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GROUP PART: A CASE STUDY ON NIO

NIO in Germany: Disrupting a foreign EV market through business-model innovation

INDIVIDUAL PART: BALANCING FUTURE GRIDS: A COMPREHENSIVE REVIEW OF VEHICLE-TO- GRID APPLICATIONS AND THEIR IMPACT FACTORS

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Abbreviations

AC	Alternating Current
BaaS	Battery as a Service
BEV	Battery Electric Vehicle
DC	Direct Current
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
HEV	Full Hybrid Electric Vehicle
ICE	Internal Combustion Engine
k	thousand
LIB	Lithium-ion batteries
M	Million
MHEV	Mild Hybrid Electric Vehicle
OEM	Original Equipment Manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
PSS	Power Swap Stations
R&D	Research and Development
SBB	Solid-state battery
US	United States

Abstract

This case study delves into NIO's strategic entry into the German electric vehicle (EV) market, examining its distinctive business models with its battery swapping technology, key success factors, and challenges faced. Drawing insights from the failure story of Better Place, the study scrutinizes NIO's strategy for sustained success.

The individual analyses focus on battery management-related topics with a comparative analysis of the economic and environmental impact of remanufacturing, reusing/repurposing, and recycling of EV batteries, an analysis of conductive, wireless, and robotic charging, and battery swapping, including related pilot projects, and a comprehensive review of vehicle-to-grid applications and their impact factors.

Keywords: NIO, Electric vehicles, Battery swapping, Subscription model, End-of-life battery treatment, Recycling, Reusing, Remanufacturing, Lifecycle assessment, Charging technologies, Wireless charging, Battery lifetime, Pilot projects, Smart grid, Vehicle-to-grid, Charging management.

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1. NIO's Bold Statement of Intentions about the German Market

In July 2022, Global CEO and NIO founder William Li announced details of NIO's expansion into the German, Dutch, Danish, and Swedish market at the Norwegian European launch event (NIO 2022b). "Serving users in Germany, the Netherlands, Denmark, and Sweden is an important step in realizing NIO's 2025 plan and offering our unique user experience in more countries around the world," he stated (NIO 2022b).

Being aware of the long-term structural change of the German automotive industry (Felser and Wynn 2023), Li met with the appointed General Manager of NIO Germany, Ralph Kranz, to discuss NIO's positioning and business model for the German market. Some of the other electrical vehicle (EV) brands were still not profitable on the market and started taking part in price wars. As NIO wanted to be perceived as a premium brand alongside its competitor Tesla and the traditional German Original Equipment Manufacturers (OEMs), they discussed how they could develop the most successful and differentiating business model and convince German customers about embracing NIO as a lifestyle brand.

"Our compelling products, game-changing charging and battery swapping services, alongside truly innovative and flexible subscription models, will change the landscape of EVs. Our commitment to the region marks the start of NIO's next chapter in our global development.", said William Li (NIO 2022b).

2. NIO's Business Model: A Novelty in the EV Market

At the core of the operations of the Chinese EV manufacturer, NIO was its Battery Electric Vehicle (BEV) manufacturing with models from luxury SUVs to high-performance mid-price EVs while emphasizing that their operations were centered around their customers (NIO 2023e). Additionally, NIO produced, operated, and maintained a network of Power Charging Stations (further explained in section 5.3), including their innovative Power Swap Stations (PSS), allowing owners to swiftly replace their depleted battery with a fully charged one

(***Appendix 1***) (NIO 2023d). The company also introduced Battery as a Service (BaaS) and ventured into the lifestyle brand sector, unveiling the NIO Phone, and operating physical showrooms, the NIO houses (NIO 2023b). The business model pursued by NIO differed from traditional EV manufacturers, which sold the battery as part of the vehicle and focused on conductive charging with cables (further explained in section 4.3.).

NIO's early success in China was characterized by its growing market share (2,1% in September 2023) and its PSS technology (CNEVPOST 2023). The company benefitted from the Chinese government's support for EVs and investments in research and development (R&D). Both contributed to its competitiveness. Nonetheless, NIO faced per-vehicle losses of EUR 32k[1] (USD 35k) per car sold for EUR 39k (USD 42k) between April and June 2023. NIO's ability to incur losses and maintain growth could be primarily attributed to the substantial government backing and financial support received. (Mihalascu 2023) In contrast to its subscription business model in China, NIO had chosen to offer the option to purchase its BEVs in the European market (NIO 2022b).

3. NIO's Path to the European Market

NIO Inc. was founded in November 2014 under the name NextEV by the Chinese entrepreneur William Li (Smith, Peter 2022) and later, secured significant early-stage financing from prominent investors, including Tencent, Hillhouse Capital, and Sequoia Capital (NIO 2016a). NIO unveiled its first production vehicle, the NIO EP9 electric supercar, in November 2016, which caught attention on the competitive EV market.

In 2017, the company rebranded itself from NextEV to NIO, symbolizing superior performance, aesthetic design, and unique user experiences. (NIO 2016b) The realignment unfolded in

[1] Average exchange rate of 1.0792 between 07.12.2022 and 07.12.2023 used for all currency conversions from USD to EUR (European Central Bank 2023).

December 2017, when the company launched its first mass-market EV, the NIO ES8, a 7-seater SUV (Stevenson 2017). To raise substantial capital, NIO went public on the New York Stock Exchange in September 2018. The funds were required for international expansion and product development to compete with the new models of EV pioneer Tesla. (Franklin and Zhu 2018)
In September 2021, the company then announced plans to expand beyond China, targeting international markets like Europe and the United States (US). NIO's first European launch was in Norway, from where the company expanded its operations to other Northern European countries. Users in Germany, the Netherlands, Denmark, and Sweden had the choice of three models in the beginning. (NIO 2022b) To keep up with the more and more technologically advanced EV models, NIO's new model ET7 (launching in 2024) would be developed with a solid-state battery (SBB)[2] - a world premiere - and a range of around 1,000 kilometers (ADAC 2023a).

Differing from the traditional vehicle-selling approach, NIO started its path in Germany, the Netherlands, Sweden, and Denmark by entering with a subscription-only model. After negative feedback on the subscription-only model, NIO started offering its customers the flexibility to purchase as well as the option to lease their BEVs for a fixed or flexible duration. (Randall 2022; Reuters 2023) In 2022, NIO expanded its European charging infrastructure and introduced a European version of NIO's charging station infrastructure network (NIO 2022b). During NIO Day 2022, NIO unveiled its latest PSS, representing the third generation of this technology, alongside the introduction of a 500kW Power Charger (NIO 2023d). To provide PSSs to the European market, NIO opened its first PSS manufacturing facility in Hungary (Reuters 2022). In October 2023, the Chinese EV manufacturer explored the establishment of a European dealer network to accelerate sales growth. This initiative came amidst the prospect

[2] SSBs use solid ceramic material instead of liquid electrolytes for carrying the electric current like in LIBs. They provide several advantages such as faster charging, a wider range, or a longer battery lifecycle (Nichols, 2023)

of potential tariffs on Chinese EVs in the European region. (Reuters 2023c) The timeline of NIO's business operations since its launch is displayed in ***Appendix 2***.

As NIO continued its expansion and innovation efforts, particularly in the European market, the question arose: Would NIO's strategic initiatives and forward-looking battery management lead to success in the highly competitive German EV market?

4. Electrification of the German Automotive Industry

The 150-year-old automotive industry was being transformed, shifting from the dominance of ICEs for decades towards fully electrification (Kodey et al. 2023; Randall 2022). By 2030, the EV market was projected to surge to two-thirds of global car sales by 2030 including the sale of all different EV types[3] (Niese, Arora, et al. 2022). This shift was beyond technological change; the entrance of Chinese manufacturers such as BYD and NIO was significantly altering the landscape of competition in the market.

4.1. Development of the German EV Market

By 2035, BEV sales in Europe were anticipated to make up 93%, compared to China and the US with approximately 82% and 68% of EVs of overall vehicle sales. The main drivers of the fast European transition to BEVs were the strict environmental regulations resulting from the Paris Agreement[4] (2015), the European Green Deal[5] (2019) and the aim of the EU to ban the registration of new combustion engines by 2035[6]. (Kottasová 2023; Niese, Arora, et al. 2022).

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[3] The EV vehicle types include (Full-) Battery Electric Vehicles (BEVs), Fuel Cell Electric Vehicles (FCEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Full Hybrid Electric Vehicles (HEVs), and Mild Hybrid Electric Vehicles (MHEVs).

[4] On the UN Climate Change Conference in Paris, 196 Parties agreed on the reduction of greenhouse gas emissions of 43% by 2030 (United Nations Climate Change 2023).

[5] Four years after the UN Climate Change Conference in Paris, the European Green Deal was passed with the target of net zero emissions by 2050 (European Comission 2023).

[6] German politicians lobbied for an exemption advocating for the registration of vehicles with combustion engines after 2035 if only CO2-neutral fuels (e-fuels, synthetic fuels) were used. (Kottasová 2023)

In 2023, China recorded BEV and PHEV sales of EUR 271M (USD 292M) followed by the US with EUR 65M (USD 70M) and Germany ranked third with EUR 46M (USD 53M) (Statista 2023b). Globally, China led the BEV industry, selling more BEVs than the rest of the world combined with a year-over-year average increase of 24% up to 9M by 2030 (***Appendix 3***) (McKinsey & Company 2021).

The development of **China's success story** dates back to the early 2000s when China realized that they were not able to compete with the US, Germany, and Japan on internal combustion engines (ICE). China was incentivized to invest in R&D prioritizing EV technology in the national planning and identified EVs as one of the core industries in the Made in China 2025 strategy. (Stauffer 2021; Zenglein 2018) Thus, China introduced purchase tax reductions on domestic and foreign brands in 2014 as well as the Dual Credit policy[7] in 2017 (Interesse 2023; Yang 2021). Additionally, the Chinese government recognized the potential of battery swapping technology as an additional charging solution, launching a variety of policies and supports to push the industry development and standardization of batteries (Ibold and Xia 2022). Another main driver for the exponential growth of the Chinese market was the introduction of affordable BEVs (Statista 2023b). The overall goal of the Chinese government was to push the shift toward carbon neutrality by 2060 with emissions peaking in 2030 (Wang and Gopal 2023).

In 2023, China was outperforming Germany and the US regarding technology innovation, particularly in battery technology and self-driving car software (Boston 2023). Throughout 2022, China had surpassed Germany in car exports (Hoskins 2023). The dominance of Chinese car brands was predictable due to the very favorable policies implemented by the Chinese government, still, German OEMs seemed to be surprised.

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[7] The Dual Credit policy was introduced to boost EV sales by awarding positive credits to produce EV and negative credits for conventional vehicles. Consequently, OEMs with conventional combustion engines were forced to purchase credits as compensation for not aligning with BEV policies. Especially the rising prices of New Electric Vehicle credits with an increase from EUR 46 (USD 50) to EUR 167 (USD 180) between 2019 and 2020, were encouraging manufacturers to reconsider its business model. (Yang 2021)

While China was innovating the car industry for more than two decades, Germany focused on optimizing its ICE to meet stringent EU emissions requirements. For two decades, **Germany led the world in the automotive industry**, especially in the lucrative premium vehicle segment, which accounted for 5% of the German economy. (Dmitracova 2023; Martin Krzywdzinski 2022)

With the diesel scandal[8] in 2015, the German government was prompted to foster innovation in the industry and drive the adoption of EVs to regain customers' trust (Krzywdzinski 2022). In 2016, the purchase premium for BEVs was introduced and reduced by early January 2023 because BEVs were now attractive to buyers in the market (Peter Haan, et al. 2023). At the same time, the federal government pursued the goal of 15M EVs on the road by 2030, but this goal was difficult to achieve based on sales figures, with only 12M BEVs expected to be achieved (Ryder 2023).

To stimulate sales of BEVs, CO2 pricing, a tax system favorable to climate protection, as in China, and the removal of bureaucratic hurdles were needed to speed up the development of traditional German car manufacturers to compete with Chinese car brands (Haan 2023; Stauffer 2021).

At the same time, German car manufacturers had been trying to develop software solutions for connected car products and driver entertainment themselves and neglected any partnership with tech giants such as Apple or Google in the past. Due to slow progress in their in-house developments, German car manufacturers in 2023 were seeking partnerships with tech companies to innovate in areas such as advanced driver-assistance features and efficient battery management. (Boston 2023) Considering the Chinese market, it was clear that the approach to technological development had to change. R&D activities in China were pushed by German

[8] In 2015, VW sold 11M cars worldwide with "defeat devices" in the engine that improved emission when being tested (Hotten 2015). The scandal was pivotal for the German government and the German ICE-focused industry.

OEMs to prevent falling behind in technological advances while in the past, research activities were kept to a minimum due to fear of knowledge spillover. (Kottasová 2023)

The year 2022 marked a historic shift since Europe imported more Chinese cars than it exported to China for the first time (Marin 2023). With an average EV selling price of EUR 56.2k (USD 60.6k), the German car market offered high potential for Chinese low to mid-price ranged EVs (Statista Market Insights 2023a). In September 2023, the European Commission announced that it would review whether to impose tariffs above the EU's standard 10% rate in response to the perception that Chinese cars may be sold at artificially low prices supported by substantial government subsidies. On average, BEVs by Chinese manufactures were sold 20% below EU-made models. According to NIO's founder, the cost advantages resulted from China controlling the BEV supply chain, including raw materials. The German automotive association VDA[9] stressed that the EU should focus on creating effective conditions for European car brands to compete with Chinese ones by minimizing bureaucratic hurdles and lowering electricity prices. (Reuters 2023b)

4.2. Traditional German OEMs Facing Chinese Market Entrants

In the German EV market in 2023, around 40% of the EVs were sold by German car manufacturers Mercedes-Benz, BMW, VW, Audi, and Opel (Statista 2023c). The German automotive market had witnessed a significant shift in the competitive landscape with the entry of Chinese OEMs.

New Market Entrants and the Changing Competitive Landscape

VW remained the largest competitor in the market with 26% market share in 2022 with an increase of 7% compared to 2021. Stellantis, with 17% market share (75% increase), Tesla

[9] The German Association of the Automotive Industry (VDA), founded in 1901 with more than 650 companies in the automotive industry with the aim of monitoring and safeguarding the framework conditions for successful business in the automotive industry (VDA 2023).

capturing 15% (76% increase) and Renault-Nissan with 1% (11% increase) gained market share. (Bay 2022) German car manufacturers were relatively late in transitioning to a strong focus on EV production. Tesla had emerged as a global leader, outselling the combined EV offerings of all German car manufacturers globally. (Nicola 2023)

Between 2020 and 2023 over ten new entrants have ventured into the European automotive market (***Appendix 4***). Especially, Chinese automakers like Aiways, Lynk&Co, and MG established their presence, and in 2022, BYD and Great Wall Motors also entered the market. (ADAC 2023a) Although their initial sales volumes ranged between 100 and 2k cars per brand annually, in 2022, these entrants had ambitious plans. BYD intended to supply 100k cars to a major rental company in Europe by 2028, and Xpeng aimed to sell 100k BEVs in Europe in 2022. (Dau, et al. 2022) The influx of numerous EV players, especially Chinese car manufacturers, has led to their dominance in the lower to mid-price range segment (Freiwah 2023).

The new entrants employed diverse sales strategies reflecting their individual strengths and market approaches. Some opted for direct-to-consumer strategies, involving the establishment of their outlets, a path embraced by companies like NIO or Lynk&Co (who included the opportunity that car owners could offer their cars for private car sharing). Others formed strategic partnerships with importers for wholesale distribution, mirroring the approach adopted by BYD. Some market participants pursued pure importer models such as Skywell. Others sought to work with retailers outside the automotive sector to expand their market presence. This approach was adopted by Aiways through a partnership with an electronics retailer in Germany (***Appendix 5***). (Dau, et al. 2022) In the years after 2023, it is anticipated that the vast majority of leading brands will originate from China, with the exception of Tesla (Nicola 2023).

Changes in the German Supply Chain and Market

German automotive suppliers, often composed of midsize companies, were facing significant challenges with the shift towards e-mobility due to the focus on electronics and software, and restricted access to raw materials. Increasing interest rates further exacerbated the financial strain on suppliers, affecting their working capital management and making external financing harder to obtain. (Majic and Schnurrer 2023) Another challenge for suppliers was posed by the efforts of OEMs like NIO to vertically integrate their production chain by shifting as much production process in-house. Automakers were controlling raw materials in the industry through its vertical integration strategy in form of investment in mining companies, refining facilities, or raw material suppliers. Strategic alliances between automakers and other companies along the supply chain further enhanced the pressure for suppliers to form alliances or meet the requirements of these partnerships (Pisano, Saba and Baldovino 2023). For example, Porsche invested in a joint venture with IONITY (see section 5.5) to develop fast-charging solutions across Europe (***Appendix 17***) (PR Office Porsche Germany 2023).

However, there was an opportunity opening for German suppliers with Chinese OEMs entering the European market, eager to expand existing partnerships and provide European-made parts to support the adaptation of vehicles for the European market. Suppliers like Bosch, ZF Friedrichshafen, and Continental were actively engaged with their Chinese customers and were in discussions regarding plans for these OEMs to build plants in Europe. (Waldersee and Amann 2023) OEMs like NIO, specified on a certain technology, faced significant procurement risks as they relied on a limited number of third-party suppliers to produce their vehicle parts without alternatives in case of e.g., price wars. (SEC 2021)

On their part, European customers were showing interest in new brands in the EV market, with customer research indicating that nearly two-thirds were open to purchasing from new brands when transitioning to EVs. Consumers anticipated a seamless, personalized, and adaptable purchasing experience. The demand for EVs was on the rise, with more consumers considering BEV and PHEV. (Furcher, et al. 2023)

Consumers' comfort with buying cars online was increasing, particularly among EV buyers. However, traditional elements like personal connections and price negotiation still hold value for many car buyers. Despite the growing interest in EVs, consumer satisfaction with the purchasing experience remained relatively low with only 53% of recent car buyers expressing high satisfaction. Key challenges were price transparency, vehicle availability, and process complexity. Future EV buyers were expected to prioritize simplicity and personalization during the vehicle-selection process. Additionally, enhanced price transparency was required. Both characteristics were features of a digital experience. (Furcher, et al. 2023)

Comparing the customer experience requirements of the Chinese and German EV markets, the following can be observed: In China, post-pandemic changes in consumer behavior reflected reduced impulsive purchases and a stronger emphasis on quality and pricing across product offerings. Chinese brands were viewed as more cost-effective and aligned with local customer needs (Deloitte 2023). The German EV market prioritized vehicle technology, particularly advanced driver assistance systems, as a critical purchase criterion, making consumers twice as likely to consider alternative manufacturers with superior technology standards (Cornet, et al. 2023). Within the European market, Chinese brands faced consumer hesitation due to trust issues and disparities in consumer preferences (***Appendix 15***) (Eberhard 2023; Waldersee 2023).

4.3. Battery Technology and Supply Chain Dominated by Chinese OEMs

To meet the increasing demand for EV batteries, the entire lithium-ion battery chain was set to reach a market size of more than EUR 371 (USD 400) billion, growing annually by over 30% from 2022 to 2030 (Fleischmann, et al. 2023).

As three-quarters of the EV battery production was still located in China (***Appendix 6***), this demonstrated a difficult trade-off for German carmakers: They deepened their integration and product development into China's system of innovation while also decoupling from the dependency on Chinese EV batteries and moving back to more local production in alignment with EU's geopolitical policymakers (Sebastian 2022; Randall 2023). To strengthen battery supply in Germany, the automotive industry started to partner with established battery companies from Asia to build production sites. For Chinese EV manufacturers coming into the German automotive market, the high battery capacity in China provided a significant advantage. (Randall 2023)

When choosing the EV battery type, most EV manufacturers built their models with lithium-ion batteries (LIB), instead of lithium-ferrous-phosphate batteries or nickel-metal hydride batteries (***Appendix 7***). The choice depended on the range capacity, charging performance, energy density and battery lifecycle regarding the used raw materials (Man 2023a). In 2023, EV manufacturers concentrated on the development of the most powerful LIBs. Some automakers like Porsche and BMW saw potential in replacing LIBs with SBBs and invested in the development and testing of LIBs for mass production (Atienza 2023), while other OEMs purely focused on increasing their LIBs potential (***Appendix 17***) (PR Office Porsche Deutschland GmbH 2023).

The raw materials needed to manufacture LIB for EVs included lithium, cobalt, nickel, aluminum, and non-ferrous metals like copper and other minerals (Backhaus 2021). Due to their non-renewable nature, the automotive industry faced challenges of battery recycling to improve the battery life cycle. In addition, access to high-quality raw materials was crucial for ensuring the reliability and performance of EVs but presented further challenges as the required raw materials often came from developing or emerging countries with social and environmental risks and challenges (e.g., child work) (BMZ 2021). To catch up with the increasing battery demand, battery supply chain players and OEMs needed to find innovative approaches to reconfigure the battery supply chain and build effective ecosystems (Niese, et al. 2022).

One of the top customers' concerns was battery range resulting from the slowly adapting charging infrastructure and the lack of sufficient public charging stations. As a result, the industry needed to emphasize the benefits and usability of EVs to encourage customers to consider EVs as a long-term investment.

The commonly used charging technology was conductive charging, which involved the transfer of electric power from a charging station to an EV using physical connectors and conductors. There were two primary types of conductive charging methods: Alternating Current (AC) charging was mostly used for private charging with a charging process taking several hours (***Appendix 8***). In comparison, fast charging stations known as Direct Current (DC) charging took 20 minutes for a recharge from 10% to 80%, however, higher prices were paid by customers (Ward 2023).

4.4. Charging Infrastructure

In 2023, the global expansion of EV charging infrastructure was led by China with around 1.7M charging points, followed by Europe with half a million (Melissa 2023). With the Fit 55 agreement[10] the EU Parliament mandated the installation of charging points every 60km along major roads and one charging point for trucks every 120km across Europe by 2028 to drive investment in EV charging infrastructure (European Parliament 2023). This was aimed at boosting the EV charging infrastructure as the demand for EV charging points in Europe was

[10] Legislative package designed by the EU commission to achieve the EU's 2030 climate targets, reducing greenhouse gas emission by at least 55% by 2030 (European Commission 2023).

expected to grow at a CAGR[11] of 25% between 2020 and 2030 from EUR 203k to 1.8M (***Appendix 9***) (Hagenmaier, et al. 2021).

Taking a closer look at the EV charging landscape within Germany, 60% of EV owners had access to home as well as work charging while the access of less than 5% of EV owners was limited to public stations. However, the public charging market showed high potential, especially for longer trips, since 65% of EV owners relied on their EVs as they did not own an additional ICE vehicle. Additionally, EV owners showed willingness to pay a price premium for public fast charging ***(Appendix 10)***. Nonetheless, the focus on the price premium for fast charging could have been short termed when looking at the top three criteria for public charging in Europe: General charging price, reliability of chargers, and the time taken to charge a vehicle (***Appendix 11***). The mass adoption in the near future could have led to reduced prices. In Europe, the EV infrastructure landscape was still fragmented, leading to a lower satisfaction level compared to China and the US. (Hagenmaier, et al. 2023)

Since range anxiety was one of the main concerns of customers, EV manufacturers and charging station operators faced a typical dilemma: Customers would purchase EVs if the number of accessible charging stations increased, while charging station operators would invest more in their charging network expansion if the number of EV sales increased. The latter would have reduced range anxiety and made the expansion of charging stations more efficient (Conzade, et al. 2022). Additionally, the integration of real-time information including charging station availability and pricing as well as a standardized and seamless charging and payment process across infrastructure operators provided a supportive argument for customers‘ EV purchase decisions (Lohrisch 2023).

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[11] CAGR is the compound annual growth rate, which includes the annual increase in growth over the next few years.

