ESADE

Business in Society for MIBA

Team Paper - Term 1

A Sustainability Audit for Volkswagen AG

BEYOND THE DIESEL SCANDAL – VOLKSWAGEN'S PATH TOWARDS SUSTAINABLE MOBILITY

Volkswagen

Name: Group 01

Word Count: 3374

Supervisor: Maja Tampe, PhD

Submission date: December 11th, 2018

Abstract

In September 2015, the automotive world was profoundly shaken when the EPA revealed its findings on nitrogen oxide emissions of Volkswagen Diesel cars. Volkswagen installed software into its TDI powered cars, which intelligently lowered NOx emissions when cars were driven under testing circumstances. On the round, Volkswagen Diesel cars were found to emit up to 40 times more than US environmental regulation permits. The Diesel Scandal was born.

In this paper, the implications of the Diesel Scandal on the Volkswagen Group are thoroughly discussed and an evaluation of the company's response to the situation is made. Next, the findings are leveraged to set goals for Volkswagen to adhere to, in order for the company to emerge as the leading player in sustainable mobility within the foreseeable future. Last, a solution is proposed which can help Volkswagen on this way, while highlighting the risks and opportunities associated with each solution. This paper is breaking new grounds by proposing Volkswagen a courageous strategy of cannibalizing its current business model to capture a leading edge within the future landscape of passenger transportation.

Key words: Automotive, Diesel Scandal, Mobility, Emissions, Climate Change

Table of contents

List of figures and tables

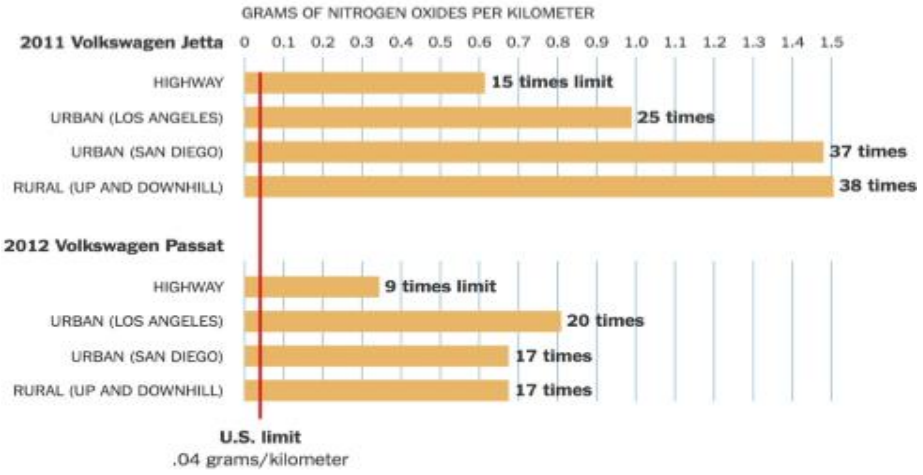
1 The Diesel Scandal

1.1 Introduction to Volkswagen Group

The Volkswagen Group (hereafter referred to as Volkswagen) is a German carmaker conglomerate that is headquartered in Wolfsburg, Germany. Volkswagen has heavily grown within the last decade and, in 2017, could secure its spot as the largest automotive company worldwide in terms of number of cars sold (Woodard, 2018), closely followed by the Japanese carmaker Toyota. Volkswagen sold an estimated 10.7 million cars in 2017 and generated an all-time high in revenues of €220 billion, making it the second-largest carmaker by sales (Statista, 2018). The company's offering encompasses a broad portfolio around automotive products and services, clustered within the four segments Passenger Cars, Commercial Vehicles, Power Engineering and Financial Services (Forbes Magazine, 2018). As a German carmaker, Volkswagen is mainly targeting the European market with twelve different car brands (please compare appendix 1). The group operates 120 production plants worldwide and employs 630,000 people, who produce ca. 43,000 vehicles per day (Volkswagen España, 2018).

1.2 Explaining the Diesel Scandal

Figure 1 - Average emissions of nitrogen oxides in on-road testing[1]



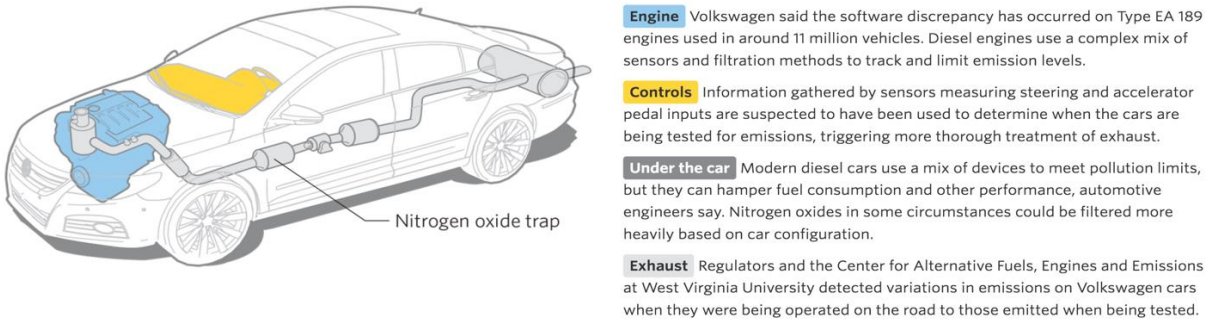
In 2014, the International Council on Clean Transportation (ICCT), an American non-profit organization focusing on eco-friendly mobility, contracted West Virginia University's Center for Alternative Fuels, Engines and Emissions (CAFFEE). The goal of this collaboration was to provide environmental regulation government agencies with independent research on eco-friendliness of vehicles. The CAFEE was responsible for carrying out standard emissions tests on three light-duty diesel cars on the road. Even though all test vehicles were officially certified according to the US

[1] Source: Thompson (2014)

Emission Standards, the researchers found that on-road emissions drastically differed from the officially stated emissions by the manufacturers. Two out of the three tested vehicles were Volkswagen Diesel cars and NOx (nitrogen oxide pollutants) emissions of those vehicles dramatically exceeded Volkswagen's claim of low emissions. For the Volkswagen Jetta, NOx emissions totaled up to nearly 40 times the permitted level in the US (Thompson, 2014).

As the findings proofed under several different testing conditions, the ICCT suspected that Volkswagen had installed a cheating software. The American Environmental Protection Agency (EPA) finally published the findings on September 18, 2015 (Thompson, 2014) - the Volkswagen Diesel Scandal was officially set into motion. The software installed automatically detected whenever a car is tested under laboratory-controlled conditions. In these situations, the cars performance was adapted accordingly to meet the regulatory emission requirements (Hotton, 2015). However, on normal roads the engine emits significantly higher levels of NOx gases. Figure 2 visually describes how filtering NOx pollutants in Diesel cars works.

