Y. L., Pan, M. S., & Green, W. H. (2020). Transition to Electric Vehicles in China: Implications for Private Motorization Rate and Battery Market. *Energy Policy*, 144.

Kay, N. M. (2018). Extending the dynamic capabilities framework: Pisano on choice, learning, and competition. *Industrial & Corporate Change, 27(6)*, 1159–1163. https://doi.org/10.1093/icc/dty045

Kim, J., Lee, C.-Y., & Cho, Y. (2016). Technological Diversification, Core-Technology Competence, and Firm Growth. *Research Policy*, 45(1), 113–124

Kueh, Y. Y. (1992). Foreign Investment and Economic Change in China. *The China Quarterly*, 131, 637–690. http://www.jstor.org/stable/654900

Lampón, J. F., Frigant, V., & Cabanelas, P. (2019). Determinants in the adoption of new automobile modular platforms: What lies behind their success? *Journal of Manufacturing Technology Management*, 30(4), 707–728. https://doi.org/10.1108/JMTM-07-2018-021

Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal*, *13*, 111–125. http://www.jstor.org/stable/2486355

Lichtenthaler, E. (2006). Using Technological Platforms for Corporate Diversification in Multinationals. *International Journal of Technology Intelligence and Planning*, 2(1)

Li, L., Guo, S., Cai, H., Wang, J., Zhang, J., & Ni, Y. (2020). Can China's BEV market sustain without government subsidies? An explanation using cues utilization theory. *Journal of Cleaner Production*, 272, N.PAG. https://doi.org/10.1016/j.jclepro.2020.122589

MacKenzie, A. (2022). 2022 Audi Q4 50 E-Tron Sportback. *Motor Trend*, 74(8), 18

Magna (2022). Hasco Magana eDrives Hit the Market on Volkswagen MEB Platform. https://www.magna.com/docs/default-source/2022-press-and-news-releases/magna-news-release_hasco-magna-edrive-volume-production_01-27-2022_final.pdf?sfvrsn=3810efed_2 [Access on 11.10.22]

McGrath, C., Palmgren, P. J., & Liljedahl, M. (2019). Twelve tips for conducting qualitative research interviews. *Medical Teacher*, 41(9), 1002–1006. https://doi.org/10.1080/0142159X.2018.1497149

Minesoft (2022). https://minesoft.com/patbase-express/ [Access on 17.09.22]

Miyazaki, K. (1995). *Building Competences in the Firm: Lesson from Japanese and European Optoelectronics*. St. Martin's Press London.

Miyazaki, K., & Giraldo, E. (2015). Innovation strategy and technological competence building to provide next generation network and services through convergence: the case of NTT in Japan. *Asian Journal of Technology Innovation* , 23, 74–92.

Morimoto, M. (2015), Which is the First Electric Vehicle? *Electrical Engineering in Japan*, 192, 31-38. https://doi.org/10.1002/eej.22550

Organization of the Petroleum Exporting Countries. (2022). Annual Report 2021. https://www.opec.org/opec_web/static_files_project/media/downloads/publications/AR%202021.pdf

Organisation Internationale des Constructeurs d'Automobiles. (2022). World Motor Vehicle Production Statistics 2021. https://www.oica.net/category/production-statistics/2021-statistics/

Panwar, N. G., Singh, S., Garg, A., Gupta, A. K., & Gao, L. (2021). Recent Advancements in Battery Management System for Li-Ion Batteries of Electric Vehicles: Future Role of Digital Twin, Cyber-Physical Systems, Battery

Swapping Technology, and Nondestructive Testing. *Energy Technology*, 9(8), 1–17. https://doi.org/10.1002/ente.202000984

Pesiridis, A., Mahmoudzadeh Andwari, A., Esfahanian, V., Rajoo, S., & Martinez-Botas, R. (2017). A review of Battery Electric Vehicle technology and readiness levels. Renewable & Sustainable Energy Reviews, 78, 414–430. https://doi.org/10.1016/j.rser.2017.03.138

Pilkington, A., Dyerson, R., & Tissier, O. (2002). The electric vehicle: Patent data as indicators of technological development. *World Patent Information*, 24(1), 5. https://doi.org/10.1016/S0172-2190(01)00065-5

Pisano, G. P. (2017). Toward a Prescriptive Theory of Dynamic Capabilities: Connecting Strategic Choice, Learning, and Competition. *Industrial and Corporate Change, 26(5)*, 747–762. https://doi.org/https://academic.oup.com/icc/issue

Prahalad, C. K., & Hamel, G. (1990). The Core Competence of the Corporation. *Harvard Business Review*, 68(3), 79–91.