To support the expansion of charging stations, the German government launched an infrastructure program worth EUR 900M to support private charging spots for households and companies and set an additional budget of EUR 6.4M to invest in public charging spots (ADAC 2023b; Reuters 2023a).

Within Europe, the three largest EV infrastructure operators in 2022 were Tesla, followed by IONITY[12] and EnBW[13] (Melissa 2023). Tesla realized customers' concerns about EV's limited range and became the global leader in the market for supercharging stations (Holtermann 2023), while planning to have around 125 supercharging stations installed in Germany by March 2023. (Tesla 2023). Tesla's superchargers could charge batteries within 15 min to drive a range of 275km (TeslaMag 2023). Thus, in 2023 an increasing number of automakers were seeking partnerships with Tesla to offer customers a larger charging network and every second Tesla station was accessible by third-party cars (ADAC 2023a).

At the same time, with the expansion of the infrastructure, the electricity demand was expected to grow simultaneously at a CAGR of 34% between 2020 and 2030 and by that projected to increase its electricity share in the EU from 0.1% to 3%. The increased charging demand was anticipated to also have a high impact on the energy grid. With many charging at peak hours, the risk of localized power outages would be increased. (Hagenmaier, et al. 2021)

5. Entry of NIO into the German EV Market

5.1. NIO as a Lifestyle Brand

According to NIO, the company had established itself as a "lifestyle brand" by prioritizing user experience and nurturing a sense of community. Its commitment to user satisfaction was evident

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[12] IONITY was founded as a joint venture of BMW Group, Ford Motor Company, Mercedes Benz AG and Volkswagen Group with Audi and Porsche backed by BlackRocks Climate Infrastructure Platform as financial investors. By partnering with charging station providers throughout Europe and close to major highways, IONITY offered an attractive charging network (IONITY 2023).

[13] EV infrastructure operator operating in 17 European countries with almost over 400k charging points in 2022 and also provides access to third party charging stations integrated in the EnBW mobility app.

through the designed NIO Houses, with which NIO tried to invite users to linger, collaborate, and partake in the brand's culture of electric mobility. NIO's in-vehicle artificial intelligence, NOMI, had sparked over 200M emotional interactions with users, fostering a sense of individuality and customization. Supporting the company's environmental commitment, NIO unveiled 2021 the Blue Sky Lab, a fashion project that upcycled materials leftover from car production to craft a line of fashion products inspired by the automotive industry. (NIO 2021f) The NIO app offered seamless interaction and content browsing for both registered NIO users and non-users (NIO 2021a). These services and other additional products offered by NIO are presented in ***Appendix 12***.

The software on NIO's vehicles was considered at the forefront of technology in the automotive industry. The over-the-air automated software updates ensured a seamless and convenient driving experience. (Pisano, Saba and Baldovino 2023)

5.2. NIO's Vehicle Ownership Options

In China, NIO has presented four main vehicle ownership options since 2021. First, customers could opt for the "Vehicle Purchase with Battery Rental" model. This allowed them to purchase the vehicle without the battery, resulting in cost savings from the car price, with the addition of a battery subscription starting from 169 EUR/month (NIO 2022c), inclusive of four battery swaps monthly, and depending on the battery chosen. Alternatively, NIO provided the "Vehicle Purchase with Battery and Charging Service Rental" option, which added access to fast-charging stations. For selected cities, the "Vehicle and Battery Subscription" plan offered a decreasing monthly cost for both the vehicle and battery, featuring four free-of-charge battery swaps per month. Lastly, customers were able to choose the "Vehicle and Battery Purchase" model, giving them the flexibility to purchase both the vehicle and the battery while still enjoying the option to use the battery-swap service. (Pisano, Saba and Baldovino 2023) An overview of subscription options can be obtained from ***Appendix 13***.

The perception among experts was that "(…) the typical German customer [was] not willing to subscribe to the battery, but rather want[ed] to own it" (***Appendix 16***) (EV Analyst of MBB Consultancy 2023). NIO responded to this preference of the German customers by offering the vehicle purchase option for customers in Germany, the Netherlands, Denmark, and Sweden besides the NIO-subscription models. Customers could choose the vehicle that best suited their needs with subscription terms ranging from just one month to 60 months.

NIO gave European customers the choice between three models, the NIO ET7, the NIO EL7, and the NIO ET5, starting at EUR 69.9k, EUR 73.9k, and EUR 49.9k plus the price for the battery. NIO users had the option to rent or purchase the battery through the BaaS model. The 75-kWh battery was available for EUR 169 and the 100-kWh for EUR 289 per month, providing users with flexibility and access to the PSS network (***Appendix 14***). For users opting to buy the battery, the 75-kWh battery was priced at EUR 12k, and the 100-kWh battery at EUR 21k. If the battery was purchased, users did not have access to the PSS network.

As Ralph Kranz, General Manager of NIO Germany emphasized: "We (NIO) are pleased to fulfill the users' request and, just a few weeks after the market launch, to now offer the purchase option - in addition to our flexible and fixed NIO subscription models through direct sales with an all-inclusive package." (NIO 2022c)

To attract European customers faster, NIO offered free battery swaps until the end of 2023 (Boldac 2023). All three vehicles were equipped with next-generation premium features and equipment as standard, with no extra charges. The subscription models in Germany came with an all-inclusive package, encompassing registration, maintenance, winter tires, service pickup and return, loaner car, comprehensive insurance, battery replacement, and the choice to extend the battery service (NIO 2022c). Experts highlighted that NIO had to put special emphasis on

“(…) invest(ing) in customer loyalty and build customer trust, especially as a Chinese manufacturer, to be recognized as an equivalent to traditional German OEMs such as Mercedes-Benz or BMW.” (***Appendix 16***) (EV Analyst of MBB Consultancy 2023).

Lastly, NIO's BaaS approach allowed customers to avoid the traditional battery ownership model by subscribing to batteries of various capacities according to their needs, paying a monthly subscription fee. This innovative CSU (Chargeable, Swappable, Upgradeable) product offering enabled both charging and swapping of batteries, providing users with the flexibility to benefit from the latest battery technology or upgrade their battery capacity as required. Overall, NIO’s BaaS model eliminated concerns about battery wear, decoupled the battery's value from the vehicle, and contributed to reduced range anxiety. (Pisano, Saba and Baldovino 2023)

5.3. NIO’s Distinctive Battery Technology and Management

As a reliable and sustainable battery management and sufficient charging infrastructure remained a challenge for EV manufacturers, NIO decided for an innovative battery management approach which differentiated them from all EV competitors and questioned the new standard of fast charging (NIO 2023c). “Battery swapping takes less than five minutes, you don’t have to leave your car, it’s fully automated and easy to access,” says Matt Galvin, UK Managing Director of NIO (Swallow 2023).

At their NIO Power Stations[14], NIO presented the driver with the options to either fast charge the car or swap the empty EV battery at the PSS. Here, the driver pulled into the PSS and the automated system would have changed the battery from underneath the car and replaced it with a fully charged battery. As the battery swapping was only selectable for NIO car users who use

[14] The NIO Power Stations provide customers with access to NIO’s charging network and battery swapping stations (NIO 2023c).

the BaaS model, the battery swapping offered high flexibility for drive planning. For each battery swap, users could select a 75kWh or 100kWh battery and easily upgrade to a higher capacity (***Appendix 14***). The full battery swapping process took under three minutes, including car alignment and safety checks, which was significantly faster than fast-charging with an average of 12 minutes – to 80% charging time and ensured a longer battery lifecycle. (Ward 2023)

Next to these improvements, NIO’s battery swapping technology also reduced the impact on the grid. As the number of EVs increased, a huge amount of electricity was required, impacting the power quality. Through battery swapping the demand for EV charging was spread over a period, reducing costly peaks in load management as it was applicable to schedule battery charging when charging demand was low, e.g., at night (Sindha, Thakur and Khalid 2023).

NIO’s second-generation PSS cost about EUR 400k including 14 battery slots and 13 battery packs and could complete up to 312 battery swaps per day. During NIO Day 2022, NIO unveiled its third generation PSS expected to account for half of the second-generation PSS costs and a capacity for 21 batteries stored, alongside the introduction of a cutting-edge 500kW ultra-fast Power Charger (NIO 2023a; Kane 2022; Gibbs 2023). NIO founder, William Li expressed concerns regarding the potential adverse effects of ultra-fast charging on battery longevity, underscoring the significance of NIO's battery swapping technology (Mendonça 2023).

In 2022, NIO provided its European customers with access to a total of 380k charging points via NIO NFC cards, while introducing a tailored European version of NIO's charging map (NIO 2022b). With the NIO NFC cards, NIO users had the opportunity to access the charging stations of competitors while NIO was expanding its charging network in Europe. NIO’s battery swapping stations, however, were only compatible with NIO EVs, preventing access for other EV brand users. To provide PSS to the European market, NIO opened its first PSS European manufacturing facility in Hungary (Reuters 2022). In addition, the investment plans included the installation of over 4k PSS by the end of 2025, with over 1k outside of China (Kane 2022). As NIO Europe expansion was advancing, they offered 13 PSS in Europe as of June 2023 while adding 70 additional locations across Europe by the end of 2023 (Ward 2023). In Germany, NIO took advantage of its ecosystem expansion through its cooperation with EnBW, Shell as well as the charging service provider Mer offering seven PSS with 50 sites planned in collaboration as of August 2023 (Huhn 2023).

When looking at the battery swapping presence in the German market, NIO was the only private car manufacturer on the German market that offered battery swapping as a business model. However there was a small indication on the markets for a long-term potential for battery swapping. First, NIO's home competitor LDV announced plans to introduce battery swapping with the 2023 LDV Mifa 9 in Australia (Law 2023). The Californian battery swapping start-up Ample signed a deal with EV manufacturer Fisker to install its swappable batteries in Fisker's upcoming Ocean SUV (Muller 2023). Previously, in 2014, Tesla also introduced a test program for battery swapping on its Model S but did not further investigate its potential as they decided that the business model would not be worth the high investments, high cost of capital, slow scaling, and instead concentrated on its Superchargers expansion (Tesla 2014). Many compared the network ecosystem approach of NIO's Power Swap stations with Tesla's strong efforts in its charging infrastructure, which was crucial for its early success (***Appendix 15***) (Eberhard 2023).

Even though the global EV battery swapping market was projected to reach a valuation of EUR 835.54M (USD 901.71M) by 2030 (GlobeNewswire 2022), experts questioned if battery swapping would be a long-term solution on the EV market or if battery fast-charging with reaching faster charging times and ranges would rather represent a differentiator (***Appendix 15***) (Eberhard 2023).

5.4 NIO's Manufacturing Supply Chain

NIO had established a supply chain approach where the company did not manufacture all its vehicle parts independently but instead was engaged in joint manufacturing agreements. Jianglai, a joint venture managed by JAC and NIO in which NIO held 49% equity interests, was responsible for parts assembly and operation management. JAC, an established automaker, continued to manufacture NIO's various models, including the ES8, ES6, EC6, and ET7, until May 2024. NIO itself focused on vehicle development, engineering, supply chain management, manufacturing techniques, and quality assurance. (NIO 2021e) Furthermore, NIO formed a partnership with battery manufacturer WeLion to produce SBBs for sale from 2024 on (Staats 2023). At the end of 2023, NIO announced to also enter a strategic partnership with Geely to cooperate on battery standards, the development of battery swapping standards, battery swapping network expansion, and battery asset management (NIO 2023f).

Taking a closer look at NIO's supply chain, NIO sourced 1.1k parts from 190 suppliers, many of which had a single source of supply, leaving little room for alternatives, and qualifying alternative suppliers was a costly endeavor. In addition, the potential inability of current cell manufacturers to meet the demand for LIB, disruptions in the supply of cells due to quality issues, and rising raw material costs posed risks to NIO's supply chain. (NIO 2020b)

6. A Cautionary Tale for NIO: The Failure Story of the Battery Swapping Inventor "Better Place"

Although the battery swapping business model showed promise for NIO according to experts and sales projections, there was a very salient failure of the same business model one decade earlier. Founded in 2007 by Shai Agassi, the Israeli-based green tech start-up Better Place aimed to revolutionize the mobility sector and reduce the dependencies of nations on oil (LaMonica 2013; Adner 2012). While other manufacturers focused on developing EV technology, Better Place introduced a business model based on the separation of car ownership and batteries that was identified as a “paradigm shift” and “massive disruption” with the potential to replace the ICE according to analysts of the Deutsche Bank in 2008 (Gunther 2013; Adner 2012).

Better Place's philosophy was to offer customers a lease of batteries that were subscribed for a predetermined annual mileage and could be changed at swapping stations (Christensen 2012). With this approach, Better Place addressed the challenges that the EV ecosystem posed for mass adoption: Price premium for expensive batteries, limited loss of battery value, grid collapse, and limited savings if short distances were driven (Adner 2012).

Agassi was able to raise about EUR 787M (USD 850M) from sophisticated investors such as General Electric, Israel Corp., HSBC, and Morgan Stanley. With this capital, Better Place invested in infrastructure in Denmark, the Netherlands, China, Australia, the US, and Japan. Nevertheless, the high capital investments increased the pressure to quickly acquire customers to generate financial returns. (LaMonica 2013) In early 2013, Better Place started to focus on Israel and Demark as pilot countries as both had beneficial conditions for testing due to high gasoline prices and government commitment to low-carbon transport alternatives (Gunther 2013; LaMonica 2013; Christensen 2012).

To tap into the market and attract customers, Better Place partnered with automaker Renault to launch the Renault Fluence ZE, an adapted version of the Renault Fluence model compatible with Better Place batteries (Christensen 2012). Together with Renault, Better Place aimed to sell 115k cars by the end of 2015 but failed (Fiske 2013). In the view of NIO’s CEO, Better Place filed for bankruptcy in May 2013, primarily attributed to its approach of constructing expensive battery swapping stations in limited regions. The substantial investment required for developing the charging and swapping infrastructure led to users having to drive long distances to swap their batteries, impacting overall customer satisfaction. (NIO 2021d)

The success of Better Place depended heavily on the standardization of battery shapes and sizes by car manufacturers, efforts that were not realized as hoped (LaMonica 2013). To use the PSS, interfaces needed to be created between the Better Place service platform and the cars' systems (Adner 2012). Further, Better Place was challenged by missing important lobbying steps (half of all new car sales in Israel were to fleet owners and not private car owners) (LeVine 2013) and a lack of support from the Israeli government and lack of tax incentives for employees to progress (Gunther 2013). In addition, Renault's decision in 2013 not to launch a new compatible model significantly damaged Better Place's confidence in its key partnership (Adner 2012). All in all, Better Place entered the industry still at its stage of inception with lower customer adoption of EVs in 2014 compared to 2021 to 2023 when NIO decided to enter the European market.

7. What is the way forward for NIO?

At the end of 2023, the Global CEO and NIO founder William Li, and General Manager of NIO Germany, Ralph Kranz met again in NIO's Munich office and looked back at their achievements in the German market. As the failure of Better Place was still looming in the background of their business, it was difficult to decide for NIO where to position on the German market in the long-term. William Li and General Manager of NIO Germany, Ralph Kranz, came together at the end of 2023 after NIO participated over a year in the German EV market to discuss the future of NIO in the Germany. Especially the history of Better Place and Tesla's decision to not continue with its battery swapping technology program seemed concerning to them. Thereby, they planned to discuss the following questions: *How does NIO's positioning compare to the other players in the German market? Has NIO what Better Place missed to be competitive with its battery swapping approach? Most importantly, does NIO's business model have a sustainable long-term potential in the German market?*

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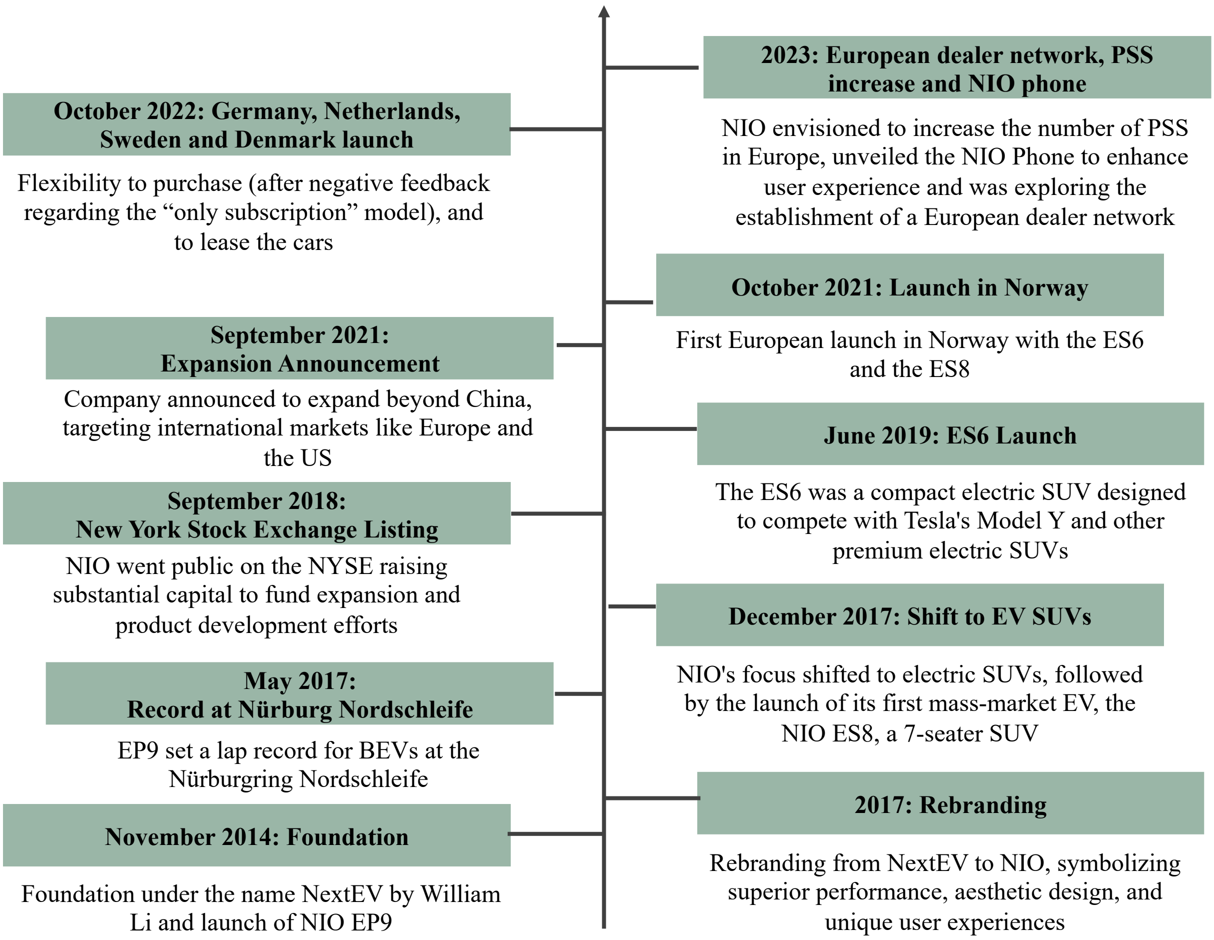
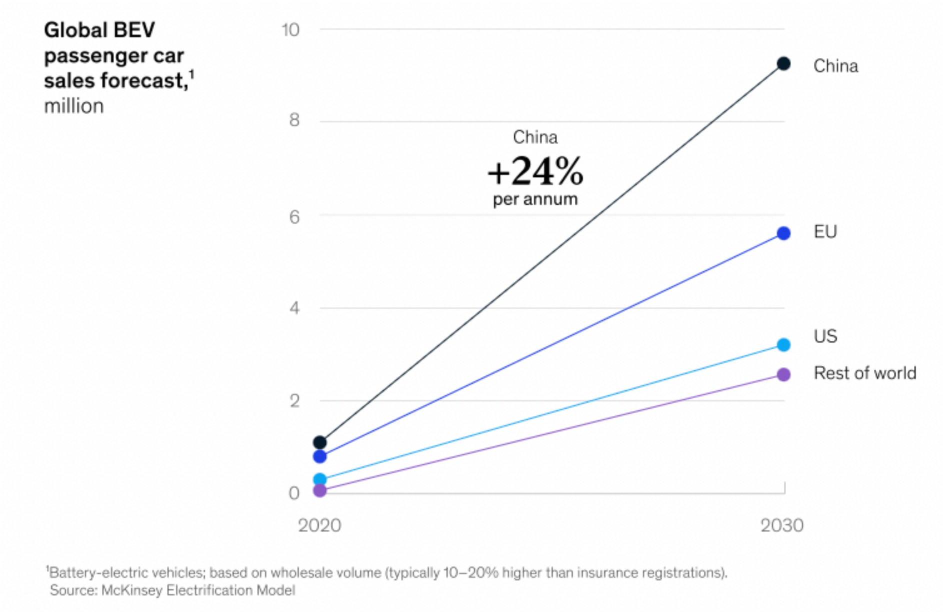
10. Appendix

***Appendix 1**: Power Swapping Stations (PSS) of NIO* (NIO 2022a)

***Appendix 2:** Timeline of NIO's business operations between 2014 and 2023* (NIO 2023b; NIO 2023d; Reuters 2023c; NIO 2022b; Randall 2022; Smith 2022; Franklin and Zhu 2018; O'Kane 2018; Stevenson 2017; NIO 2016)



Appendix 3*: Anticipation of BEV sales until 2030 – Situation of the industry in 2021* (McKinsey & Company 2021)



***Appendix 4**: Chinese OEMs' entry date, strategy and sales volume in the European market - Situation of the industry in 2023* (Hieke 2023; Opletal 2023; Maxus SAIC 2023; GWM 2023; Manning 2023; MG Media & MG Life 2022; PR Newswire 2022; BYD 2022; NIO 2022b; Reuters 2021; Aiways 2021; Fusheng 2020)