Figure 2 - NOx filtering in Diesel cars[2]



1.3 Volkswagen's response to the Diesel Scandal

Shortly after the publication by the EPA, Volkswagen officially admitted that it manipulated the emissions of its Diesel cars, affecting 500,000 cars in the US and 11 million vehicles worldwide. After the company's market capitalization fell by 33% within a month, Volkswagen had to quickly come up with a solution.

Volkswagen's first reaction to the Diesel scandal was to publicly apologize for the manipulation (Hotton, 2015). However, apologies were perceived as too late. Stakeholders and the public expected the company to be proactive about the cheating in the first place. Also, Volkswagen released information very gradually and not the full truth right upfront (Garcia, 2015). Maurice Schweitzer, a Wharton professor, claims that the company failed to specify how they ended up in

[2] Source: Center for Automotive Research (2015)

the manipulation and how they would solve the situation (Lebowitz, 2015). As a consequence, Volkswagen did not manage to regain trust through its apologies.

As another measure, the company voluntarily offered to refit up to 11 million diesel cars running with TDI engines worldwide (Thomson Reuters, 2015). In the US, customers who did not want to refit their car could sell it to Volkswagen at a "clean trade-in value" set by the National Automobile Dealers Association. Additionally, the company also paid cash compensations to affected American car owners, ranging from $5,500 to $9,900 per car (Bartlett, 2017). Additional, Volkswagen invested ca. €7 billion into fixing its TDI engines to comply with official regulation standards (Ewing, 2017).

Lastly, Volkswagen underwent structural changes for top-level management and Martin Winterkorn, the former CEO, and all main US executives resigned. Also, other top management executives within the Volkswagen Group were dismissed (The Week, 2017), including Hein-Jakob Neusser (VW head of R&D and brand development), Ulrich Hackenberg (Audi head of R&D) and Wolfgang Hatz (Porsche head of R&D).

1.4 Repercussions of the Diesel Scandal

1.4.1 Effects on health and environment

Besides Volkswagen's loss in market capitalization and brand damage, the Diesel Scandal also had tremendous effects on the environment, caused through high emissions of Nitrogen Oxide (NOx) pollutants into the air. NOx is an irritant gas that can, at high concentrations, cause inflammation of airways, which then result into smog, acid rain and the formation of ground level ozone. Further, the gas can react with other chemicals in the air resulting in acid rain. Most importantly, NOx indirectly acts as a greenhouse gas by producing ozone and therefor has a direct influence on global warming (Park, 2016).

NOx has also direct negative effects on human health, causing respiratory conditions ranging from coughing to asthma and more serious diseases (Icopal-Noxite, n.d.). In the long-run, consequences on human health are assumed to be even more disastrous. According to the Department of Environment Food and Rural Affairs (DEFRA) in the UK, excessive NOx levels in the air have reduced average life expectancy of the British population by six months. It is estimated that the UK death rate has increased by 4% due to NOx pollutions, translating into 23,500 extra deaths and GBP 16 billion in healthcare costs per year (Park, 2016).

1.4.2 Consequences for Volkswagen

Volkswagen's Diesel Scandal had raised unprecedented attention from the public. Immediately after the EPA revealed its findings, the company's share price drastically fell from €162 on September 18, 2015 to a yearly low of €92 on October 2, 2015 (Yahoo Finance, 2018). In 2015, Volkswagen withheld bonuses of €5.7 million for twelve board members (McGee, 2016), among them the company's brand chef whose salary was cut by ca. 50% (Chiacu, 2017). Appendix 2 gives an overview of the company's financial performance in 2015 and subsequent years.

Besides the financial losses, Volkswagen's brand was also heavily damaged. Over the course of the investigation, more and more managers were revealed to be involved, creating significant distrust among the public. It is also assumed that VW's former CEO was aware of the manipulation (Mansouri, 2016). The company's indexed brand score dropped from 75.0 in 2015 to 61.3 in 2016 (Statista, 2017), while its brand value dropped by 36% to $42.2 billion in 2016 (Brand Finance, 2017).

Starting in September, organizations from many countries started lawsuits against Volkswagen, with the US, Canada, China and the UK in the lead. By American law, the company had violated the US consumer protection law and the Federal Clean Air Act. A fine of up to $37,500 per vehicle (total of ca. $18 billion) was imposed, affecting ca. 500,000 cars. This constitutes the by far highest fine ever imposed on an automotive company. General Motors (caused 174 direct deaths) and Toyota (caused 5 direct deaths)[3] faced significantly lower penalties (Latif, 2017). This is for two reasons. First, America's protective trade policy justifies high penalties for foreign companies. Second, the long-term health consequences of NOx emissions are far more outreaching than direct deaths caused by hardware failures. Up until September 2018, Volkswagen paid $32 billion in settlements and faces $10 billion in the future. Additionally, shareholders sued the company for a total compensation of €9.2 billion (Matussek, 2018).

1.5 Status quo and current trends

Revealing Volkswagen's manipulation of diesel engines also affected other carmakers. With increasing awareness for emissions cheating, the UK Department of Transport started to retest diesel cars from various car manufacturers in September 2015. In France, official authorities launched emission investigations into Renault, Peugeot and other brands. Testing results showed that diesel cars from Peugeot and other manufacturers, which were not disclosed by the French authorities, showed very high levels of nitrogen oxide emissions and Renault committed to recalling

[3] GM produced an ignition switch defect causing 174 deaths; Toyota built a faulty accelerating system causing five deaths. Please compare appendix 3.