Prahalad, C. K., & Hamel, G. (2003). The Core Competence of the Corporation. In J. Kay (Ed.), *The economics of business strategy* (pp. 210–222). Elgar Reference Collection. International Library of Critical Writings in Economics, vol. 163.

Qiu, P., Nunes, B., Vaidya, K., van de Kaa, G., & Greeven, M. (2022). Technological capabilities development model in Chinese energy service companies. *Journal of Cleaner Production*, 330, N.PAG. https://doi.org/10.1016/j.jclepro.2021.129551

Reuters. (2003). Retrieved from https://jp.reuters.com/article/betterplace/update-3-electric-car-venture-better-place-files-to-liquidate-idUSL2N0E70FJ20130526

Riley, M., Wood, C.R., Clark, M. A, Wilkie, E., & Szivas. E. (2000). *Researching and Writing Dissertations in Business and Management*. Thomson London.

Scrosati, B., & Garche, J. (2010). Lithium batteries: Status, prospects and future. *Journal of Power Sources*, 195(9), 2419–2430. https://doi.org/10.1016/j.jpowsour.2009.11.048

Seo, W. (2022). A patent-based approach to identifying potential technology opportunities realizable from a firm’s internal capabilities. *Computers & Industrial Engineering*, 171, N.PAG. https://doi.org/10.1016/j.cie.2022.108395

Sperling, D. (2018). Electric vehicles: Approaching the tipping point. *Bulletin of the Atomic Scientists*, 74(1), 11–18. https://doi.org/10.1080/00963402.2017.1413055

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, 18(7), 509–533. http://www.jstor.org/stable/3088148

Teece, D. (2018). Tesla and the Reshaping of the Auto Industry. *Management and Organization Review*, 14(3), 501-512. doi:10.1017/mor.2018.3

Teece, D. (2019). China and the Reshaping of the Auto Industry: A Dynamic Capabilities Perspective. *Management and Organization Review*, 15(1), 177-199. doi:10.1017/mor.2019.4

Tushman, M. L., & Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly*, 31(3), 439–465. https://doi.org/10.2307/2392832

Van Biesebroeck, J. (2007). Complementarities in Automobile Production. *Journal of Applied Econometrics*, 22(7), 1315–1345.

Volkswagen AG. (2021). *Annual Report 2021*. Retrieved from https://www.volkswagen-newsroom.com/en/publications/corporate/annual-report-2021-835

Volkswagen Newsroom. (2019). Retrieved from https://www.volkswagen-newsroom.com/en/stories/is-lithium-replaceable-4808 [Access on 18.09.22]

Volkswagen Newsroom. (2021). Retrieved from https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-group-china-builds-battery-system-factory-in-anhui-to-strengthen-bev-value-chain-7509 [Access on 08.11.22]

Volkswagen Newsroom. (2021). Retrieved from https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-group-and-gotion-high-tech-team-up-to-industrialize-battery-cell-production-in-germany-7316 [Access on 12.11.22]

Volkswagen Newsroom. (2022). Retrieved from https://www.volkswagen-newsroom.com/en/press-releases/ground-breaking-in-salzgitter-volkswagen-enters-global-battery-business-with-powerco-8050

Volkswagen Newsroom. (2022). Retrieved from https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-and-ford-expand-collaboration-on-meb-electric-platform-7808

Wang, Y., Sperling, D., Tal, G., & Fang, H. (2017). China's Electric Car Surge. *Energy Policy*, 102, 486–490.

World Intellectual Property Organization. (2022). Retrieved from https://ipcpub.wipo.int/?notion=scheme&version=20220101&symbol=none&menulang=en&lang=en&viewmode=f&fipcpc=no&showdeleted=yes&indexes=no&headings=yes&notes=yes&direction=o2n&initial=A&cwid=none&tree=no&searchmode=smart [Access on 28.09.22]

Xinhua. (2021). Retrieved from http://www.xinhuanet.com/english/2021-03/18/c_139819934.htm [Access on 18.09.22]

Yin, R. K. (2009). *Case Study Research: Design and Methods*. Sage Publication.