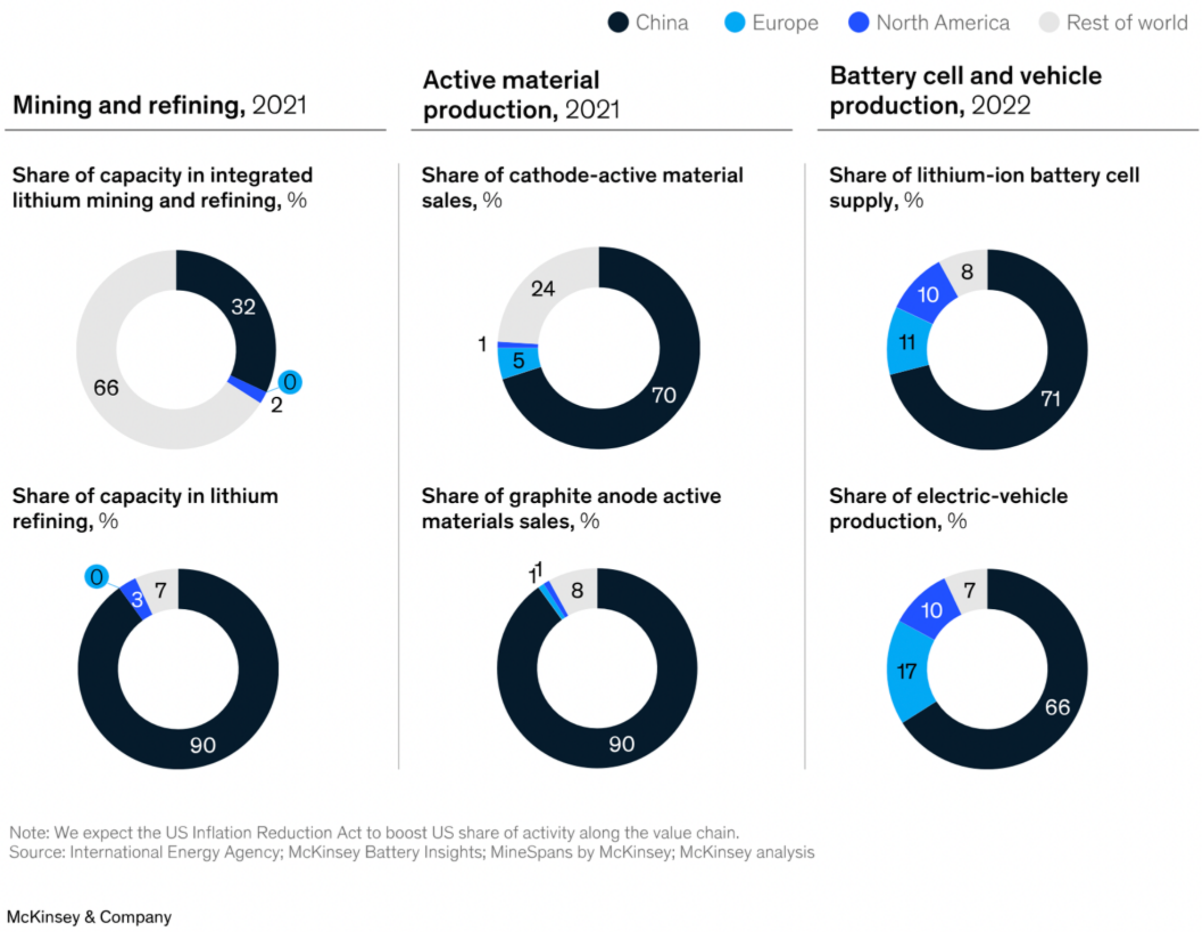
Corpor-ation	Brand	Strategy	Time of entry	Sales since entry (September 2023)
SAIC Motor	**Maxus**	• Emphasis on electric commercial vehicles such as electric vans and light trucks	First half 2020	3
Geely	**Polestar**	• High-performance EVs with luxury and scandinavian design	Q3 2020	506
Aiways		• Long-range electric SUVs providing German consumers with affordable yet high-capacity EVs designed for everyday use	October 2020	n.a.
Geely	**Lynk & Co**	• Sharing-centric mobility allowing users to share their vehicles within a community or use a subscription-based model, promoting efficient utilization and sustainability • Connected experience with features like always-on internet connectivity, over-the-air updates, and a digital ecosystem	Q4 2020	150
SAIC Motor	**MG**	• Focus on affordable electric passenger cars	July 2022	777
Geely	**Lotus**	• High-performance sports cars and track-focused vehicles • Incorporation of technology and innovations from Lotus' motorsport experience into their road cars	Q3 2022	26
BYD		• Manufacture of key EV components in-house, including batteries • Product portfolio includes passenger cars but and commercial vehicles, electric buses, and energy storage solutions	September 2022	196
NIO		• Focus on creating cutting-edge EVs with advanced technology • NIO builds an ecosystem around its EVs, providing services to enhance the ownership experience	October 2022	80
GWM		• SUV and Pickup focus • Cost-effective and budget-friendly vehicles	Q4 2022	333
Geely	**Zeekr**	• Targeting a higher-end market segment in Germany in difference to the other Geely brands	Planned Q1 2024	0

Appendix 5*: Asian EV entrants in Europe differed in their go-to-market strategies – Situation of the industry in 2022* (McKinsey 2022)

Strategy	Own retail	Agency	Import+	Import only
Character-istics	**Full ownership** of all sales channels and focus on **experience partly "beyond the car"**	**Agency distribution** with established dealers, while OEM grows own presence in Europe	Strategic partnerships with distributors who take over sales in a **wholesale model.** OEM keeps some brand presence and customer interaction	OEM delivers cars to importers with **no direct customer interaction**
Core beliefs	**Sufficient demand for direct sales can be created (customer pull)**	**High speed to market through partner networks and reliability of volume ramp-up**		
Further beliefs regarding...				
Capabilities	Strong own lead generation, analytics, and digital marketing capabilities		Benefit from experience and capabilities of local partners for selected activities (eg, import administration) Desire to develop own capabilities through partners in the medium-term (eg, local demand generation)	Benefit from local experience and partners' capabilities
Brand	Brand is/will be strong enough to create sufficient customer pull—demand will outpace supply		Benefit from reach of partner networks to position the brand	
Customer experience	Brand is/will be strong enough to create sufficient customer pull—demand will outpace supply		Desire for presence of brand (eg, via own website) but customer interaction handled through partners (eg, in dealerships)	Customer experience in line with experience through established local channels
Investment	Resources for significant local investment for physical channels and local capabilities available	Resources for significant local investment for physical channels and local capabilities available	Reduction of upfront investment	
Examples	**NIO**'s GTM is centered around customer satis-faction and experience, engaging the customer throughout the lifecycle	**Xpeng** interacts directly with customers online and in their brand-experience stores. The company partners with experienced distributors through an agency model	**Great Wall Motors** partners with Emil Frey as importer and dis-tributor for the its brand **Ora**. However, the GWM European headquarters is involved, trying to gain expertise	Importer Elaris renamed the Chinese models from **Skywell** and **ZhiDou** and organized partners for aftersales
Further examples	Lynk & Co., VinFast	MG, Aiways, WEY	Hongqi	JAC, Dorcen

Note: Chosen strategies can vary by country.

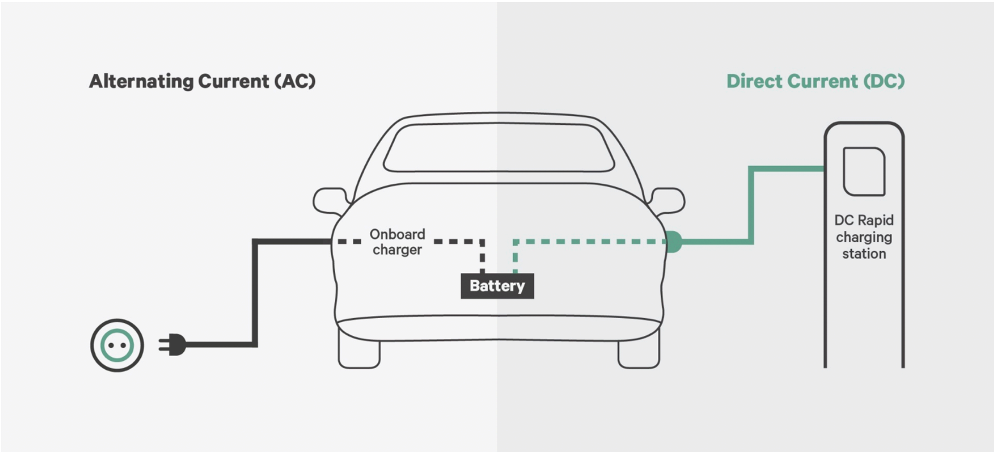
Appendix 6: Critical parts of the battery value chain were concentrated in China – Situation of the industry in 2023 (McKinsey 2023)



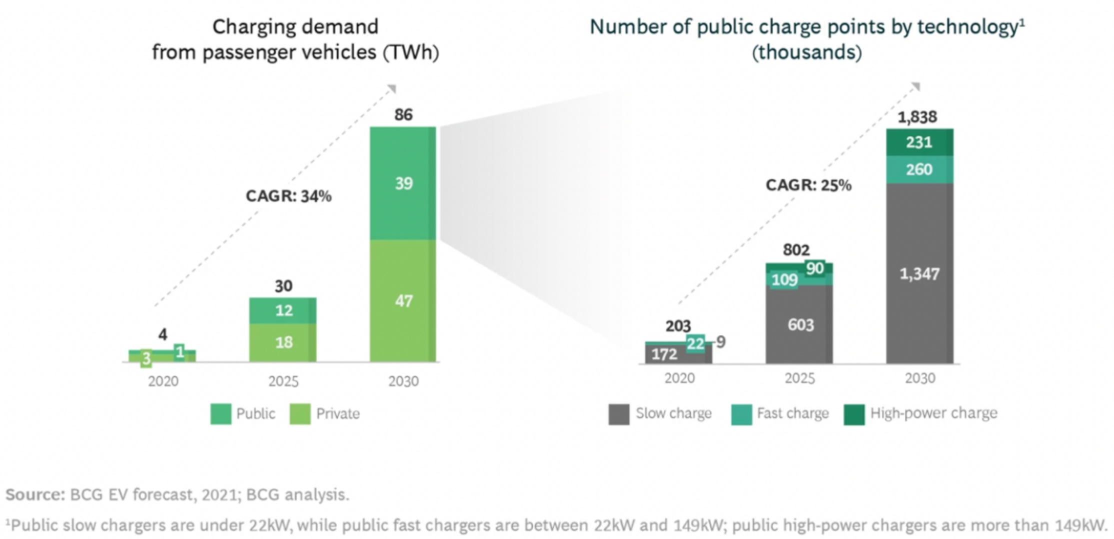
Appendix *7: Overview of battery types and their usage in the industry in 2023* (Mohammadi and Saif 2023; Nichols 2023)

<table>
<tr><th colspan="2">Type of Battery</th><th>Advantage</th><th>Disadvantage</th></tr>
<tr><td rowspan="2">LIB (LIBs used liquid electrolytes to carry the electric current)</td><td>Nickel-manganese-cobalt (NMC)</td><td>• Moderate to high energy density
• Most commonly used in EV models
• Good charging performance</td><td>• Up to several hours charging time
• Scarcity of resources such as lithium
• Shorter battery lifecycle
• High thermal runway risk</td></tr>
<tr><td>Nickel-cobalt-aluminum (NCA)</td><td>• Moderate to high energy density
• No usage of unsustainable manganese
• Good charging performance</td><td>• Up to several hours charging time
• Scarcity of resources such as lithium
• Shorter battery lifecycle
• High thermal runway risk</td></tr>
<tr><td colspan="2">LiFePO 4 battery</td><td>• Longer battery lifecycle than Li-ion batteries
• Cheaper in production and used in cheaper EVs to make them more affordable
• Low thermal runaway risk</td><td>• Scarcity of resources such as lithium (highest usage)
• Lower energy density
• Charging performance is temperature-sensitive</td></tr>
<tr><td colspan="2">Solid-state battery (SSB) (SSBs used solid ceramic material instead of liquid electrolytes for carrying the electric current)</td><td>• Cheaper and lighter
• Faster to charge than LIBs (around 15 minutes charging time)
• Capability of up to 1000km range, eliminating range anxiety
• Less risk of explosion or fire wherefore less components for safety are needed
• Shorter manufacturing times resulting in less costs and more production efficiency
• Longer battery lifecycle and reduction of carbon footprint of EV batteries by 40%</td><td>• Scarcity of resources such as lithium (they need more than Li-ion batteries)
• Hurdle to broader implementation as materials such as graphite and lithium were less efficient to recycle than nickel and cobalt in Li-ion batteries
• New to the market which faced risks of low mass adoption and missing economies of scale</td></tr>
</table>

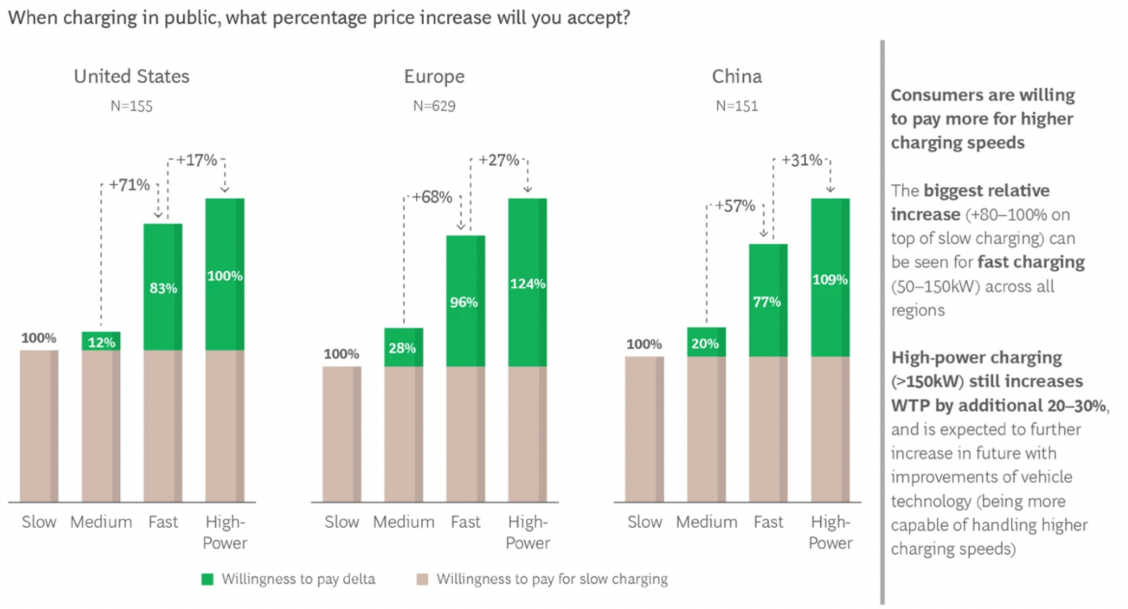
Appendix 8*: Conductive charging as commonly used EV charging technology in 2023* (Wallbox 2023)



Appendix 9*: Europe's projected EV charging demand until 2030 –Situation of the industry in 2023* (Hagenmaier, et al. 2021)



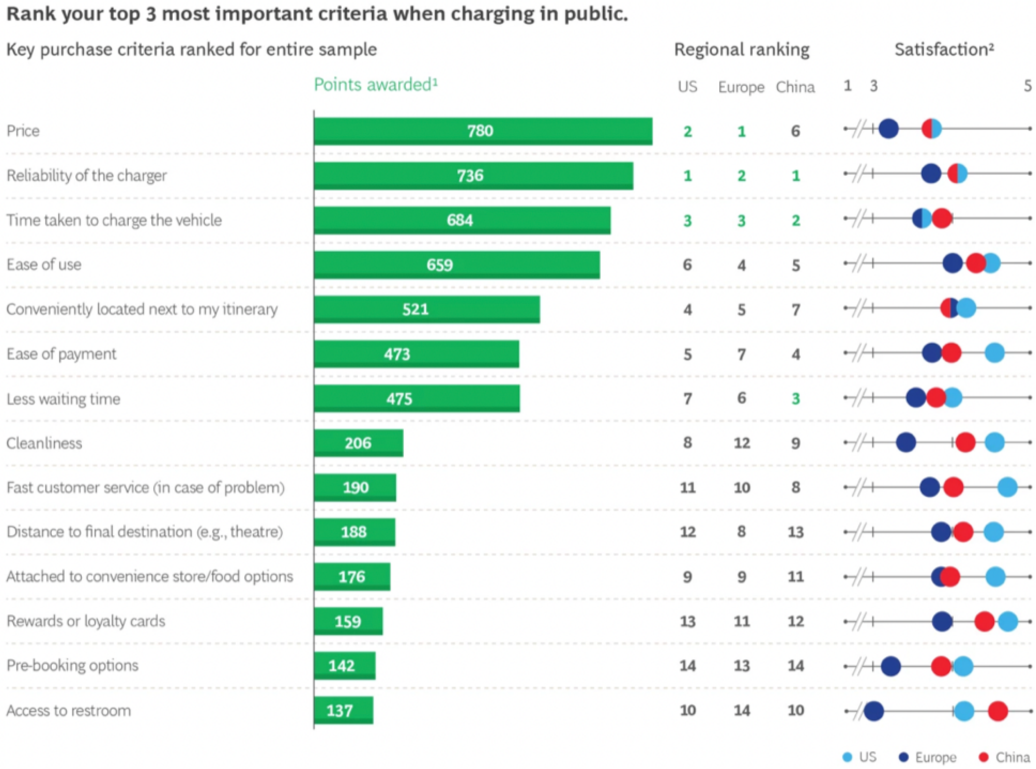
Appendix 10*: EV Owners were willing to pay a price premium for fast charging – Situation of the industry in 2023* (Hagenmaier, et al. 2023)



Source: BCG EV Charging Survey.

Note: WTP = Willingness to Pay; Slow: <=22kW; Medium: >22kW to <50kW; Fast: >=50kW to <150kW; High-Power: >=150kW; Percentage increase in how much EV owners are willing to pay for faster charging speeds are calculated relative to the cost for slow charging in same region; For Europe, the allocation is based on weighted average of Germany, Italy, Norway, Spain, UK, and France. Weighted based on BEV+Plug-in Hybrid Electric Vehicle (PHEV) ownership in 2021.

Appendix 11*: Ranked evaluation criteria for public EV charging – Situation of the industry in 2023* (Hagenmaier, et al. 2023)



Source: BCG EV Charging Survey.

Note: For Europe and Global, the allocation is based on weighted average based on country/region BEV+Plug-in Hybrid Electric Vehicle (PHEV) ownership in 2021.

[1]Respondents choose and rank top 3 criteria: 3 points for first choice, 2 for the second choice, and 1 for the third. (Maximum possible points if all respondents assigned as their first option: 921*3= 2763 points).

[2]1=not satisfied at all and 5=completely satisfied.

Appendix 12*: Overview of NIOs lifestyle products in 2023* (Cheng 2023*;* NIO 2021a*;* NIO 2021b*;* NIO 2021c; NIO 2020a)

NIO Phone

The NIO phone, launched 2023, was an Android smartphone that cost between EUR 841 (USD 900) and EUR 935 (USD 1k) and had only been launched on the Chinese market. The smartphone was available to everyone regardless of ownership of the NIO car. Key differentiator of the phone was its function as a key for the car.

NIO House

With the purchase of an NIO car, customers gained access to all NIO houses in China. While at first glance the NIO houses resembled the showrooms of premium car manufacturers, the houses included an NIO café with its own coffee drink, a library for borrowing books or DVDs, a conference room for talks or forums, a meeting room for use by individual users, a living room and a childcare area.

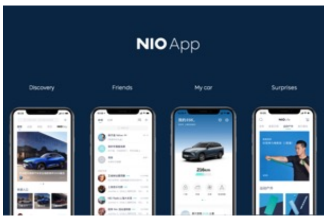
NOMI

NOMI was an advanced digital assistant that used artificial intelligence to provide personalized and emotional interaction with drivers and passengers. By learning the driver's preferences and behaviour, NOMI was able to perform tailored tasks such as adjusting vehicle settings and providing entertainment, which would be of importance with autonomous driving in the future.

Blue Sky Lap

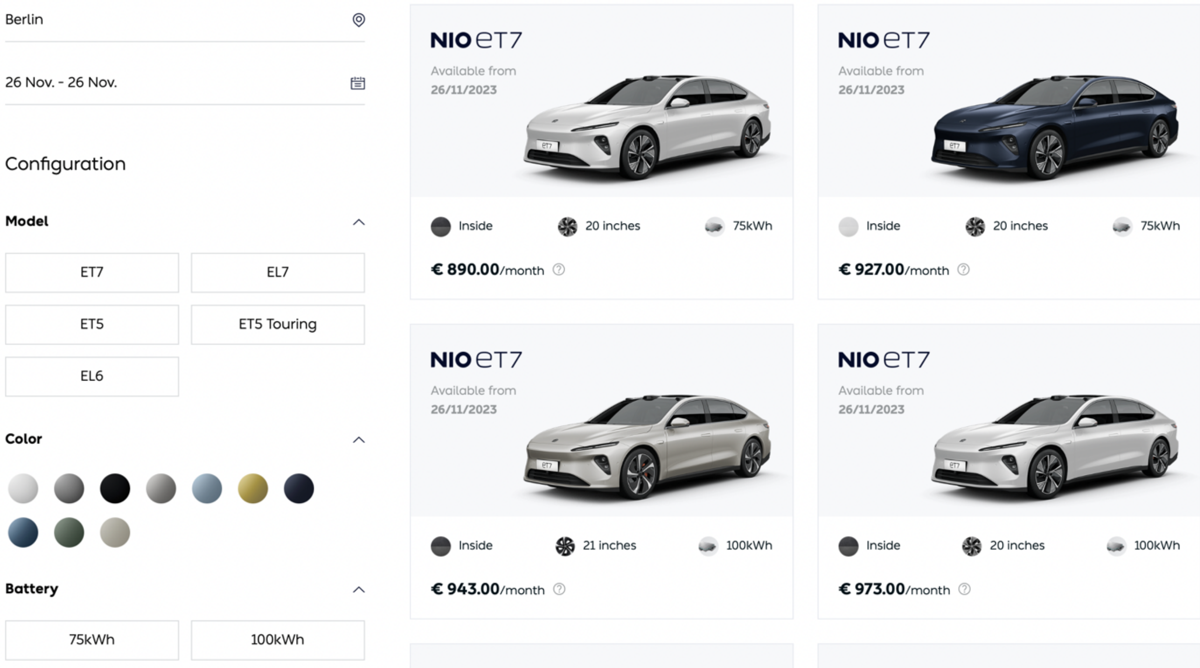
In 2021, NIO launched its first circular fashion collection that recycled leftover materials from automotive production, such as airbags, seat belts, etc. More than 80 designers worked on the project.

NIO App



The NIO app received a 4.5-star rating, the highest among 20 other mainstream automakers. The app provided access to the latest NIO news posted by users, NIO employees or even the founder, CEO William Li, real-time messaging with users and NIO employees, scheduling of test drives as well as customizations and car purchases, and last but not least, merchandises offers from leading designers.

Appendix 13*: Overview of NIO's model subscription options on the market in 2023* (NIO 2023g)



Appendix 14*: BaaS vs. Battery purchase options at NIO offered in 2023* (NIO 2022c)

	Battery 75 kWh capacity	**Battery 100 kWh capacity**	**Battery swapping applicable**
Battery subscription*	**169 EUR/month**	**289 EUR/month**	**X**
Battery purchase*	**EUR 12k**	**EUR 21k**	

** Choice of battery independent from decision on car purchase or subscription*

Appendix 15: *Expert Interview with Tim Eberhard, Senior Director at Capgemini Invent (2nd October 2023)*

Constanze: **So first, I would like to thank you for taking your time for this expert interview and for the contribution to our work project. As we explained, we want to focus on the rising power of Chinese EV manufacturers in the German car market. We saw in the last three years that Chinese car brands gained strong relevance in the German car market by disrupting it with their EVs. So how would you explain their key success factors?**

Tim: *I think it is fairly simple. The first thing is they are quicker than the others. Then, they are more convincing when it comes to digital integration in the vehicle. And the third thing is, they live a different kind of cultural mindset when it comes to fulfilling their cars and trying to erect their cars in a different way.*

Constanze: **Okay, great. So, if we also go a bit more into the details of what they do different than German OEM, what do you think makes them outstanding and also attractive to customers in Germany, which were before focusing quite a lot on purchasing German car brands?**

Tim: *Well, I think first it started off with a certain kind of reluctance from the customers saying, well, okay, this is a Chinese brand, and we all know China is a state where basically most of the people are being observed by the state. So therefore, I think it is, was the bad image of China in combination with their political system. And most of the customers also might be a little bit reluctant because they were thinking data will not only go to the Chinese OEMs but will be transferred any further. What we can see right now is that this has changed a little bit because the image obviously really was a bit outweighed by the usability of the cars. In other words, from my point of view they realized that on the one hand side, there is a risk of data privacy and on the one hand side, there is also a big chance of comfort and easiness or ease* *when it comes to driving and using cars. And I think this was a paramount shift, which just has taken place only recently.*

So, this is the first argument why basically Germans tend to decide for Chinese brands more likely now than they did in the past. The second thing which needs to be discussed is the price. Obviously, the price seems to be a little bit lower.

Looking into the future, that might be an interesting part because we are not so sure whether the price will be lower also in the future, looking at what the EU parliament also is discussing right now and also the value for money you are getting. So basically, you get more by paying a lower price in comparison to the traditional offerings of the German OEMS. So, in other words, they are not putting that much into building up brand than a Mercedes-Benz, BMW or Audi is doing right now.