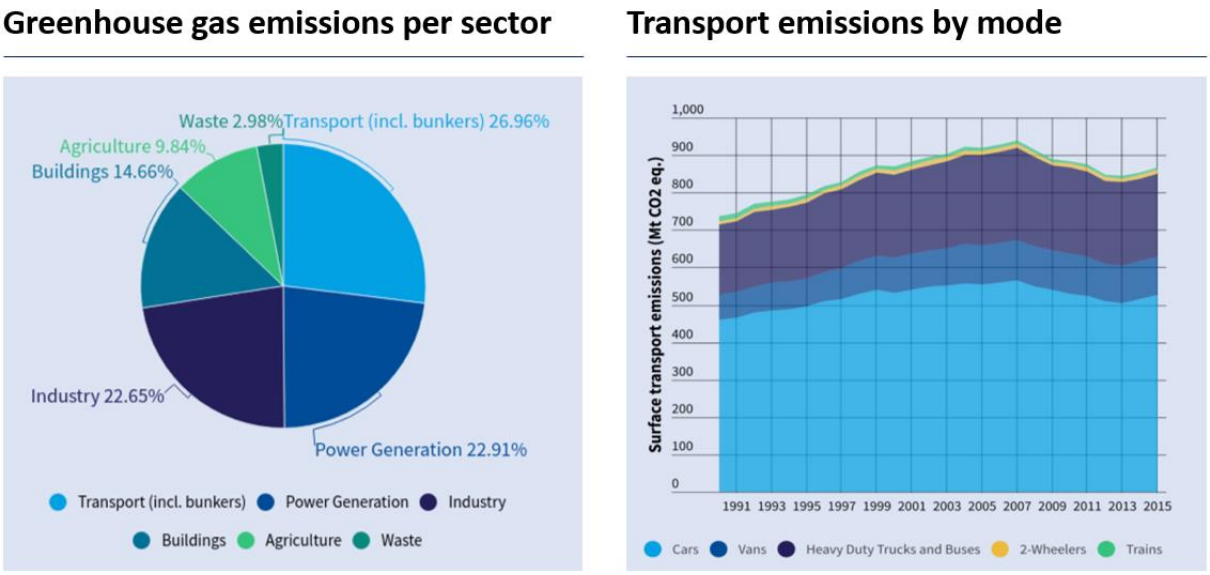
more than 15,000 cars as a response (BBC, 2016). Nissan, Hyundai, Citroen, Fiat, Volvo and other carmakers were tested and nitrogen oxide levels of 10 times the allowed levels were detected (Carrington, 2015).

2 Ambitious sustainability goals for the future

2.1 Beyond the European Commission's target for 2030

The automotive industry is in the spotlight of current regulation and increasingly attracting attention, as transportation constitutes the single largest emission factor globally, accounting for 27% of the EUs CO2 emissions with about two-third of it coming from cars and vans (compare figure 3).

Figure 3 - Greenhouse emissions in transportation sector[4]



Additionally, automotive is the only sector in which emissions have risen since 1990. To reach the target of limiting global warming to 2 degrees as set by the Paris Agreement, the European Commission proposes a reduction of emissions by cars and vans of 30% by 2030 compared to emission levels of the year 2021 (European Commission, 2018 (1)). For 2021, a target of 95g/km was set, with heavy fines for carmakers failing to meet the emission target.

Currently, carmakers in Europe are expected to meet the 2021 target. However, most of them, including Volkswagen, rely heavily on what is called flexible compliance mechanism (figure 5 offers a comprehensive overview). The regulations foresee that measures unrelated to direct emissions are counted towards the goal, including endeavors such as eco-innovations, super credits

[4] Source: Todts (2018)

and pooling. Also, regulation proposes a strong incentive for carmakers to hold back innovation, notably electric cars, to have higher emissions in 2021 and therefore lower the bar for their 2030 target (TransportAndEnvironment, 2018). Another point of critique is that the new proposal is weaker than the short-term goals set for 2021: the yearly reduction of 3.2g/km (3.9%) from 2021 to 2030 is below the 5.8g/km (5%) from 2015 to 2021 (Dornoff et. al., 2018).

Figure 4 - Expected date of reaching CO2 targets using flexibility mechanics in the EU[5]

	Without using flexibilities	With using flexibilities		
		Minimum level	Moderate level	Maximum level
Volvo	2017	2017	2017	2017
Mitsubishi	2018	2018	2017	2017
Toyota-Lexus	2019	2018	2017	2017
Daimler	2020	2019	2019	2017
Jaguar-Land Rover*	2020	2019	2019	2018
Peugeot	2020	2019	2018	2017
Citroën-DS	2020	2019	2018	2017
Nissan-Infiniti	2020	2019	2018	2017
Renault Group	2021	2020	2019	2017
Volkswagen Group	2022	2021	2020	2018
BMW Group	2023	2022	2021	2018
Ford	2023	2022	2021	2018
Suzuki*	2025	2024	2022	2020
Mazda*	2026	2024	2023	2021
Opel-Vauxhall	2027	2026	2024	2021
Kia	2028	2026	2025	2022
Subaru*	2028	2026	2025	2022
Honda	2029	2028	2026	2023
Fiat-Chrysler	2030	2028	2026	2022
Hyundai	2033	2030	2028	2024

*Manufacturers with a niche derogation target

Note: dates before 2020 are illustrative – super-credits cannot be earned and used before 2020

We believe that the flexibility measures are hypocrite and a potent manufacturer as Volkswagen should not make use of it. Especially after the diesel scandal, we recommend Volkswagen to disclose full transparency about how they plan to meet the 2030 target. Therefore, we set Volkswagen the goal to reach the 2030 target without making use of the flexibility measures, but solely through increasing its share of electric vehicles and reducing direct emissions of combustion engines.

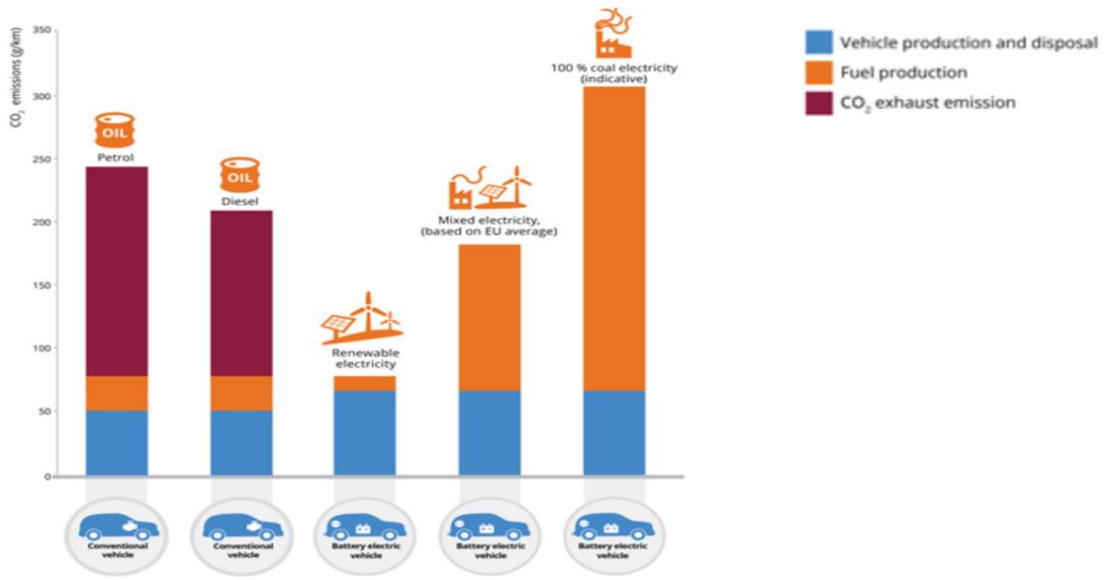
2.2 Considering the vehicle's lifecycle

As the second goal for Volkswagen, we focused on increasing vehicles' life cycles. Appendix 4 shows that the life cycle of cars has been constantly decreasing since the 1980's (Center for Automotive Research, 2017). This becomes even more alarming when considering the high emission generation during a cars production and disposal process. It translates to the equivalent