Yuan, F., & Miyazaki, K. (2017). Trajectory Identification as Proxies for Discerning the Dynamic Nature of Technological Change - The Case of Electric Vehicles Industry. *International Journal of Innovation & Technology Management*, 14(1), 1. https://doi.org/10.1142/S0219877017400065

Zapata, C., & Nieuwenhuis, P. (2010). Exploring innovation in the automotive industry: new technologies for cleaner cars. *Journal of Cleaner Production*, 18(1), 14–20. https://doi.org/10.1016/j.jclepro.2009.09.009

Appendix 1

1. Please introduce your department functions and main tasks.
2. Do you feel any changes or differences in your work since VW accelerated electrification and what are they?
3. How has your organization/division evolved?
4. What kind of work activities is VW doing in China and Germany? In what ways will the work you are conducting be used?
5. Are there any important Chinese component makers or suppliers?
6. In your opinion, who are the main competitors?
7. How does VW develop its own key components technology?
8. Which parts or subsystems are the most important for EVs?
9. What kinds of new techniques does VW need for EVs, and how to obtain them?
10. By analyzing the number of EV key component patents from VW and BYD, I found that the patents filed by BYD are much more numerous than VW's. Do you think it means VW falls behind BYD in terms of EV technologies?
11. BYD is selling a lot more EVs than VW, do you think it is due to the products themselves or other reasons? What is it that the competitors do better?
12. In your opinion, what are the strengths of VW in producing traditional vehicles? When it comes to EVs, are these strengths still important or helpful?
13. What kinds of weaknesses do you think affect VW's EV production? How best to conquer them or improve?
14. Can you elaborate the importance of MEB? What is the long-term plan for MEB?
15. What do you think of the new group strategy (NEW AUTO STARTEGY)? How does it impact your daily work?
16. Has VW been learning anything from China?
17. Is the partnership with Horizon Robotics a crucial step?

Appendix 2

Critical events	Organizational features	Role of other agents
		1978 - The Chinese government identifies and chooses Volkswagen as a partner.
1983 - VW's first "made in China" product – Santana rolls out	**1983 -** The joint venture agreement for Shanghai Volkswagen Automotive Co. (today: SAIC VOLKSWAGEN) is signed in Shanghai	
1991 - FAW-VW is established as VW's the second joint venture. The first Jetta is assembled in FAW factory.		
2016 - Volkswagen announces a family of 10 electric vehicles to the Chinese market between 2020 and2025	**2016 -** New organization model implements in all product lines, G4 - an electric-only created	
2016 - Volkswagen AG and Anhui Jianghuai Automobile Co., Ltd. (JAC) sign a Memorandum of Understanding in Wolfsburg, to determine the next phase of negotiations between the two companies in order to achieve long-term cooperation in the joint development of EVs in China		
2017 - VW and JAC establishes a new Joint		**2017 -** VW expands collaboration with relevant government

Venture for Chinese battery electric vehicles.		departments, industry participants and other organizations
2017 - VW launches the "Roadmap E" strategy. With this, Volkswagen Group declares become a leader in the electric vehicle industry by 2025		
2018 - Volkswagen nominates battery cell supplier **2018 –** VW and Ford sign MoU to explore strategic alliance to extend capabilities, strengthen Competitiveness		**2018 -** The Chinese government notes a strong basis of supportive government policies, leveraging extensive industry experience and taking advantage of the momentum in EVs development are key to enhancing the international competitiveness of Chinese automotive industry **2018 -** SK Innovation, LG Chem, Samsung and CATL are officially VW's battery suppliers **2018 -** Ford becomes a partner to develop EVs
2019 - ID3 debuts, it is the first BEV model from VW		
2020 - Acquires 26% of Gotion High-Tech, becoming the largest shareholder **2020 -** SVW begins to produce the pure electric models, ID. X, on the		**2020 -** Gotion High-tech and JAC further strengthens the partnership with VW

new MEB platform in Anting plant. FAW-VW begins to produce ID. CROZZ models in Foshan MEB plant		
2021 - Volkswagen Group China commences construction of a battery system production factory in Hefei (Anhui province)	**2021 -** VW Anhui Components Company founded, it is the first battery system plant wholly owned by the Group in China	
2021 - VGC builds battery system factory in Anhui to strengthen BEV value chain. **2021** - VW Group presents "NEW AUTO strategy" through 2030 – a new plan of transformation into a "software-driven mobility company."		
2022 – VGC creates a joint venture with Horizon Robotics to build new competencies in important future fields		**2022** – Chinese National Energy Administration publicly issues The blue book that promotes development and progress of advanced electrification technology and equipment in various fields. In the transportation field, fossil fuel vehicles should be fully replaced by new energy and hydrogen fuel cell vehicles **2022 -** Horizon Robotics partners and helps VW to build the competences

		like high-tech semiconductors, algorithms and software solutions.