Constanze: That is a very interesting point you raise here. If we talk now about the changing customer preferences also for Chinese EV brands like NIO or BYD, do you also see a shift for the Chinese EV brands from direct car ownership towards more flexible mobility solutions? Many of the Chinese EV manufacturers also come into the market offering very flexible ownership models. For example, Lynk & Co offers a subscription-based model in combination with their app on which customers can offer back their car to other people similar to a carsharing concept. So, do you also see that as a competitive advantage of the Chinese EV brands?

Tim: *I think on the first side it will be ownership. It will be the traditional market which they are going to conquer from my point of view, so majorly looking towards customers who would like to buy and own a car on the firsthand side. But I think in the midterm that also can be possible because right now it makes the decision quite easy for Germans to decide for Chinese cars, as mentioned earlier. In the midterm, we can well imagine that they also might enter subscription and car sharing patterns as long-lasting business models. And they might be also* *quite successful in that because car sharing in Germany is not profitable right now. So, there is no one out there who is right now offering a car sharing service which is profitable. And if you have lower capital costs, and this will be the case for the Chinese car brands, I can well imagine that this might be a spot they might jump into. From that point, yes, but only in the mid-to-long-term.*

Constanze: **When we take a closer look at the Chinese EV manufacturer NIO, they first entered the European market via Norway and in the end of 2022, also entered the German car market. How would you describe their position within the German car market, especially in comparison to the German OEMs, but also to the other Chinese EV brands as they are one of the few foreign EV brands which position themselves at the higher price point?**

Tim: *Yeah, that is right, I agree on that. I think NIO and its current lineup with the ET5, ET7 sedans and the EL7 SUV (former known as ES7 in China) is purely positioned in a premium segment, but so is also BYD with their new models coming up and so is Funky Cat from Aura, if you might want to say this is premium. Also, Xpeng and Seeker are basically trying to position themselves in a more premium segment now, so we see a shift here as well. Speaking of NIO, they are probably a little bit ahead of the curve just due to the fact that they expanded already in Europe, so we can basically see them also in the premium segment. But, of course, depending on the sales strategies of the other Chinese brands, they will also be competing with them in the in the premium segment. In comparison with the traditional, luxury and premium brands BMW, Mercedes-Benz, Audi and probably also Porsche, they position themselves more with their brand values. The brand values of NIO are really focusing on putting everything into community, trying to convey a certain kind of lifestyle, which you can see also in the NIO houses, and also trying to position themselves when it comes to innovation. Because obviously innovation is arguable, but also lifestyle and especially community is something which they are* *doing quite good, also towards the other. So, if you ever been in the house, you can really sense what I am saying because it is a completely different style. They might be comparable with the new Porsche concept "Destination Porsche", which is live in Germany as well, where people are going to to gather around in order to build up a certain physical community to not only buy cars and accessories, but also trying to network with each other. In a physical world, but also in a virtual world, NIO is really having the pack and leading the pack. The NIO app in China is really outperforming because everybody wants to be part of NIO as a lifestyle object and not necessarily as a as a potential car user. And therefore, if that comes over to Germany, then I can imagine that this would be also a great differentiator NIO will have towards the others.*

In addition, of course, they offer the battery swapping technology with the Power Swap Stations of which they already have several in use in Germany. These are the major differentiators.

Constanze: You already touched upon on our next question, which is actually about NIO as a lifestyle brand. They focus, as you said, on having a strong interaction with their customers and their user experience. They perform very well with their unique combination of their different business models which are all built around the customer's comfort. Especially, battery management is a very pressuring topic for all EV manufacturers on the market and NIO offers a quite unique solution. They decided to go back again to the battery swapping technology, which we already saw 10 years ago with the Israelian startup Better Place, but which eventually failed at that time. Would you consider battery swapping as a long-term solution on the market, considering the current developments with SBBs coming onto the market and also the range of the current batteries increasing? And would you expect other EV manufacturers to follow NIO's example?

Tim: *Well, first of all, I think it is a differentiator in the market, which will play a role on the short-term for sure because it makes it unique and probably quicker. Currently, it still takes on* *average more than 30 minutes to charge your car, while swapping the battery is much faster. But the big thing are the capitalization costs. From a customer perspective, it will be a kind of differentiator, from an OEM perspective, it is a differentiator, but will also have a high impact on capitalization costs, because these battery swapping stations cost a tremendous amount of money. I am not so convinced that OEMs will invest in that accordingly. The question will be, does it make sense to jump on a partner network here? From my point of view, I think the profit which you can gain from a partner network is fairly small, and therefore I do not think that it is a great option.*

Therefore, I think it is more kind of an image perspective, what NIO does here. It will be differentiating for them a in a short-term and maybe midterm, but when battery developments are gaining more and more traction and getting more and more performance, then, this will be for sure not a solution which will last forever. So, for the long-term it is a bridge. Right now, it makes sense that this can be done, but there a probably good reasons why Better Place was not successful. It was not that they were probably a little bit ahead of their time, but also the high capitalization costs which you need to cater for.

Constanze: That is very true. If we take a broader look at NIO's long-term positioning and sales strategy again, would you consider them a long-term competitive player on the market and which competitive advantages do you expect them to hold?

Tim: *Well, I mean, it is only the perception we are having right now when it comes to NIO. They only have a short history on the European market and are only present in Germany since 2022. When you look into their brand, I think they are quite ambitious, although they are doing a lot of things right. I have also made quite a lot of experiences being in the NIO house and I was really surprised. They need to change it though, because when you are new to their House it is tremendously big and people are not gathering right now, although there is a cafe, although there is accessory and their cars. But around all of that are costs and from my point of view* *they are not there yet. I think in the future they really need to change that concept a little bit more towards efficiency. In that sense, they might be also successful in the future.*

I am not sure whether they will tackle BMW, Audi, and Mercedes-Benz, especially in Germany since people have grown up with those brands. And if there was another brand called NIO, for instance, they might first get accustomed to it. There might be one that argues, okay, it worked before in the smartphone era. There was Apple and others, but these are younger brands in the end of the day. And since cars are quite an emotional product, especially in Germany, I believe that they will play a role and, they came to stay here. But they will not be in the same premium-plus league as Audi, Mercedes-Benz and BMW, but in the prime premium-minus league. They will tackle the market, but they will need some time in order to bring the spirit and bring the lifestyle towards Germany.

Constanze: I think that is fair to say. You now already tackled a bit on the race of the German OEMs against the Chinese EV manufacturers on developing the most competitive EVs. What do you think the German OEMs need to do differently and what they should also invest in to position themselves stronger against the Chinese EV brands?

Tim: *Well, I think there are different facets. First of all, when it comes to the products, I think they need to be quicker in the development process. They need to be more user and customer centric. And you can really sense that when it comes to digitalization. So, for instance, if you go to a Chinese car and try to connect your smartphone with your personal area network, it connects super-fast without any platform barriers. In contrast, in the traditional premium OEMs it will take you forever to connect your smartphone to the car while also the software updates are still not automated. In Chinese EVs, the updates are happening over the air and truly over the air. This is from my point of view, what the Chinese are doing fairly well, next to the American brands like Tesla, who had a similar approach in building their own ecosystem infrastructure as NIO does it now.*

Second thing is they need to be quicker when it comes to development cycles. So, the development cycle for a new model in Germany is still seven years. This is due to the fact that the German brands are following a first-time right approach which is common for a premium brand. But they need to realize that having China as the top one market, the Chinese do not expect this high quality. They can do the pareto principle 80 to 20 percent. Because when you have been to a development department, they are really thinking of each and everything to bring up the car. The Chinese brands are doing it completely differently as they are living a permanent, better approach in terms of trying to bring up a car fast and trying to improve it over the time. And this will hinder the Germans to be quick when it comes to a great product lineup and a great variety in the product lineup.

Another thing is, from my point of view, that German engineers are fairly good in optimizing and making things even better. So, for instance, take the diesel auto motor which is in place for 150 years already. A German engineer was always tasked in optimizing the system. Now the EV motor comes up. The Germans also have a lot of experience EV development, but the Chinese are a bit more disruptive in their mindset. They like to turn the big wheel and not only the small wheel. So, basically the Chinese engineers are quicker when it comes to disruptions.

Then the next important aspect are the customers which are expecting more community. You can really feel that in the end of the day as there are a lot of OEMs there who are already looking nervously towards the Chinese because they also would like to create a considerable community. So, right now they are copying the Chinese, which is quite interesting as a couple of years ago, the Chinese were copying the Germans. And now it is basically vice versa when it comes to community development.

And the last thing, from my point of view, is creating a "can do" mindset because you can really feel that there is an optimism right now in the Chinese community which I cannot spot right now in the German traditional premium OEMs. And this is probably the biggest hurdle.

Constanze: **Exactly, as you said, it is important to realize that there is still a race to win again the Chinese EV manufacturers, but the German OEMs need to change a lot of things, especially in terms of pace. Thank you very much your time and to our contribution to our work project.**

Appendix 16*: Expert Interview with EV Analysist of MBB Consultancy (4th October 2023)*

In the last three years, we saw Chinese Car Brands gaining strong relevance in the German car market by disrupting them with their battery electric vehicles. How would you explain their key success factors?

It is true that Chinese OEMs dominated this year's IAA. However, you must take into account the history of how Chinese brands are trying to enter the European and especially the German market. NIO is trying to enter the European market through the Nordic countries, which already have a strong penetration of electric vehicles. In Sweden, for example, BYD was the best-selling electric car on the market in July 2023. However, in Europe, NIO only has a 0.14% market share within the premium electric vehicle segment in H1 2023. From my perspective, at current stake Chinese automakers do not have the strong market position as it seems to be now, at least not within the premium segment. Nevertheless, they have the potential to play a dominant role, especially in the entry-level segment, due to lower prices and superior technology, where they were already able to catch 11% market share in H1 2023, mainly driven by the MG brand.

Which changes do you also recognize in customer preferences which makes the Chinese EVs like NIO or Lynk&Co attractive brands? Do you recognize a strong shift from car ownership towards more flexible mobility and ownership and if yes, for which customer profiles?

In terms of customer profile, NIO's car subscription model attracts the younger generation, probably Generation Z, who want to be flexible and independent of ownership. However, NIO's premium prices are too expensive for this customer group. In my view, NIO's price segment and cars are more suitable for the older generation who are willing to pay a premium for a luxury car. However, these people are probably not attracted to NIO as a lifestyle brand and want car ownership rather than subscription. Considering that the battery accounts for 30%-40% of the car price, it can be assumed that the typical German customer is not willing to subscribe to the battery, but rather wants to own it. Overall, I would say that NIO is in a difficult position to become successful on the German market considering the different needs of customers and their current approach to tackle the market.

From your perspective, which customers should NIO target to successfully meet customer needs?

From my perspective, NIO's ownership model is best suited for cab and corporate fleets, as the subscription model offers flexibility to companies. NIO's battery swap model and the long range of the vehicles allow company employees to travel long distances without long charging breaks. Especially taxi fleets are highly attractive, given they mostly leverage premium cars and the battery swapping provides them with a fast and reliable charging experience.

What do the Chinese EV manufacturers do differently than the German OEMs and what makes them that outstanding and attractive to customers in Germany?

The key success factors in the European market for Chinese EV brands are their price competitiveness and technological progress. With about 71% of global battery production located in China, Chinese brands have access to lower battery costs, while some of them are already highly vertically integrated. Taking the example of BYD, the company controls the *whole supply chain, from raw materials to their own auto transport ships. The company managed to transform from ICE to electric only within five years, while keeping their gross margin constant. Nevertheless, looking into the example of NIO, the company postponed their battery in-house production plans due to current market developments. In terms of software development, new entrants - as which most Chinese manufacturers count - differ from European OEMs in that they have in-house software development from a single source, while European OEMs tend to source software from a variety of their tier 1 suppliers.*

Do you see the Chinese EV brands as a threat to the German car manufacturers? What should NIO do and where should NIO invest in to win the race?

For the entry-level segment, Chinese manufacturers can be seen as a threat offering lower prices for superior technology. In the premium segment, where NIO and Tesla operate, NIO needs to lower prices to compete with Tesla and put themselves a price advantage over incumbent premium OEMs. Looking into their home market in China, Tesla recently started a price competition, where not every local player is able to compete with, and NIO is one of them that specifically announced not to compete on these price developments. Nevertheless, back in June the company cut their prices by approx. USD 4.2k in China. Although, customers in the premium segment are less price sensitive and purchase decisions depend on product quality and brand experience or brand loyalty. In addition, NIO needs to invest in customer loyalty and build customer trust, especially as a Chinese manufacturer, to be recognized as an equivalent to traditional German OEMs such as Mercedes-Benz or BMW.

Appendix 17*: Expert Interview with Porsche Deutschland GmbH (12th October 2023)*

Is the market entry of Chinese manufacturers seen as a threat to Porsche's success? If so, what is Porsche's strategy to remain competitive on the German/European market?

Personally, I don't see any fundamental issue when new players enter the market. It is a common process for new competitors to arrive and for some of them to disappear again. We align our products and services with the market needs: What does the customer expect from Porsche? How can we win new target groups? How can we excite our existing customers? With this approach we have been successful in the past and are convinced that we will continue to do so going forward.

Porsche has something very special that not many brands can boast: our heritage. We have a long tradition and the Porsche 911 is a true icon. In 2023, we celebrated 75 years of sportscars with the Porsche brand as well as the 60th birthday of the 911. But of course, innovations are also important in order not to be left behind by the competition. In 2019, we launched the first fully electric Porsche, the Taycan. The vehicle was named the most innovative vehicle of the year in 2020 and shows how innovation and tradition can be combined ("AutomotiveINNOVATIONS Report" from the Center of Automotive Management).

As NIO establishes a lifestyle brand as a premium EV manufacturer focused on customer experience, is Porsche adapting its strategy in response to the new competition?

The main purchasing criterion for our customers is the brand, followed by design and performance. I think there are already many different programs and ways available today to experience the Porsche brand: Our Porsche Centers offer various events for our customers on a regular basis: for example, road book tours, sports events, such as golf tournaments and other community events.

By ways of our other formats such as the Porsche Experience Centers, the Porsche Brand Store ‚Driven by Dreams‘ in Stuttgart or temporary formats such as Porsche NOW or the Porsche Art Studio we also make the brand accessible to enthusiasts and prospects. During this year's "Festival of Dreams" at the Hockenheimring, we welcomed more than 80,000 Porsche fans and were able to present the Porsche brand in an exciting manner.
But we also organize small and exclusive events, such as Track & Snow, which featured unique driving experiences with the new 911 Dakar. This allows us to create unforgettable "money can't buy" moments.

Do you see any potential for Porsche to adapt battery swapping technology as it allows for a more convenient charging process?
In my opinion, we are very well positioned with our current strategy. Porsche is investing in a comprehensive Porsche charging infrastructure. We offer charging solutions for convenient charging at home. With Destination Charging, we cooperate with exclusive hotels, restaurants and other locations to offer our customers free charging at these locations. Our dealer partners, the Porsche Centers, are equipped with high performance charging solutions for our customers. At the end of July, we opened the first exclusive Porsche Charging Lounge in Bingen, which enables Porsche customers to conveniently charge on long journeys. These are all Porsche exclusive solutions. But Porsche is also invested in the Ionity joint venture and is thus promoting the public expansion of fast charging solutions across Europe.

With regards to the market shift towards SBBs, is Porsche also investing in SBB development or keeping its focus on improving its revolutionary lithium- based batteries?
For now, we are focusing on lithium-ion technology. Of course, we are always open to new technologies and monitor developments very closely.

Given the increasing global demand for batteries containing critical resources such as lithium, do you see any risks for Porsche in selling EVs? If so, what are the risks and how is Porsche trying to minimize these?

All resources in the world must be used responsibly. Improvements are certainly possible here. We strive to repair defective batteries as often as possible before replacing them completely. There are also various pilot projects on how the batteries can be given a second life after use in the vehicle and can be used for alternative purposes. At the same time, Porsche is also researching the topic of eFuels with other partners in order to operate combustion engines with potentially almost CO2-free fuel in the future. Porsche and other international partners entered into a collaboration with HIF Global. HIF opened the 'Haru Oni' pilot plant in Punta Arenas, Chile, which began producing synthetic fuel in late 2022.

TEACHING NOTE

1 Case Synopsis

The year 2022 marked a historic turning point since Europe imported more Chinese cars than it exported to China for the first time. It was visible that the traditional automotive industry was being transformed, shifting from the dominance of ICEs towards EVs, strongly driven by Chinese EV manufacturers such as NIO and BYD.

This case on NIO's market entry into the German EV market presents the versatile challenges of business model innovation, the development of an ecosystem as well as market entry strategies and positioning. NIO was a true technology pioneer with its innovative battery swapping technology and the respective battery swapping infrastructure. The case is set at the end of 2023, one year after NIO entered the German EV market. It discusses the challenges but mostly the superiority of Chinese EV brands such as NIO, when entering the European EV market. Here, NIO's unique business models with its BaaS approach and battery swapping technology is particularly emphasized. Furthermore, NIO succeeded in building an outstanding brand image and community through its app interaction and NIO community houses. To consolidate its positioning in the market, NIO adapted its business model to the customer feedback on the respective markets. After a response from customers in the German market, NIO started offering a purchase option for their EVs in addition to their typical subscription model with flexible durations. The case ends with global CEO and NIO founder William Li meeting with the appointed General Manager of NIO Germany, Ralph Kranz, in the German headquarters in Munich to discuss NIO's achievements in the German EV market and evaluate its market positioning and strategy approach through the combination of different business models.

2 Target Audience and Learning Objectives

The case is tailored to general strategy or business model innovation courses for graduate or MBA students. Given the case's demand for a comprehensive understanding of fundamental internal and external strategic analysis concepts, business model innovation, and sustainable competitive advantage analysis, it is best suited for inclusion in the concluding classes of a course curriculum. By the end of classes, students should have acquired the following abilities:

- Understand the different purposes and underlying strategies of market expansions.
- Analyse a company's market positioning within highly competitive and technologically advanced markets.
- Evaluate the business model potential of business model innovations for sustainable long-term success.
- Understand the requirements and activities for a functioning ecosystem and the need for network externalities.

Appendix 18 serves as a guide for the teaching plan, outlining the recommended timing, and enabling case discussions in alignment with the specified learning objectives.

3 Case Analysis

3.1 External Analysis

3.1.1 Identify key market characteristics and describe how they have shaped the Chinese and German EV markets.

To open the class discussion, the lecturer is advised to start with a discussion on the market characteristics of the German and Chinese EV market which the students prepared in their preparatory analyses. Students are further encouraged to apply the PESTEL framework to identify the key success factors and challenges of the automotive market in both countries, in a similar style as presented below. The analysis will provide students with a comprehensive understanding of both markets to evaluate in the following question how NIO is expanding its business from the Chinese to the German market and whether the company will be successful.

First, students should be able to recognize that Germany was one of the world's leading automotive export nations in the past. The German success story is based on cars with internal combustion engines, especially in the premium segment. Due to increasing environmental concerns worldwide, the automotive industry shifted to EVs. While Germany focused on optimizing ICEs, China began investing in R&D for EVs in the early 2000s and was then the leader in the EV market, both in terms of domestic sales and international car exports. In addition, students should conclude that China's success story was due to several legislative and policy initiatives, such as the Dual Credit policy as well as financial incentives for car manufacturers, which encouraged R&D investments in the EV industry. The German market was becoming more favourable for EV manufacturers because of political considerations like the Fast-Charging Act in 2021 that included recharging station targets for Germany until 2025. Economically, the German automotive industry offered potential due to its size and diminishing customer loyalty towards traditional automotive brands for EV purchases. However, in terms of legal considerations, ongoing discussions about the introduction of import tariffs for Chinese companies could pose a future challenge for OEMs planning to expand to the German market. For a detailed description of the PESTEL analysis for the German and Chinese EV market view ***Appendix 19***.

3.1.2 What were the drivers for the rise of Chinese OEMs in the German EV market? Keep in mind the different dimensions when entering a new market.

The question can be answered with an extended Porter’s National Diamond Model and specific drivers identified as status quo in the German EV market. The lecturer should begin by asking the students what the key factors are that contribute to the international competitiveness of companies within a particular nation and lead them to the use of Porter’s National Diamond

Model. The Porter's Diamond Model of National Competitive Advantage analyses why specific industries within a particular nation can compete internationally (Porter 1990). Students should demonstrate that they understand the strong role of Chinese automotive manufacturers coming from their home market to international expansion. Therefore, the six dimensions, Firm Strategy, Structure and Rivalry, Factor Conditions, Demand Conditions, Related and Supporting Industries, Government, and Chance, should be analysed. A detailed explanation of the six factors is not necessary as the framework was discussed in the preliminary class. Additional research next to the content of the case study is recommended to dive deeper into the Chinese market conditions.

Dimensions	Conditions on the Chinese EV Market
Firm Strategy, Structure, and Rivalry	• Strategy of Chinese car manufacturers was concentrated on early EV R&D • Strong domestic rivalry with many EV manufacturers on the market strengthening competitiveness while preparing for international expansion • Push of battery swapping technology by the Chinese government
Factor Conditions	• The EV battery supply chain was concentrated mainly in China, thus, Chinese EV brands benefitted from lower EV battery costs • China pioneered the EV market and held outstanding technological knowledge; a huge advantage for expansion into German market
Demand Conditions	• China became the world's largest market and producer of EVs while Germany, traditionally known for their expertise in combustion engine vehicles, was falling behind • Chinese EV brands offered affordable EVs in contrast to German OEMs
Related and Supporting Industries	• Majority of the global battery supply chain was located in China • Related industries such as chip production drove the supply chain of raw materials in addition
Chance	• Through the outbreak of the Russia-Ukraine conflict the sales of EVs in China increased as China was less affected by the mechanisms of energy prices and the dependency on electricity • Paris Agreement, European Green Deal as well as the EU ban demanded to restrict the registration of ICEs by 2035 and by that to increase the demand for EVs also from Chinese manufactures
Government	• Integration of EV research in national planning and identification of EVs as one of the core industries in which China aimed to become a global superpower • EV purchase tax reduction on domestic and foreign brands in 2014 • Dual Credit policy in 2017

Through the analysis of the framework, students should be able to identify the main circumstances and drivers that led to the rise of the Chinese EV manufacturers in the European, but especially the German EV market: China's governmental EV support and innovation, the technological advancement of Chinese EV brands, the Chinese focus on customer's demand for customization, and the favorable regulatory environment for EVs on the German automotive market. The drivers are explained in more detail in ***Appendix 20***.

3.1.3 How did the competition environment in the German EV market change because of the new market entrants from China?

Diving deeper into the analysis of the industry, this question focuses on the competitive landscape. Students should gain insights into how the automotive industry in Germany is being changed by the new entrants from China. Therefore, we suggest that students answer this question using Porter's Five Forces Framework to assess the competition in the market and its influencing factors (Porter 1980). While most information can be derived from the case study, students are encouraged to further conduct research and utilize knowledge from other lectures. In the following, key findings are discussed, and a comprehensive overview of Porter's Five Forces analysis is summarized in ***Appendix 21***. The results should help students to recognize NIO's potential in the German market as the following questions assess the strengths and weaknesses of NIO's business model.

The **threat of new entrants** was assessed as **moderate** in the German market. Different regulatory requirements in the European market and lower subsidies for EVs increased the hurdle for Chinese suppliers to enter the German market. Nevertheless, Chinese car manufacturers were in an advantageous position in the battery supply chain, resulting in lower battery costs. In addition, the demand for partnerships from German OEMs was reducing barriers in the German market owing to Chinese innovation in the EV market. Also, the demand for EVs was expected to further increase going forward, driven by EU regulations to achieve net zero emission targets.