[5] Source: TransportAndEnvironment (2018)

of 50g/km for regular cars and 65g/km of greenhouse gas emissions for electric cars considering a mid-class vehicle and a millage of 220.000 km (compare Figure 7). Unfortunately, longevity and life-cycle emissions are currently not considered by regulations (McGee, 2017). Following the European Commission's proposal for 2030, we would like Volkswagen to pursue an emission reduction of 30% by 2030 also for the manufacturing and disposal process.

Figure 5 - CO2 lifecycle emissions of different vehicle types



2.3 Increasing the usage rate per car

Following research by Donella Meadows, the first leverage point in a system is its underlying paradigm (Meadows, 1999). In the transportation industry, this paradigm is the concept of everybody owning his own car. Considering that a car is on average used only 10% of the time, transporting 1.5 people (TransportAndEnvironment, 2017), the most effective and efficient way of reducing emissions in the car industry is to reduce the number of cars on the road and therefore drastically lower production.

As a car manufacturer, Volkswagen can contribute to this goal by developing shared mobility services and autonomously driving cars. A McKinsey study projects that in 2030, for 105 million sold private cars, 10 million will be shared vehicles (McKinsey, 2016). Therefore, we assume that by 2030 there is demand for shared vehicles in the amount of 10% of new cars sold. In order to tie this goal to Volkswagen's ambitious growth plans, we suggest that Volkswagen needs to get one shared vehicle operating at full capacity for every sold ten new vehicles by the year 2030.

3 Solutions for a sustainable Volkswagen Group

3.1 The status quo of Volkswagen

3.1.1 Past and future efforts in E-Mobility

To reach the 2030 emissions target, Volkswagen will rely on a substantial number of electric vehicles in their fleet (Rauwald, 2017) and it already has a viable product in place. An internal study shows that the eGolf has 26% less emissions over its lifecycle than its combustion powered counterpart (McGee, 2017). Unfortunately, Volkswagen did not scale its ambitions, with only marginal sales of their two fully-electric models e-Up! and the eGolf (Shahan, 2018). For plug in hybrid cars, Volkswagen has a bit more to show. In 2017, it sold 70.314 cars. However, Volkswagen, as the largest car manufacturer in the world, only ranks 7ths for electric cars sold (Kane, 2018).

We nevertheless see huge see huge growth potentials for the company. In 2017, Volkswagen announced to invest more than €20 billion into R&D and €50 billion in battery sourcing contracts to become the leading player in the electric vehicle space with 50 electric car models, expected to make up for 25% of sales by 2025 (Rauwald, 2018). Nonetheless, it is to assume that Volkswagen get there by maxing out the offered flexibilities of super-credits, eco innovation and pooling (TransportAndEnvironment, 2018).

3.1.2 Low efforts for recycling and shared mobility

Volkswagen has shown very little ambitions in improving vehicles' afterlife, with only one small project in recycling and one in repurposing batteries as energy storage (VW, 2018 (1), VW, 2018 (2)). In contrast, the company's competitors are positioned significantly better (Stinger & Ma, 2018). BMW, for example, announced to build a fully-sustainable battery supply chain in Europe (Evarts, 2018). To reduce emissions within the production process, Volkswagen aims for an emissions reduction of 45% based on 2010 levels by 2025 (VW, 2018 (3)). However, the company plans to switch from coal to gas, which is, however, still far from clean energy. Therefore, we see still a huge potential for reducing life-cycle emissions for Volkswagen.

With regards to rethinking the future of mobility, Volkswagen shows low ambitions. For 2018, it planned to launch MOIA, an electric shuttle bus service in selected German cities. However, due to undisclosed reasons the project was postponed and is expected to be launched in 2019. In 2019, Volkswagen also plans to launch a zero-emissions shared mobility service in Germany (VW, 2018 (4)), as well as a self-driving taxi service in Israel (Hawkins, 2018). Its German competitors Daimler and BMW are way ahead in shared mobility, both with DriveNow and car2go already successfully positioned within the market and now planning to join their forces through a merger

(BMW, 2018). Especially considering that Volkswagen is the largest car manufacturer in the world, past and future commitments towards shared mobility are weak.

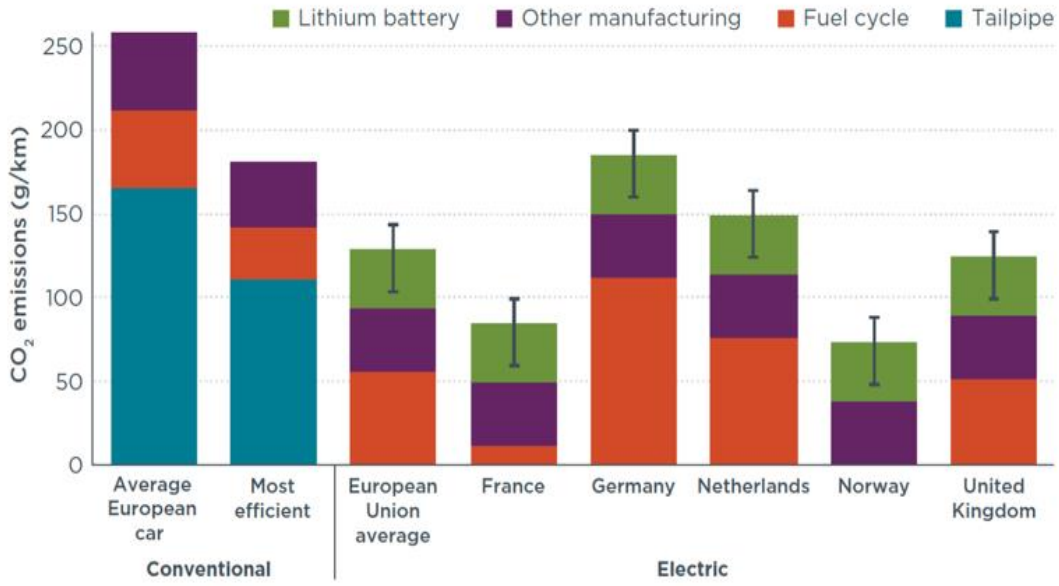
3.2 The status quo of Volkswagen

To reach our set target of reducing emissions by 30% across the Volkswagen fleet by 2030 without applying flexibility mechanism, the straight forward approach is to roll-out more electric and hybrid vehicles. However, to reach beyond direct car emissions, we suggest two high leverage solutions, which are both accompanied by the use of renewable energies (despite gas) across the whole group.