The **power of suppliers** was considered **moderate**. On the one hand, in the German EV market, many EV parts were sourced from single-source suppliers giving them power against automakers. The acquisition of alternative suppliers would result in substantial plant development and training investments. On the other hand, more and more automakers were making efforts to move the majority of their supply chain in-house which could pose a loss of power for suppliers not engaged in these newly formed contracts with EV manufacturers. This lock-in effect of suppliers could also reduce the total number of suppliers on the market and thereby, contribute to an imbalance of supply and demand whereby demand would exceed supply.

The **power of buyers** was evaluated as growing and relatively **high**. This assessment was based on European customers showing interest in new EV brands and buyer perception in the EV market undergoing a significant transformation expecting a seamless, personalized, and adaptable purchasing experience. The initial hesitation to purchase from Chinese brands was slowly diminishing but still existing. Also, online purchasing was gaining traction and brand loyalty was diminishing, giving buyers significant power in the development of the industry.

For the German EV market, the **threat of substitution** was **moderate**. On the one hand, there were other modes of transport on the market that were attractive to customers, including local public transport, which was subsidized by the German government, and ICEs. In addition, new urban mobility concepts such as shared use of cars, bicycles, and scooters were reducing the demand for ownership. However, the regulations imposed by the EU Commission, which restricted the registration of ICEs until 2030, for example, were forcing a shift in individual transportation from ICEs to EVs.

Those factors led to the **intensity of competition rivalry** being classified as **high**. The traditional automakers in the market were challenged by Chinese OEMs entering and revolutionizing the charging infrastructure through innovative technologies and business models that were adapted to EV customer requirements differing from those in the ICE industry.

3.2 Internal Analysis

3.2.1 Which expansion strategies did NIO use in recent years to enter new markets and grow in their existing markets?

To start with the internal analysis, the lecturer should ask the class for an appropriate framework to assess NIO's market expansion strategies. Students should propose the Ansoff Matrix. According to H. Igor Ansoff businesses should be engaged in continuous market and product diversification for long-term success (Ansoff 1957). To stimulate discussion and develop students' presentation skills, the lecturer should divide the class into groups of four to five people, each of whom is assigned a market expansion strategy. After a period of five minutes, one group for each expansion strategy is randomly selected to present their findings. If other groups disagree with the assignment of products and services, the lecturer should moderate the discussion. In the following, NIO's expansion strategies are presented. The overall teaching goal of this question is for students to better understand the business model of NIO. This understanding will facilitate students to elaborate on the competitive advantages of NIO's business model in question 3.2.2, also in comparison to OEMs that dominated the ICE market.

As depicted in ***Appendix 22*** NIO's **market development** efforts in Europe have been strategic. The company embarked on its European expansion journey by making a calculated entry into Norway, a nation known for its strong demand for EVs and well-established EV infrastructure. This strategic choice was further reinforced by supportive government policies, including incentives for EV buyers. Following its successful entry into the Norwegian market, NIO ventured into the key European countries Germany, the Netherlands, Denmark, and Sweden.

As part of its market development strategy, NIO introduced the second-generation PSS in Europe, with plans to cover major cities and expressways.

NIO's **market penetration strategy** involved the expansion of its charging infrastructure, the introduction of more affordable vehicle models, and the adoption of innovative ownership models. NIO was not only focusing on premium SUVs but was also directly competing with industry leaders like Tesla in the mid-size SUV segment. With NIO’s BaaS, customers gained the flexibility to lease batteries separately, thereby reducing the upfront costs associated with purchasing EVs. In the realm of autonomous driving, NIO introduced SkyOS to enhance safety, efficiency, and a LiDAR chip product to support the navigation of complex traffic scenarios. NIO's Central Computing Cluster improved computing power for assisted and intelligent driving and the introduction of NIO Link enhanced the focus on connectivity technology. The Navigate on Pilot Plus (NOP+) feature further improved user benefits by saving time and reducing accidents.

NIO's **diversification strategy** revolved around product and service diversification. The BaaS model represented a service diversification especially since NIO was offering adaptations of the service in different countries and regions. In Germany, NIO was offering the option to purchase the car instead of just offering the leasing option. Through these diversified approaches, NIO was positioning itself as a versatile and customer-focused player in the EV industry.

NIO's holistic **product development** strategy encompassed innovations in EV models, battery technology, autonomous driving, and complementary products, positioning the company for continued growth and success. Regarding EV development, NIO introduced its debut model, the EP9 supercar in 2016, establishing itself as a luxury brand. In 2019, the company launched the ES6, emphasizing efficiency and affordability, reflecting a shift towards a broader market segment. For NIO's battery technology advances, the company announced plans to manufacture high-voltage battery packs in 2024. The introduction of the third-generation PSS, with a capacity increase of 30% to 408 swaps per day, enabled rapid battery swapping. NIO also introduced to its product line its first flagship phone, the NIO Phone, to augment the convenience and smart features of NIO cars and NIO Power Home vehicle charging station.

3.2.2 How did NIO position itself within the market and how would you evaluate the company's value proposition, activities, capabilities, and resources?

To open the discussion on this question, the lecturer should recall the frameworks studied in the pre-class to evaluate which frameworks could be applicable to answer the question on NIO's value proposition, capabilities, and resources. The students should recognize that the NICE Framework with the four value drivers by Amitt and Zott gives a sufficient overview over NIO's business model and could thereby be chosen for the introduction to the question. To further analyse NIO's resources and capabilities in more detail, the lecturer can then guide the students to use the VARC (Value, Activities, Resources, and Capabilities) framework (see ***Appendix 23***) which serves as a robust analytical tool, enabling us to delve into the intricacies of how a company creates value, engages in key activities, and leverages its resources and capabilities to gain a competitive advantage. It provides a systematic way to assess the strategic landscape, facilitating a nuanced understanding of a company's positioning within its market. To put special emphasis on NIO's capabilities to achieve a sustainable advantage, the application of the capability framework by Collis and Montgomery (2008) proves useful (see ***Appendix 24***).

Appendix 25 shows the Novelty, Lock-Ins, Complementaries, and Efficiency of NIO's business model. The company prioritized **novelty** through the battery swapping technology and the BaaS model, challenging traditional EV ownership by separating the battery lease and therefore, reducing the upfront cost of an EV and granting greater flexibility to customers through the battery subscription. **Lock-in** was established through BaaS, fostering customer loyalty as users become intertwined with NIO's ecosystem. **Complementarities** were evident in NIO's diverse product range and services, offering a spectrum of vehicle models and physical spaces like "NIO Houses" to enhance customer engagement. Lastly, operational **efficiency** was a focal point, with NIO leveraging digital technology for customer interactions, community building, and addressing concerns about charging times through its battery-swapping infrastructure and BaaS model.

Value Proposition - NIO's value proposition was centered on their EVs with innovative battery technology including battery swapping and consistent R&D efforts. Beyond the mere provision of EVs, NIO stood out by introducing a unique approach with its BaaS model. This distinctive strategy allowed customers to purchase vehicles without the battery, which could be leased separately, significantly reducing the initial cost of ownership. Moreover, NIO did not limit its offerings to just vehicles; it extended services that complement the traditional customer-seller relationship. The brand was dedicated to creating a holistic experience, weaving in infrastructure for battery swapping and establishing spaces like NIO Houses, fostering a community-driven, interactive, and engaging environment for its users.

Activities - NIO's core activities spanned the manufacturing of EVs and the continuous development of innovative battery technology, crucial in creating products such as the NIO Phone and home chargers. The company's diverse activities extended further into constructing and maintaining PSSs, an essential element in their strategy for building a robust charging infrastructure. Alongside these, NIO invested consistently in R&D, focusing on advancements in semiconductor chips and autonomous driving systems.

Capabilities and resources - To analyse NIO's most significant resources and capabilities regarding how they might have created a competitive advantage, students should work with the resource and capabilities analysis by Collis and Montgomery. ***Appendix 26*** provides a detailed analysis of NIO's resources and capabilities and the respective evaluation outcome. It can be concluded that NIO mostly competed with its innovative battery technology and battery swapping technology, its battery swapping infrastructure, its BaaS model, and its unique customer engagement and offerings. Here, it can be evaluated that NIO seemed to create a sustainable competitive advantage with its battery technology and its BaaS model, while its battery swapping infrastructure and its customer engagement rather create an exproriable and temporary advantage.

3.3 Better Place

3.3.1 How did Better Place position itself within the market and how would you evaluate the company's value proposition, activities, capabilities, and resources?

To compare Better Place's situation and positioning with NIO, students should recognize that they should apply the same frameworks as in the previous question for NIO. To guide the students, the lecturer might introduce the discussion by asking "*As this question asks for a similar analysis as in the previous question on NIO, how would you approach the analysis of the question*?" Students then need to first work out the NICE framework of Amitt and Zott, should analyse the VARC framework afterward, and put again emphasis on the resources and capabilities analysis through the framework by Collis and Montgomery.

Appendix 27 summarizes the Novelty, Lock-in, Complementarities, and Efficiency aspects of Better Place's business model. First, novelty was achieved by introducing an innovative battery swapping technology to the emerging Israelian EV market that redefines traditional car ownership. Second, the unique battery swap subscription model locked in customers due to the dependency on Better Place's charging infrastructure. Third, the need for a compatible car with battery swapping technology created business opportunities for manufacturers to tap into new customer market segments. Finally, the Better Place business model enabled fast charging, lower BEV prices, and removed the depreciation risk from customers, proving efficiency.

Value Proposition - Better Place's value proposition was established through the introduction of an innovative charging concept that was seen as disrupting the market at the time. In addition, the battery subscription model in combination with the charging infrastructure formed the core of Better Place's business model and represented a solution to the problem of range anxiety, as charging times were reduced to just a few minutes.

Activities - In general, Better Place's business activities could be simplified to the expansion of the battery exchange infrastructure, the provision of the Better Place service platform and the cooperation with the car manufacturer Renault.

To also analyse Better Place's most relevant resources and capabilities at that time in order to evaluate whether they represented a competitive advantage, students should again conduct the Resource and Capabilities Analysis by Collis and Montgomery. ***Appendix 28*** shows a detailed overview of Better Place's resources and capabilities and the respective evaluation outcome. It can be summarized that Better Place was in a worse position than NIO as it created no sustainable competitive advantage but rather a temporary advantage. Better Place mostly competed with its exclusive partnership with Renault and its swapping station network.

3.4 Comparison to NIO and its long-term sustainable competitive advantage

3.4.1 Which potential threats or weaknesses existed that led to the failure of Better Place's business model? How do these differ from the weaknesses and threats of NIO?

The aim of this question is for students to evaluate the reasons for the failure of Better Place to derive lessons for NIO in the next step. Students should distinguish between weaknesses arising from Better Place's and NIO's business model (internal) and threats from the environment (external). The "O" and "T" of the SWOT model can be used for this purpose, which also allows relevant results from the previous analysis to be summarized. To answer the question, the same learning groups should be formed as for question 3.2.1. Half of the groups should analyse the weaknesses of both companies, the other groups the threats. Here it is important that the students not only list the weaknesses of both companies, but also understand to what extent the weaknesses and threats of Better Place have been solved by its successor NIO and which newly added ones NIO will face in the future. To work on the questions, the groups should be given five minutes to prepare their results. Again, two groups are selected randomly to present their findings. Exemplary answers are presented in the following. Overall, the findings on this question are crucial for the subsequent assessment of NIO's potential in the German market.

As described in detail in ***Appendix 29,*** **Better Place** showed significant **internal weaknesses** regarding its dependence on the partnership with Renault and the geographical resource allocation instead of focusing on two countries for expansion. Ultimately, those weaknesses contributed to the failure of the company because the business model had not yet reached maturity in the pilot countries and Better Place's battery swapping stations were primarily designed for Renault's Fluence Z.E. model, limiting the variety of vehicles that could use their infrastructure.

Better Place encountered several **external threats** *(see **Appendix 30**)* that significantly contributed to the company's failure. Firstly, governmental support and subsidies were lacking when Better Place entered the market at an early stage. It was assumed that Israel, the founding country of Better Place, did not offer subsidies for the purchase of EVs in 2014. Without the necessary governmental backing, the company faced difficulties in implementing its business model. Secondly, the lack of industry standardization hindered Better Place's ability to establish a widespread, interoperable network, making it difficult for the company to scale its operations effectively and offer a seamless experience to EV users, ultimately contributing to its failure. High infrastructure costs were also a major concern. The extensive network of battery swapping stations and charging infrastructure required substantial investments, straining the company's financial resources. Customer acceptance challenges and customer range anxiety significantly contributed to Better Place's failure. There was a lack of trust in EVs and the ambitious shift away from the traditional car ownership model resulted in slow market adoption. Additionally, the concerns related to the limited range in early EV models and the resulting range anxiety discouraged potential customers and ultimately undermined Better Place's efforts to gain traction in the market and left the company struggling to attract and retain customers. Lastly, global economic conditions, including the aftermath of the 2008 global financial crisis, negatively impacted the automotive industry and consumer spending. This economic instability hampered Better Place's efforts to attract customers to its EV model.

In contrast to Better Place, **NIO** approached its market expansion and partnership strategy differently (see ***Appendix 29***). While Better Place struggled due to its dependence on Renault and geographical resource allocation, NIO determined Norway as its pilot country for its Europe expansion. Before the company entered the German market, it ensured that its business model was viable in Norway, incorporated learnings in its strategy, and ensured charging infrastructure coverage before its entry into the German market. Regarding NIO's partnerships, the company's EVs were compatible with power charging stations of various producers, eliminating range anxiety of European customers. However, NIO faced high capital requirements due to investments symbolizing its business model **weaknesses,** especially in charging infrastructure and fewer sales volumes.

NIO has faced some **external threats** in its journey (see ***Appendix 30***), some of which were similar to challenges faced by Better Place. Even though the company was receiving governmental subsidies, high capital investments in infrastructure could harm NIO's sustainable viability in the European market. Additionally, an upward pressure was placed on

NIO's prices in the European market, if the European Commission decided to impose tariffs on Chinese cars exceeding the EU's standard 10% rate.

This situation was different from the one Better Place faced, as governmental support and subsidies were lacking when the company entered the market, making it difficult to implement its business model. However, the acceptance of EVs in general and new technologies from novel brands in specific was immensely higher compared to 2014 with 2023. NIO tackled the range anxiety of customers by establishing a reliable charging infrastructure before its entry in a market and by forming partnerships with already established power charging providers. The level of battery standardization in the market was also higher, making the potential standardization for NIO's PSS more likely for a wide range of EVs. The competitor acceptance of the battery swapping technology, however, was still questionable which may have hindered NIO's overall acceptance and growth. However, NIO was exploring potential partnerships with automakers like Mercedes and Geely to eliminate this threat. Yet, it must be considered that partnerships harboured the threat of knowledge spillover to traditional German automakers. The overall adoption of battery swapping could have been beneficial for NIO, nonetheless it could also diminish NIO's differentiation on the market.

3.4.2 What are the learnings from Better Place's example that can be applied to NIO's case?

The aim of this question is for students to understand how Ron Adner approaches innovation and the surrounding ecosystem in his strategy book "The Wide Lens". The book is listed as the mandatory class reading for students to prepare prior to the class covering the failure story by Better Place. To start off, the lecturer should share the following statement: *"Winning in ecosystems requires winning more than just the execution race. It demands that you create coherent alignment among a network of partners, each of whom will succeed in their own execution, and each of whom is willing to collaborate productively with the other partners. How should you build this system?"* (Adner 2012, 282). To ensure that all students have the same understanding of Ron Adner's strategic approach to innovation, the lecturer should ask students to explain this statement. Answers should cover that commonly managers focus heavily on the execution strategy while neglecting the ecosystem in which products or services are introduced. These blind spots result from purely innovating the product or service while neglecting ecosystem elements. To move on, the lecturer should ask students for the three learnings from the Better Place failure story stated in the book. Additionally, students should provide an explanation referring to Better Place, and derive implications for NIO as presented in the exemplary solution below.

1. *"In ecosystems, we must monitor the burn rate of partner patience just as carefully as the burn rate of investment capital."* (Adner 2012, 344)

   Better Place was highly dependent on external financing and cooperation with Renault. Both the financial investors and Renault missed a stable financial situation of Better Place as resources were not properly allocated. As NIO was a listed company making financial losses, NIO must prove a positive business development to gain the trust of partners and investors.

2. *"A strategy of ecosystem reconfiguration must incorporate within it a strategy for setting ecosystem boundaries. Establishing a Minimum Viable Ecosystem (chapter 8) is a critical element of any such plan."* (Adner 2012, 345)

As a growing company, Better Place targeted too many countries simultaneously. Given that the success of the business model depended on external parties such as traditional OEMs, governments, and customers' openness to technology, the company should have focused on a viable business model in Denmark and Israel first. For NIO, the conclusion could be drawn to first build a viable and sustainable business in the Nordic countries and Germany. NIO did well in first entering the Norwegian market and building up the battery swap stations before entering other European countries.

3. *"In a world of ecosystems, great execution is no longer sufficient for success, but it remains a necessary condition."* (Adner 2012, 346)

In terms of execution, one of the main reasons for Better Place failure was the misallocation of resources to drive global expansion, while the business model in the pilot countries Denmark and Israel was not even fully developed. Limited financial resources slowed down the expansion of PSS, forcing customers to travel longer distances to PSS, which had a negative impact on customer satisfaction. The implications of this for NIO were to plan the market entry in other countries well. The initial product portfolio should be well tailored to the behavior of the buyers in the respective country, as NIO has done with the introduction of the ownership model. In addition, the entire customer journey should be well prepared to not disappoint customers, as in the case of Better Place.

3.4.3 What requirements did NIO's battery swapping and BaaS model need to fulfil to make their battery swapping ecosystem successful in the long-term? Please refer to the defined ecosystem requirements in the Wide Lens by Ron Adner.

The elaboration on the question on the requirements of NIO's BaaS model again bases on Ron Adner's Wide Lens perspective and aims to teach students the requirements of ecosystem innovation and network externalities. To open the discussion on the question, the lecturer can ask the students to name the three dimensions of successful ecosystem adoption which were identified in the Wide Lens perspective (*see **Appendix 31***).

The students should first identify the relevant co-innovation which explains who else needs to innovate in the same technology area to make its own innovation matter. Then, the right execution focus must be set. It is crucial that sufficient customer insight is developed, and the right competencies are built to beat the competition. Lastly, an adoption chain must be fulfilled, which explains who else needs to adopt the innovation until the consumers can experience the full value of the innovation. After that, the lecturer should guide the students in identifying the requirements NIO needed to fulfill to make their battery swapping ecosystem successful in the long-term. Students should work out for each dimension what NIO needed to do to achieve adoption of their battery swapping technology and the respective BaaS model:

Co-Innovation: The lecturer is recommended to start the guidance by asking *“Was it only NIO that needed to innovate in the battery swapping environment?”* NIO had a long-term dependency on charging network providers, energy suppliers, car manufacturers, and suppliers to support the expansion of the battery swapping infrastructure and invest in a functioning ecosystem. Building battery swapping stations required high capitalization costs and long amortization, therefore it was important for NIO to engage in partnerships with energy technology companies to co-innovate in the development of advanced energy storage solutions. The collaboration with renewable energy companies to explore innovative ways of integrating renewable energy into NIO's operations proved also to be beneficial. Besides, it would have been important for NIO to closely collaborate with governmental entities for support in the NIO Power Station expansion. This could have been implemented e.g., through the establishment of several EU production sites, grants and subsidies for battery swapping compatible vehicles, or the development of a regulatory framework to establish standardization.

Execution Focus: After that, the lecturer should support the students in identifying the relevant activities NIO needs to perform in their execution by asking *“Which activities could have supported NIO’s execution of their BaaS model and what risks did they need to be aware?”* They should realize that NIO’s approach to building its own Power Station network was rare besides Tesla which built its own Supercharger network. NIO needed to be aware of the time-intensiveness when building its own charging and swapping station network which might give OEMs time to catch up in development instead of accepting and supporting NIO’s battery swapping standard. Given NIO’s financial losses, a feasibility study of the economic viability of swapping stations should have been a crucial part of the execution process. To prevent the situation Better Place was caught in, NIO needed to remain flexible in its R&D efforts and ensure charging flexibility by offering users the ability to fast-charge their EVs or swap the battery.

Adoption Chain: Lastly, the lecturer is recommended to work on the question “*Who else needed to adopt NIO’s BaaS approach and standards to make consumers experience the full value chain of the BaaS innovation*?” with the students. NIO’s charging network was an outstanding differentiator on the market which enhanced brand image and could boost the brand’s EV sales. However, a vertical collaboration in the supply chain was relevant for NIO’s BaaS model to be adopted by end consumers. First, the brand could set technological and legal standards through a close governmental collaboration and therefore, control customers’ charging experience in terms of e.g., personal design of charging stations, offering of special use cases, and eased reliability of stations. The government could also support the BaaS success through innovation programs and subsidies for building battery swap stations. In addition, EV manufacturers needed to standardize battery designs for compatibility to allow for similar swapping processes. Without a sufficient level of standardization, NIO’s swap stations would only serve their own models and would not be scalable for other operators. Charging network providers could collaborate or integrate their services with NIO's PSSs by building PSSs next to their fast-charging stations and be incentivized through monetary margins. Distributors and energy providers needed to adapt their infrastructure and build swapping stations on their existing forecasts along major road networks to meet energy demands required from the battery swapping stations, keeping in mind the strongly increasing energy demand through higher EV sales. Industry standards organizations played a vital role in standardizing protocols for interoperability. Maintenance and service providers should adjust practices to align with swappable battery technology. This collective effort ensured NIO users could seamlessly utilize the innovative battery swapping infrastructure, maximizing its convenience and effectiveness.

3.4.4 Was NIO in a "better place" than Better Place to succeed?

The question if NIO is in a “better place” than Better Place to succeed sums up the analyses conducted in the previous questions by analysing if NIO holds a competitive advantage and which opportunities might evolve in the German market. The question requires supportive guidance by the lecturer in the class discussion as the students should assess NIO’s competitive longevity in the market by deriving the following impact drivers: Political support, Innovation Ecosystem, Customer Journey and Perception, and Timely Execution. The drivers are not identified through an academic framework but should demonstrate that the students were able to take away the most important drivers for NIO’s success evaluation. Starting the discussion, the lecturer could ask the students *“Which external or internal drivers, capability, or strategy can you identify that might have created a competitive advantage for NIO?”* Depending on the students’ replies, the lecturer should guide the discussion from driver to driver by highlighting the perspective on the external environment (e.g., political landscape), the battery and charging ecosystem, NIO’s market positioning and strategic expansion focus, and customer targeting. If needed, the lecturer can allow students to support their analysis with external research. A more detailed solution to the driver explanations can be found in ***Appendix 32***.

Political support: NIO received substantial governmental and legal support previously on the Chinese market for EV product development and the respective innovations. China identified EVs as one of the core industries in the Made in China 2025 strategy, incentivizing early R&D

in EV technology. In 2016, in Germany, the purchase premium for BEVs was introduced but reduced by early January 2023 on the grounds that BEVs were now attractive to buyers on the market.

Innovation Ecosystem: NIO's strategy to establish a robust innovation ecosystem in the German market must have incorporated investments in infrastructure and partnerships. Therefore, NIO's commitment to battery swapping technology, positioned the company as an innovative newcomer in battery technology and different ownership approaches. NIO also expanded its charging infrastructure, providing access to an extensive network of 380k charging points through NIO NFC cards. Planned expansions with esteemed automakers such as Mercedes-Benz, reputable suppliers like Bosch, and collaborations with car dealerships demonstrated NIO's intent to attract a wider buyer base and build an agile and innovative ecosystem.

Customer Journey and Perception: As resistance against Chinese brands diminished in the German market, NIO benefited from a more receptive customer base. NIO addressed their most critical concern, range anxiety, by offering innovative solutions like 3-minute battery swaps and charging options. NIO's flexible subscription models, encompassing leasing and purchasing options at various price points and durations, aligned with the preferences of German customers who valued flexibility but at the same time ownership.

Timely Execution: In terms of their market entry strategy for their battery swapping business model, NIO could be classified as an Early Adopter. As Better Place was ahead of its time in the EV market, NIO faced a more promising EV environment where investments were high, and the adoption of new ecosystems had stronger potential.

The students should further evaluate the future potential of NIO’s business models focusing on the opportunities that arise. The increasing adoption of EVs in Germany, fueled by governmental incentives and a growing array of purchase options, provided NIO with strong sales and subscription potential. The projected growth of the global EV battery swapping market, expected to reach EUR 835.54M by 2030, underlined the market potential. The high adoption rate of NIO's subscription model, with 60% of owners regularly utilizing battery swapping technology, signified the opportunities for economic separation of car and battery ownership. The growing NIO community further strengthened its image, opening doors to potential business models such as allowing NIO owners to offer their cars for carsharing, similar to successful models like Lynk & Co. Additionally, NIO's innovative approach to battery swapping played a crucial role in shaping the future of EV charging. By spreading the demand for charging over specific time periods and enabling users to schedule charging during low-demand periods, NIO contributed to efficient grid management and cost reduction. Lastly, NIO’s and other Chinese EV brands’ superiority in EV knowledge provided opportunities for partnerships with German car manufacturers to bridge their gap in EV know-how.

3.5 Case Wrap-Up

As a conclusion to the class, the lecturer should ask the students to evaluate NIO’s business model potential on the German EV market based on the previous analyses in one sentence. They could conclude that there seemed to be a moderate to strong potential for NIO’s battery swapping technology in the German market, mostly in the short-to-midterm. Their success depended mostly on the adoption and network externalities of their battery swapping and how the battery market would evolve when solid-state batteries were in place and charging times improved to the same level of battery swapping. Regarding the comparison to Better Place, it could be summarized that NIO apparently was in a “better place” than Better Place at its time.

Appendix

Appendix 18: Teaching Plan

The structure of the case discussion is divided into three sections in the teaching plan: The Pre-Class, the Preparatory Analysis, and the Class Discussion. In the Pre-Class, the instructor should discuss various frameworks suitable for the external and internal analyses of a specific company and the industry it operates in. External frameworks that should be in focus are a PESTEL analysis, Porter's five forces framework, and Porter's National Diamond. For internal analyses, the instructor should introduce the students to the VARC framework (adapted from Afonso Almeida Costa) (see ***Appendix 23)***, the Capability framework by Collis and Montgomery, and lastly the Ansoff Matrix. As the case includes a very specific comparison between the capabilities of NIO and the previous battery swapping startup Better Place, the students are required to read the introduction, chapters 7 and 8 as well as the epilogue of the book Wide Lens by Ron Adner in which the author represents the specific reasons for Better Place's failure and the respective Wide Lens perspective on innovations of ecosystems. Additionally, students should watch Better Place founder Shai Agassi's Ted Talk to learn about his innovative business idea. The class discussion in questions 3.4.2 and 3.4.3 will focus on the Wide Lens. Questions 1 to 5 should be given to the students after the pre-class and prior to the class discussion to conduct their own preparatory analyses. Questions 1 and 4 are optional for the case discussion and with the exclusion of those, the case discussion is outlined for a 120-minutes class. Nevertheless, the design of the case and teaching notes cover sufficient material to extend the class discussion by up to 30 minutes if the lecturer wishes to highlight specific perspectives on the case and include questions 1 and 4.

Part	Subject	Duration	
Pre-Class	The PESTEL analysis, the Porter's five forces framework, Porter's National Diamond, the VARC framework (adapted from Afonso Almeida Costa), the Capability framework by Collis and Montgomery, the NICE framework by Amitt and Zott, and the Ansoff Matrix should be discussed in the preliminary class.	45 minutes	
Preparatory Analysis	Students review the provided material and question 1 to 5 about one week before the class.	1 week	
	For preparation purposes, the students receive mandatory and further readings about one week before the class.		
Class Discussion	The lecturer gives a short overview of the class session.	5 minutes	
	Students discuss question 1 under instruction by the lecturer.	(10 minutes)	
	Students discuss question 2 under instruction by the lecturer.	10 minutes	
	Students discuss question 3 under instruction by the lecturer.	15 minutes	
	Students discuss question 4 under instruction by the lecturer.	(15 minutes)	
	Students discuss question 5 under instruction by the lecturer.	20 minutes	120 minutes
	Students discuss question 6 under instruction by the lecturer.	10 minutes	
	Students discuss question 7 under instruction by the lecturer.	15 minutes	
	Students discuss question 8 under instruction by the lecturer.	10 minutes	
	Students discuss question 9 under instruction by the lecturer.	15 minutes	
	Students discuss question 10 under instruction by the lecturer.	15 minutes	
	The lecturer wraps up the case and answers outstanding questions.	5 minutes	

Mandatory readings

Adner, Ron. The Wide Lens: What Successful Innovators See That Others Miss. United Kingdom: Penguin Publishing Group, 2012. (following sections to read: Introduction, Chapter 7 and 8, Better Place Epilogue)

Video: Agassi, Shai. "A new ecosystem for electric cars", TED2009 TED conference, February 2009. 17:47 (recommended to watch until 10:01 minutes)

https://www.ted.com/talks/shai_agassi_a_new_ecosystem_for_electric_cars?language=en

Recommended readings

Ansoff, H. Igor. "Strategies for diversification." *Harvard business review* 35, no. 5 (1957): 113-124.

Amit, Raphael and Zott, Christoph. "Business Model Innovation Strategy: Transformational Concepts and Tools for Entrepreneurial Leaders". *Wiley,* 2020.

Porter, Michael E. "New Global Strategies for Competitive Advantage". *Planning Review, 18* (3) (1990): 4-14.

Appendix 19: *PESTLE analysis of the German and Chinese EV market environment*

German EV Market	
PESTEL Drivers	**Description**
Political	• Purchase premium for BEVs launched in 2016 after diesel scandal • Fast-Charging Act in 2021
Economical	• Leading nation in the automotive industry for two decades • Automotive industry contributed 5% (2023) to German economy
Social	• Major purchasing criteria was technology, in particular advanced driver assistance • Consumers were twice as willing to shift to alternative manufacturers, however, European consumers were also hesitant to purchase from Chinese car brands
Technological	• Slow progress on in-house developments • Investments in R&D activities in China to take advantage of pioneering position of China on the EV market
Environmental	• Paris Agreement (2015) • European Green Deal (2019) • EU ban of internal combustion engines (2023)
Legal	• BEV exports from Chinese manufacturers to the EU reviewed by the EU commission to make a decision on the introduction of import tariffs

Chinese EV Market	
PESTEL Drivers	**Description**
Political	• Prioritization of EV market in political decisions • Integration in national planning and identification as core industry of the Made in China 2025 strategy • Reduction of EV purchase taxes
Economical	• Since 2022, China exported more cars to Europe than it imported • In 2022, China surpassed Germany in terms of car exports
Social	• After pandemic, consumers paid more attention on the quality price ratio and are less prone for impulsive purchases
Technological	• Outperforming Germany and the US in BEV technology, especially in battery technology and self-driving car software
Environmental	• Targets to become carbon neutral before 2060 with emissions peaking around 2030
Legal	• Dual Credit policy introduced to promote EV production

Appendix 20: *Assessed drivers of the Chinese OEM's entrance into the European market derived from the analysis of Porter's National Diamond Model*

Drivers	Description
Chinas Governmental EV Support and Innovation	• China presented a constant support of governmental subsidies for EVs. The Chinese EV manufacturers, e.g., NIO and Xpeng, were impactfully developing as the traditional OEMs just picked up the speed on R&D of EVs.
Technological Advancement	• German OEMs have fallen behind Chinese brands who succeeded at offering affordable EVs with technology and software tailored to local needs. • Through the technological and software advantages in the EV development, Chinese brands were outperforming the local German car manufacturers that were far slower in developing new EV models. • Lastly, China's EV manufacturers benefited from declining battery prices (battery prices made up 30% to 40% of an EV's cost of goods sold).
Customer Centricity	• With the increasing demand for customized and diversified products and services in the vehicle environment, OEMs were forced to change their portfolio and the way they approach customers. • Chinese OEMs performed strongly with their highly technological and connected EVs, focused solely on customer comfort with highest flexibility and community integration. • Through the seamless integration of all touchpoints along the customer journey, they offered their customers a whole new mobility experience with a community sense.
German EV Boost	• When the ban for new ICE vehicles from 2035 onwards was announced, the European Union disrupted the global automotive industry and paved the way for EVs. • The focus of car manufacturers' product development strongly shifted towards EVs, e.g., German carmakers like Volkswagen committed to a billion EV and battery program investment by 2030.

Appendix 21: Porter's Five Forces analysis of the EV industry in Germany

Legende
+ Argument for high power, threat or rivalry
- Argument against high power, threat or rivalry
x Argument for both high and low power, threat or rivalry

Threat of New Entrants: MODERATE

+ **Innovation strength** of Chinese manufacturers in EVs increased the interest of German OEMs in partnerships
+ Chinese manufacturers had a strategic advantage in **global battery supply**, especially in terms of cost
+ Imposed regulations by the European Commission drove demand of EVs
- **Different regulatory requirements** and lower subsidies in the German market
- Strong **German focus on the automotive industry**, therefore pressure to keep up with EV innovations, leading to increased competition from German OEMs

Power of Suppliers: MODERATE

+ Many **automakers relied** on a **limited number of third-party suppliers** for vehicle parts leading to procurement risks in case of disruptions, price wars, or delays in component development
+ **Substantial investment demands** for EV suppliers to adapt their plants to EV parts production
x **Lock in through long-term contracts** (vertical integration) reduced the overall flexibility of the number of suppliers on the market

Intensity of Competitive Rivalry: HIGH

+ Increased pressure for established German automakers since **international players** like Tesla and Stellantis have shown **higher growth potentials**
+ **Entry of several Chinese OEMs between 2020 and 2023** in the lower to mid-price range segment added to the industry's competitiveness players
+ **Plans of OEMs** like Xpeng and Zeekr to **expand to Europe** in 2024
+ **Substantial investment and expansion plans** of established and new players further intensified the competition in the industry
+ **Innovation efforts** of potential entrants like battery swapping or solar panel roofs opening the possibility for technology adapters

Power of Buyers: HIGH

+ **Changing buyer expectations**, with a demand for seamless, personalized, and adaptable purchasing experiences
+ **Brand loyalty was diminishing**
+ With the launch of new brands on German EV market, buyers had a **wide choice of options**
+ **Previous hesitation** to buy from **Chinese automakers** for German customer

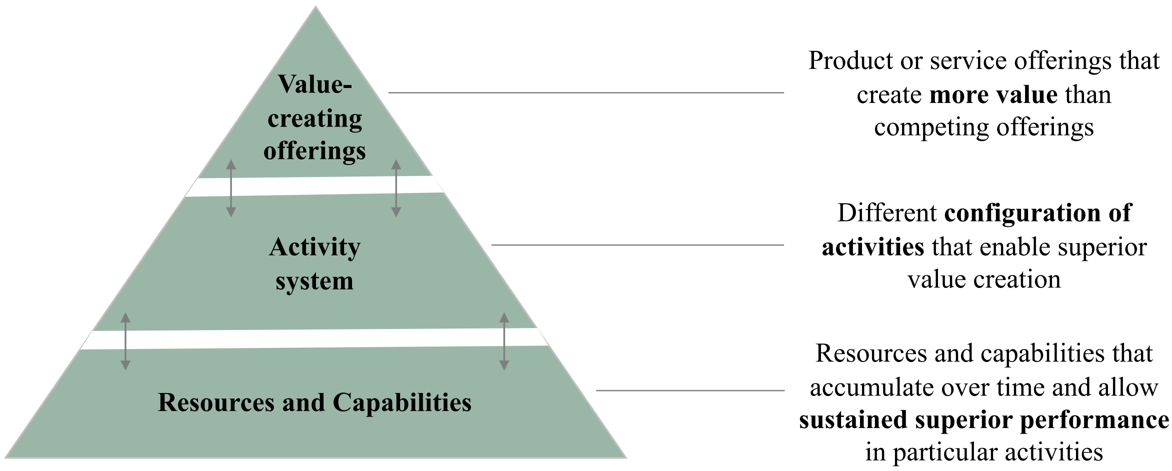
Threat of Substitutes: MODERATE

+ Other modes of transport:
  + Many consumers still preferred **ICEs** due to range anxiety with EVs
  + Government support to increase the attractiveness of **public transport** by introducing the "German Ticket" in 2023, allowing the use of most public transport in Germany for €50 per month
+ **New urban mobility concepts** such as car, bike and scooter sharing. Higher vehicle utilization reduced the overall demand for EVs
- Regulations imposed on future registrations of ICEs driving EV sales

Appendix 22: *Evaluation of NIO's expansion strategies using the Ansoff Matrix*

	Existing products	New products
New markets Europe	**Market Development** • NIO expanded into the **European market** with the start in Norway, followed by Germany, the Netherlands, Denmark, and Sweden • NIO expanded its **charging infrastructure in Europe**, including second-generation PSS, with plans to cover major cities and expressways by the end of 2022 • NIO's progress in **autonomous driving:** Released SkyOS, a chip product for LiDAR, the Central Computing Cluster (CCC), NIO Link and Navigate on Pilot Plus (NOP+) for highways and cities	**Diversification** • **Adjusted service offer** for **new market Europe**, where it was also possible for NIO's customers to purchase the EVs instead of leasing because of consumer preferences
Existing markets China	**Market Penetration** • **Expansion of PSSs** with the goal to reach 2,300 battery swapping stations in China by the end of 2023 • NIO's **market segment strategies** initially focused on premium SUVs but was then in direct competition with Tesla in the mid-size SUV segment • **BaaS Model** introduction to lease batteries separately, reducing upfront vehicle costs	**Product Development** • NIO's **EV development**: First model, EP9 supercar, positioned NIO as a luxury brand in 2016; ES6 in 2019, focusing on efficiency and affordability, aligning with Tesla's path • NIO's **battery technology development:** Plan to manufacture high-voltage battery packs in 2024 and third Generation PSS • **Additional products:** NIO Phone, NIO Power Home vehicle charging station, Power Mobile

__Appendix 23:__ The VARC (Value, Activities, Resources, and Capabilities) framework (Original content)



Source: Illustrated with permission and adapted from Afonso Almeida Costa (2023)

Appendix 24: *Five tests to evaluate a firm's resources and capabilities as a source of sustainable competitive advantage* (Collis and Montgomery 2008)

1. The test of competitive superiority: Whose resource is really better?
2. The test of durability: How quickly does this resource depreciate?
3. The test of inimitability: Is the resource hard to copy?
4. The test of substitutability: Can a unique resource by trumped by a different resource?
5. The test of appropriability: Who captures the value that the resource creates?

✓ Yes

✗ No

Resources/ Capabilities	1. Superior?	2. Durable?	3. Hard to copy?	4. Hard to substitute?	5. Can appropriate value?	Outcome
…	✗					Not competitively superior (no source of advantage)
…	✓	✗				Superior but not durable (shirt-lived advantage)
	✓	✓	✗			Imitable (temporary advantage)
	✓	✓	✓	✗		Substitutable (temporary advantage)
	✓	✓	✓	✓	✗	Not appropriable (expropriable advantage)
	✓	✓	✓	✓	✓	Sustainable competitive advantage

Source: Adapted with permission from Afonso Almeida Costa's slides (2023)

__Appendix 25:__ Amit and Zott NICE Framework for NIO

Novelty	NIO fostered the concept of novelty through its innovative **battery-swapping technology** and **BaaS model,** which challenged traditional **EV ownership**. The company's approach to provide EVs without the battery, leasable separately, reduced the upfront cost and made EV ownership more affordable. NIO's expansion to new markets and **diversified product range** further exemplified its focus on novelty
Lock-In	NIO's business model fostered lock-in as well through its BaaS offering. When customers **leased the battery separately**, they became locked into NIO's ecosystem, as switching to another brand's vehicle would require abandoning the leased battery. This created a **strong customer-business relationship**, enhancing customer retention and loyalty. NIO has also established a strong **digital presence and NIO houses**, creating a sense of community among NIO owners
Complement-arities	NIO built complementarities by offering a **range of vehicle models** and services that enhance the **value of its core EVs**. The introduction of more affordable models, like the **NIO EC6 and ES6**, complemented the **premium ES8 model**, making NIO's products accessible to a broader customer base. The company's **"NIO Houses" and "NIO Spaces"** served as complementarities by creating physical locations for customer engagement and showcasing NIO's EVs and services. NIO's BaaS model was a complementary service that reduced the upfront cost of vehicles and addressed concerns about battery degradation over time
Efficiency	NIO emphasized **operational efficiency** by **leveraging digital technology**. NIO had a strong digital presence, using platforms like Weibo and WeChat for customer engagement streamlining **customer interactions** and fostering a sense of community among NIO owners. NIO's battery-swapping infrastructure and BaaS was designed for efficiency, addressing customer concerns about charging times and range

Appendix 26: *Resources and Capabilities analysis of NIO* (Collis and Montgomery 2008)

Resource/ Capability		Superior?	Durable?	Hard to Copy?
Resource	**Innovative Battery Technology**	Yes: Particularly its development of solid-state batteries, was superior to traditional lithium-ion batteries in terms of energy density, charging speed, and safety features	Yes: Due to their stable and solid electrolyte structure, which could resist wear and tear over time	Yes: Due to the extensive investment, specialized knowledge, and infrastructure required to replicate NIO's ecosystem
Resource/ Capability	**Battery Swapping Infrastructure**	Yes: It offered quick and convenient battery replacement, reducing charging times and addressing range anxiety, despite facing challenges related to industry acceptance and standardization	Yes: It was designed to be durable and has undergone extensive testing to ensure reliability and longevity	Yes: Due to its integrated ecosystem, proprietary technology, and the extensive infrastructure required but NIO was hoping that competitors will adapt the technology for higher industry standardization
Capability	**Battery as a Service (BaaS)**	Yes: As it offered a flexible and cost-effective approach to EV ownership, allowing customers to separate the cost of the battery from the vehicle purchase, reducing the upfront cost, and providing the option to upgrade batteries over time	Depends: could been durable as it offered long-term flexibility and cost benefits for EV owners but if a more advanced battery technology would be developed or changes in governmental regulations occured, it could impact the long-term viability	Yes: As it required a substantial investment in infrastructure and the development of a compatible battery technology ecosystem
Capability	**Customer engagement offerings**	Partly: Tesla also had established a network of Tesla Stores and Service Centers and a strong digital and social media presence, and offered a dedicated app for customer support and vehicle control, NIO however just launched the NIO phone, first of its kind	Yes: Contributed to brand loyalty and create a sense of community among NIO owners, providing lasting value to the company	No: NIO's offerings were built on customer-focused principles and technologies that were not entirely unique and could be replicated or adapted by competitors with the right investments and strategies

Resource/ Capability		Hard to substitute?	Can appropriate value?	Outcome
Resource	**Innovative Battery Technology**	Yes: It encompassed advanced R&D, proprietary technologies, and significant investments. Moreover, NIO's technology was integrated into its entire ecosystem, making it challenging for others to replicate without extensive R&D	Yes: By securing patents, maintaining proprietary trade secrets, fostering a strong brand community, and continuously innovating in the EV space	Sustainable competitive advantage
Resource/ Capability	**Battery Swapping Infrastructure**	Yes: It required substantial investments, a widespread network of swapping stations, and integration with the company's overall ecosystem	No: While NIO wanted to ensure its intellectual property rights of the specific PSS technology, the company would highly benefit from widespread standardization and adoption by other players in the market	Exproriable advantage
Capability	**Battery as a Service (BaaS)**	Yes: It offered a unique approach to address the upfront cost of EVs by allowing customers to lease the battery separately reducing the financial barrier to entry for customers, and is integrated with NIO's ecosystem	Yes: BaaS was appropriable due to its integration with NIOs vehicles and the continuous relationship created with customers	Sustainable competitive advantage
Capability	**Customer engagement offerings**	Yes: Due to their innovation, significant infrastructure investments, and the strong emotional connections they have fostered with their user base, making it difficult for others to replicate the same level of engagement and experience	Yes: NIOs adaption efforts to the European market by considering consumer feedback before the launch showed their constant effort to ensure the appropriability of their service offerings	Temporary advantage

Appendix 27: *Amit and Zott NICE framework for Better Place*

Novelty	Better Place launched a novel concept to the traditional automotive industry by separating the ownership of the battery from the car. By that, Better Place **redefined the traditional car ownership** and offered a solution to the market that addressed several EV mass adoption challenges such as expensive Better Place.
Lock-In	Better Place`s business model fostered lock-in effect by offering a **subscription model** for batteries and creating dependency on the Better Place **swapping infrastructure**. This allowed the company to generate constant and regular cash flows through monthly leases and regular battery swaps.
Complement-arities	Better Place businesses model created business **opportunities to car manufacturers** such as Renault to **build compatible cars** and by that tap into a new customer segment.
Efficiency	The innovative battery swapping business model offered several advantages to the customer, such as **faster charging, lower prices** for BEVs as the batteries were leased, access to an infrastructure network, **no depreciation risk** for the battery, and no need to drive long distances to make the purchase of a BEV profitable.