3.2.1 Low efforts for recycling and shared mobility

Suggestions for increasing the lifecycle of cares are hard to derive without profound technical knowledge. However, for electric and hybrid cars, improving batteries constitutes the highest leverage point. Electric batteries produce ca. half of the emissions of the manufacturing process (see figure 7), with only 5% of lithium-ion batteries being currently recycled in the EU, whereas worn-out car batteries still carry 70% of their capacity (Zacune, 2013). Therefore, we suggest, that Volkswagen confidently invests in recycling and repurposing technologies.

Figure 6 - Lifecycle emissions of different car types by country (>150,00km travelled)[6]



3.2.2 Shifting a paradigm with shared mobility

Shared mobility is on the rise. Gartner, a global research institute, has projected that, by 2025, 20% of all urban cars will be shared. Currently, 42% of people interviewed were open to alternative

[6] Source: Hall, D., Lutsey, N. (2018)

ownership forms like subscription pricing, adding to 24% interested in fractional ownership. Moreover, 50% of millennials are open to sharing rides with others (V12Data, 2016).

To enter the shared mobility segment, Volkswagen needs be aware of its unique position as the world's leading car manufacturer. Admittedly, the company is currently far from agile in reacting to change. However, the rise of shared mobility as an alternative ownership form is the biggest threat to Volkswagen's current business model of selling cars. McKinsey projects recurring revenue from shared mobility to grow by 30% until 2030, making up 22% of the automotive industry's revenue (McKinsey, 2016). Volkswagen cannot miss out on this opportunity, especially after the company already missed to successfully enter the electric car segment. Considering its financial and operational strength, the company has the capacity to push the boundaries of mobility, as they did with the first Volkswagen Kaefer. Therefore, Volkswagen should heavily ramp up its investments for current projects in alternative and shared mobility and seek out new opportunities in other spaces as well.

3.3 Opportunities and risks

Our suggested solutions do bear certain risks, which are, however, offset by the vast upside they promise.

3.3.1 Tremendous potential for batteries

By investing in battery recycling and repurposing technology, Volkswagen can position itself as the market leader in this field. With the current EU legislation in place, European electric car manufacturers must take care of the disposal of the batteries (European Commission, 2018 (2)) and currently there is no recycling system in place to handle the upcoming wave of worn-out batteries (Sanderson, 2017). On the one hand, Volkswagen will have to deal with this issue for their own batteries no matter what. On the other hand, a forecasted shortage of batteries by 2030 would put Volkswagen into an advantageous position in the industry, as it could source its raw materials internally and even reap revenue from recycling its competitors' batteries (Stinger & Ma, 2018).

3.3.2 A state-owned company

Volkswagen is in a unique position to change an industry and our society simultaneously. It is the largest car manufacturer in the world and 20% of the company is owned by the German state Niedersachsen, which holds a veto right in all major decisions (History, 2009; Land Niedersachsen, 2018). That means that long term goals that equally benefit society as well as the company can be pursued more easily with less profit-driven justification. Also, as the government has unique insights into Volkswagen and the automotive industry, it might promote new technologies to work

for our society through regulations in favor of self-driving cars, alternative taxi services or battery technology.

3.3.3 Fast follower advantage

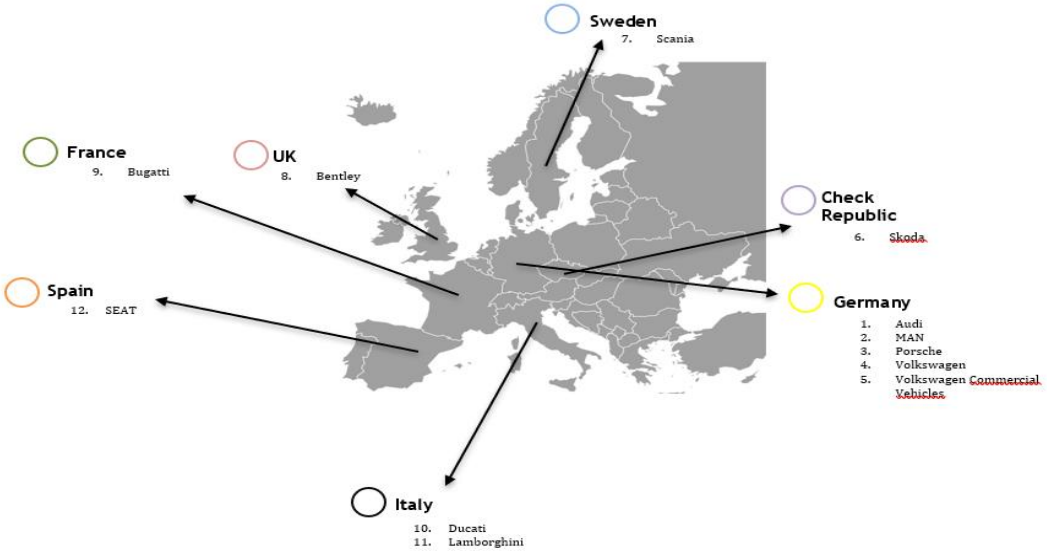
Against common intuition, there is an opportunity of not being the first in the game, in Volkswagen's case in the area of electric and shared mobility. First movers do not only have advantages but also face considerable risks. They must invest heavily into R&D, test the market and deal with new regulations and changes in public opinion (Kellogg, 2013). Tesla and Uber come to mind with regards to burning cash to be the first move in the space of future of mobility. If they will stay the first, is highly questionable. Volkswagen can take this opportunity as a fast mover and enter the now opened market with full speed and overtake the incumbents with its financial power and operational expertise. Admittedly, purposely shifting the fundamental paradigm of its current business model is risky and will cannibalize certain revenues. However, shared mobility is on the rise and this change will happen, with or without Volkswagen.