Appendix 28: Resources and Capabilities analysis of Better Place (Collis and Montgomery 2008)

Resource/ Capability		Superior?	Durable?	Hard to Copy?
Capability	**Partner-ship with Renault**	Yes: With Renault, Better Place established a partnership with an established automotive brand. This recognized as superior capability in particular Better Place operated as a start-up in an emerging market	Yes: As Renault wanted to sell the newly developed car model to Better Place customers, while Better Place's business model depended on a compatible car on the market, both companies were dependent on each other	Yes: The development of a customized vehicle for battery swap technology was difficult to replicate since it required a financial commitment as well as a strong and trusting relationship between the parties. Therefore, this partnership was hard to copy
Resource	**Swapping Stations Network**	Yes: At the time Better Place was founded, the charging infrastructure was still inadequate as the industry was still at an early stage. Therefore, the charging infrastructure was a superior resource	Yes: If built, infrastructure brought long-lasting value to customers	No: Building infrastructure required high capital investments and fixed costs. However, Better Places mismanagement of financial resources could have allowed other companies to replicate the infrastructure and expand it at a higher speed

Resource/ Capability	Hard to substitute?	Can appropriate value?	Outcome
Partnership with Renault	Questionable: Although Better Place's business model was unique at the time, it was likely that Renault would have also collaborated with other BEV start-ups to tap into the EV market at an early stage	No: Given that the collaboration with Renualt was based on the company's trust in Better Place's business model, no adequate value was created. As Better Place mismanaged its financial resources, Renault terminated the collaboration shortly before Better Place's bankruptcy	Exproriable advantage
Swapping Stations Network	Yes**:** Even though other charging options were on the market, no technology with charging times was available to reduce the range anxiety of consumers	Yes: Due to the novelty of the infrastructure, Better Place attracted numerous sophisticated investors and also introduced a solution to the EV range anxiety on the market	Exproriable advantage

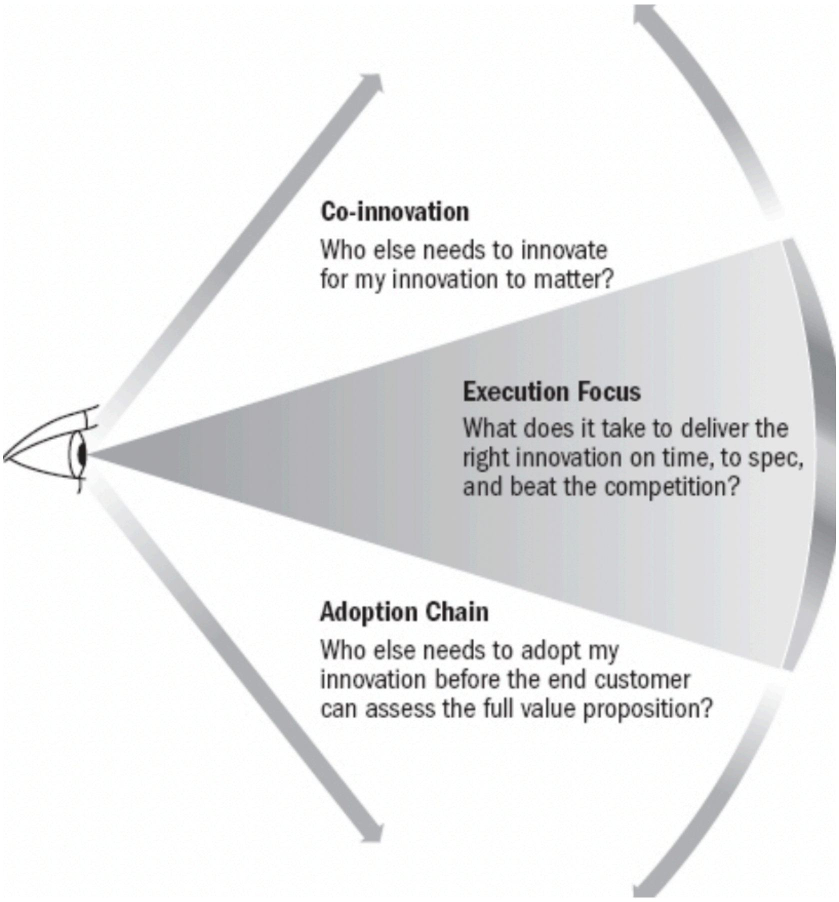
Appendix 29: *Weaknesses of NIO and Better Place*

Internal Weaknesses	
NIO	**Better Place**
• **Financial instability:** NIO faced per-vehicle losses of EUR 32k per car sold for EUR 39k in a specific period, indicating financial challenges. NIO's extensive battery swapping infrastructure in Europe may have posed financial challenges due to high implementation costs and uncertain demand, as consumer preferences could vary across regions. High capitalization costs were needed to build the required charging and battery swapping infrastructure (one of the reasons why competitors like Tesla did not further investigate battery swapping). • **Dependence on Chinese market:** Overreliance on the Chinese market could restrict NIO's strategic flexibility. The company might have found it challenging to explore new markets, expand its product range, or adjust its business model to respond to changing global dynamics.	• **Partnerships**: With its partnership with Renault, Better Place was able to launch its business model. However, Better Place was highly dependent on Renault and the development and launch of future car models to offer its service in the market and to win customers. • **Lack of Standardization & Integration Challenges**: The long-term success of the Better Place business model was highly dependent on car manufacturers standardizing batteries to increase the customer base that can use Better Place swapping technology. Additionally, interfaces were required between the Better Place services and third parties. • **Resource Allocation**: Instead of focusing on Israel and Denmark to test the business model, Better Place lost focus and invested in a variety of countries. Consequently, Better Place ran out of capital and required additional funding but had not generated any returns for investors.

Appendix 30: *Threats of NIO and Better Place*

External Threats	
NIO	**Better Place**
• **Tariffs and Price Disadvantage:** If the European Commission decided to impose tariffs above the EU's standard 10% rate on Chinese cars, it could lead to higher prices for Chinese BEVs, including NIO's, in the European market. This could erode the cost advantage that Chinese automakers enjoyed at the time as BEVs from Chinese manufacturers were sold 20% below EU-made models. Higher tariffs could make NIO's vehicles less competitive in terms of pricing. • **Competitor acceptance:** The success of battery swapping technology relied on industry-wide adoption and the establishment of a broad and accessible network of swapping stations. If competitors resist this technology, it could hinder its overall acceptance and growth, making it less appealing to consumers who may be concerned about long-distance travel and charging option.	• **Government support and subsidies**: Better Place entered the market at an early stage, when the government and authorities had not yet recognized the change in the automotive industry and therefore did not yet support Better Place's business model. • **Customer acceptance**: Since customers had not yet built-up trust in EVs, the switch to a business model that also overturns the traditional model of car ownership was a huge change and possibly an overly ambitious move. • **Lack of Industry Standardization:** The absence of industry-wide standards for battery technology and charging infrastructure posed a significant environmental threat. • **High Infrastructure Costs:** Building an extensive network of battery-swapping stations and charging infrastructure required significant investments. The high costs associated with constructing and maintaining these stations strained the company's financial resources. • **Global Economic Conditions:** Economic challenges, including the global financial crisis of 2008, negatively affected the automotive industry and consumer spending. • **Customer range anxiety:** Consumer concerns about the limited range of early EV models created range anxiety, making it difficult for Better Place to convince potential customers that EVs were a viable alternative to traditional combustion vehicles.

Appendix 31: *The Wide Lens Perspective to develop innovative strategies* (Adner 2012)



Appendix 32: *NIO's impact drivers*

NIO's Impact Drivers	Description
Political support	• NIO benefited from significant government and legal support in the Chinese market for EV product development • China's strategic plan Made in China 2025 prompted incentives for early R&D in EV technology • Chinese government's support included purchase tax reductions for both domestic and foreign EV brands since 2014, the Dual Credit policy implemented in 2017, and a growing number of subsidies for EVs • In Germany, a purchase premium for BEVs was initiated in 2016, but was decreased in early January 2023 as BEVs became market-attractive enough • German government also encouraged the growth of the EV charging station network by launching a program with a budget of EUR 6.4M for public charging infrastructure investment

NIO's Impact Drivers	Description
Innovation Ecosystem	• NIO's strategic approach on building a robust innovation ecosystem in the German market focused on investment in both infrastructure and strategic partnerships • With regard to infrastructure development, NIO recognized the fragmented landscape of Europe's EV charging infrastructure with Tesla in the industry-leading position • NIO's advancement in battery swapping technology, notably with its third-generation Power Swap Station (PSS), positioned NIO as a competitive newcomer with a competitive edge in battery technology and alternative ownership models • NIO expanded its charging network, providing access to over 380k charging points through NIO NFC cards, supplying customers with all-time charging access • NIO recognized the importance of partnerships in building a vertically integrated supply chain in Europe. Expansion plans involved partnerships with esteemed automakers like Mercedes-Benz, reputable suppliers such as Bosch, and collaborations with car dealerships to attract a broader customer base
Customer Journey and Perception	• Reservations against Chinese brands diminished more and more in the German market, so NIO benefited from a more receptive customer base • NIO addressed customers' most critical concern, range anxiety, by offering innovative solutions like 3-minute battery swaps and charging options via NIO NFC cards, easing the transition from traditional charging to battery swapping • NIO's flexible subscription models, encompassing leasing and purchasing options at various price points and durations, aligned with the preferences of German customers who value flexibility but also ownership
Timely Execution	• In terms of the market entry strategy for NIO's battery swapping business model, NIO could be classified as an Early Adopter, following Better Place as a First Mover • As Better Place was ahead of its time on the EV market, NIO faced a more promising EV environment where innovation support and investments were high, and the adoption of new ecosystems had stronger potential

A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics

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Professor Afonso Almeida Costa

20-12-2023

1. Introduction

The ongoing transformation in electrification towards net zero pressures researchers and industry leaders to develop technology innovations. The goal is to achieve a balanced electrical grid[1] that provides sufficient energy across peak times. But the rising demand for electricity puts this goal at challenge. The electricity share of full energy consumption is expected to increase globally from 20% in 2023 to more than 50% by 2050 (International Energy Agency 2023). At the same time, electricity networks often face energy storage problems against limited capacity for electricity generation (Güngör, et al. 2011). With the growing demand for electric vehicles (EV), a holistic energy management will become inevitable. To meet the rising energy demand, it is crucial to integrate EVs into the grid infrastructure to realise energy storage potential through smart charging and discharging energy from EV batteries back into the grid, known as vehicle-to-grid (V2G). (Ibeawuchi 2023)

This comprehensive review serves as an exploration of literature findings on the future of smart grids and grid energy balancing including V2G applications, predefined impact factors, and industry pilot projects. Emphasizing the importance of the shift towards a balanced and sustainable grid, two questions arise:

1. What is the status quo on V2G technology in the EV industry?
2. How does V2G applications impact the balancing of future grids?

In the following, the study continues with an exploration on the relevant theories of smart grid and V2G technologies. Afterwards, the research methodology is presented which consists of an comprehensive literature review followed by a qualitative analysis of current V2G impact factors and recent V2G industry pilot projects. In the subsequent discussion, the influence of the V2G impact factors are evaluated and guidance on V2G's viability is given. Strengths and

[1] The electrical grid describes a wide-area transmission network that enables the trade of high electricity volumes across large distances (Energy Education 2023)

limitations of the study are presented. Lastly, an overall conclusion on the research findings and an outline on possible directions for future V2G research is given.

2. Theoretical Foundation

To be able to understand the potential of V2G technologies for a circular battery and grid management, it is necessary to understand the underlying technologies.

Smart Grid Technology

For many decades, the structure of basic electrical power grids did not change: The energy was transferred from A to B. But with the increasing demand for electricity, technology innovation revolutionized the electrical power grid with the concept of smart grid. This technology sets new standards for enhanced energy efficiency and modern energy management through optimization techniques, not only in smart cities and homes but also with the integration of EVs. (Alsharif, et al. 2021) Relevant optimization techniques include a seamless grid integration of various charging technologies and solutions for renewable energy intermittency problems (Alsharif, et al. 2021). In contrast to basic grids, a smart grid can be classified as "a modern electric power grid infrastructure for enhanced efficiency and reliability" (Güngör, et al. 2011). The technology behind smart grids relies on high-power converters, an interconnected communication infrastructure, and new energy management techniques that offer automated control to balance energy demand and optimize network availabilities (***Appendix 1)*** (G. 2020). To fulfil future grid requirements that address the issues of environmental emissions, smart grids easily integrate alternative and renewable energy sources (RES) which enhances efficiency and reliability through real-time communication and reduces power losses (Alsharif, et al. 2021). Some examples of smart grid technology use cases are the integration of powerline networking, home area network device communication, or EVs (G. 2020). With the increase in EV charging demand, the risk of unbalanced impacts on the reliability of the grid system and power quality endangers the grid system stability, especially, at peak loads (Habib, et al. 2018).

Vehicle-to-grid

Through the evolving concept of smart grids, EVs are set to take on a new role by exchanging energy with the power grid to reduce power loss and power reuse. (Liu, et al. 2013)

This is where V2G applications come into play. For this technology, the type of power flow must be differentiated. Unidirectional flow transfers the electricity in only one direction which is from the grid to the vehicle (G2V). The car only receives the power into the battery and uses it for driving purposes. In contrast, bidirectional energy flow, which is used for V2G applications, revolutionizes the way energy can be stored and transferred. Through V2G technology, the energy can be drawn from the power source to the gridable electric vehicle's (GEV) battery, but also the energy can be transferred back to the grid or offer reactive power support to the grid (***Appendix 2***) (***Appendix 3***). (Alsharif, et al. 2021) (Liu, et al. 2013) For the application of V2G integration, an universal smart charger controller is essential which defines the optimal power flow based on battery lifetime, grid utilization, and the EV user's charging requirements. The control unit functions as the communication interconnection between the load management system and the EV (***Appendix 4)***. (Hemavathi and Shinisha, 2022)

Through V2G technology the issues of peak loading can be overcome and even provide continuous power supply during potential power outages (Awasthi, et al. 2017).

Next to V2G applications, bidirectional charging finds various use cases for energy flow from the vehicle to some kind of power storage. The most common technologies are here Vehicle-to-Load (V2L), Vehicle-to-Home (V2H), or Vehicle-to-Vehicle (V2V). The technology differentiations can be found in ***Appendix 5*** and ***Appendix 6***. Currently, mainly two V2G standards have been defined for integration, which are the IEEE 1547 and UL 1741 (***Appendix 7)***.

3. Methodology: Qualitative Comprehensive Review

This individual analysis explores the current research on the integration of EVs into a smart grid including V2G applications and its impact on a sustainable and more balanced grid. As a deductive "top-down" research approach often falls short on exploratory techniques, Woo et al. (2017) find that inductive research provides more analysis opportunities for a holistic understanding to address the often-stated problem of "not enough theory" in a deductive research. To present valuable analyses where space for methodological techniques are missing, this study explores an inductive, comprehensive review (Bryman and Burgess 1994).

A preliminary literature research has been performed to define the research domain and research questions. Resulting from this review, the keywords in ***Appendix 8*** were used to identify suitable scientific papers and websites. These keywords were then used for a more detailed literature review to identify the emerging grid technologies with the relevant use cases and corresponding V2G impact factors. Several different platforms were used for the literature exploration: Scopus, Science Direct, EBSCO, and Google. Across all search engines and platforms, the following criteria were chosen: the article and paper language should be English and the keywords must appear in the paper's abstract.

Due to the fast-changing developments in the V2G domain and to not exclude any V2G use cases, no publication date restriction was set, and not only highly ranked papers got included. The selection process is summarized in the PRISMA flow diagram in ***Appendix 9***.

Building on the theoretical concepts of smart grid integration and V2G, a comprehensive literature review of V2G technologies was performed, identifying relevant V2G use cases and industry pilot projects, and analysing the impact of V2G technology for predefined factors. The following discussion then evaluates the viability and potential of V2G application opportunities. Lastly, a conclusion on the future V2G technology potential is drawn and future directions for research are given. A quantitative evaluation of the technology potential, feasibility, and customer acceptance is excluded from the study.

4. Analysis

The majority of previous research on V2G focus on economic aspects and technical features of V2G, "notably renewable energy storage, batteries, or load balancing" (Sovacool, et al. 2018, 1). Only few studies include research on the environmental assessment or the societal acceptance of a V2G transition (Sovacool, et al. 2018) (Gandhi and White 2021).

V2G Use Cases

In contrast to V2H, V2G best involves a large number of GEVs which can impact the grid due to the small battery storage capacity of a single GEV. Besides, V2G applications can interact with V2H or V2V operations. Liu et al. (2013) find that V2G can be used at various charging points ranging from parking lots, smart buildings or smart homes to fast-charging stations on the road or even at battery swapping stations[2] where the V2G application takes place through the decoupled batteries which are conjointly charged. As an EV is on average parked 95% of the time, many opportunities arise to make use of V2G technologies (Chen and Folly 2022). Some of the main functions of V2G are to use GEVs as an energy source to provide ancillary services to the grid to reduce the risk of outages, to release surplus energy back from the GEV to the grid at peak loading with high prices, or to provide a storage for less expensive energy during off-peak times (Liu, et al. 2013). With the right load management, V2G can better control loads and stabilize the grid for short-term periods in small scales. The effectiveness of current V2G applications is dependent on various factors including the grid's power, the GEV battery types, the number of available GEVs in the grid at a specific time, user driving habits, and electricity prices (Liu, et al. 2013). The interaction of these factors display V2G as a flexible

[2] In a battery swapping station, the empty EV battery is swapped with a charged one in a fully automated process which takes less than three minutes. The batteries are then conjointly charged in the battery swap station at off-peak times. (NIO 2023)

solution to manage the grid energy, however, requires complex control and operation in a large scale, and poses high infrastructure complexity (Liu, et al. 2013).

Impact Analysis

Using EVs as an energy storage through V2G can bring many environmental, economic, grid, and societal benefits (Chen and Folly 2022). These four impact factors are analysed.

In terms of an **economic impact**, V2G provides cost efficiency as it can reduce the total cost of ownership by using the battery to store energy at lower peaks with lower prices and by receiving money through selling electricity back to the grid during high demand (Chen and Folly 2022) (Li, et al. 2023). The profits of EV users are dependent on the charging rate and efficiency. In a study from the University of Rochester in 2021, researchers found that an EV user with a V2G charging system can reduce its annual electricity bill by $150 (Gandhi and White 2021). Overall, a widespread V2G adoption can decrease investments in new power generation facilities (Khalid, et al. 2022). With regard to V2G's **environmental** impact, V2G benefits the grid as it can easily integrate RESs such as wind or solar (Li, et al. 2023). The battery can be used for energy storage of RESs which offer better efficiency with clean power (Ahmad, Alam and Chabaan, 2018) (Hemavathi and Shinisha, 2022). Overall, a V2G integration can reduce greenhouse gas emissions and the uncertainty of effectively storing and later using energy of RESs (Sovacool, et al. 2018)Das, et al. 2020). When looking at the **impact on the grid**, V2G can minimize power loss, reduce peak loads, and overall, stabilize the grid (Li, et al. 2023). By flattening the energy usage curve, V2G reduces pressure on power plants as it functions as a temporary energy battery storage. With the integration of V2G, a better power management and peak load demand estimation can be achieved. (Das, et al. 2020) From all four impact factors, the societal acceptance and customer norms are researched least (Sovacool, et al. 2018). V2G's **societal advantages** comprise mainly additional revenue streams for cleaner vehicles and an improved reliability of the grid (Kempton and Tomic 2005). Furthermore, V2G can increase social welfare as countries with more base load plants are likely to face higher differences in electricity prices at peak and off-peak times. In these countries, there will be greater benefits from utilizing EV's electricity storage capacities. So, EV owners will be more motivated to purchase batteries with larger storage capacities (Greaker, Hagem and Proost 2019). A detailed investigation of the four impact drivers can be found in ***Appendix 10***.

Industry Pilot Projects

In recent years, several pilot projects for V2G solutions have been initiated around the world. Some remarkable examples are the ongoing "Leaf to home" project in Japan by Nissan with over 4000 chargers involved or the "Fiat-Chrysler V2G" in Italy with over 600 chargers, led by the OEM players Chrysler and Fiat. In 2018, in a pilot project in the UK, Volvo collaborated with the energy software company Kaluza and the utility firm OVO to start bidirectional charging services. The project resulted in EV users saving on average $533 on yearly household electricity costs (Willing 2023). Most of the pilot projects were tailored at investigating load balancing, time shifting for optimal charging times, and energy emergency backup (Chen and Folly 2022). As Chen and Folly (2022) present in their pilot project overview until 2022 (***Appendix 11)***, many of the V2G pilot projects were only initiated in recent years.

Building on the overview provided by Chen and Folly (2022), several additional pilot projects were recently initiated, aiming at testing the viability of V2G technologies in wider scopes. In the UK, the project "eFuture" installed 1,000 chargers across the UK to demonstrate the opportunities in which V2G can support the grid. The chargers were connected to a cloud platform to improve the discharging and charging of EVs to lower energy costs and offer ancillary grid services. (Ibeawuchi 2023) In addition, the Japanese V2G company Nuvve partnered with Honda, Nissan, and Mitsubishi to integrate their EV models to take part in V2G through a V2G aggregation platform[3] to generate revenue for EV users (Ibeawuchi 2023). A similar objective was set in the pilot project of Shell Recharge Solutions[4] which aimed at presenting an earnings framework for EV owners while boosting the use of RESs. Therefore, they collaborated with the Japanese car manufacturer Mitsubishi and grid operator TenneT. (Shell Recharge Solutions 2023) But not only the direct integration of private EVs is in focus of recent V2G research developments. The Swedish EV manufacturer Polestar develops a Virtual Power Plant[5] to contribute to wide-ranging energy transitions in Gothenburg, Sweden, to assess business models for V2G across different regions (Polestar 2023). Moreover, the global leading electric bus manufacturer BYD introduced the discharge “Bus2Grid project” at its London’s bus depot in which they fed back energy stored onboard the buses into London’s power grid to increase load efficiency and support the network balancing (BYD 2023). In addition, car manufacturers BMW, Honda, and Ford founded the new V2G company ChargeScape to develop “a single, cost-effective platform connecting electric utilities, automakers and interested electric vehicle customers” (Hawkins 2023, 1) to simplify the logistics between EV users, single EV manufacturers, and utility providers. Lastly, also other industry players investigate the potential of a V2G integration. In a pilot project since 2023, German Ministry for Economic Affairs and Climate Action supports Fraport financially to develop and implement bidirectional charging in aircraft handling (flightchic 2023).

As bidirectional power flow applications present high potential in recent research, many EV manufacturers rely on integrating bidirectional charging in their EV models to use V2G technologies most beneficially (Chen and Folly 2022). Currently, most progress in integrating bidirectional charging and V2G technology in private EV models come from Asian and

[3] Nuvee’s aggregation platform copes with the bidirectional electricity flow between the grid and EVs (Ibeawuchi 2023)
[4] Shell Recharge Solutions is a mobility provider of EV charging solutions and part of the Shell Group (Shell Recharge Solutions 2023)
[5] Virtual Power Plants are clusters of distributed small-to-medium energy resources, such as batteries or solar panels, that are combined to assist the electricity grid (Reuters 2023)

American EV manufacturers such as BYD, Nissan, Mitsubishi, Hyundai and Ford. An overview of car models in which bidirectional charging is so far integrated, can be found in ***Appendix 12***. In addition, BMW, Volvo, and Porsche recognized V2G's technology potential and announced plans on integrating or testing the functionality of bidirectional charging in their future models. Tesla announced that all of their models offer bidirectional charging by 2025 while General Motors will make bidirectional charging standard in all their models by 2026. (Avery 2023) As research finds that the willingness to pay for GEVs is on average higher than without the V2G integration, it can be expected that in the long-term the majority of EV producers will integrate bidirectional charging as an inevitable standard (Noel, et al. 2019) (Parsons, et al. 2014).

5. Discussion

As research presents, V2G technologies provide relevant potential for the grid balancing of the future as the CAGR of the global V2G market was around 15% during 2015–2020 (Hannan, et al. 2022). Some of the main advantages of V2G are that no additional battery storage system is required for the application, emissions can be reduced, it provides ancillary services to the grid, and reduces costs for EV owners. In contrast, the integration of EVs into the grid can face various issues. It is most important to carefully view the risk of battery degradation and evaluate the high upfront investment costs. (Chen and Folly 2022) In addition, the financial benefits of V2G vary dependent on the location due to the disparity in electricity costs (Gandhi and White 2021). To create a long-term potential for V2G integration, charging infrastructure providers as well as vehicle and equipment manufacturers need to align on access standards and battery design to ensure interoperability to communicate between the grid and charging stations (Willing 2023). Lastly, more research will be required on V2G customer acceptance.

Strengths and Limitations

The foregoing review has several strengths. Firstly, this study provides an insightful overview of recent research on V2G technologies, while presenting current industry pilot projects.

Furthermore, it contributes to literature with a qualitative analysis of impactful V2G factors. Like any research piece, the presented analysis also has its limitations. First of all, not only high-ranked papers and scientific websites were used as information sources as there was not always sufficient and current academic on all presented impact factors. Then, the study's scope were limited to V2G applications through bidirectional charging, excluding a detailed overview of the various vehicle integration technologies presented in ***Appendix 5***. Moreover, the study mostly excluded empirical data for a detailed evaluation of the technological feasibility, requirements for standardization, and the economical sustainability of V2G technologies.

6. Conclusion

In this study, the technology developments for a more sustainable, smart grid were discussed. It was outlined that the integration of EVs into grid energy management through V2G present strong potential. Several recent V2G pilot projects were presented that aim at testing the viability of V2G technologies. Through the analysis of the four impact factors, it can be found that V2G applications have a more positive influence on economic, environmental, and grid balancing aspects. In conclusion, sufficient energy management strategies and control techniques need to be implemented to achieve GEVs' optimal V2G integration into the grid.