Appendix

Appendix A

Volkswagen Group, headquartered in Germany, encompasses twelve different car brands across whole Europe.

Figure 7 - Brands within the Volkswagen Group



Source: own map

Appendix B

Because of the Diesel Scandal, Volkswagen was facing a significant financial loss in 2015. Please compare the year's Profit/Loss and Return on Equity figures.

Figure 8 - Development of Volkswagen's key financials

Key financials & employees of Volkswagen from 2013 to 2017

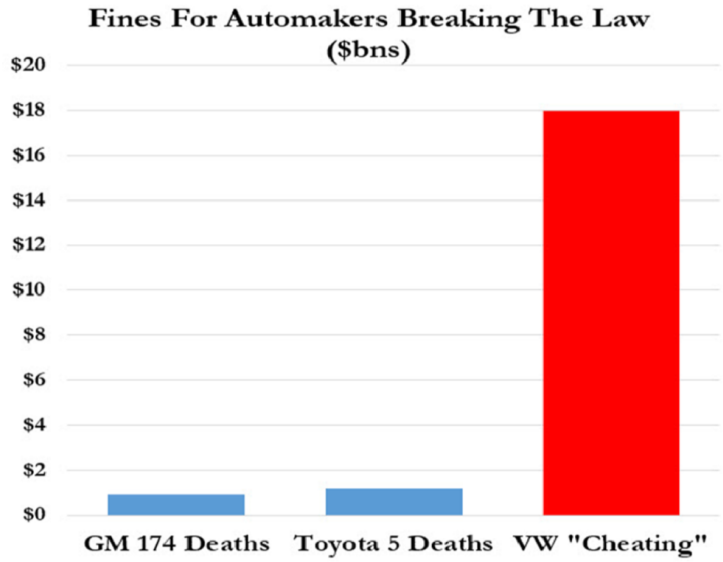
Consolidated	31/12/2017 m EUR	31/12/2016 m EUR	31/12/2015 m EUR	31/12/2014 m EUR	31/12/2013 m EUR
Operating revenue (Turnover)	245.916	231.198	226.395	212.756	206.964
P/L before tax	13.913	7.291	-1.301	14.794	12.429
P/L for period [= Net Income]	11.638	5.379	-1.360	11.068	9.145
Cash flow	25.937	19.064	11.648	22.819	19.637
Total assets	422.193	409.732	381.935	351.210	324.333
Shareholders funds	109.077	92.910	88.270	90.189	90.037
Current ratio (x)	1,90	1,74	1,84	1,83	1,92
Profit margin (%)	5,66	3,15	-0,58	6,95	6,01
ROE using P/L before tax (%)	12,76	7,85	-1,47	16,40	13,80
ROCE using P/L before tax (%)	5,49	3,63	0,42	7,25	6,51
Solvency ratio (Asset based) (%)	25,84	22,68	23,11	25,68	27,76
Number of employees	616.505	601.384	587.066	566.278	546.811

Source: Amadeus

Appendix C

The fines imposed on Volkswagen by US authorities over the course of the Diesel Scandal constitute a historic high.

Figure 9 - Historic fines imposed on carmakers

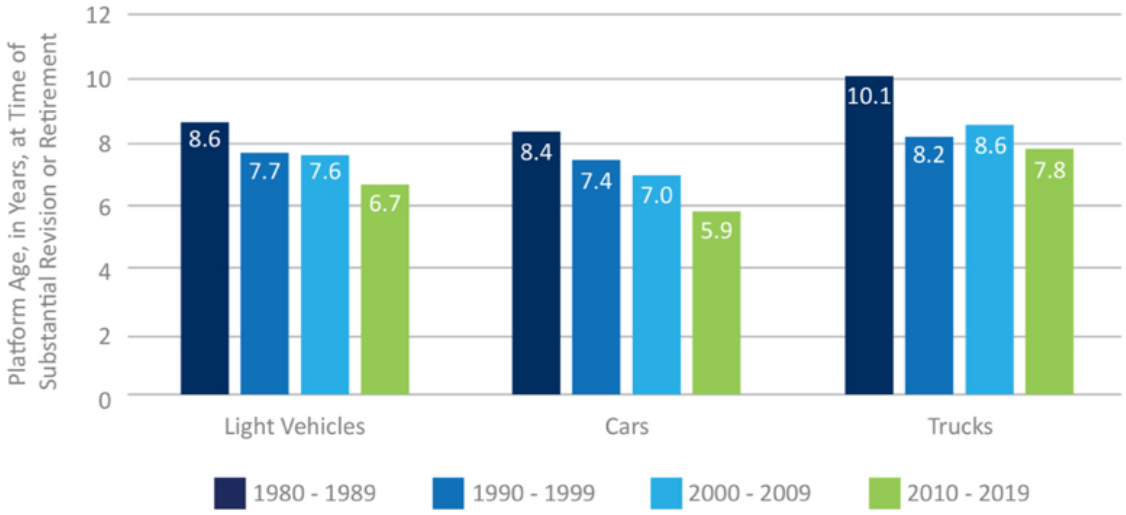


Source: Latif (2017)

Appendix D

The total lifecycle of light vehicles, cars and trucks has been constantly decreasing since the 1980s up to now.

Figure 10 - Platform age of cars at time of substantial revision or retirement



Source: Center for Automotive Research (2017)

List of references

Atiyeh, Clifford. "Everything You Need to Know about the VW Diesel-Emissions Scandal." *Car and Driver*, Car and Driver, 2016, www.caranddriver.com/news/everything-you-need-to-know-about-the-vw-diesel-emissions-scandal.

"Automotive Product Development Cycles and the Need for Balance with the Regulatory Environment." *Center for Automotive Research*, Center for Automotive Research, 20 Sept. 2017, www.cargroup.org/automotive-product-development-cycles-and-the-need-for-balance-with-the-regulatory-environment/.

Bartlett, Jeff S. "Guide to the Volkswagen Emissions Recall." *Product Reviews and Ratings - Consumer Reports*, 23 Oct. 2017, www.consumerreports.org/cro/cars/guide-to-the-volkswagen-dieselgate-emissions-recall-.

Bloomberg, Factset. "Volkswagen Group on the Forbes World's Best Employers List." *Forbes*, Forbes Magazine, 2018, www.forbes.com/companies/volkswagen-group/.

BMW. "BMW Group and Daimler AG Agree to Combine Mobility Services." *Three Years since the Market Launch of BMW i. 100,000 Electrified BMW on the Road.*, 2018, www.press.bmwgroup.com/global/article/detail/T0279654EN/bmw-group-and-daimler-ag-agree-to-combine-mobility-services?language=en.

Business, The Week. "VW Scandal: Emission Fix Leaves Thousands with Problems." *The Week UK*, The Week UK, 13 July 2017, www.theweek.co.uk/65351/volkswagens-us-boss-steps-down-with-immediate-effect.

Carrington, Damian. "Wide Range of Cars Emit More Pollution in Realistic Driving Tests, Data Shows." *The Guardian*, 30 Sept. 2015, www.theguardian.com/environment/2015/sep/30/wide-range-of-cars-emit-more-pollution-in-real-driving-conditions-tests-show.

Center for Automotive Research, U.S. Regulators. "In Charts: The Volkswagen Emission Scandal." *The Wall Street Journal*, Dow Jones & Company, 25 Sept. 2015, graphics.wsj.com/volkswagen-emission-scandal-charts/.

Chiacu, Doina. "Volkswagen CEO Gets 7.78 Million Euros in Pay and Benefits for 2016." Edited by Sonya Hepinstall and Lisa Shumaker, *Reuters*, Thomson Reuters, 14 Mar. 2017, www.reuters.com/article/us-volkswagen-bonuses-mueller/volkswagen-ceo-gets-7-78-million-euros-in-pay-and-benefits-for-2016-idUSKBN16L153.

Dornoff, Jan, et al. *The European Commission Regulatory Proposal for Post-2020 CO2 Targets for Cars and Vans: A Summary and Evaluation*. The International Council of Clean Transportation, 2018, *The European Commission Regulatory Proposal for Post-2020 CO2 Targets for Cars and Vans: A Summary and Evaluation*.

European Commission, (1). "Proposal for Post-2020 CO2 Targets for Cars and Vans." *Proposal for Post-2020 CO2 Targets for Cars and Vans*, European Commission, 6 Nov. 2017, ec.europa.eu/clima/policies/transport/vehicles/proposal_en.

European Commission, (2). *Batteries & Accumulators*. 2018, ec.europa.eu/environment/waste/batteries/.

European Environment Agency. "Range of Life-Cycle CO2 Emissions for Different Vehicle and Fuel Types." *European Environment Agency*, 22 Nov. 2017, www.eea.europa.eu/signals/signals-2017/infographics/range-of-life-cycle-co2/view.

Evarts, Eric C. "BMW Sets up End-to-End Battery Recycling in Europe." *Green Car Reports*, 22 Oct. 2018, www.greencarreports.com/news/1119405_bmw-sets-up-end-to-end-battery-recycling-in-europe.

Ewing, Jack. "Volkswagen Issues Profit Warning Over Cost of Diesel Repairs." *The New York Times*, The New York Times, 29 Sept. 2017, www.nytimes.com/2017/09/29/business/vw-diesel.html.

Future of Car Sharing. *The Future of Car Sharing*. Collaborative Fund, futureofcarsharing.com/.

Garcia, Tonya. "Volkswagen's PR Response Made Problems Worse, Experts Say." *MarketWatch*, MarketWatch, 25 Sept. 2015, www.marketwatch.com/story/volkswagens-pr-response-made-problems-worse-experts-say-2015-09-25.

Hall, Dan, and Nic Lutsey. "Effects of Battery Manufacturing on Electric Vehicle Life-Cycle Greenhouse Gas Emissions." *The International Council on Clean Transportation*, 2018, www.theicct.org/publications/EV-battery-manufacturing-emissions.

Hawkins, Andrew J. "Volkswagen, Intel, and Mobileye Will Launch a Self-Driving Taxi Service in Israel in 2019." *The Verge*, The Verge, 29 Oct. 2018, www.theverge.com/2018/10/29/18039216/volkswagen-intel-mobileye-self-driving-ride-hailing-israel-2019.

History.com. "Germany Passes Controversial 'Volkswagen Law.'" *History.com*, A&E Television Networks, 2018, www.history.com/this-day-in-history/germany-passes-controversial-volkswagen-law.

Hotten, Russell. "Volkswagen: The Scandal Explained." *BBC News*, BBC, 10 Dec. 2015, www.bbc.com/news/business-34324772.

KANE, MARK. "Plug-In Electric Car Sales Ranked By OEM For 2017." *Inside EVs 81 of Electric Vehicle Charging Is Done at Home Comments*, Inside EVs, 1 Mar. 2018, insideevs.com/plug-in-electric-car-sales-ranked-by-oem-for-2017/.

Land Niedersachsen. "Volkswagen AG Beteiligung." *Nds. Finanzministerium*, 13 Feb. 2018, www.mf.niedersachsen.de/themen/beteiligungen/volkswagen-ag-wolfsburg-1590.html.

Latif, Adnan A. *Volkswagen Brand: the Fall of an Auto Empire*. vol. 10, J. Global Business Advancement, 2017, *Volkswagen Brand: the Fall of an Auto Empire*.

Lebowitz, Shana. "3 Reasons Volkswagen's Apology to the US Government Was Completely Ineffective." *Business Insider*, Business Insider, 9 Oct. 2015, www.businessinsider.com/why-volkswagens-apology-was-ineffective-2015-10?IR=T.

Matussek , Karin, and Elisabeth Behrmann. "VW Can't Escape the Diesel Scandal Fallout." *Bloomberg Businessweek*, 12 Sept. 2018, www.bloomberg.com/news/articles/2018-09-12/vw-can-t-escape-the-diesel-scandal-fallout.

McGee, Patrick. "Electric Cars' Green Image Blackens beneath the Bonnet." *Financial Times*, Financial Times, 8 Nov. 2017, www.ft.com/content/a22ff86e-ba37-11e7-9bfb-4a9c83ffa852.

McGee, Patrick. "Former Volkswagen Chief Executive Escapes Pay Clawback." *Financial Times*, 28 Apr. 2016, www.ft.com/content/10b1780a-0d3f-11e6-ad80-67655613c2d6.

McKinsey . *Automotive Revolution – Perspective towards 2030*. McKinsey and Company - Advanced Industries, 2016, *Automotive Revolution – Perspective towards 2030*, www.mckinsey.com/~/media/mckinsey/industries/high%20tech/our%20insights/disruptive%20trends%20that%20will%20transform%20the%20auto%20industry/auto%202030%20report%20jan%202016.ashx.

Meadows, Donella. "Leverage Points Places to Intervene in a System." *The Sustainability Institute*, 1999, pp. 1–19.