Directions for Future Research

The presented review points to directions for future research which can contribute strongly to the evaluation of the potential of specific V2G applications. More quantitative analyses are required to investigate the economic as well as societal impact V2G technologies will have in the foreseen future. Moreover, this study finds that systematic studies on the optimal balance of electricity grid management and the contribution of EV integration are required to fully understand the optimal load and battery management in the long-term.

Lastly, research on customer acceptance and involvement in V2G applications can be explored.

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8. Appendix

Appendix 1

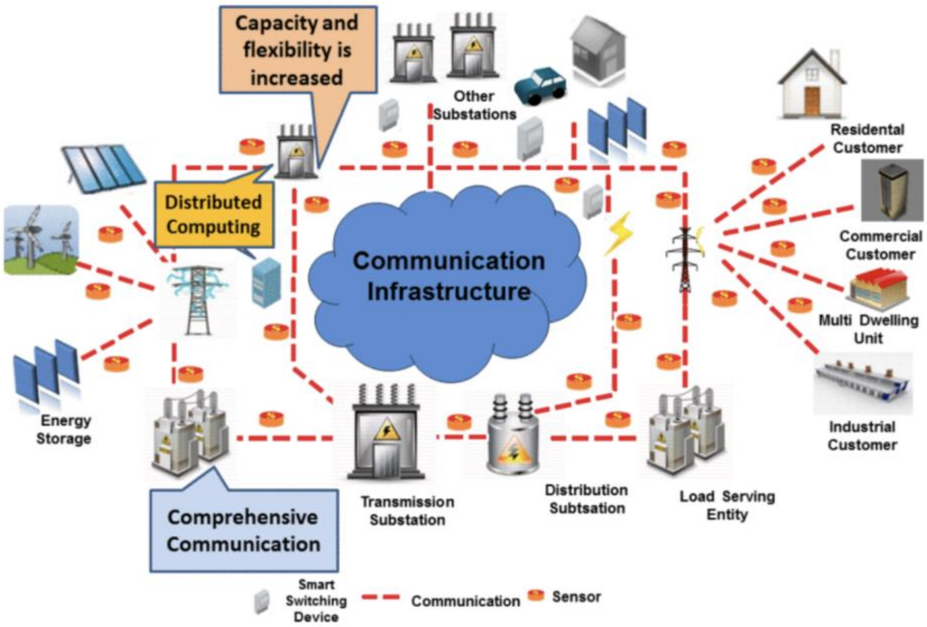

Figure 1. Smart grid architecture provides advanced sensing and control through modern communications technologies (Güngör, et al. 2011)

Appendix 2

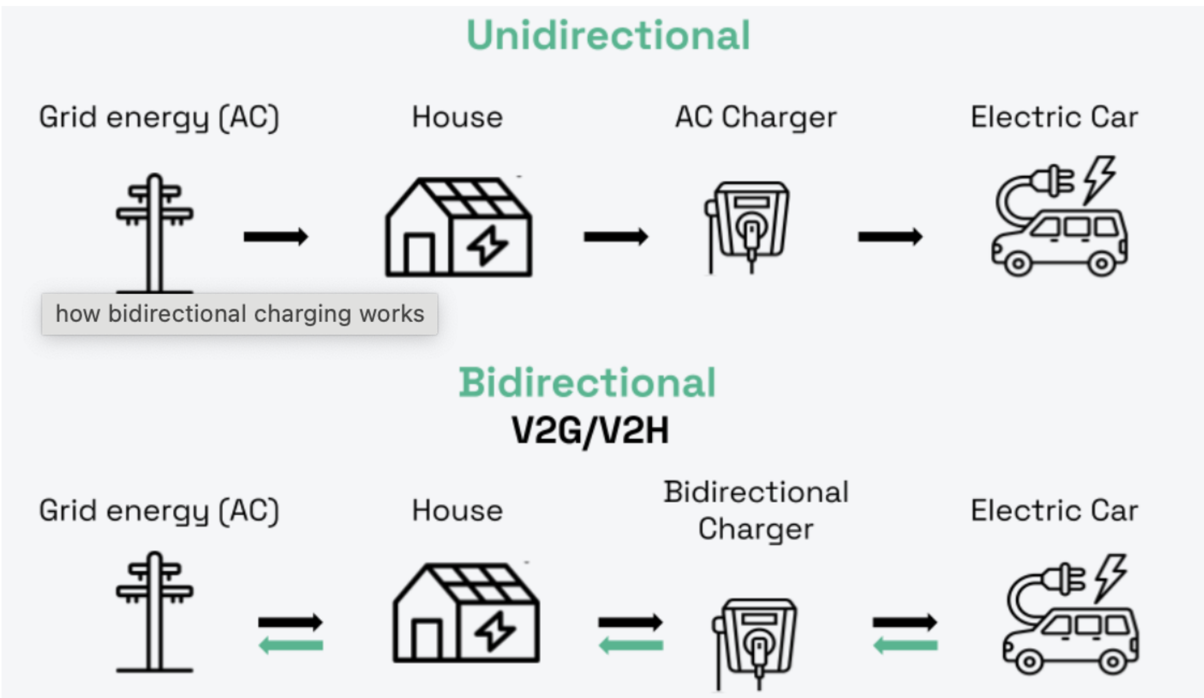

Figure 2. Illustration of unidirectional vs bidirectional charging (zecar 2023)

Appendix 3

Type	Basic characteristics	Safety issues	Available controls	Power rating	Cost comparisons	Effects on Battery	Advantages	Challenges
Unidirectional chargers	Only G2V power flow, Diode (D) bridge cascade with one-way converter	Both isolate and non-isolated configurations are available	Active control, Control for energy pricing available	For all power level	Less costly	No additional damage n battery life	Provides reactive power control Voltage and frequency control	Connection with grid
Bidirectional charger	Two-way power flow, Bidirectional communication for charging/ discharging	Isolated or non-isolated with extensive safety measures, Issue of anti-islanding interconnection protection	Complex control, Extra drive control	Only suitable for Level-2	High cost	Degradation due to frequent discharging reduces life	Grid balancing ancillary services, Load following coordinate charging	Sensors suitable metering for measuring power flow communication and power loss

Table 1. Comparative analysis of unidirectional and bidirectional chargers (Khalid, et al. 2022)

Appendix 4

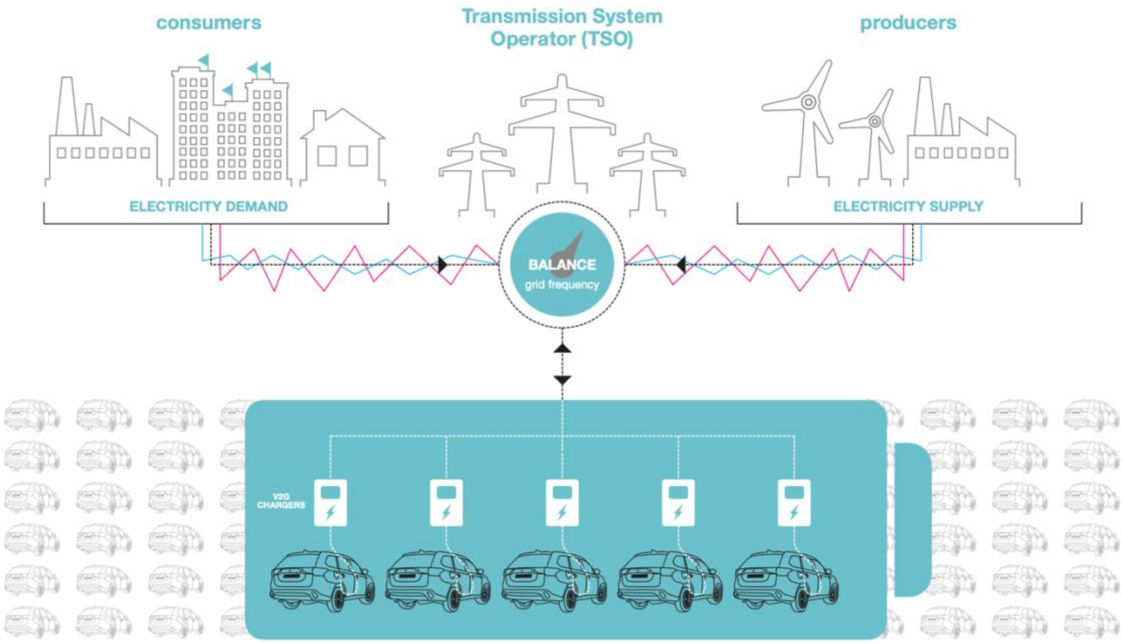

Figure 3. How V2G Charging Works (Shell Recharge Solutions 2023)

Appendix 5

Technology	Characteristics
V2L	V2L is the most simple implementation of bidirectional charging as it only requires a V2L adapter which is plugged into the type 2 charging access and enables the EV to work as a battery pack.
V2H	Through V2H application, an EV's battery storage can be used to power the home by transferring back the electricity from the battery. A common EV battery can provide energy to a home for up to two days as it can provide around 60 kilowatt-hours energy, resulting in lower energy bills.
V2G	V2G uses energy from the EV battery to support the grid stabilization with the help of a smart bidirectional charger. It can connect to the grid to obtain energy or to transfer energy back to the grid.
V2V	V2V enables EVs to wirelessly communicate with other vehicles and exchange information. The EVs can transfer energy through local grids and then allocate the energy among EVs.

Table 2. Bidirectional charging as the "umbrella" term for V2L, V2H, V2G, and V2V technologies (zecar 2023) (EV Connect 2023) (Avery 2023) (Liu, et al. 2013)

Appendix 6

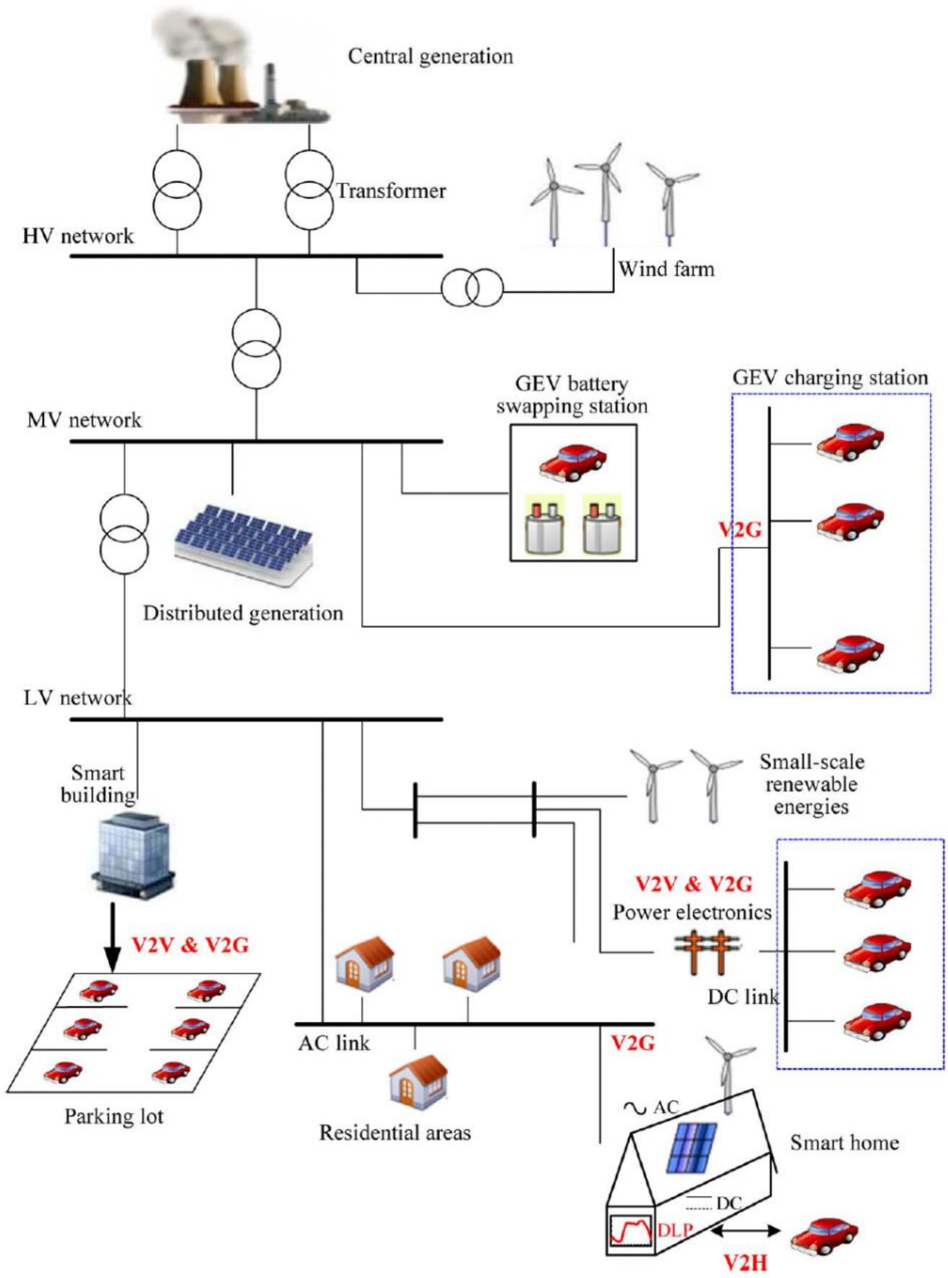

Figure 4. Proposed framework for V2G applications. LV = low-voltage, MV = medium-voltage, HV = high-voltage. (Liu, et al. 2013)

Appendix 7

Classification	Standards references	Scopes
Power quality standards	IEEE-519	Recommended practice and requirements for stable harmonics limitation of the voltage and current (THD<8%)
	SAE J2894	Power quality for plug-in electric vehicle chargers in US (THD<10%)
	IEC 61000	EMC requirements for power supplies in Europe (THD<8% for low and medium voltage)
	GB/T 14549	Harmonics standards for power supplies in China (THD<5% for low voltage)
V2G standards	IEEE 1547	Standards for interconnection between the grid and distributed energy resources. Compared to UL 1741,
	UL 1741	IEEE 1547 adds the test of the voltage unbalance, the saltation of the frequency and phase angle
Safety standards	UL 2202	Safety for EV OBC charging system supplied by a branch circuit of up to 600V for recharging the battery
	IEC 60950	Safety of technology equipment for a voltage rating lower than 600V
	ISO 6469	Safety for personal protection and EV storage system
OBC connector standards	CCS1 SAE JI772	North America standard: up to 240V AC and 16/80A AC
	IEC62196	European standard: up to 500V AC and 32A/63A AC
	GB/T 20234	Chinese standard: up to 440V AC and 32A AC

Table 3. Regulatory charger standards (Yuan, et al. 2021)

Appendix 8

Keyword combination		
Electric vehicle*	Smart Grid*	Application*
Energy storage*	Bidirectional Charg*	Comparison*
	Vehicle-to-everything*	Comprehensive Review*
	Vehicle-to-grid*	Evaluation*
	Vehicle-to-home*	Impact*
	Vehicle-to-load*	Assessment*
	Vehicle-to-vehicle*	

Table 4. Keywords search (Original content)

Appendix 9

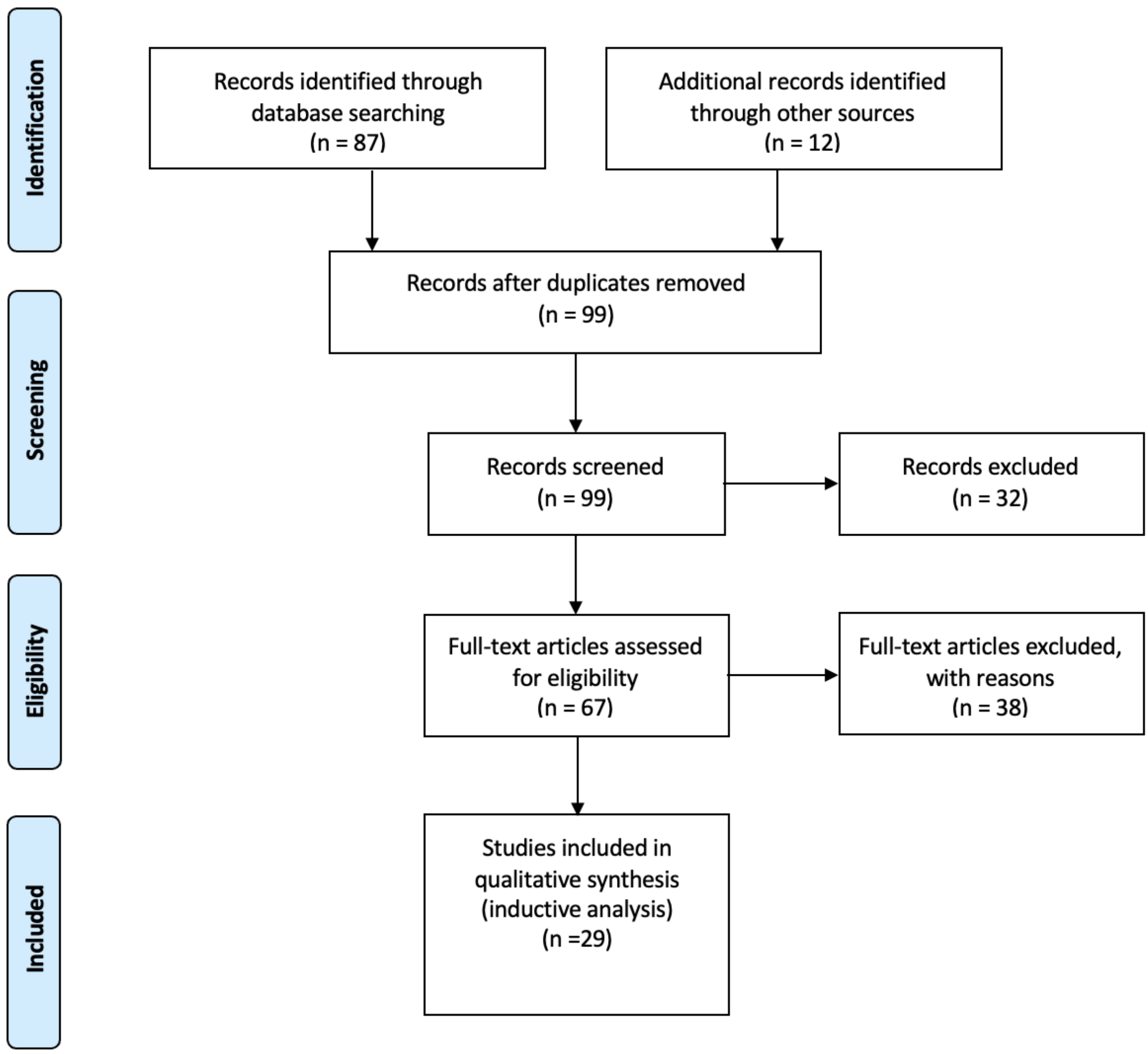

Figure 5. PRISMA Flow Diagram on strategic paper selection (Original content)

Appendix 10

Impact Factor	V2G Technology
Economic impact	• V2G provides cost efficiency as it can reduce the total cost of ownerships by using the battery to store energy at lower peaks with lower prices and by receiving money through selling electricity back to the grid during high demand (Chen and Folly 2022) (Li, et al. 2023) • The profits of EV users using V2G are dependent on the charging rate and efficiency. In a study from the University of Rochester in 2021, researchers found that an EV user with a V2G charging system can reduce its annual electricity bill by $150 (Gandhi and White 2021)

	• A widespread V2G adoption can decrease investments in new power generation facilities (Khalid, et al. 2022) • Taking part in V2G applications can reduce the EV cost ownership, while enhancing their adoption
Grid impact	• The "transition to V2G could enable vehicles to simultaneously improve the efficiency of electricity grids" (Sovacool, et al. 2018) • When looking at the impact on the grid, V2G can minimize power loss, reduce peak loads, and overall, stabilize the grid (Li, et al. 2023) • By flattening the energy usage curve, V2G reduces pressure on power plants as it functions as a temporary energy battery storage. With the integration of V2G, a better power management and peak load demand estimation can be achieved (Das, et al. 2020) • A community-grid operation can be supported by a group of GEVs (Liu, et al. 2013) • For the best grid balancing, EVs should be connected over a long period of time (Liu, et al. 2013)
Environmental impact	• V2G benefits the grid as it can easily integrate RES such as wind or solar (Li, et al. 2023) • The EV battery can be used for energy storage of RES which offer better efficiency with clean power (Ahmad, Alam and Chabaan, 2018) (Hemavathi and Shinisha, 2022) • A V2G integration can reduce greenhouse gas emissions and the uncertainty of effectively storing and later using energy of RES (Sovacool, et al. 2018) (Das, et al. 2020) • On the downside, V2G could cause power quality and stability issues on the grid, because of the uncertain nature of the environmental conditions (Das, et al. 2020)
Societal dimension	• V2G's societal advantages comprise mainly additional revenue streams for cleaner vehicles and an improved reliability of the grid (Kempton and Tomic 2005) • V2G can increase social welfare as countries with more base load plants are likely to face higher differences in electricity prices at peak and off-peak times. In these countries, there will be greater benefits from utilizing EV's electricity storage capacities. So, EV owners will be more motivated to purchase batteries with larger storage capacities (Greaker, Hagem and Proost 2019). • Use of V2G technology in EVs can contribute to the societal awareness on the positive impact of EVs on the environment and therefore, enhance the overall EV adoption (Singh and Singh 2022)

Table 5. Summary of most important impact factors of V2G

Appendix 11

Project Name	Country	No. of Chargers	Timespan	Service
Realising Electric Vehicle to Grid Services	Australia	51	2020–2022	Frequency response, reserve
Parker	Denmark	50	2016–2018	Arbitrage, distribution services, frequency response
Bidirektionales Lademanagement—BDL	Germany	50	2021–2022	Arbitrage, frequency response, time shifting
Fiat-Chrysler V2G	Italy	600	2019–2021	Load balancing
Leaf to home	Japan	4000	2012–ongoing	Emergency backup, time shifting
Utrecht V2G charge hubs	Netherlands	80	2018–ongoing	Arbitrage
Share the Sun/Deeldezon Project	Netherlands	80	2019–2021	Distribution services, frequency response, time shifting
VGI core comp. dev. and V2G demo. using CC1	South Korea	100	2018–2022	Arbitrage, frequency response, reserve, time shifting
SunnYparc	Switzerland	250	2022–2025	Time shifting, pricing scheme testing, reserve
Electric Nation Vehicle to Grid	UK	100	2020–2022	Distribution services, reserve, time shifting
OVO Energy V2G	UK	320	2018–2021	Arbitrage
Powerloop: Domestic V2G Demonstrator Project	UK	135	2018–ongoing	Arbitrage, distribution services, emergency backup, time shifting
UK Vehicle-2-Grid (V2G)	UK	100	2016–ongoing	Support power grid
INVENT—UCSD/Nissan/Nuvve	US	50	2017–2020	Distribution services, frequency response, time shifting
SmartMAUI, Hawaii	US	80	2012–2015	Distribution services, frequency response, time shifting

Table 6. Summary of significant pilot projects worldwide (Chen and Folly 2022)

Appendix 12

EV manufacturer	Model	Status
Nissan	Leaf ZE1	
MG	ZS EV	Only V2L
Kia	EV 6, Niro	Only V2L
Hyundai	Ioniq5, Ioniq 6	Only V2L
Genesis	GV 60	Only V2L
Ford	F-150 Lightning	
Mitsubishi	Outlander	
VW	ID.4	
BYD	Atto 3, Han EV	Only V2L
Cupra	Born	

Table 7. Current overview of EV models capable of bidirectional charging (Shell Recharge Solutions 2023) (Avery 2023) (EV Connect 2023)