"Mobility, Car Sharing and the Future of the Automotive Industry." *V12Data*, 16 Aug. 2016, www.v12data.com/blog/mobility-car-sharing-and-future-automotive-industry/.

"Nitrogen Oxide (NOx) Pollution." *Icopal Noxite A NOx Depolluting Roofing Membrane System*, www.icopal-noxite.co.uk/nox-problem/nox-pollution.aspx.

"An Open Letter to California Air Resources Board Chairman Mary Nichols." *TakePart*, 17 Dec. 2015, www.takepart.com/open-letter-to-california-air-resources-board-chairman-mary-nichols/.

Park, Mungo. "Environmental Impact of the VW Emissions Scandal." *VW Emissions Action - Leading the UK's Legal Action against the Emissions Scandal.*, Oct. 2016, www.vwemissionsaction.com/news/environmental-impact-of-the-vw-emissions-scandal.

Plumer, Brad. "The World's CO2 Emissions Dipped in 2015. But Don't Celebrate Just Yet." *Vox.com*, Vox Media, 8 Dec. 2015, 4:25pm, www.vox.com/2015/12/8/9873372/emissions-drop-2015.

Rauwald, Christoph. "VW Builds Europe's Biggest E-Car Plant to Halt Tesla's March." *Bloomberg.com*, Bloomberg, 2018, www.bloomberg.com/news/articles/2018-12-08/market-shaking-u-s-case-against-huawei-cfo-rolls-into-next-week.

Rauwald, Christoph. "VW to Build Electric Version of All 300 Models by 2030." *Bloomberg.com*, Bloomberg, 2017, www.bloomberg.com/news/articles/2017-09-11/vw-ceo-vows-to-offer-electric-version-of-all-300-models-by-2030.

"Renault to Modify 15,000 New Cars in Emission Scare." *Renault to Modify 15,000 New Cars in Emission Scare*, BBC, 19 Jan. 2016, www.bbc.com/news/business-35350474.

Reuters, Thomson. "Volkswagen Admits Rigging of 8 Mln Cars in EU -Handelsblatt." *Reuters*, Thomson Reuters, 5 Oct. 2015, www.reuters.com/article/volkswagen-emissions-eu/volkswagen-admits-rigging-of-8-mln-cars-in-eu-handelsblatt-idUSL8N12548G20151005.

Sanderson, Henry. "Electric Car Growth Sparks Environmental Concerns." *Financial Times*, Financial Times, 7 July 2017, www.ft.com/content/8342ec6c-5fde-11e7-91a7-502f7ee26895.

"The Second-Mover Advantage." *Kellogg Insight*, 26 Nov. 2018, insight.kellogg.northwestern.edu/article/the_second_mover_advantage.

Shahan, Zachary. "How Serious Is Volkswagen About Electric Revolution?" *CleanTechnica*, 8 Sept. 2018, cleantechnica.com/2018/09/07/how-serious-is-volkswagen-about-electric-revolution/.

Statista, Statista. "Car Manufacturers by Revenue." *Statista*, 2018, www.statista.com/statistics/232958/revenue-of-the-leading-car-manufacturers-worldwide/.

Stringer, D., and J, Ma. "Where 3 Million Electric Vehicle Batteries Will Go When They Retire." *Bloomberg.com*, Bloomberg, 2018, www.bloomberg.com/news/features/2018-06-27/where-3-million-electric-vehicle-batteries-will-go-when-they-retire.

Thompson , Gregory. "In-Use Emissions Testing of Light-Duty Diesel Vehicles in the United States." *In-Use Emissions Testing of Light-Duty Diesel Vehicles in the United States*, 15 May 2014, www.theicct.org/sites/default/files/publications/WVU_LDDV_in-use_ICCT_Report_Final_may2014.pdf.

Todts, William. *CO2 EMISSIONS FROM CARS: the Facts*. European Federation for Transport and Environment AISBL, 2018, *CO2 EMISSIONS FROM CARS: the Facts*, www.transportenvironment.org/sites/te/files/publications/2018_04_CO2_emissions_cars_The_facts_report_final_0_0.pdf.

TransportAndEnvironment. "Most Carmakers Will Meet Their 2021 CO2 Targets. Here's How." *Transportenvironment.org*, European Federation for Transport and Environment AISBL, 2 May 2018, www.transportenvironment.org/news/most-carmakers-will-meet-their-2021-co2-targets-heres-how.

"Volkswagen - Reputation 2017 | Statistic." Edited by Reputation Institute, *Statista*, Feb. 2017, www.statista.com/statistics/516426/volkswagen-reputation/.

Volkswagen, Espana. "Volkswagen España." *VW Configurador - Volkswagen España*, 2018, www.volkswagen.es/es.html.

"Volkswagen to Be Sued by Norway Fund over Emissions Scandal." *BBC*, 16 May 2016, https://www.bbc.com/news/business-36298591.

"VOW3.DE : Summary for VOLKSWAGEN AG VZO O.N." Edited by Yahoo! Yahoo! Finance, *Yahoo! Finance*, Yahoo!, 4 Dec. 2018, finance.yahoo.com/quote/VOW3.DE?p=VOW3.DE.

VW, (1). "New Power from Old Cells: Audi and Umicore Develop Closed Loop Battery Recycling." *Volkswagen Group*, 2018, www.volkswagenag.com/en/news/2018/10/audi_umicore.html.

VW, (2). "Recycling." *Volkswagen Group*, 2018, www.volkswagenag.com/en/sustainability/environment/recycling.html.

VW, (3). "Volkswagen Group Realigns Energy Supplies: Company Power Stations to Change over from Coal to Gas." *Volkswagen Group*, 2018, www.volkswagenag.com/en/news/2018/03/Volkswagen_Group_realigns_energy_supplies.html.

VW, (4). "MOIA." *Volkswagen Group*, 2018, www.volkswagenag.com/en/brands-and-models/moia.html.

"VW Plans Huge Investment to Become Electric Cars Leader." *BBC News*, BBC, 16 June 2016, www.bbc.com/news/business-36548893.

Woodard, Collin. "Volkswagen Group Was the World's Largest Automaker in 2017." *Motor Trend*, Motor Trend, 8 Jan. 2018, www.motortrend.com/news/volkswagen-group-worlds-largest-automaker-2017/.

"The World's Most Valuable Brand Portfolios Revealed." *Brand Finance*, 2017, brandfinance.com/images.

Zacune, Joseph. *Factsheet Lithium*. GLOBAL 2000, Friends of the Earth Europe, 2018, *Factsheet Lithium*, www.foeeurope.org/sites/default/files/publications/13_factsheet-lithium-gb.pdf.